Ministério da Agricultura e do Abastecimento



XXI INTERNATIONAL CONGRESS OF ENTOMOLOGY

XVIII Brazilian Congress of Entomology

ABSTRACTS

BOOK I

The XXI International Congress of Entomology is a joint promotion of:





Foz do Iguassu - Brazil 2000 - August 20th to 26th



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To request this publication, please contact:

ANT Embrapa Soja Caixa Postal 231 - Distrito de Warta 86001-970 - Londrina, PR - Brasil Telefone: (43) 371-6000 Fax: (43) 371-6100



ISSN 1516-781X

Printing: 4500 issues EDITOR Décio Luiz Gazzoni

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International Congress of Entomology (21. : 2000 : Foz do Iguassu) Abstracts of International Congress of Entomology / -- Londrina : Embrapa Soja, 2000. Vol. I p.664.

2 v. -- (Documentos / Embrapa Soja, ISSN 1516-781X ; n.143).

1. Entomology-Congress. 2. Agriculture-Congress. I. Título. II. Série.

632.7 - CDD 21

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EDITORIAL NOTES

This book contains the complete texts of the Plenary Lectures and the abstracts of the oral and poster communications presented at the XXI International Congress of Entomology. Although all abstracts were revised by the Scientific Committee, in order to fulfill the abstracts rules, their contents are printed as received and are exclusive responsibility of the authors.

Dear Authorities Dear Members of the International Council Dear Directors of Entomological Societies Dear Entomologists Ladies and Gentlemen

Four years after the Florence Congress we have the chance to meet again to establish the state of the art on the entomological science. Nowadays, four years represents more than four centuries of the ancient Aristotele era, or four decades of a century ago. Some definitive scientific trues of last congress will be history at use end of this Congress. By force of my position as president of the XXI International Congress of Entomology, I had the chance to view each one of the abstracts, and read almost all of them. So, I realized that better than trying to make my own point, was using the findings and words of the lecturers to make an overview of the Congress, so I will use some of the presentations to anticipate how much we have advanced.

In about one hour we will have the unique chance to hear Dr. John Lawton's lecture. Entomologists preserving biodiversity was the challenge put to the session convenors, symposia coordinators and to all of you, to make an insight reflection of the importance of our science for the next generations. We know we have more species on the Order Lepidotera than birds in the world. Dr. Lawton will use this comparison to call the attention to the importance of insects for the biodiversity. Were the world to be almost destroyed by a catastrophe, if only a dozen species were to survive, they would surely be insects. They are present along all complex food chains, and are part of the ecosystems. Not only beneficials but even pests have a role on the natural systems, and more than philosophy this is something we should take into account on our daily tasks.

My country, Brazil, had the unique chance of helding the Rio de Janeiro Convention on Biological Diversity, a milestone for sustainable conservation of the earth's genetic resources. The preservation of biodiversity is an essential prerequisite for the future development of the earth as a viable habitat. New insights into processes and structures, and genes of animals and plants, will also help us to find new ways of combating disease, safeguarding the food supply of the world's growing population and protecting the environment. The preservation and sustainable utilization of the diversity of species is of vital importance for the interests of all mankind, for the countries that supply these resources and, last but not least, for the health and food industries.

We should consider insect diversity conservation beyond single species or endangered taxa, because of its importance on the natural systems, its stability and continuity. We can either think that "small is beautiful", by having this goal in mind every day, on the lab, on the field, on the university, on the institutes. But we have also to consider our role on the global society, helping planning, building or composing network mentality for conservation, taking part of concrete actions for preserving biodiversity. That will be our contribution for sustainability, a major claim of the contemporary society.

We have to consider the limitations of insect propagation to new geographic locations, due to climatic restrictions. Right now we are located at the edge of one of the Brazilian National Parks, essentially a tropical forest. In the tropical area live the majority of the insect species. The climatic change, or the global warming is one of the threats our society is facing and discussing right now. We know that warmer climates offer better possibilities of wintering and lead to a higher density of population, earlier presence of insects and an increased risk of invasion by migratory insects. Higher atmospheric CO_2 concentrations increase the carbon assimilation of plants and modify the carbon distribution pattern, and the secondary plant ingredients. The increase in bound carbon in a plant causes a reduction of the nitrogen concentration. The result is that nitrogen may become more and more a limiting factor for the development of insects. In economically important species, this will finally lead to an increased uptake of biomass.

Insect-dependent plant pollination will also change as a result of climatic changes and thus also the productivity of plants. Climatic changes do not only have effects on local and regional food chains, but even on complete food systems. Such changes will affect the biodiversity of some regions. We must also consider the insect services, under a new category that could be called natural services. I am talking about the services that are provided for free by Mother Nature, like the cleaning of air or water, or the natural pest control. In this sense, it is very important that all of us, that have the privilege of being on the entomology science, to understand that insects can survive very well without us, but we - like most other terrestrial organisms - would have no chance without them.

Sustainability should be a permanent challenge to us, scientists, aiming to leave a better world to future generations. Those of us dealing with all branches of entomology but focusing on agricultural improvement should understand how different is the concept of sustainability to rich societies and to poor countries. To ones that have food in the table every other day, and those that are exploiting resources far distant from the necessary care that would lead to sustainability, including biodiversity protection. Away from the widely accepted concept of sustainability which says that " the process over the long term that enhances environmental quality and the resource base on which agriculture depends; provides for basic human food and fiber needs; is economically viable; and enhances the quality of life of farmers and society as a whole". Dr. Marcos Kogan, one of our

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distinguished plenary lecturers will drive your attention to the Holly Bible of sustainability, by stating that a sustainable agriculture system

- a. is based on the prudent use of renewable and/or recyclable resources;
- b. protects the integrity of natural systems so that natural resources are continually regenerated;
- c. improves the quality of life of individuals and communities;
- d. is profitable;
- e. is guided by a land ethic that considers the long-term good of all members of the land community

Integrated Pest Management is largely based on sustainability, which is an empty concept if not linked to biodiversity preservation. Much of the complexity of an ecosystem resides in its biodiversity, and it is precisely this biodiversity that is most negatively affected by input-driven agriculture. We have to resist to the temptation of minimizing or making the issue linear, by just opposing two major points of view: the first defending that "agricultural intensification is necessary because the worldwide area of highly-productive arable land is limited and diminishing, and only by increasing yields per unit area we will be able to meet the demands of a growing world population." The argument from the 'high-input' side, however, assumes that this agricultural intensification is necessarily tied to high-inputs and mechanization. On the other side, the extreme situation is the claiming of new processes like organic agriculture being a final goal, and not a means to produce food and fiber. We will have the pleasure to listen to Dr. Settles experience on Southern Asia IPM Programmes implementation, addressing all these questions.

I beg your full attention now: In the next thirty years the world will have to produce more food than over the whole of the last 10,000 years According to widely accepted statistics, the real problem is:

- a. The world has 800 million people that are food insecure;
- b. Out of them, 180 million are preschool children;
- c. In 20 years, the Asian population will increase 1 billion people;
- d. During the same period, Sub-Saharan population will increase 80%;
- e. Setteris paribus, the food production will have to increase 60%;
- f. Increasing world wealth will demand 200% increase on meat production;

The dimension of the challenge will call for all our intelligence, creativity and cleverness, to design system approaches that will feed the people from one side and leave a better world for our sons on the other side.

Pests in general, insects in particular, represent serious threat to the full expression of the productivity and quality potential of all major crops. Some insect pests are so widespread, have a diversity of hosts and potential of damage that are considered key agricultural pests. Among them we have fruit flies and white flies. They deserve special space during this Congress. The organizing committee was especially wise on inviting Dr. Dan Gerling to revisit the white flies world. But why have whiteflies been chosen as the group to be revisited? The increased fitness, the ability to leave larger progeny relative to the abilities of other individuals or populations, has led to the emergence of new and better-adapted forms of life. Once detected, it is of special interest to learn in what way such forms stand out and how their traits contribute to greater fitness. Whiteflies have been schown and studied for over 250 years. The research conducted reflects the changes in their economic status and advances in biological theory and scientific methodology. During the last 100 years, whitefly species, differed from other economic species in defying attempts at classical biological control and have become economic pests of worldwide proportions. During the past 15 years, *whiteflies* has caused damages sometimes reaching \$500 million or more per year. Concomitantly, *Bemisia. tabaci* races and biotypes were found. The most prominent one, biotype 'B', showed increased fitness in relation to the former 'A' biotype. It eventually replaced it in extensive regions, and has been described as a separate species: *Bemisia argentifolii*.

You are all invited to carefully listen and discuss Dr. Gerling opinions regarding severe and widespread outbreaks of white flies. Will the growers be able to handle the problem, or should we think on national or regional programs? It is critical that nanagement, including employment of natural enemies, be implemented as soon as viable. This is especially important since the chances for resistance build-up already at the "invasive stage outbreaks" are substantial, and the resistant populations will be carried over to the "stable stage outbreaks" hampering IPM attempts in the future. And he will also claim your attention to the fact hat the mere discovery and description of new biotypes has little value unless the relationship to functional traits is elucidated as a ever for better biological, ecological and agricultural understanding, leading to better management.

The challenge will also arise a series of new questions. Dr. Gatehouse is provoking us asking "Transgenic Plants; an Environmentally-Friendly Method of Pest Control?". This question would be ridiculous if placed during the XXIV International Congress of Entomology, but the world society is asking to us to present a convincing answer right now, not in twelve years. Is the biotech, or the high tech world better than the present system? Do we have the same treats, risks, and hazards? Is the food safe, our health protected, the environment not endangered? Going to specific points, do we agree that the price for meeting the food lemands can be too high, with irreversible depletion or destruction of the natural environment?

Whilst pesticides are very effective in combating the immediate problem of insect attack on crops, and have been responsible for dramatic yield increases in crops subject to serious pest problems, non-specific pesticides are harmful to beneficial organisms including predators and parasitoids of those target pest species. In response to public concerns, the agrochemical industry has introduced a number of less harmful and less persistent pesticides. But, the real question is: what is the most convenient scenario for the world society, the biotechnological or the pesticide paradigm, both or none of them. How will the IPM programmes be conformed under the new concepts coming out of our laboratories.

Fortunately, transgenic plants are not the only breakthrough on the opening of the new millennium. Scientists participating in this Congress are responsible for continuous advancing of science, and new approaches on how to manage insects come out all the time. I carefully read Dr. Bernays review on Plant – Insect Interactions. Year after year we learn more and more on insect relations, including tritrophic interactions. Dr. Bernays will conclude that the details of behavior and physiology, especially neurophysiology, have suggested an approach to the study of insect-plant interactions, namely the constraints on neural processing and the diverse effects of these constraints in ecology and evolution. This approach will allow us to understand more about all aspects of the insect-plant interaction in a way that has been difficult in recent decades.

Dr. Hassell is responsible to elucidate the latest advances on insect – parasitoid interactions. Insect ecologists have always asked what determines the abundance and patterns of fluctuation of insect populations. Parasitoids play a major role on insect regulation, and are amongst the most abundant of all animals, comprising some 10% or more of all metazoan species. They have been popular subjects for ecological study for a variety of reasons. First, their importance in biological pest control programmes has stimulated a large amount of work seeking to identify and quantify the attributes that enhance the effectiveness of parasitoids as pest control agents. Second, the study of host-parasitoid population dynamics has greatly benefited from the way that parasitoids make ideal subjects for the development of relatively simple population models.

On studying plant-insect and insect insect-interactions, one major issue that comes to our minds is taxonomy (either plant or insect classification). The organizing committee understood to be important reviewing the impact of Hennig's 'phylogenetic systematics' on contemporary entomology, inviting Dr. Andersen to discuss Hennig's contribution with us. Phylogenetic systematics comprises the principles and methods by which we reconstruct the evolutionary histor of organisms and transform this reconstruction into a biological classification of these organisms. Whereas the contingency between classifications of organisms and their evolutionary history had been known since Darwin, it was not until the middle of the last century that real progress was made in designing the tools for phylogenetic reconstruction. This important progress was in part initiated by the German entomologist Willi Hennig, who clarified or redefined the goals of phylogenetic systematics in his today's classic book published in 1950.

The potential of practical use of insect interactions and insect communication is tremendous. Dr. Leal, from the University of California, have the mission to lead the discussion on chemical ecology, during the Congress. We know that chemical communication involves the production and release of specific chemicals by the emitter, and the detection and olfactory processing of these signals leading to appropriate behavioral responses in the receiver. Chemical attraction is the major means of sexual recruitment in scarab beetles. Females are normally the emitters and males the receivers, and in this case, the semiochemicals are referred to as sex pheromones. Male-released aggregation pheromones have also been reported for a few Dynastinae. Largely, the present research projects are aimed at the development of attractants (pheromones or food-type lure compounds) for possible applications in management programs. On the one hand, scientists have focused on the chemistry of the emitters (identification and synthesis of pheromones) and studied the biology, biosynthesis and physiology of pheromone production. On the other hand, investigation has been conducted to identify the molecular mechanisms of the olfactory processing in the receivers.

But are we exclusively talking about plants and insects? Not at all, animals and insect interaction are also a major interest during this Congress, and Dr. Nuttal will approach the tick-parasite interactions at the host interface. To survive, the ticks must attach and remain feeding on a host for several days, even weeks. The physical and chemical processes of feeding, and long duration of attachment provoke host haemostatic, inflammatory and immune responses. Ticks counterattack with anti-haemostatic, anti-inflammatory and immunomodulatory substances secreted in their saliva. Included in this armory are proteins that bind immunoglobulins, histamine, and serotonin, and various cytokine regulators that affect the production or activity of several cytokines, including interferon. As a result of the pharmacological activities of this rich cocktail of bioactive saliva molecules, the feeding pool within the skin becomes an immunologically privileged site. Any pathogens (viruses, bacteria, protozoa) transmitted by infected ticks into the feeding pool, or that are acquired by feeding ticks from infected hosts, will benefit from a supportive ecological niche created by the tick. Such a phenomenon, often referred to as 'saliva-activated transmission,' has been reported for several tick-borne pathogens. Then, the challenge is determining whether this immunologically privileged feeding site can be destroyed, and pathogen transmission prevented.

Some of the answers we are looking for are somewhat lost in the time, and that's why we have asked Dr. David Grimaldi to tell us something about the Mesozoic radiations of the insects and origins of the modern fauna. We know that insects are among

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the earliest terrestrial organisms, with a fossil record extending to the Devonian, pterygotes appearing in the Carboniferous, and some modern orders in the Paleozoic. In the 400 million years since the earliest hexapods, they have proliferated into the most diverse group of organisms in the entire Phanerozoic. Extensive radiations of modern faunas, however, did not occur until the Cretaceous, based on diversification of species of ecological keystone groups: Isoptera, cimicomorphan and pentatomorphan bugs, phytophagan beetles, aculeate wasps, cyclorrhaphan flies, and glossatan moths. These groups alone today represent well over half of all insect species, and their diversification can be related directly or indirectly to the angiosperm radiations in the mid Cretaceous.

And we also widely recognize the overall importance of the advances obtained on basic entomology for the benefit of the World Society. I happen to know Dr. Karel Slama on the European Congress of Entomology, and during the two and a half hours drive between Prague and Ceske Budejovice he spoke nothing but insect hormones and insect respiration. I felt all of you would love to hear the enthusiasm Dr. Slama put when speaking on a new look into insect breathing. As an entomology student, I was told that terrestrial arthropods either were able to ventilate actively the tracheal system in response to hypoxia or accumulation of CO₂, or that a simple passive diffusion of O₂ or CO₂ through the air-filled tracheal system could account sufficiently well for all respiratory requirements, without a need for active ventilation. Most insect physiologists accepted this "diffusional theory" as a model of insect respiration for the whole 20th century. But Dr. Slama discovered the presence of special, periodically repeated pulsations in mechanical pressure of the haemocoelic body cavity. These extracardiac pulsations were produced by simultaneous contractions of abdominal somatic muscles, which caused positive pressure peaks in the haemocoele. The movements of body segments, associated with this "abdominal pressure pump", were rather small and invisible by a naked eye, but still they were large enough to cause a bulk flow of gas through some spiracles that were just open. He also observed that spiracular valves pulsated selectively in synchrony with the upward or downward strokes of the pressure pulse, producing an actively regulated unidirectional stream of air. This type of active insect breathing was achieved by means of an autonomic cholinergic, neuromuscular system (coelopulse), driven by a nervous center in the thoracic ganglia of the ventral nerve cord. I am absolutely sure you all will benefit of Dr. Slama's lessons as I did.

I must also recommend that you all bookmark Dr. Tolbert speech on neural development during embryonic and metamorphic development in insects. Why study the development of insect nervous systems? Beyond satisfying sheer curiosity, knowledge of insect neural development holds the hope of revealing novel and specific paths for biologically sensitive intervention, to protect or to control specific populations of insects. Furthermore, for developmental biologists, insects offer a rich source of material. The development of the nervous system in insects follows different paths, depending on the life history of the species, yet many of the cellular and molecular mechanisms underlying neural development appear to be common across disparate insect species, and even common between insects and mammals. Individual species variations confer particular experimental advantages to the investigator using insects. For all of these reasons, recent years have seen a huge research effort to understand neural development in insects. Insect nervous systems develop along widely differing timetables, depending on the life stages of the species. Dr. Tolbert will provide background on embryonic development and metamorphosis of the nervous system, but will focus mostly on intercellular interactions that play key roles no matter what the timetable, no matter what the extent of post embryonic reorganization, of the developing nervous system.

Basic science can contribute much more. Dr. Eberhardt accepted to tell us why is it that male genitalia tend to evolve rapidly and divergently in so many animal groups. He will summarize data and ideas from insects and arachnids that have appeared in the last 15 years that relate to various hypotheses (species isolation by mechanical lock and key; pleiotropy; malefemale conflict of interests; cryptic female choice) that have been proposed to answer this question. Dr. Eberhardt will also present:

- a. demonstrations that multiple genitalic contacts and copulations by the female, a prerequisite for the male female conflict and cryptic female choice hypotheses, is more common than previously thought, even in groups previously thought to be monandrous;
- b. realization that there are many female processes that can affect the chances that a given copulation will result in fertilization of a female's eggs;
- c. documentation from literature reviews and a survey study that courtship during and following copulation is extremely widespread among insects and spiders, and also though apparently to a lesser extent, among scorpions;
- d and the realization that the well-documented evolutionary trend for male seminal products to stimulate several female reproductive processes that benefit the male's reproduction is probably a result of either male-female conflict or sexual selection by cryptic female choice.

We come to this congress to hear about insect genitalia, but also the role of the insect gut microbiota, which is the subject of Dr. Dillon's lecture. It is a premise that the success of the Class Insecta in our world is beyond dispute. What is less known is the extent to which microorganisms contribute to this success. The intestinal tract of many insects has been shown to harbor a large diverse microbial community. Although we are now aware of mutualistic associations between a number of insect species and their extra cellular gut microbiota, many species are known to contain a substantial microbiota whose impact on insect survival is unknown. There are still relatively few studies on the role of the normal microbiota of insects compared to their

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obligate pathogens. This is partly due to the difficulty in recognizing beneficial relationships. One area of progress is the contribution of microbiota to the nutrition of the host. Nutritional contributions may take several forms; improved ability to live on sub optimal diets, improved digestion efficiency, acquisition of digestive enzymes and provision of vitamins.

We invited Dr. Manfred Kern to anticipate the most probable scenarios, and he will network with you all during the closing lecture, discussing the Entomology For The Third Millennium - Scientific And Technological Challenges. Food production, Food Security, Food Justice, Integrated Pest Management, Sustainable Agriculture, International Trade and Crop Protection, Biotechnology, all of them will be recurrent issues during this congress, dedicated to the present status, and will surely on the stage during the closing lecture, as big challenges as the door for the next millennium is opening.

Dr. Kern will go even further. He will tell us not only how will entomologists preserve biodiversity, help implementing sustainable agriculture, and feed a hungry world, but also what is the relationship between global warming and insects. How the continuous movement of people from rural to urban area, creating the megalopolis, will affect public health. Will insect vectors just accommodate to the new situation, or will they react to the new environment?

It will be particularly amazing to discuss with Dr. Kern the nano-insects technology. The "nano era" of the twenty-first century will revolutionize - or evolutionise - entomology. Biochips will be expressed in insects, and with the aid of nanotechnologies, nanoelectronics, nanomechanics, nanobiology, nanomanufacturing, nanocontrol and nanomicrology, it will be possible to construct mechanicai insectoids, hybrid cockroach robots and ant robots.

Just a fantasy or free thinking? What about genetechnology-based entomology. In fact, entomology in the twenty-first century will bear the title "Gen(e)ntomology". The large number of highly diversified insect species, the successful evolution of insects, their enormous adaptive potential, their many different survival strategies, their immensely efficient communication systems, and their highly organized society formation will become key fields for molecular biology and gene technology in the future. Transgenic strains of arthropod vectors will become commonplace. We will also be in a position to create and produce new insect species.

Just imagine the scope of possibilities: one thousand grams of DNA (dissolved in one cubic meter) would have a larger storage capacity than all computers which have ever been built, or about 100 billion times the storage capacity of our brain. Thirty grams of DNA work one hundred thousand times faster than the fastest computers we know today .The genetic code of life is a gigantic biological manuscript that we have scarcely yet begun to examine or decode. "Drosophila - completely decoded" was the great headline at the beginning of the year 2000. This means that we now know the 13,601 genes of each separate cell and also those for the development from egg to adult fruit fly.

At the same time as we are advancing our knowledge of the macro-world, we are also engaging in unremitting exploration of the micro-world. After undergoing the "catalysis" of modern science and technology, certain notions that used to be looked on as wild tales are now confronting mankind "as if coming to life". Some of man's fantasies are to manufacture extremely small-scale electrical machinery that can only be seen under a microscope, an "intelligence chip" that could be transplanted into the brain of an insect, or a "remote controlled submarine". We will have the responsibility of ensuring that all these things do not become a knife "cutting both ways" and threatening social stability. "Microscale electromechanical insects" or "modified insects" should never be used as nanotechnology weapons"!

Ladies and gentlemen, I must finish my speech. But before finishing, I have to mention some key persons: without their contribution that would never had happened the XXI International Congress of Entomology:

I would like all the members of the Council for the International Congresses of Entomology to stand up, to be recognized for their wisdom and for the help and support they provided to the Organizing Committee; I personnaly have to thank all of you for the unique professional opportunity you gave to me as President of this Congress.

I would also like the Session Convenors to stand up, to be recognized for their unique work on building the Session Programme;

Please, members of the Local Scientific Committee, would you mind standing up to be recognized for your almost secret work during all the Congress organization;

To you all I can only say: Very thank you, it was very easy to be leader of clever, cooperative and pro-active people.

I must also ask the President and the Director of Embrapa to stand up, to be recognized for the unconditional support to the Congress;

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And I beg your pardon for some necessary personal acknowledgements:

To my first entomology professor, Dr. Elio Corseuil who opened my eyer to the amazing world of insects;

He was only fourteen years old when he designed and broadcasted for the first time the congress homepage, the most important tool we had to organize this Congress. He is my elder son, Decio;

He also was only fourteen years old when he first started check spelling and verifying the compliance of the Congress abstracts to the rules. I'm talking about my younger son, Bruno;

She stood up as an example of woman and companion. Looking back, I can not understand how she could stand these last 1460 days, when she had to give up of any chance of leisure time because I was completelly involved with the Congress organization at the time I was supposed to be with my family. Now I have to say to my wife Rose Mary: Darling, very thank you for being at my side during the last 4 years. You was really great.

Very thank you all.

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ENTOMOLOGISTS AND THE CONSERVATION OF BIODIVERSITY.

J. H. Lawton.

Natural Environment Research Council, Polaris House, North Star Avenue, Swindon SN2 1EU, UK,

INTRODUCTION

Insects dominate global biodiversity. There are roughly an order of magnitude more named species of insects in the single Order Lepidoptera than there are species of birds in the world. But despite their numerical inferiority, global conservation efforts devoted to birds exceed those devoted to all insects (not just Lepidoptera) by several orders of magnitude (although reliable figures are hard to come by). I doubt that this imbalance in effort reflects conservation needs, in the sense that birds as a group are much more highly threatened than insects. Rather, it reflects conservation priorities set by society based on other criteria. Although as entomologists we might be reluctant to admit it, birds are more charismatic than bugs. In the UK, we have a Royal Society for the Protection of Birds. It is hard to imagine a Royal Society for the Protection of Beetles, and certainly not one with 1 million members. In other words, contemporary species conservation has more to do with people's wishes, desires and value judgements than it has to do with scientific logic or need. Indeed, deciding what to conserve and where to conserve it is not, first and foremost, a scientific question. We apply science to conservation after we have decided what it is we wish to conserve, and in the greater scheme of things, the 'what' may have no other basis than personal likes and dislikes. Unfortunately, a few charismatic groups of insects aside (butterflies, dragonflies and glow-worms are good examples), people prefer to devote considerably more conservation efforts to birds and mammals than they do to 'creepy crawlies'.

The shear diversity of insects also means that the approaches adopted by bird and mammal conservationists are ill suited to insect conservation. Again speaking in very general terms (all these comments admit of exceptions), we take a species-by-species approach to the conservation of birds and mammals: "Save Leadbetter's possum!" "Save the n-thousandth species of undescribed weevil" does not have quite the same ring to it. In Britain at least, we have had successful conservation programmes directed at individual species of insects, particularly butterflies, but also dragonflies and Orthoptera, but these are very much the exception. By and large, the overwhelming diversity of insects makes a species-by-species approach to their conservation quite impossible.

PROTECTED AREA NETWORKS

Against this background, entomologists confronted with pressing, not to say depressing, conservation issues need to take a broader view. Indeed it is a view that is also appropriate for the effective conservation of all taxa – not just insects – and it is being increasingly adopted by conservation biologists from all the different rooms in the Ark. We should seek to conserve habitats, better still intact ecosystems, not individual species. Some important consequences follow from taking this approach, to which I will return later. A logical starting point, however, is to focus on the core of any long-term conservation strategy, namely the establishment of a network of protected areas, be they called national parks, nature reserves, wildlife conservation and use areas, or what have you. How do we select such areas, how big should they be, how many, and where? There is a rich literature on these problems with, for example, extensive discussions of efficient reserve selection algorithms that seek to maximise the number of species represented on at least one reserve at minimum cost, or on a minimum total area. The approach is heavy on computing and mathematics, and rather little of it explicitly considers insects. I do not propose to review it here, except in passing. Rather, I want to deal with some more general biological issues.

USING MACROECOLOGICAL PRINCIPLES TO SET STRATEGY

An important set of guidelines for designing protected area networks is provided by macroecology. Macroecology is a rapidly emerging blend of biogeography, ecology and evolutionary biology, and seeks big, bold repeated patterns in the distributions and abundances of species. Three patterns, one very familiar, the other two less so, offer insights into designing conservation strategies based on protected area networks. If we focus on a particular taxon, say passerine birds, or freshwater fish, or butterflies, we find:

1. Across species, a positive correlation between average local abundance and the size of the geographic range of each species.

2. A positive correlation between the regional species richness of a taxon, and its local species richness.

3. A species-area relationship.

The third of these will be familiar to most people, and has been variously praised and criticised as a tool for designing reserve networks. But its basic message is very simple – a big conservation area will hold more species than a small area. One can then get into arcane arguments about whether one large, or several small, reserves is better, but for all sorts of reasons I have no doubt that given a choice conservation biologists should go for large reserves, not many pocket-handkerchief sized areas. This may seem obvious for large animals like birds and mammals, but in Britain at least, the existing network of generally small reserves is making a very poor job of protecting butterflies. Large reserves will aid insect conservation as much as they help bird and mammal conservation.

The first two macroecological patterns are less familiar, but they are also, now, well documented in the literature, and together argue that no reserve is an island. The systematic destruction of regional biotas by human activities threatens surviving populations of species, even in protected areas. Impoverished regional diversity must, sooner or later, lead to reductions in local diversity (pattern 2), with pattern 1 providing insights about the mechanism(s) involved. These are not yet fully understood, but metapopulation dynamic models predict that regional reductions in the geographic ranges of species (by habitat destruction, for instance) will lead to reductions in population abundances, even in surviving, unmodified habitat patches. The basic mechanism is increasing isolation of surviving habitat patches, which reduces or eliminates movement of animals between patches. These models predict that inevitably, populations in increasingly isolated protected areas will decline, and that some will decline to the point of local extinction. These forces can be counteracted by having networks of reserves, close enough together, or connected by corridors, to maintain significant dispersal of individuals between patches. Work on butterfly populations in Britain and Scandinavia illustrates these processes very clearly. The message for conservation is simple. Not only do we need large reserves, we also need inter-connected networks of reserves. Isolated reserves, even big ones, are unlikely to be as effective as we might hope.

Problems of reserve isolation are magnified or reduced by the nature of the greater landscape outside designated areas. 'Gently managed' landscapes may allow considerable movement of species between protected areas, decreasing the effects of isolation. Corridors may work in the same way. Intensively altered and managed landscapes - urbanisation and intensive agriculture in particular - may make it impossible for species to move between reserves, creating severe problems of isolation.

CHALLENGES

All this is fairly simple. But there are some challenges. For example, where should entomologists devote conservation efforts? Where should the protected areas be? Huge areas of the globe remain effectively unexplored entomologically. If we do not even know what is there, how can we design sensible conservation strategies? One hope would be to use indicator taxa, on the assumption that well-studied groups like birds or butterflies can act as indicators of unusually species-rich regions, or regions of high endemism, for all kinds of much less well known and more poorly studied creatures. I wish we could, but fear we cannot. There have been, and still exist, enthusiastic proponents of the indicator-species concept, usually suggesting their own favourite group as ideal. The data say otherwise. Patterns of endemism, species richness, and rarity are, more often than not, poorly correlated across different taxa, at any scale that is useful for the design of reserve networks. Ultimately, we may have to make some difficult choices on selecting protected areas, knowing that information is incomplete. Waiting until we have perfect knowledge is not an option. There will be little left worth conserving if we are unwilling to act until we have better information. In the end, any network of large reserves is better than none!

How many reserves do we need and how close together? Here the reserve selection algorithms referred to above can be useful for well known taxa – which rules out most insects. My belief is, in any case, that for most regions of the world the question is academic. We can never acquire, or manage, enough land to save everything (the species-area relationship proves that). Hence we must settle for as much as possible! We should seek to establish as many reserves as possible, that are as large as possible, and as close together or as well linked as possible. Whatever we get, it will not be enough to save everything.

The biggest challenge lies in global change. Even under 'normal' climatic conditions, Nature does not stand still. Communities gradually 'unravel' as species change in relative abundance, some rare species become common, formerly common species become rare, and other members of the original community disappear altogether. With global climatic change, these processes will inexorably accelerate, tearing apart existing assemblages and creating new ones. Experiments with insect assemblages in the laboratory reveal some very unexpected changes in the distributions and abundances of species under simulated global warming and rising carbon dioxide concentrations. We somehow have to design reserve networks that can cope with a rapidly changing world. One consequence of global change is that sooner or later, most reserves will be in the wrong place, as climatic conditions change markedly. A large, inter-connected network of reserves along the lines advocated above at least gives species a chance of migrating and hence of coping with climate change. Although some conservation biologists are arguing that it will be necessary to move species artificially from reserves where the climate no longer suites them, to areas where it does, we are extremely unlikely to be able to do this for anything other than a tiny handful of species. The vast majority of insects will have to find their own way to new homes, and my guess is that many will fail. Whatever we do, human-induced global change can only make conservation of biodiversity more difficult.

It will not have escaped your notice that the nature of the landscape that surrounds protected areas is now key to which, and how many, species will be able to track their preferred environment in a rapidly changing world. To this extent, butterflies may be more fortunate than buffaloes. Less frivolously, it draws attention to the fact that effective conservation increasingly has as much to do with what happens in the greater landscape as it has to do with what happens on reserves. Reserves are vital for the conservation of many species, and will continue to be so for the foreseeable future, but we can no longer ignore what happens outside reserves.

INSECTS AND NEMATODES

Finally I want to finish with a twist to the story that is sobering because it illustrates how little we actually know about global biodiversity, and hence the challenge of defining what it is we are trying to conserve, and why. I started this abstract with the statement that insects dominate global species richness. Being entomologists, I suspect few readers questioned that opening comment. But is it true? What about nematode worms? The tiny number of studies that exist on the species richness of terrestrial nematodes suggests that this group could be staggeringly diverse. If as entomologists we feel neglected and unloved in the conservation beauty contest that exists between insects and the more charismatic birds and mammals, think what it is like to be a nematologist! I believe we can learn from this lesson. Nobody can be an expert on everything, but we need to remember that insects are not the be-all-and-end-all of the biosphere. Nematodes play vital, albeit still poorly understood roles in virtually all ecosystems. For instance, we have no idea how loss of nematode species might impact on vital soil processes. Much the same could be said about the progressive loss of almost any taxon as we relentlessly simplify the earth's biota. Poor pollination and impaired pest control are two possible consequences of reductions in insect species-richness, for example.

CONSERVATION OF BIODIVERSITY IS REALLY ABOUT DELIVERING A SUSTAINABLE BIOSPHERE

In other words, rather than single-mindedly focussing on the conservation of individual species, or particular taxa, we need to design robust conservation strategies that focus on all taxa, upon the integrity of ecosystems, and on the 'goods and services' provided by biodiversity that sustain the biosphere, and ultimately ourselves. This means moving beyond a protected area network mentality for conservation, to consider how we treat and manage the entire biosphere. Or, in less grandiose terms, to consider not only networks of protected areas, but also the nature of the surrounding areas in which the reserves are embedded, and in which most of humanity live out our daily lives. If, in fifty or one hundred years time, most creatures that you and I regard as 'interesting' are found only on reserves, leaving the greater landscape to rats, cockroaches and sparrows, we will have failed, however many species survive in total on earth. The most important message that entomologists can give to the world is that conservation of biodiversity is not ultimately about ensuring the survival of the spectacular (*Morpho* butteflies) or the bizarre (giant wetas, *Deinacrida*), significant as this undoubtedly is. Nor is it just about the survival of that minority of species blessed with scientific names, or those that are charismatic and easily loved. It is about delivering a sustainable biosphere, and with it a fighting chance for all organisms to survive to the end of this new century and beyond. We must strive for sustainable ecosystems. If we can achieve that goal, many of the species that enrich our lives will be able to look after themselves. With so many species of insects to care about, we really have no alternative.

Index terms: global environmental change; macroecology; metapopulation dynamics; reserve networks; sustainability.

THE IMPACT OF W. HENNIG'S 'PHYLOGENETIC SYSTEMATICS' ON CONTEMPORARY ENTOMOLOGY

N. M. Andersen

Zoological Museum, Univ. of Copenhagen, Universitetsparken 15, DK-2100 Copenhagen, Denmark

INTRODUCTION

Phylogenetic systematics comprise the principles and methods by which we reconstruct the evolutionary history (phylogeny) of organisms and transform this reconstruction into a biological classification of these organisms. Whereas the contingency between classifications of organisms and their evolutionary history had been known since Darwin, it was not until the middle of the last century that real progress was made in designing the tools for phylogenetic reconstruction. This important progress was in part initiated by the German entomologist Willi Hennig (1913-1976; biography, see Anonymous 1978; Schlee 1981), who clarified or redefined the goals of phylogenetic systematics in a book published in 1950: *Grundzüge einer Theorie der phylogenetischen Systematik* (Hennig 1950).

For various reasons did Hennig's 1950 *Gründzüge* remain virtually unknown outside German-speaking countries. One of few exceptions was Lars Brundin, a Swedish entomologist of high international standing, who was among the first to apply Hennig's phylogenetic systematics in works written in English (e.g. Brundin 1966). An extensively revised version of the 1950 *Grundzüge*, translated into English by D. Dwight Davis & Rainer Zangerl of the Field Museum of Natural History in Chicago, was published in 1966: *Phylogenetic Systematics* (Hennig 1966) and soon became the main reference to Hennig's 'phylogenetic systematics' although Hennig himself in 1965 published a short review-paper in English (Hennig 1965). The original, German text of the 1966-book was published in 1982 by Willi Hennig's son, Wolfgang Hennig (Hennig 1982).

PHYLOGENETIC SYSTEMATICS

Although Hennig recognised the shortcomings of the biological species definition when it comes to delimiting species in time, he nevertheless regarded species to be 'real' organisms. In discussing group-categories of higher order by which he meant supraspecific taxa (genera, families, orders, etc.), Hennig argued that if species are real, higher taxa can also claim some reality because they originate by speciation. Thus, higher taxa are real because they are in a historical sense identical to their stem species. Higher taxa originate by speciation where a stem species splits into two sister-species. Hennig decided that the methodologically best solution is to consider the stem species extinct at the speciation event. Following this view of how higher taxa originate, phylogenetic relationships must be defined through the recency of common ancestry. This lead Hennig to redefine the term 'monophyly': "Only those species groups – and it applies to all group categories of higher order – can be called monophyletic which can be traced back to a common stem species. . . It has to be added that monophyletic groups not only ought to contain species that are descendants of one common species, but they must also include all species that come from that stem species." (Hennig 1950: 307-308, translated). As an example of a widely recognised taxon that is not monophyletic in the strict sense, Hennig used the now famous case of 'Reptilia' (Hennig 1950: 257). The term 'paraphyletic' for this kind of non-monophyletic group was not used in the 1950 *Grundzüge*, but first appeared in the 1965-review and the 1966-book.

After having introduced a strict concept of monophyly, Hennig took the initial steps towards designing methods for reconstructing systems exclusively composed of monophyletic groups. He introduced the terms 'apomorphic' for relatively derived species and 'plesiomorphic' for relatively primitive species and occasionally also applied these terms for higher taxa. Hennig soon realised, however, that the concept of apomorphy and plesiomorphy only have meaning when applied to characters instead of taxa. The most important tool in phylogeny reconstruction was the differentiation of ancestral or primitive similarity, which Hennig called 'symplesiomorphy', from advanced or derived similarity, which he called 'synapomorphy'. Only the last kind of similarity can be taken as evidence of phylogenetic relationship. When applied to a group of species or higher taxa, synapomorphies are identified and used to join sister-groups into more comprehensive, monophyletic groups as presented in Hennig's well known 'argumentation plan of phylogenetic systematics' (e.g., Hennig 1965: fig. 3).

During his scientific carrier, Hennig earned a high reputation as systematic entomologist and first and foremost as a specialist on Diptera. He published about 100 original papers and books of which his *Die Larvenformen der Dipteren* (Hennig 1948-1952) and his contributions to Lindner's *Fliegeń der paläarktischen Region* are outstanding. He also became interested in fossil insects embedded in amber and believed - unlike many contemporary neontologists - that knowledge of extinct insects also is important to understanding relationships among living insects. This view penetrates Hennig's most important contribution to insect phylogeny, the book *Die Stammesgeschichte der Insekten* (Hennig 1969) which was translated into English in 1981. The impact of Hennig's 'phylogenetic systematics' on modern paleontology is very obvious in a recent text book by Andrew B. Smith (Smith 1994) and a case study by the present author (Andersen 1998).

EARLY OPPONENTS

The reception of Hennig's 'phylogenetic systematics' in the world community of systematists and other evolutionary biologists was slow and reluctant, especially in North America. During the 1950s and 1960s, biological systematics was dominated by the 'new

systematics', named after a book edited by Julian S. Huxley (1940) and forcefully promoted by a group of Harvard systematists headed by Ernst Mayr. The new systematists, or evolutionary systematists as they more commonly are called, focused on specieslevel problems and largely neglected the study of higher taxa which, in their opinion, are not objective in the same sense as species are. Hennig took a completely different position and concluded that higher taxa are as real as species because they are in a historical sense identical to their stem species, given, of course, that the higher taxa are strictly monophyletic.

Ernst Mayr assumed a critical attitude towards Hennig's 'phylogenetic systematics' which he called 'cladism' or 'cladistics' to emphasise that Hennig's phylogenetic system only conveys information about the splitting events in evolution (cladogenese), but not about the changes that take place in between splitting (anagenese) (Mayr 1969; Mayr & Ashlock 1991). Mayr's major point of criticism concerned the conversion of phylogenetic relationships into classifications by recency of common ancestry or the position of branching points on phylogenetic trees. In an exchange of viewpoints with Mayr in 1974 (Mayr 1974; Hennig 1974), Hennig carefully addresses and refutes the arguments presented, in particular the notion that a phylogeny cannot be transformed into a hierarchic classification, that monophyly cannot be defined precisely and is unimportant for reconstructing phylogenetic system, and that strict dichotomous branching is a necessary principle of cladistics.

NEW DEVELOPMENTS

Almost simultaneously with the publication of Hennig's 1966-book did a new field of systematics arose, numerical taxonomy or 'phenetics', which took the advantage of the rapid development in computer-assisted techniques for analysing large data sets (Sneath & Sokal 1973). Through the inovative works of James S. Farris (e.g., Farris et al. 1970; Farris 1972), it soon became obvious that Hennig's 'phylogenetic systematics' could be formalised in a way that is well suited for quantification and computerisation. From this amalgamation of cladistics and numerical taxonomy emerged an approach to phylogenetic reconstruction that most appropriately can be called 'quantitative cladistics' (Andersen 1999). Along with this development, the theoretical and methodological foundation of cladistics was elaborated and modified through the 1980s and 1990s (Nelson & Planick 1981; Maddison & Maddison 1992; Kitching et al. 1998) and the methods of quantitative cladistics were implemented in a number of programs for personal computers which are routinely used in modern systematics (Hennig 1988; Maddison & Maddison 1998).

The past two decades or so have witnessed an enormous development in 'molecular systematics', including studies of the evolutionary history of organisms as inferred from molecular data (Hillis et al. 1996). Whereas early methods in molecular systematics estimated genetic distances between organisms (and therefore are essentially phenetic), the Polymerase Chain Reaction (PCR) technique yields sequences of nucleotides in strands of DNA and RNA. Following the principles of phylogenetic systematics, molecular data can be treated as a set of characters, each with four states (A, G, C, T or U), which can be used to reconstruct phylogenies in the same way as morphological characters. Furthermore, by applying the methods of quantitative cladistics, molecular data from different genes may be combined with each other and with morphological characters to yield phylogenies based on total evidence (Andersen 1999).

CLASSIFICATION

One of the main goals of biological systematics is to construct a general reference system or classification. Hennig forcefully advocated that only a phylogenetic system can achieve that goal: "Making the phylogenetic system the general reference system for special systematics has the inestimable advantage that the relations to all other conceivable biological systems can be most easily represented through it. This is because the historical development of organism must necessarily be reflected in some way in all relationships between organisms." (Hennig 1966: 22-23). The structure of phylogenetic relationships is hierarchic and consequently a hierarchic classification is an adequate form for representation for the phylogenetic relationships between species. The phylogenetic system only recognises strictly monophyletic groups, that is groups containing an ancestral species and all of its descendants. The most important task of phylogenetic systematics is therefore to recognise and possibly eliminate non-monophyletic groups in classification.

Hennig's 1953 paper Kritischen Bemerkungen zum phylogenetischen System der Insekten was the first major publication in which he applied his 'phylogenetic systematics' outside his own special group (Diptera). In a recent review, Niels P. Kristensen (1995) evaluated the status of the systematics of insects (or hexapods) and, in particular, the impact of Hennig's 'phylogenetic systematics'. No one questions that groups like 'Apterygota', 'Thysanura', Hemimetabola, 'Orthopteria', 'Hemiptera-Homoptera', 'Microlepidoptera', and 'Hymenoptera-Symphyta' are non-monophyletic. The monophyly of the 'Entognatha', 'Psocoptera', 'Hemiptera-Auchenorrhyncha', 'Diptera-Nematocera', and 'Mecoptera' has also been seriously questioned. In general, phylogenetic studies have lead to a better understanding of the evolution of insects and to more 'natural' classifications. This is particularly the case in the Hemiptera-Heteroptera, Lepidoptera, social Hymenoptera, so-called higher Diptera, and in the Coleoptera. This trend is likely to continue through the united efforts of taxonomists, comparative morphologists, and molecular systematists, applying methods developed within the framework of Hennig's 'phylogenetic systematics'.

Recently, de Queiroz & Gauthier (1992) have proposed a 'phylogenetic taxonomy' which abandon the Linnean system of biological nomenclature and replaces taxon names with apomorphy-based definitions without Linnean types and ranks. The merits of such a system are currently under debate and only the future will show if it is viable.

ECOLOGICAL PHYLOGENETICS

Firmly based phylogenetic hypotheses are significant in answering questions on the evolution of ecological and behavioural traits in insects. In a phylogenetic system, sister-groups by definition have the same age of origin (but not necessarily the same age of differentiation) which allows meaningful comparisons. In one of the first studies of this kind, C. Mitter et al. (1988) made independent comparisons of species numbers across wide-ranging taxonomic groups of insects. In all cases were phytophagous groups more diverse than their non-phytophagous relatives.

Thus, by integrating phylogenetic and ecological information we can infer the evolutionary history of ecological traits through an approach most appropriately referred to as 'ecological phylogenetics' (Spence & Andersen 1994). Phylogenetic information can be used in two ways: (a) ecological and behavioural data about extant taxa are placed on phylogenies to reveal probable patterns of evolution and to determine the sequence of changes that generated these patterns; (b) comparative analyses may be corrected for effects of phylogeny to explicitly measure so-called phylogenetic constraints. These methods have applied successfully to ecological and behavioural problems in many insect groups as reviewed by Miller & Wenzel (1995).

A recent collection of papers edited by Philippe Grandcolas (1997), report several case studies where phylogenetic inference tells us a different story than expected. Halictine bees (Hymenoptera: Apidae) include several genera comprising both social and solitary species and seem ideal to test the selective advantage of eusociality in insects. However, phylogenetic analyses indicate that in most genera it is the solitary behaviour that is the evolutionary novelty and eusociality is ancestral (Packer 1997). In primarily winged insects, wing polymorphism is usually treated as a derived trait which has evolved in species using the most stable habitats. However, in northern temperate pondskaters (Hemiptera: Gerridae), phylogenetic inference has shown that the polarisation must be reversed, and that obligatorily winged species most probably have evolved from wing polymorphic species (Andersen 1997). Finally, a study of European *Polistes* (Hymenoptera: Vespidae) tests Emery's rule stating that social parasites are more closely related to their hosts than to each other. Cladistic optimisation of traits associated with social parasitism on a reconstructed phylogeny leads to the rejection of Emery's rule (Carpenter 1997).

CLADISTIC BIOGEOGRAPHY

Hennig's 'phylogenetic systematics' has also had a significant impact on historical biogeography. The general acceptance of continental drift has confirmed the idea that disjunct biotic patterns and geological patterns are due to the same events in earth history. The pioneering work by Brundin (1966) superimposed the disjunct distribution of southern hemisphere chironomid midges (Diptera: Chironomidae) upon reconstructed phylogenies and showed that observed patterns were more or less congruent with hypothesised relations between Gondwanian land areas now widely separated. Fused with cladistics, historical biogeography has now become 'cladistic biogeography' which holds great promise as an equal partner to paleontology and paleogeography in explaining the historical causes of the present distribution of insects (Humphries & Parenti 1999). As principles of biogeography have a permanent place in conservation biology, phylogenetic systematics also has impact on issues related to the 'biodiversity crisis', for example in providing phylogenetic information about regional biotas as one of the criteria for choosing which areas to preserve.

CONCLUSIONS

Hennig's 'phylogenetic systematics' undoubtedly was a very significant contribution to systematics. It is now widely recognised that Hennig's redefinition and clarification of the concepts of monophyly and phylogenetic relationships created a sound foundation for systematics in general. His second contribution was perhaps equally important. After decades of focussing on species-level problems, Hennig redirected the interest of systematists towards the study of higher taxa and the reconstruction of phylogenetic relationships between them (Richter & Meier 1994). Hennig's 'phylogenetic systematics' has a significant impact on contemporary entomology. A phylogenetic system is now almost universally accepted as the most useful general reference system for biology. It has been able to accommodate new developments in systematics, evolutionary biology, historical biogeography, and information technology, and has also been suggested to found a new practise in classification and nomenclature.

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Index terms: Cladistics, classification, ecological phylogenetics, biogeography

PLANT-INSECT INTERACTIONS - A SYNTHESIS

E.A.Bernays

Entomology Department, Univ. of Arizona, Tucson, AZ 85721, USA. E-mail: schistos@ag.arizona.edu

Background

The study of plant-insect interactions is necessarily multidisciplinary. Historically, however, the leaps forward have usually involved specific aspects of the interaction. In the early the 20th century, several biologists recognized the importance of plant secondary metabolites in host choice (e.g. Vershaffelt, Brues, Fraenkel) and in the 1950s and 1960s the mechanisms of host-plant choice by insects was a major focus of study (e.g. Kennedy, Schoonhoven, Dethier, Jermy, Ishikawa). The 1960s and 1970s saw a flowering of theories invoking the importance of chemical defenses in the co-evolution of plants and their associated insects (e.g. Ehrlich, Raven, Feeny, Rhoades and Cates). Other groups, meanwhile, were contributing to our understanding of broader community-level interactions (e.g. Janzen, Root, Strong, Zwolfer, Gilbert, Southwood, Price). Eventually, sophisticated studies of chemicals and their roles in interactions evolved, and the field of chemical ecology was born (e.g. Eisner, Berenbaum, Brattsten, Rosenthal, Rothschild).

More recently, a host of additional approaches have been added. Nutritional ecology (e.g. Scriber, Slansky, Simpson) phylogenetics (e.g. Mitter, Moran, Farrell, Pasteels), biogeography and genetics (e.g. Singer, Gould, Rausher, Via, Jaenike, Futuyma, Feder, Thompson, Mitchell-Olds) have all provided unique insights, and the impacts of other trophic levels in herbivory are now better appreciated (e.g. Gilbert, Lawton, Strong, Dicke, Stamp, Denno). Finally, it has become abundantly clear that plants are quite active participants in their interactions with herbivores (e.g. Coley, Bryant, Baldwin, Tumlinson, Tallamy, Karban).

In addition to these topics and many new researchers in them, important contributions now come from morphologists, neurobiologists, palaentologists and molecular biologists. My presentation will focus on some new and little-tested ways to think about and study the interactions of plants and insects. My attempt to explain the pertinence of these novel interactions will require that I draw together a number of the disciplines involved, though I cannot attempt to review the whole field.

Introduction

My principal focus concerns the insect rather than the plant and, in particular, on how insect neurobiology affects the plant-insect interaction at all levels. Behavior, including host plant-related behavior is an expression of neurobiology that is modified by many physiological factors. Limitations inherent to the nervous system constrain how much information may be processed and can influence choices made, attentiveness to diverse stimuli, and responsiveness to risk (e.g. of predation). Evolutionary adaptations of the sensory system and brain for accommodating these constraints may govern how host affiliations evolve. Changes in the nervous system as a result of experience may also affect fitness in different ways. Both genetically and environmentally based neurological traits may help explain patterns of herbivore-host associations and diet breadth.

Making a choice among plants

Insects searching for an acceptable host plant must first locate and identify the appropriate plant species. We know that the speed of host-finding may be important. There may be time limits for various reasons, while other ecological circumstances commonly impose a need for speed, such as when resources are rare or

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scattered and predators make searching risky. The accuracy with which host taxa are selected, and individual plant quality assessed, are also important, especially for insects with narrow host ranges and specific nutritional requirements for larval development. If the speed, accuracy and quality of choices are all to be maximized by very small animals in a very complex sensory world, strong selection for efficient neural processing might be expected as might the adoption of high-contrast signals (Bernays & Wcislo, 1994).

The majority of insect species use a very restricted number of hosts that typically share characteristic phytochemicals, some volatile and some nonvolatile. A subset of these compounds seems to be of great importance for identification of the host (see Bernays & Chapman, 1984; Städler, 1992; Schoonhoven et al., 1998), and in some extreme specialists great sensitivity to one or a few host-specific chemicals totally dominates in host selection (e.g. Ferguson et al., 1983; Pereyra & Bowers, 1988; Roessingh et al., 1997). Plant taxa heavily endowed with relatively unusual chemicals or suites of chemicals (non-apparent plant syndrome of Feeny, 1975) are often hosts for relatively large numbers of specialist insect species (e.g.Berenbaum, 1983). In addition, specialists tend to be deterred more than generalists by non-host secondary metabolites. I will make the case that specialists benefit from the strong contrasts between cues from hosts and non-hosts.

Additional mechanisms for acceptance/rejection used by different insect groups may heighten perceived contrast in various ways. An insect's response to a chemical mixture may not be predictable based on its responses to each chemical separately. Specifically, interactions among chemical stimulants at the level of the chemoreceptors can result in major changes in concentration-response functions of particular stimulants, with deterrents reducing input from positive inputs and vice versa (e.g. Shields & Mitchell, 1995; Schoonhoven et al., 1998)). I will demonstrate how such interactions could potentially alter the total input from a mixture of conflicting inputs to either a clear positive or a clear negative signal. Such process may be important in producing the particular and synchronous firing of a suite of taste cells, that appears to occur in some beetles only when the requisite mixture of plant chemicals is present (Sperling & Mitchell, 1991). In addition, highly synergistic effects of multiple host compounds are seen in some cases (e.g. Städler & Buser, 1984; Spencer et al., 1999), Thus a variety of mechanisms can provide the clear signal needed for rapid decision-making in a highly complex chemical world. Data so far suggest that the predominant mechanisms vary among insect taxa. In any case, the mechanisms could influence the evolutionary lability of host associations, and the trajectory for a clade of insect herbivores evolving with respect to host affiliation.

Some herbivorous insects alter their preferences as a result of experience. In some cases this results from increased or decreased sensitivity of their chemoreceptors to certain metabolites (Renwick & Lopez, 1999). So far, such changes have been recorded in species that feed on plants in at least several genera and lead to increased acceptability of the experienced food, sometimes with a concomitantly decreased acceptability of other potential foods - once again, an increase in contrast between alternatives. Diet quality also alters relative acceptability of alternatives depending on nutrient need - a flexibility dependent on variation in the strength of inputs from different nutrient chemoreceptors (Simpson & Raubenheimer, 1993).

A minority of insect herbivore species are extreme individual generalists, apparently adapted to situations where food plant quality or abundance is variable or unpredictable, or to situations where the food plants may all be very rich in potentially noxious secondary metabolites. Such herbivores engage in food mixing, eating a variety of plants and frequently making choices about what to eat and what to ignore. Such food mixers often appear to be stimulated by novel chemicals, potentially reducing the inefficiency and complexity of decision making (e.g. Bernays et al., 1997).

Evidence for limited efficiency among generalists

Data will be presented from experiments with butterflies (Janz & Nylin, 1997), caterpillars (Bernays & Minkenberg, 1997), whiteflies (Bernays, 1999), aphids (Bernays & Funk, 1999) and grasshoppers (Bernays, 1998), indicating that having a choice of suitable foods reduces efficiency of foraging, and that the specialists have significant advantages. These benefits include the amount of time taken to reach the host plant, the times taken to make decisions to accept or reject potential food, the time taken to begin ingestion and the time spent in pauses during a meal. In addition, the degree of fidelity to the most suitable host in the presence of less suitable host species and genotypes and the ability to choose superior hosts in the presence of a choice of mixed-quality hosts are shown to be greater in specialists than relative generalists.

Fitness benefits of behavioral efficiency in host choice

Data will be presented indicating that efficient decision-making has positive fitness effects. This appears to be true for ovipositing insects not just with respect to limitation on time overall, but also for evasion of predation through rapid oviposition. Evidence will also be presented for costs associated with the poor quality decisions made by the relatively generalized Lepidoptera and Hemiptera due to reduced growth rate, reduced survivorship and reduced fecundity (Janz & Nylin, 199 7; Bernays & Minkenberg, 1997). Locomotor activity is known to be risky with respect to predator and parasitoid attack, and field studies demonstrate that predation may be 100x more likely during feeding than during resting (Bernays, 1997), thus illustrating fitness costs of with reduced feeding rates. In addition I argue that intermittent, hesitant, or picky feeding behavior and any kind of dithering is dangerous not only because it is conspicuous, but because an animal attentive to food-related activities is unlikely to be attentive to simultaneous environmental risks (Dukas, 1998).

Since protein is often at low concentration in leaves (especially older leaves) and the nitrogen requirements of insects tend to be relatively high, herbivores often compensate by eating large amounts. Not only is high quality food better for growth, but the risk of mortality via predation is reduced on nutritious hosts since less time must be spent feeding and vulnerable to predators. Indeed, perhaps the fitness advantage associated with predator avoidance exceeds that enjoyed due to increased growth rate. Safety and growth are important together of course at a larger time scale - feeding on high quality foliage may also reduce development time, reducing the lifetime risk.

Leaves present very diverse physical challenges, and highly diverse solutions have been found by insects through adaptations of mouthpart morphology. The frequency with which certain mandible types have evolved in separate insect lineages with similar types of food indicates the adaptive value of these structures (Bernays & Janzen, 1988; Bernays, 1991). Furthermore, evolution of mouthparts can be very rapid (Carroll & Boyd, 1992). In view of the ever-present risk of predation, structures that determine handling time may be under great selection pressure. Indeed, the preponderance herbivores that feed on young easily-handled leaves, is probably a matter of safety as much as nutrition.

Secondary chemistry of plants

Among the hundreds of thousands of phenols, alkaloids, terpenoids, iridoids, flavonoids, steroids, and other chemical compounds of plants have been the subject of considerable study (Rosenthal & Berenbaum, 1991). Many appear to have no effects at all on insect herbivores, while others stimulate feeding and/or growth. Some are sequestered, and of these many are clearly toxic in general and serve as plant defenses against many herbivores Such chemicals have often been considered toxic when close study demonstrated they were actually deterrent only, the effects on test insects due to starvation. Some herbivores, however, suffer

deleterious postingestive effects and perform poorly in some way, or learn to avoid the plant as a result of feeding on it and move elsewhere, both of which can be bad outcomes. In many cases, it is not at all clear whether an ability to deal with toxins has been lost, as suggested in the case of grass-feeding grasshoppers (Bernays, 1990), or whether the plants have evolved specific defenses against particular insect herbivores (Berenbaum, 1983). It seems likely that both scenarios occur.

Sequestering these secondary metabolites for defense against predators is also common among herbivores (Bowers, 1990). Besides clear and well-documented fitness benefits of sequestration in highly aposematic species, there are many more subtle cases, in which insects deposit chemicals in the cuticle yet are not warningly colored (Bernays et al., 1991), and others where they gain protection from predators as a result of the gut contents alone (Sword, 1999). Although such processes are not specifically relevant to the theme of neuroecology, they do highlight once more the crucial importance of natural enemies in the lives of insects on plants.

In this presentation, I will also emphasize the very important roles of plant secondary metabolites in signaling. First of all the remarkable diversity chemicals found among plant taxa and within individual plants allows potentially clear signals for every specialist herbivores at taxonomic levels from plant species to plant family (Bernays, 1996). That butterflies such as checkerspots home in on plants from multiple families, simply because of the presence of iridoid glycosides in host plants that are otherwise extraordinarily diverse physically and chemically (Bowers, 1983), is startling evidence of the influence of simple chemical signals on insect behavior. Evidence is beginning to suggest that such cases are not unusual. In addition, deterrence of non-host compounds, being greater for specialists, increases sensory contrast between host and nonhost.

Diversity and the association of insect and plant clades

It has become clear from both fossil studies (Labandiera, 1998) and molecular phylogenies (Farrell & Mitter, 1993) that among all the herbivorous insect groups studied, great diversification is historically associated with the expansion and increased diversity of angiosperms. Although this could arise through coevolutionary processes associated with arms races, I argue that it could be at least partly the result of herbivore tracking diverse genotypes in a plant population and subsequent speciation of herbivores on established plant host races or species.

The selective pressures on the sensory system and its central nervous projections, would favor those insects that match the fine tuning of their detection of distinctive signals with particular plant chemotypes, and would thus be acting through the agency of ecological risk. So, as plants changed and diversified chemically, insect herbivores, being so dependent on specific cues, also changed and diversified so that discrimination of signals from hosts could be maintained at maximum levels of contrast. In this way, vigilance for predators could be maintained at maximum levels. Evidence for tracking chemicals in this way has been demonstrated in one study of a group of beetles and their host plants (Becerra, 1997), and a model is presented to further illustrate this scenario.

Although I will make the case for tracking of chemotypes, it is not impossible for diversification of insect herbivores, driven by such neural processes, to result from coevolutionary processes. However, rather than invoking toxins, the currency would be in terms of signal information.

Plants as active players

The widespread occurrence of herbivory-induced chemical changes in plants (Karban & Baldwin 1997; Agrawal et al., 1999) will be discussed not only as a direct defense but also as an indirect one, that plays on the vulnerability of these small herbivores to multiple risks from predators and parasitoids. Plants may encourage mortality of herbivores by causing them to decrease vigilance. This could involve increased searching and foraging activity, intermittent feeding, and restlessness that is induced by unusual or increasing levels of ingested secondary metabolites.

Conclusions

The synthesis presented here depends on knowing the insect - understanding it as an organism. The details of behavior and physiology, especially neurophysiology, have suggested a theoretical approach to the study of insect-plant interactions, namely the constraints on neural processing and the diverse effects of these constraints in ecology and evolution. I believe that this approach will allow us to understand more about all aspects of the insect-plant interaction in a way that has been difficult in recent decades. The importance of avoiding anthropomorphism and subjectivity in the study of animals may have mitigated against the study of them as individuals with behavioral and neural limitations that impact every aspect of their lives.

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CHEMICAL COMMUNICATION IN SCARAB BEETLES

W. S. Leal, Dept. Entomology, University of California, Davis CA 95616, USA, Email: wsleal@ucdavis.edu

Chemical communication involves the production and release of specific chemicals (semiochemicals) by the emitter, and the detection and olfactory processing of these signals leading to appropriate behavioral responses in the receiver (Roelofs, 1995). Chemical attraction is the major means of sexual recruitment in scarab beetles, in particular, rutelines and melolonthines. Females are normally the emitters and males the receivers, and in this case, the semiochemicals are referred to as sex pheromones. Male-released aggregation pheromones have also been reported for a few Dynastinae. Although a few studies have reported the chemical ecology of the dung beetles (Scarabaeinae), most of the emphasis by research programs on chemical communication in scarab beetles has focused on the subfamilies Cetoniinae, Melolonthinae, Dynastinae, and Rutelinae because of their economic importance as agricultural and/or turf pests. Largely, these research projects are aimed at the development of attractants (pheromones or food-type lure compounds) for possible applications in management programs. In my laboratory, we have taken a comprehensive approach to chemical communication in order to gain a better understanding of both the emitters and receivers and pave the way for the development of environmentally sound control strategies. On the one hand, we focused on the chemistry of the emitters (identification and synthesis of pheromones) and studied the biology, biosynthesis and physiology of pheromone production. On the other hand, we investigated the molecular mechanisms of the olfactory processing in the receivers.

PHEROMONE CHEMISTRY

Recent studies have led to the identification of the sex pheromones of various species in the subfamily Rutelinae and Melolonthinae (Leal, 1998). In general, the pheromones of the former are fatty-acid derived compounds, whereas the latter utilizes phenolic, terpenoid, and amino acid derived compounds. Two interesting exceptions to this general rule are the pheromones of *Heptophylla picea* and *Phyllopertha diversa*. Although belonging to the Melolonthinae, *H. picea* utilizes (R,Z)-7,15-hexadecadien-4-olide (Leal et al., 1996), most likely biosynthesized from stearic acid. On the other hand, *P. diversa* (Rutelinae) produces an intriguing alkaloid pheromone, which also has medicinal properties (Leal et al., 1997).

Utilizing pheromone blends that consist of just a few semiochemicals or even a single constituent, closely related species have attained isolated chemical communication channels and reproductive isolation (Leal, 1999a; 1999b). Species that have the same pheromone system are isolated either temporarily or geographically. Interestingly, *Anomala osakana* and *Popillia japonica* utilize enantiomers of a chiral pheromone (japonilure), with one stereoisomer being an attractant and the other a behavioral antagonist. *P. japonica* and *A. osakana* produce (R)- and (S)-japonilure, respectively (Tumlinson et al. 1977; Leal, 1996). The pheromone of one species is a behavioral antagonist for the other. It seems that this agonist-anatagonist activities of the enantiomeric pheromones have evolved as part of the isolation mechanism between these two species that share the same habitats in Japan. In general, scarab beetles can detect only the enantiomer produced by the conspecific females, but *P. japonica* and *A. osakana* have evolved the ability to detect both enantiomers, one as an attractant and the other as a behavioral antagonist (stop signal).

PHEROMONE BIOLOGY

Pheromone gland cells in *A. cuprea* females were identified as modified integumental epithelia of the terminal abdominal sclerites (Tada and Leal, 1997). The gland cells are composed of round pheromone secretory cells with canal structures bearing an end apparatus. On the other hand, we determined that in *Holotrichia parallela* the pheromone is produced in the posterior part of a ball-shaped sac exposed during female calling. Light microscope observation of the posterior part of the gland revealed a cuticular epithelium layer composed of columnar cells, which was assigned as the tissue involved in the pheromone production (Kim and Leal, 1999).

PHEROMONE BIOSYNTHESIS AND PHEROMONE REGULATION

A typical structure of the sex pheromone of rutelines is the five-membered gamma-lactones having a long unsaturated hydrocarbon chain, such as (R,Z)-5-(—)-(oct-1-enyl)oxacyclopentan-2-one (buibuilactone) and (R,Z)-5-(—)-(dec-1-enyl)oxacyclopentan-2-one (japonilure), which are pheromones for a number of species. Using deuterated precursors, it has been demonstrated that the biosynthesis of these compounds starts from saturated fatty acids (palmitic and stearic acid), involves their desaturation followed by stereospecific 8-hydroxylation, chain shortening and cyclization (Leal et al., 1999). Various scarab species have developed pathways to produce unique pheromone molecules by changing either stereospecificity or regiospecificity of the hydroxylation step. Anomala cuprea and Popillia japonica utilize the (R)-8-hydroxylase, whereas the hydroxylase of A. osakana is specific to the (S)-substrate. It seems that A. rufocuprea is devoid of the enzyme so it makes methyl Z-(5)-tetradecenoate (Tamaki et al., 1985). Pheromone biosynthesis in scarabs is regulated by a PBAN-like factor. The pheromone titer

in the glands of decapitated females dramatically decreased 24 hr after surgery, but it resumed after injection of the brain extracts from virgin females. The activity of the brain extracts is lost after treatment with proteinase K. Because BmPBAN is also active, characterization of the gene encoding the peptide was pursued by library screening and PCR. Hitherto, none of the molecular approaches led to the identification of the PBAN gene in scarab beetles. On the other hand, a bioassay-oriented strategy lead to isolation of the active peaks by reversed phase HPLC and ion-exchange chromatography. The small amount of the isolated peptide prevented any further characterization.

MOLECULAR BASIS OF OLFACTION

For their survival, insects heavily depend on their ability to detect chemical signals from the environment, which are buried in complex mixture of odors from a myriad of sources. This has been highlighted in the literature by their highly sensitive and selective olfactory systems for the detection of sex pheromones, particularly in Lepidoptera, which approach the theoretical limit for a detector. While minimal structural modifications to pheromone molecules render them inactive (Kaissling, 1987), a single molecule of the native ligand is reported to be sufficient to activate the pheromone-specific olfactory neurons in the antennae of the silkworm moth, *Bombyx mori* (Kaissling and Priesner, 1970). There is growing evidence in the literature that this inordinate sensitivity is achieved by a combination of the roles of various olfactory specific proteins, including odorant receptors, odorant-binding proteins, and odorant-degrading enzymes. In order to gain a better understanding of the molecular basis of olfaction, we aimed at identifying and characterizing the pheromone-degrading enzymes, studying the neurophysiological details of pheromone perception "in vivo," and isolating, identifying, and cloning the genes encoding the pheromone- and odorant-binding proteins. In order to elucidate the function(s) of these proteins, we have been conducting structural studies in collaboration with Jon Clardy (Cornell University) and Kurt Wuthrich (ETH-Switzerland).

PHEROMONE-DEGRADING ENZYMES

Antennal proteins from the extracts of several species of scarab beetles can degrade buibuilactone and japonilure, even those from species that do not use this group of compounds as their pheromones. In some cases there was only one metabolite, identified as the corresponding hydroxy fatty acid. It seems that the deactivation of the lactone signal is obtained by the opening of the lactone ring. Some species, however, degraded the pheromone into several more products. The esterase from *A. octiescostata* showed significant preference for (R)-japonilure over that of the (S)-enantiomer. This observation is consistent with the fact that this species produces only the (R)-enantiomers of the two pheromone components and it is anosmic to the (S)-lactones.

Analysis of the degradation products of the unique pheromone from *P. diversa* revealed that only the antennal extract of this species can degrade the pheromone. The antennal extracts from 10 other scarab species and 4 lepidoptearn species produced no activity at all. Separation of the antennal extracts showed that the enzymatic activity was associated with the membrane fractions in the absence of cytosol. Analysis of the degradation reaction suggested that the major degradation product was due to a demethylation at the N-1 position; the second product was due to hydroxylation of the aromatic ring. Studies on the degradation along with potential cofactors or inhibitors showed that the enzymatic system requires NADPH and NADH for activity. On the other hand, the enzymatic activity was inhibited by proadifen and metyrapone, two general widely used inhibitors for cytochrome P450 (Wojtasek and Leal, 1999).

DEGRADATION OF PHEROMONES "IN VIVO"

The discovery of the unique pheromone-degrading enzyme in *P. diversa* and the identification of enzymatic inhibitors opened the way to study pheromone inactivation "in vivo." When metyrapone was introduced by diffusion into the pheromone-specific sensilla in the antennae of *P. diversa*, the pheromone detectors became "silent" to lower concentrations after application of a large concentration of the pheromone. The effect of the inhibitor is remarkably different from adaptation as will be discussed later. In addition, metyrapone treatment had no effect on the sensila of *P. diversa* tuned to (Z)-3-hexenyl acetate nor did it affect the pheromone-detecting systems in *P. japonica*, for which pheromone inactivation is achieved with a sensillar esterase.

IDENTIFICATION AND CLONING OF OBPs

We have identified, cloned, and characterized the odorant-binding proteins from a number of scarab species. It is now clear that scarab beetles possess two families of odorant-binding proteins, one with 116 and the other with 133 amino acids, which we named OBP1 and OBP2, respectively. While OBP1 is well conserved among all species of scarab beetles, OBP2 belongs to a more diverse group and, in contrast to OBP1, it has not been detected in all species. Interestingly, OBP2 possesses isoforms, which can be separated by native gel electrophoresis. These isoforms have different binding affinities. For example, one isoform of OBP2 from *P. diversa* binds bombykol, whereas the other conformation binds japonilure (Wojtasek et al., 1999). Microheterogeneity of the OBPs in scarab beetles is not derived from different gene products, but it is due to the conformational flexibility of the proteins. Consistently, we found only one gene encoding OBP2 in various species.

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Interestingly, in both *A. osakana* and *P. japonica*, we could detect only one PBP in the antennal extracts; the proteins from the two species showed a 96% similarity. Due to the limited sensitivity of the detection methods, one cannot rule out the possibility of the presence of proteins expressed at low levels. However, electrophysiological experiments suggest that if two PBPs were involved in the signal transduction of the enantiomers of japonilure they would be expressed at nearly the same level. Single sensillum recordings from the antennae of the Japanese and Osaka beetles showed that enantiospecific receptor neurons respond equally to (R)- and (S)-japonilure. These findings and the observation that a single PBP from *A. osakana* bound both enantiomers of japonilure apparently with the same affinity suggested that in the antennae of these species, the same PBP may recognize both the pheromone and the "stop signal", i.e., the enantiomers of japonilure (Wojtasek et al., 1998).

STRUCTURAL BIOLOGY AND FUNCTION OF PBPs

We envisaged that in order to determine the molecular basis of insect olfaction and elucidate the function of PBPs, we needed to study the three-dimensional structure of the pheromone-binding proteins and its interaction with ligands. We embarked in collaborations with two groups (Jon Clardy and Kurt Wuthrich) to determine the 3D crystal and solution structures of the pheromone-binding protein from *Bombyx mori*. Functional expression of BmPBP was achieved in *E. coli* periplasm. The protein appeared as a single band in gel electrophoresis and it was homgeneous in most chromatographic systems. However, NMR experiments conducted by the Wuthrich group indicated the existence of at least two conformations at pH 6.2. Throughout the analysis of both the native and recombinant proteins, a remarkable feature of the PBPs appeared. These proteins have dynamic structures, altering their conformations in pH-dependent ways. Studies with model membranes suggested that upon an interaction with the dendritic membrane, PBPs undergo a conformational change that may lead to the release of the pheromone ligand (Wojtasek and Leal, 1999).

The three-dimensional structure of the BmPBP with bound bombykol has been determined by X-ray diffraction (Sandler et al., 2000). BmPBP has six helices, and bombykol binds in a completely enclosed hydrophobic cavity formed by four antiparallel helices. Bomkykol is bound in this cavity through numerous hydrophobic interactions. It has been suggested that a pH drop would result in protonation of the histidine residues that form the base of a flexible loop and protonated histidines could destabilize the loop covering the binding pocket.

Although the crystal structure did not show clear evidence for dimers, a comprehensive study (Western immunoblotting experiments, mass spectral analysis, gel filtration estimation of molecular masses, and cross-linking reactions), showed that BmPBP is a monomer at acid pH and a dimer at basic, neutral, and slightly acid pH. This suggests that the physiologically relevant pH for the early olfactory processing is not only that of the sensillar lymph (bulk pH), but also the pH at the surface of the dendrides (localized pH) (Leal, 2000).

ACKNOWLEDGMENTS

I gratefully acknowledge the great contribution that my past and present collaborators and members of my research group made to this work. My research projects in Japan were financially supported by a special coordination fund for promoting science and technology by the Science and Technology Agency of Japan and by the Programe for Promotion of Basic Research Activities for Innovative Biosciences (BRAIN). Work in the US was made possible through direct financial support from the department, college, and Chancellors office at UCD.

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Index terms: pheromones, pheromone-binding proteins, pheromone-degrading enzymes, biosynthesis

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TRANSGENIC PLANTS; AN ENVIRONMENTALLY-FRIENDLY METHOD OF PEST CONTROL?

A. M. R. Gatehouse¹ & J. A. Gatehouse², 1 Agric. & Environmental Science, Univ of Newcastle, Newcastle NE1 7RU, UK. 2 Dept Biological Sciences, Univ. of Durham, Durham DH1 3LE, UK.

With a projected increase in world population of 9-10 billion over the next four decades, an immediate priority for agriculture is to achieve maximum production of food and other products. Unfortunately the price for achieving such levels can be too high, with irreversible depletion or destruction of the natural environment making certain agricultural practices unattainable in the longer term. Whilst pesticides are very effective in combating the immediate problem of insect attack on crops, and have been responsible for dramatic yield increases in crops subject to serious pest problems, non-specific pesticides are harmful to beneficial organisms including predators and parasitoids of those target pest species. In response to public concerns, the agrochemical industry has introduced a number of less harmful and less persistent pesticides. The emergence of technologies that have allowed plants to be stably transformed with foreign genes has been timely, with the commercial introduction in 1996 in US of crops expressing genes encoding the insecticidal δ -endotoxin from *Bacillus thuringiensis*. Although not as yet a commercial reality, other strategies for engineering crops to give endogenous resistance to insect pests, such as the use of plant-derived genes encoding defensive proteins (enzyme inhibitors and lectins), genes encoding other insecticidal proteins, and novel solutions such as manipulating plant secondary metabolism, are actively being pursued. Combinations of these and other emerging transgenebased crop protection methods will increase both the range and durability of resistance. To avoid the possibility of pests becoming resistant to transgenic insect-resistant crops, and for a variety of other reasons, deployment of transgenic insect-resistant crops is taking place as part of a recommended stratgey of integrated pest management (IPM); consequently, the engineered crops must be compatible with the other components of IPM. Thus ideally, genes expressed in transgenic plants for control of pest species should at the same time produce no directly deleterious effects on beneficial insects (predators and parasitoids) which play an important role in biological control. Inevitably, the removal of the host or prey for beneficial insects will be deleterious, but any toxic effect of the transgene product will decrease the viability of biological control. It may also indicate that widespread use of transgenic crops could have undesirable ecological consequences, such as global reductions in beneficial insect populations; however, it is important that the effects of such crops on beneficial organisms are compared with the effects of current agricultural practices. This paper will discuss the role of GM crops in agricultural systems and their potential environmental impact on natural enemies of insect pests, and will consider both the deployment of Bt expressing crops, and those expressing a range of plant-derived genes.

MESOZOIC RADIATIONS OF THE INSECTS AND ORIGINS OF THE MODERN FAUNA

David Grimaldi Department of Entomology American Museum of Natural History Central Park West at 79th Street, N. Y., New York 10024-5192 USA E-mail: grimaldi@amnh.org

ABSTRACT

Insects are among the earliest terrestrial organisms, with a fossil record extending to the Devonian, pterygotes appearing in the Carboniferous, and some modern orders in the Paleozoic. In the 400 million years since the earliest hexapods, they have proliferated into the most diverse group of organisms in the entire Phanerozoic. Extensive radiations of modern faunas, however, did not occur until the Cretaceous (140-65 Ma), based on diversification of speciose, ecological keystone groups: Isoptera, cimicomorphan and pentatomorphan bugs, phytophagan beetles, aculeate wasps, cyclorrhaphan flies, and glossatan moths. These groups alone today represent well over half of all insect species, and their diversification can be related directly or indirectly to the angiosperm radiations in the mid Cretaceous (90-110 Ma). This scenario is in contradiction with the hypothesis by Labandeira and Sepkoski, that the angiosperm radiations had little or no effect on insect diversity in the Cretaceous. Differences in the two hypotheses are due to analyses of past diversity using the taxic approach (used by Labandeira and Sepkoski) and the phylogenetic approach, the latterespoused here.

Introduction

Twenty-four years ago, at the XVI International Congress of Entomology, the late Professor Frank Carpenter outlined the state of knowledge on the geological history of insects. He stated in the Proceedings (pg. 63) "...our knowledge of fossil insects has more than doubled during the past 30 years." Nearly 30 years later, that statement still holds true, particularly for discoveries of insects from the Mesozoic Era (230-65 Ma), but also with respect to theoretical and empirical developments in systematics, both molecular and morphological. Carpenter's review appeared six years after Willi Hennig's original, German edition of Die Stammesgeschichte der Insekten; the English, annotated edition (Insect Phylogeny) appeared in 1981, and promoted Hennig's synthesis much more widely. Although contemporaneous with Hennig, Carpenter was extremely conservative in the classification of living and fossil insects (Carpenter, 1992; Carpenter and Burnham, 1985; Carpenter, 1997). His approach was not cladistic; a result of which was the adoption of paraphyletic Martynov-Crampton taxa, such as "Apterygota," "Paleoptera," and "Endopterygota." Carpenter's conservatism had some advantages, though: he was very cautious not to over-interpret fossils, so his classifications were not highly hierarchical, and he discouraged the naming of new higher taxa in lieu of substantial evidence. Despite the fact that the fossil record of insects is relatively incomplete compared to that of vertebrates and marine invertebrates, for Carpenter and many others, the fossil record was virtually necessary for deciphering the evolutionary history of insects. For Hennig, completely preserved extant taxa would always provide the basis for phylogenetic studies of insects, and thus for understanding evolutionary histories. He spent, however, the last 15 years of his life largely with the study of Diptera in amber, along with living relatives of those fossils. His Insect Phylogeny is devoted largely to Paleozoic and Mesozoic insect fossils. With a cladistic framework established largely from living taxa, and given sufficient number and preservation of insect fossils, Hennig maintained that the "true phylogeny" could then be unraveled. This approach, unfortunately, has rarely been adopted in paleoentomology.

Within the past two to three decades there have been several very significant individual works, each representing a "quantum leap" in the study of insect paleontology. Besides Hennig's 1981 book, perhaps the

most significant work was Carpenter's 1992 Hexapod fascicle for the *Treatise on Invertebrate Paleontology*. It assembled an extremely arcane literature (up to 1984) that was widely scattered among entomology and geology. Also significant was the 1991 English translation of B.B. Rohdendorf's Arthropod volume of the *Fundamentals of Paleontology*; this edition of the 1962 Russian original allowed an accurate understanding of the extensive older Russian literature. Ironically, the study of insect fossils has its firmest foundation thus far in various studies of modern orders. Niels P. Kristensen (e.g., 1975, 1991, others) has focused exclusively on modern taxa, but the care and comparative extent of his research and his assessment of published data has set a standard far exceeding that of Hennig's work. Recent studies have generated abundant new molecular data on higher relationships in insects. These studies have stressed analyses of "total" (morphological and molecular) evidence (Whiting et al., 1997), although virtually all of the morphological data derives from the papers of Kristensen. With the exception of a few, enigmatic taxa like the Strepsiptera, these large molecular studies have been unable to substantially modify the hypotheses of Kristensen.

Methodology

There are several methods with which to examine the past diversity of insects, principally the taxic and phylogenetic approaches. In the former, taxa like genera and families are treated as equivalent historical units across all groups, and changes are examined in taxon number over time. The phylogenetic approach treats each group as a separate lineage, and focuses on the cladistic position of fossils. The study by Labandeira and Sepkoski (1992) examined the ordinal and family-level diversity of insects throughout the entire history of the Class; it is a widely cited paper that is a classic example of the taxic approach; another taxic study of insect history is by Jarzembowski and Ross (1996). Several patterns proposed by these studies were: the impact on insects incurred by the Permian/Triassic extinctions (the largest extinction event for all organisms in the Phanerozoic); a general lack of extinction of insect families through the Cretaceous/Tertiary boundary; and minimal effect of the angiosperm radiations on the diversity of insects. As I will elaborate below, angiosperm radiations had a dramatic impact on the radiations of insects, if the fossil record is analyzed phylogenetically. Smith (1994) compared attributes of the taxic and phylogenetic approaches, the main drawback of the former being substantial effects due to an indifference towards, and use of, paraphyletic groups. For a paraphyletic group, patterns of historical diversity can appear "bottom heavy" (that is, particularly diverse in nascent stages), and the latest fossil record for that "group" is not an accurate index of extinction. The so-called Protorthoptera, for example, are a paraphyletic group comprising primitive, extinct orthopteroid insects, to the exclusion of the Orthoptera. "Extinction" of the Protorthoptera in the Triassic is illusory, since one lineage derived from it (i.e., the Orthoptera) actually continued to flourish, much the way birds did after the demise of the rest of the dinosaurs. With the taxic approach, mass extinctions can be exaggerated. Another unrealistic assumption of the taxic approach is the equivalence of a taxonomic category (e.g., genera, families) among different groups (e.g., orders). Rank, of course, is inconsistently applied among groups and greatly affected by taxonomic conventions. The many families of lower Mesozoic Diptera described by Rohdendorf (1964), for example, are now being dramatically revised by the modern Russian paleoentomologists. Only the phylogenetic approach is capable of range interpolation and discerning gaps in the fossil record. There is, in general, a remarkable correspondence between the rank of a clade and its stratigraphic position for many groups of organisms throughout the Phanerozoic (Benton et al., 2000); marked departures from the correlation are powerful predictors of insufficient stratigraphic sampling.

Cladistic analyses employ parsimony in order to optimize a scheme of character evolution; so the number of characters has a great impact on the results of an analysis. As such, it is not at all surprising that cladistic analyses based on much more complete living taxa have dominated systematic entomology and the classifications of insects. But, some fossils are much more complete than others. Insects from the Upper

Triassic of Virginia, USA, for example (Fraser et al., 1996), are preserved in an extremely fine-grained shale that preserves even microtrichia, but they are entirely two-dimensional. No fossilization can compete with the exquisite, life-like preservation in amber, which preserves external and soft internal morphology with fidelity (Grimaldi, 1996). Much of my work has focused on insects in amber, in order to have as complete an array of fossilized characters as possible. Such preservation strengthens the phylogenetic interpretation of extinct taxa. Preservation in amber biases against larger insects that could extract themselves from the miring resin, but tiny insects (<3-4 mm) are the most diverse, and amber preserves components of faunas rarely seen in compression deposits. No pre-Cretaceous amber insects are known thus far, and any found are likely to be very rare.

Mesozoic Radiations

Cuticular remains of primitively wingless hexapods occur in the Devonian (400-360 Ma). By the Carboniferous, 300 Ma, 14 orders appeared, including the Ephemeroptera, Protodonata, Paraplecoptera, Orthoptera, and the extinct, beaked insects in the paleodictyopteroid orders. By the Permian, 14 other orders appeared, some of which were short lived, and others, like the Coleoptera, endured to the present. A Paleozoic history is reviewed by Kukalová-Peck (1991)(but see also Willmann [1997]). The Permian was clearly a period of impressive radiation of basal clades of insects. Numerous Paleozoic records exist of welldocumented insect-plant interactions, as based on feeding damage and structure of insect mouthparts (reviewed by Labandeira, 1998a). Despite an ancient and intimate association of insects and plants, Labandeira and Sepkoski (1993) concluded from their taxic analysis of insect families that diversity was unaffected by the radiations of the angiosperms that occurred in the mid-Cretaceous (Crane et al., 1995). This hypothesis is probably an effect of taxic analysis, and it also does not account specifically for those insect groups that depend today on angiosperms. Insects infiltrated several "adaptive zones" in the Mesozoic, among the most significant being freshwaters (Ponomarenko, 1996; Pritchard et al., 1993; Wootton, 1988), breeding in carrion (Grimaldi and Cumming, 1999), and vertebrates ectoparasitism (e.g., Borkent, 1995, 1996)(see also Labandeira, 1998b). Here, however, I am focusing on the origins of the predominant adaptive zone of modern insects: their association with angiosperms through herbivory and pollen+nectar feeding. A phylogenetic treatment of the history of insect pollinators was provided elsewhere (Grimaldi, 1999), parts of which I refer to below.

DICTYOPTERA. Relationships based on studies of DNA and morphology of the Mantodea, Blattaria, and Isoptera are currently contentious (e.g., Kambhampati, 1995; Thorne and Carpenter, 1992; Klass, 1995). The geological record is inconsistent with the apparent cladistic relationships of these orders, in that Mantodea and Isoptera have much younger records than the Blattaria. By Blattaria, I refer specifically to the extant group of roaches that possess a highly vestigial, internalized ovipositor (Klass, 1995); as distinguished from the Blattodea s.l., which include those Paleozoic and Mesozoic roach-like insects possessing an ovipositor. The Blattaria apparently had their origins in the Triassic and appear to have derived from some group within the Blattodea s.l. (Grimaldi, 1997), which would help explain the discrepancy in cladistic rank among living dictyopteran orders and their fossil records (Grimaldi, 1997). The oldest mantises are from the Upper Jurassic of Eurasia and the Cretaceous of several continents. The oldest, Cretaceous Isoptera are primitive Hodotermitidae, Termopsidae, and possible Mastotermitidae; the extant derived families Kalotermitidae, Rhinotermitidae, and Termitidae did not appear until the Tertiary (reviewed in Thorne et al., 2000). Indications are, thus, that origins of the Isoptera were no earlier than the Upper Jurassic. Cretaceous termites are uncommon and Tertiary fossils of them usually common, indicative also of much greater ecological success in the Tertiary. This chronology reflects the evolution of grasses in the mid-Tertiary (Jacobs et al., 1999); grasslands today comprise one-third of the earth's vegetative cover. Radiation of

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grasses probably fueled the impressive diversification and biomass of grass-feeding termites in savanna and prarie ecosystems.

THYSANOPTERA. The oldest definitive thrips is a very primitive genus, as yet undescribed, from the Upper Triassic of southern Virginia (Fraser et al., 1996). It is very similar to *Jurassothrips*, from the Jurassic of Eurasia, and another undescribed genus in mid-Cretaceous amber from New Jersey USA. All have wings that are broader and with a venation more complete than any other thrips; they possess some venational apomorphies of the Thysanoptera, as well as the wing fringe. All Mesozoic thrips known thus far in Cretaceous ambers from Burma, Canada, Lebanon, New Jersey, Siberia, and Spain, are no more derived than the extant Merothripidae. This is a small cosmopolitan family of mycelial-feeding species, and the apparent sister group to all other thrips (Mound et al., 1980). The Eocene Baltic amber contains the first evidence of modern families like Aeolothripidae, Heterothripidae, Thripidae, and Phloeothripidae (most of which feed on higher vascular plants), indicating that origins of modern groups of thrips did not occur until sometime in the Cretaceous.

HETEROPTERA. Interpreting the fossil record of this group has benefited greatly from recent cladistic work (e.g., Schuh and Slater, 1995). Unfortunately, relationships among the "Homoptera" (Auchenorrhyncha and Sternorrhyncha) are not nearly as well understood, even though homopterans have a more extensive fossil record that extends to the Permian. Homopterans are also one of the major groups, besides Lepidoptera and Phytophaga beetles (below), that are entirely phytophagous or virtually so, so their evolution is likely to be intimately related to the evolution of plants. Many heteropterans, however, are predacious (particularly the basal lineages), and even mycophagous. The oldest definitive heteropterans are gerromorphs and nepomorphs from the Upper Triassic and Lower Jurassic (e.g., Fraser et al., 1996; Grimaldi and Fraser, 2000); like living relatives, they were almost certainly freshwater predators. The most primitive infraorders, the Enicocephalomorpha and Dipsocoromorpha, have an incomplete fossil record that doesn't extend beyond the Lower Cretaceous. The earliest phytophagous heteropterans are Cimicomorpha and Pentatomorpha from the Upper Jurassic of Karatau and the Cretaceous (Popov, 1986; Grimaldi, 1990). These two infraorders are the most speciose groups of the Heteroptera, and most species are phytophagous on angiosperms, so diversification was probably greatly affected by radiations of the angiosperms in the mid Cretaceous, as the fossil record suggests.

DIPTERA: This order is abundant and diverse in fossil sediments of lacustrine origin, and the oldest definitive flies are found in the Triassic of Kyrgystan, Australia, France, and Virginia (USA)(the attribution of Permotipula to the Diptera [Willman, 1989] being unlikely [Shcherbakov et al., 1995]). A taxic-based account of Mesozoic Diptera would conclude that the order was extremely diverse, with 76 Mesozoic families, but this is very inflated because of Rohdendorf's (1964) taxonomy. By the Triassic and Jurassic, though, Tipulomorpha, Ptychopteromorpha, Psychodomorpha, Culicomorpha (especially Chironomoidea), and Bibionomorpha were present, as well as several families whose affinities are not entirely clear. Interpretation of the early dipteran fossils is currently compromised by confusion over relationships of the nematocerous Diptera (Wood and Borkent, 1989; Oosterbroek and Courtney, 1995; Michelsen, 1996; Shcherbakov et al., 1995; Yeates and Wiegmann, 1999). Notwithstanding, there are several significant features of the early fossil record of the Diptera: A. A recent, well-supported scheme hypothesizes that the extinct, Triassic-Jurassic "family" Procramptonomyiidae is a paraphyletic stem-group to the living groups Cramptonomyiidae, Pachyneuridae, Anisopodidae s.l., and the Brachycera (Coram and Jarzembowski, 1999). B. The Anispodidae s.l., and Mycetobiinae in particular, are among the most ancient Diptera, and even hypothesized to be the living sister group to the Brachycera (Shcherbakov et al., 1995). Identity of the oldest brachyceran is controversial. Krzeminski (1992) placed the Viriginia Triassic fossil Alinka (Alinkidae) as the first brachyceran. It is certainly not a true brachyceran since the multisegmented antennae have filiform flagellomeres (Stuckenberg, 1999). Also, Shcherbakov et al. (1995) and Fraser et al. (1996)

indicated that, on the basis of venation, that *Alinka* is actually in the Procramptonmyiidae or thereabouts. The oldest definitive brachyceran is from the Lower Jurassic, *Protobrachyceron*. C. The evolution of biting (bloodsucking) culicomorphan midges is largely a Cretaceous phenomenon, with their earliest origins in the Upper Jurassic. Only very primitive Simuliidae, Ceratopogonidae, and Culicidae occur in the Cretaceous; phlebotomines were diverse by the lower Cretaceous (Azar et al., 2000). Studies by Borkent (1995, 1996) indicate remarkably good correlation between clade rank and stratigraphic age of Ceratopogonidae preserved in various Cretaceous ambers. Vertebrate blood feeding, at least by extant ectoparasitic insect groups, is relatively recent in the history of tetrapods.

Relationships of extant lower Brachycera are better understood than for nematocerans (Woodley, 1989; Yeates, 1994; Sinclair et al., 1994). Rhagionids were diverse in the Jurassic and Cretaceous (e.g., Grimaldi and Cumming, 1999). Nemestrinidae with long proboscides from the uppermost Jurassic may have been the earliest obligate pollen feeders and pollinators (Ren, 1998; Grimaldi, 1999). Cretaceous ambers have yielded a remarkable diversity of Eremoneura, especially Empidioidea (25 genera) and the oldest Cyclorrhapha (Grimaldi and Cumming, 1999). In Lower Cretaceous amber from Lebanon are the oldest and most plesiomorphic members of the Ironomyiidae, Lonchopteridae, Platypezidae, and Sciadoceridae; the oldest Phoridae occur in slightly younger amber from the Lower Cretaceous of northern Spain. An unusual genus of Eremoneura occurs in Lebanese and Spanish amber, *Chimeromyia*, which has features of Empidoidea and Cyclorrhapha. Cretaceous ambers have also revealed a strikingly diverse fauna of microphorines (Empidoidea), which is a group that is clearly relict today. With the exception of a fossil pupa of controversial age (putatively Upper Cretaceous), the oldest Schizophora did not appear until the Tertiary. The oldest and most diverse fauna in the Tertiary is in Eocene Baltic amber (Hennig, 1965). The Baltic amber Schizophora all represent modern families, but virtually all are primitive at generic levels. Indications are that the radiation of some 50 Schizophora families did not occur until the Paleocene.

HYMENOPTERA. Like Heteroptera and Diptera, interpreting the fossil record of Hymenoptera is vastly improved by good understanding of phylogenetic relationships among living families (Brothers, 1999; Gibson et al., 1999; Ronquist et al., 1999). Comprehensive paleontological work on the order is by Rasnitsyn (e.g., Rasnitsyn, 1988, for summary). The oldest fossil wasps are Xyeloidea from the mid and Upper Triassic of Australia and Eurasia. This is consistent with position of the living Xyeloidea as the sister group to all other Hymenoptera. Other primitive, symphytan wasps appear in the Jurassic. Extant xyeloid larvae feed predominantly on conifers, as do diprionids and anaxyelids, but major evolutionary shifts of host use in symphytans are obscure since many symphytans also feed on angiosperms. By the mid and Upper Jurassic there occur various families of lower Apocrita, like Anomopterellidae, Ephialtitidae, Jurapriidae, Karataidae, Praeaulacidae, and primitive megalyrid-like taxa (Rasnitsyn, 1988). Their relationships and ovipositor structure indicate that most (probably all) were parasitoids, especially of wood-boring insects. The oldest aculeates are the extinct family Bethylonymidae, from the Upper Jurassic and lowermost Cretaceous. Evolution of the Aculeata, then, has taken place virtually entirely within the Cretaceous and Tertiary. Not only does this encompass an impressive number of families, but also includes several of the most ecologically important groups of insects. The oldest ants include a primitive ponerine and the Sphecomyrminae (monophyly of the latter doubtful) in 90 Ma amber from New Jersey, USA (Grimaldi et al., 1997); sphecomyrmines and other primitive ants also occur later in the Cretaceous. Ants today, some 14,000 species, are an ecological keystone group, particularly in the tropics, and their origins certainly did not extend beyond the upper part of the Lower Cretaceous. They must have undergone a spectacular radiation in the Lower Tertiary, which is revealed best by the rich fauna in Baltic amber. Bees are a very special case. The Apidae sensu lato is one of the largest and most successful families of insects (ca. 20,000 species), and virtually all bees feed obligately from flowers. There is, however, only one record of ambiguous Cretaceous age (Michener and Grimaldi; Engel, 2000); Grimaldi (1999) hypothesized that the amber fossil originated from latest Cretaceous (Maastrichtian) strata. Like the ants, the first impressively
diverse and well preserved assemblage of bee fossils occurs in Baltic amber, now under monographic revision (Engel, 2000.). All bee genera and most tribes in Baltic amber are extinct. In the context of the fossil record for the sphecoid relatives of bees and aculeates in general, which is fairly extensive throughout the Cretaceous, the time of origin of bees must be constrained to the upper part of the Lower Cretaceous. Clearly the mid Cretaceous angiosperm radiations greatly affected the diversification of bees, and vice versa. The ecological success of ants and some bees (only some are social) is due at least in part to their sociality, which greatly increases the efficiency of resource utilization and, thus, competitive ability. Why the origins of eusociality in the three major groups of insects (ants, bees, and termites) coincided in the Cretaceous is unclear.

COLEOPTERA. Higher-level relationships within the Coleoptera are the least understood of all the major orders of insects. This fact, plus the general lack of wing venation characters compromises full interpretation of fossil Coleoptera. Yet, some coarse and important evolutionary patterns are apparent. Archostemmatan cupedoids were clearly among the first on the scene and quite diverse in the Permian and Triassic; today they are relict. Primitive adephagans and even some polyphaga like Staphylinidae appeared by the Triassic (Fraser et al., 1996; Grimaldi and Fraser, 2000). The earliest "Phytophaga" (Curculionoidea and Chrysomeloidea), which comprise well over half of all beetles, originated in the Triassic (Curculionoidea: Obrienidae). By the Jurassic, definitive weevils and putative chrysomelids are quite diverse (Arnoldi'i et al., 1991). Farrell (1998) addressed the phylogeny of the Phytophaga using sequences for the 18S rDNA gene and 115 exemplar genera, and 212 morphological characters from other sources. On the basis of this phylogeny several patterns were apparent: A. The most primitive living clades of weevils and chrysomeloids are conifer feeders, including araucarians. B. Species diversity among clades is highly correlated with angiosperm feeding, indicating yet another example of where the angiosperm radiations had a major impact on the diversification of insects.

LEPIDOPTERA. This is the largest clade of phytophagous insects; rare appearances of fungivory, coprophily, and even parasitism are obviously secondarily derived. A recent review of the Mesozoic history of the order was presented by Grimaldi (1999), based on phylogenetic results of basal Lepidoptera by Kristensen, Nielsen, and Davis (op. cit.), and some 20 records of Mesozoic Lepidoptera. The oldest *definitive* lepidopterans appear to be several genera from the Upper Jurassic of Eurasia. All Cretaceous Lepidoptera sufficiently preserved to display critical features (e.g., wing scales, mouthparts) occur mostly in amber, and these are all either primitive mandibulate moths or basal glossatan ("tongued") moths. Lepidoptera is apparently the most recently evolved insect order, and it clearly explosively radiated in the Upper Cretaceous and even the Tertiary, doubtless due to the angiosperm radiations.

Conclusions

Interpreting the fossil record is a highly imprecise science. Historical hypotheses are greatly influenced by gaps in the fossil record, the incompleteness of fossils, and how data are interpreted (e.g., the taxic vs. phylogenetic approaches). Methods of analysis, as discussed here, can dramatically alter interpretations of the same fossil record. While I view the phylogenetic method as essential to interpreting the fossil record, a few new analytical methods are still required that aid in interpreting historical patterns like radiations. There is already considerable dialogue, for example, on statistically assessing clade-age rank correlations. Given the dramatic effect that angiosperm radiations had on insect diversification, the next step would be to analyze patterns and timing of angiosperm cladogenesis with that of pertinent insect groups. It is essential not to become too preoccupied with analytical methods, though, since data are the ultimate source of hypotheses and controversy. Besides exploration for diverse new Paleozoic and Mesozoic deposits of insects, the study of fossil insects fundamentally depends on rigorous comparative morphology.

(ed.), Biotic Recovery from Mass

Acknowledgments

I am grateful to Vladimir Blagoderov, Michael Engel, Amy Berkov, and Caroline Chaboo for reviewing previous versions of this paper, and to Tam Nguyen for producing the figure.

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Annual Review of Entomology 44, 397-428.higher-level phylogeny of Diptera.

A highly schematic chronology of Holometabola in the Mesozoic and Cenozoic. Topology largely follows Kristensen (1991), except for position of Strepsiptera (from Whiting et al., 1997). Fossil records are from various sources: Kukalova-Peck (1991), Grimaldi and Cumming (1999), Grimaldi (1999, overview of Lepidoptera), and Rasnitsyn (1988).

SUSTAINABLE DEVELOPMENT AND INTEGRATED PEST MANAGEMENT

M. Kogan, Integrated Plant Protection Center and Dept. of Entomology, Oregon State Univ., 2040 Cordley Hall, Corvallis, OR 97331 USA, Email <u>koganm@bcc.orst.edu</u>.

INTRODUCTION

Sustainable Development, as applied to agriculture and Integrated Pest Management (IPM), are complementary concepts that emerged in the last third of the 20th century. Early proponents of these concepts reflected the growing awareness of the fragility of the environment in the face of mounting human interference. Both concepts were born in controversy because, while they found broad popular appeal, there arose sharp distinctions among different constituencies as to the intrinsic meaning and practical use of the terms. Just as IPM has generated numerous interpretations and as many different definitions (Bajwa and Kogan 1996), sustainable development has been variously defined to suit the views of specific interest groups. In its broader sense sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (The Brundtland Report, in Conway 1993). Sustainable development, when applied to agroecosystems, was defined as "the ability of an agroecosystem to withstand disturbing forces – particularly threats to its overall productivity" (Conway 1993). This definition evokes the idea of ecosystem resilience. Sustainable development is a multidimensional concept that reaches far beyond agriculture. It permeates all levels of human endeavor, economic, social, and cultural. The following discussion attempts to focus on the broad issues of sustainability as applied to agricultural development and IPM as a fundamental component of sustainable agriculture.

The sustainability of agroecosystems is challenged by severe social, economic, and environmental problems. There are positive models of sustainable agricultural systems deployed around the world and effective IPM systems have been implemented in many countries, but the persistence of those systems themselves is threatened by the same factors that undermine the long-term sustainability of agriculture as a whole. At issue here is not just the preservation of effective methodologies of crop production or pest control. We must not only try to understand and anticipate the factors that may affect the permanence of established IPM programs, but much more importantly, consider that those same factors threaten the very integrity of the ecosphere. Most of those factors arose as consequence of the explosive growth in human population coupled with an unevenly distributed but considerably improved standard of living in many developing countries. The discussion that follows is divided into four main topics: 1. The impact of demographics on essential resources for sustainable development in agriculture; 2. Sustainable development, agriculture and IPM; 3. Anthropogenic disasters and the permanence of IPM; and 4. IPM achievements and expectations.

DEMOGRAPHICS AND SUSTAINABLE DEVELOPMENT

Between 1950 and 2000 world population increased from 2.5 to 6.1 billion, an increase of 3.6 billion. Another 2.6 billion people will be added to the planet by 2050, at a rate of 80 million per year to reach 8.9 billion. More people were added to the Earth from 1950 through 2,000 than in the 4 million preceding years since humanoids appeared on the planet (Brown 1999). Thomas Malthus in the late 18^{th} century was one of the first to call attention to the potential risk in the disparity between population growth rates and rates of increase in food production. Technological developments of the 19^{th} and 20^{th} centuries may have postponed the day that Malthusian predictions became a reality. But, the carrying capacity of the Earth is limited and, in many parts of the world, we are quickly exceeding it and irreversibly exhausting key finite resources. The population issue has been amply debated since Paul Erhlich's 1968 publication of the "Population Bomb". Relevant demographic figures that have potential impact on sustainability have been summarized (Brown 1999, FAO 1999). Essentially demographics determine the pressure to increase food production, which in turn leads to the often unsustainable use of fundamental resources for food production – land, water, and energy.

SUSTAINABLE DEVELOPMENT, AGRICULTURE, AND IPM

The need to adopt a sustainable approach to development stems from both affluence and poverty. Affluent societies tend to overexploit resources through excessive consumerism and waste. Poverty and under development, on the other hand, exacerbate environmental degradation often as the only short term solution to survival. Sustainable agriculture (SA) is an obvious extension of the more inclusive concept of sustainable development. The American Society of Agronomy defines a sustainable agriculture as one that "over the long term, enhances environmental quality and the resource base on which agriculture depends; provides for basic human food and fiber needs; is economically viable; and enhances the quality of life of farmers and society as a whole".

Five guiding principles and goals have been proposed for the sustainable management of agroecosystems: "a sustainable agriculture system a) is based on the prudent use of renewable and/or recyclable resources; b) protects the integrity of natural systems so that natural resources are continually regenerated; c) improves the quality of life of individuals and communities; d) is profitable; e) is guided by a land ethic that considers the long-term good of all members of the land community. An agroecosystem is a dynamic interdependent community composed of soil, water, air and biotic species. All parts are important because they contribute to the whole" (Cavanaugh-Grant 1999). These principles generally coincide with the basic tenets of IPM.

With a theoretical foundation in agroecology (Altieri 1987, Gliessman 1990), proponents of the sustainability concept for crop production have found great affinity with the principles and approaches of IPM. Indeed, IPM provided both a conceptual and an

implementation paradigm for SA. From an IPM perspective, the concept of SA provides a platform for propelling IPM to higher levels of integration (Kogan 1998). Entomologists seem to have had priority in the use of the terms "Integrated Management" when they coined the expression IPM in 1972 (Kogan, 1998). Since then the concept of integrated management received widespread acceptance in a range of agricultural, industrial, and social activities. It is fundamental to SA. Figure 1 depicts the relationships of the components of a crop or livestock production system, suggesting that the whole system, as well as its components, is under integrated management. A key feature of the integrated management paradigm is the analysis of benefits and costs of management decisions. Sustainability increases along a continuum depending on whether the costs and benefits are limited to the farm enterprise, or whether they also include values for societal and environmental costs and benefits. There are difficulties in setting monetary values for environmental and social (Turner and Pearce 1993) but once the methodologies are agreed upon they will be equally applicable to SA and to IPM decision making.



Figure 1. Integration of management components in an agricultural system.

<u>IPM and Food Production</u>: Increased food production was the highest priority at the end of World War II. With pest (insect, plant pathogen, and weed) damage accounting for over 30% of losses in total agricultural production, pre- and post harvest, plant protection specialists and producers were eager to adopt any new technology that had potential to reduce those losses. That technology was assumed to be the newly discovered organo-synthetic pesticides. It is estimated that since 1947 2.985 billion kg of chlorinated hydrocarbon insecticides were used. Initial results were spectacular leading to predictions that "some pests will become extinct". Early on, there was little awareness or concern about the possible side effects of what would become one of the most pervasive intrusions of man-made chemical molecules into the environment. Early success overshadowed obvious signs of problems and abuses. The need to keep food production apace with population growth overwhelmed any environmental considerations. Success of the green revolution varieties was to a large extent dependent on the availability of insecticides, as many of those varieties were susceptible to insect pests and pathogens. The health and environmental risks of the heavy reliance on pesticides were, however, too real to ignore. Rachel Carlson's 1962 book was a wake up call that helped concerned scientists more aggressively pursue the path that led, 10 years later, to establishment of IPM. Despite recent advances in pest control technologies and IPM program expansion worldwide, world crops in the 1990s still suffered up to 30 percent losses to the aggregate impact of pre- and post-harvest pests, a level similar to those suffered at the beginning of the century (Schwartz & Klassen 1981). These losses persist even while pesticide use continues to rise worldwide.

ANTHROPOGENIC DISASTERS AND THE SUSTAINABILITY OF IPM

IPM programs, by definition, should tend to be sustainable, despite the need to resort to inputs that are energy demanding, e.g., pesticides, motorized sprayers, complex synthetic semiochemicals, to mention only a few (Pimentel and Pimentel 1996). After almost 30 years of IPM implementation, there is an impressive record of achievements documented in many publications (Kogan 1998). The permanence (=sustainability) of these programs, however, is threatened by the same environmental, social, and economic pressures that also threaten the sustainability of agriculture. Those pressures stem from resource limitations, from human generated (anthropogenic) environmental disasters, and from societal pressures.

Impact of Resource Limitations: The pressure that rising populations exert on all components of an agricultural production system -- air, land, water, and energy --have a direct impact on the sustainability of IPM. Plants growing on sub-standard soils are stressed and usually susceptible to insect pests and diseases and are less competitive against invading weeds (Dale 1988, Heinrichs 1988). Scarce water supplies force growers to increase intervals between irrigation cycles or reduce the amount of irrigation; water stressed plants exacerbate arthropod pests (Holtzer 1988). Energy enters the IPM equation through equipment, monitoring equipment, pesticides. The potential indirect effect of shortages would be felt through price increases for essential inputs. Cost already is a limiting factor on crops of a few developing countries of Africa where pesticides are needed as part of the IPM system

(Abate 1996). Thus resource limitations that add to plant stress or impede use of desired IPM tactics tend to aggravate the impact of insect pests and may eventually set back established IPM programs. However, the most serious impacts on the sustainability of IPM systems come from human activities that are independent of demography, albeit magnified by population pressures.

Impact of Anthropogenic Disasters: Despite available scientific means, it has been difficult to anticipate environmental disasters. The best models of natural phenomena behavior tend to be linear and rather simplistic. Yet, nature is complex and full of surprises (Bright 2000). Small incremental changes suddenly result in a major catastrophe. Events in Honduras illustrate the convergence of multiple factors such as shifting land use, climate change, overuse of pesticides, deforestation, and malaria epidemics, coupled with natural meteorological events (hurricanes) to magnify environmental disasters as well as social calamity. The anthropogenic disasters that potentially impact on IPM systems may be grouped into two categories: a) those resulting from shifting environmental pressures, and b) those resulting from shifting social pressures.

<u>Shifting Environmental Pressures</u>: Examples of disruptive environmental phenomena are climate change, biological invasions, and loss of biodiversity.

Climate change no longer is a matter of opinion or speculation. Of concern now is the assessment of the extent of the changes and their potential impacts. Expected consequences of global warming trends include a shifting of climatic zones, changes in species composition and productivity of ecosystems, increases in extreme weather events, and impacts on human health (UNEP 2000). Atmospheric CO2 concentration, a major contributor to the greenhouse effect, has been both negatively and positively affected by agriculture. Negative effects include: a) changing the amount of carbon stored in the vegetation of terrestrial ecosystems (deforestation and reforestation) and in soils, b) burning fossil fuels in all phases of agricultural production and associated industries. Potentially positive effects are: a) providing renewable energy resources to substitute for fossil fuels, e.g., sugar-cane for ethanol production, and b) producing energy from biomass that recycles carbon rather than allowing it to be released to the atmosphere (Pimentel and Pimentel 1996). In addition to the direct effect on climate, the increase in atmospheric CO2 concentrations affects several plant and ecosystem processes, in turn capable of magnifying the "greenhouse" effect.

Fruit IPM in the USA offers an example of potential impact of climate change. Fruit IPM has reached a high level of sophistication and adoption among producers (Prokopy and Croft 1994). The codling moth, *Cydia pomonella* (L), is a key pest of apples, pears, and other fruit and nut tree-crops. Its management is based on accurate monitoring following a biofix date and events predicted by phenology models. The pest usually has one and a half or two generations per year. A yearly increase of but 2° C in average daily temperatures would cause a third generation to occur forcing growers to spray exactly at the time when fruit is closer to harvest and spray restrictions are most strict. Such warming trend in the region could derail one of the most advanced IPM systems in the USA.

Biological invasions have increased with globalization of trade and intensification of tourism. The potential economic impact of invasive species is not only when they becomes pests, but also results from restrictions imposed on imports by quarantine regulations. A comprehensive assessment of the number and frequency of invasions worldwide would be difficult. There are, however, useful regional studies that provide a basis for extrapolating to other parts of the world. These provide an approximation of the magnitude of the problem (Kiritani 1999, Wilson 1983, OTA 1993). According to Sailer (1983) of the over 2000 non-indigenous insects introduced into the USA, intentionally or not, 235 species have become serious agricultural and forestry pests having caused cumulative losses of about 92.6 billion dollars between 1906 and 1991 (OTA 1993). Invasive species can seriously impact established IPM systems. The 1980s' invasion of Brazilian cotton fields in São Paulo and Paraná by the boll weevil, *Anthonomus grandis grandis* Boheman, set back established IPM systems at the time.

Loss of biodiversity is associated with the gradual destruction of natural ecosystems both marine and terrestrial, biological invasions, pollution, and over-hunting. The GEO-2000 report states that "At the broadest level, biodiversity loss is driven by economic systems and policies that fail to value properly the environment and its resources, legal and institutional systems that promote unsustainable exploitation, and inequity in ownership and access to natural resources, including the benefits from their use. While some species are under direct threat, for example from hunting, poaching and illegal trade, the major threats come from changes in land use leading to the destruction, alteration or fragmentation of habitats." For example, two-thirds of Asian wildlife habitats have been destroyed with the most acute losses in the Indian sub-continent, China, Vietnam and Thailand and, in the Latin American region, the average annual deforestation rate during 1990–95 was 2.1 per cent in Central and South America (UNEP 2000). It has been suggested that we live "amid the greatest extinction of plant and animal life since the dinosaurs disappeared some 65 million years ago, with species losses at 100 to 1000 times the natural rate" (Brown 1999).

In addition to the loss in species diversity, food crops around the world face an alarming narrowing of genetic diversity. With advent of high yielding varieties associated with the "green revolution" many local races were replaced by new varieties. China reduced the number of planted wheat varieties from ca. 10,000 in 1949 to ca. 1,000 in the 1970s' (Brown 1999). Both loss of traditional land-races and loss of wild relatives make breeding of new varieties increasingly dependent on a restricted genetic base. From an IPM perspective, the loss of genetic diversity increases crop plants' susceptibility to insects and diseases and reduces the chances for incorporating host plant resistance as a component of IPM systems.

The relationship between biodiversity and stability of ecosystems is still being debated in ecological circles (Schowalter 2000). The debate has a direct bearing on the argument about the importance of biodiversity for IPM. Altieri (1993) defends the argument that "biodiversity is a salient feature of traditional farming systems in developing countries and performs a variety of renewal processes and ecological services in agroecosystems." He argues that it is important to understand the role biodiversity plays in reducing pest problems, when vegetation management is used as a basic tactic in small-scale sustainable agriculture. Altieri concludes that "the ensemble of traditional crop protection practices used by indigenous farmers represents a rich resource for modern workers seeking to create IPM systems that are well adapted to the agroecological, cultural and socio-economic circumstances facing small farmers throughout the developing world."

<u>Impact of Shifting Societal Pressures</u>: Established IPM systems also are vulnerable to pressures that derive from real or perceived societal problems with pests and the techniques used for their management. Examples of such pressures are: 1. concerns about the safety of food supplies, particularly to infants; 2. the public debate about the introduction of genetically modified organisms (GMOs') in agriculture; and 3. the intermittent and often muffled rural/urban conflict.

Food safety is monitored by several U.S. agencies. Analyses of over 8500 samples in 1998 showed no residues in 64.9 percent of domestic samples and 68.1 percent in import samples. None of the samples of grains, grain products, fruits, or vegetables had detectable residues above levels that violate current limits (FDA 1999). The food supply appeared to be reasonably safe. Yet, whether real or perceived, public pressure in developed countries has led regulatory agencies to revise existing standards for food safety. Meanwhile, in most developing countries of the world the plight of chronic starvation often overwhelms any concern about food safety.

In the USA the revision of food safety standards produced new guidelines usually known as the "Food Quality Protection Act" (FQPA) of 1996. The potential impact of these new regulatory laws on current IPM programs in the short run may be potentially disruptive. For example, removal of OPs' for use in fruit crops may increase incidence of codling moth and reduce effectiveness of established mating disruption programs. In the long run, however, FQPA may force producers and researchers to look hard for alternatives and propel IPM to higher levels of adoption and integration

Genetically modified organisms (GMOs') were met with a mix of excitement, controversy, and skepticism. The advent of cotton, potato, soybean, and other major crop varieties genetically modified to incorporate δ -endotoxin-producing genes of the bacterium *Bacillus thurigiensis* was heralded by some as the next silver bullet in agricultural pest control. The level and tone of the criticism, however, has exceeded expectations. Is there is a place for GMOs' in IPM systems? It is questionable whether GMOs' will be the silver bullet that some have anticipated. It is likely, also, that they are not the Pandora's box that some fear to open. The true role of GMO's will probably be as yet another tactic in the IPM arsenal that if used wisely will provide new and potentially powerful strategic options. It is essential to remember that "integration" is the key term in the IPM equation. If GMOs' are carefully integrated within IPM systems, taking into account resistance management prescriptions, interactions with other control tactics, and careful monitoring of undesirable side effects, all within the context of ecosystem integrity, then the answer to the question is an emphatic YES, there is a place for GMOs' in IPM systems.

The urban/rural dichotomy often is cause for friction and misunderstanding. Generations of urbanites, growing up in huge megalopolises, distant from rural areas, are generally oblivious of the intricacies of how food is produced. The lack of understanding of farming practices and intensive marketing lead grocery shoppers in big cities to demand fresh produce both unblemished and free of chemical residues. In many instances, cosmetic standards alone determine the level of pesticide use in a crop. Organic farming is helping educate the public that a certain amount of bruising in an apple or a few aphids in a head of broccoli are acceptable. This lack of understanding is a key factor in the slow adoption of IPM practices, if they fall short of guaranteeing the desired cosmetic standards. Food exporting countries of the third world must abide by the standards of their import markets. Even if farmers would adopt IPM practices for the local market, they would still be pressured to rely on chemicals for the export market.

Other areas of potential rural/urban conflict that impact IPM systems are the acceptance of the need to prevent biological invasions through eradication of incipient infestations of potentially serious pests. Large urban areas in the USA Pacific Northwest must be occasionally sprayed to eradicate nuclei of gypsy moth infestations. Eggs often hitchhike on trailers and campers of cross-country vacationers. Should the gypsy moth become established in the highly forested region, the result would be disastrous and a real challenge to pest managers. Authorities in charge of spray programs are often the target of irate urbanite critics who often misunderstand the nature of the problem and the safe nature of the approach. At the interface of city and farm other problems arise. In fruit growing areas of Oregon and Washington, for instance, it is common to find backyard grown apple and pear trees. Management of these isolated trees is often deficient allowing them to become reservoirs of insect pests and diseases that spread to adjacent commercial orchards. These three aspects of the urban/rural dichotomy serve to demonstrate that IPM within the broader context of sustainable agriculture, must encompass society as a whole. When this is achieved then IPM is truly moving toward higher levels of integration.

IPM ACHIEVEMENTS AND EXPECTATIONS:

The concept of "sustainability" is relative because it all depends on a time scale. Even if agriculture has been practiced for at least 10,000 years in some parts of the world, this represents but a brief moment in evolutionary time. Yet, even in this relatively short time span, we have witnessed the consequences of failing to consider the fragility of the environment and the disruptive impact of agriculture to natural ecosystems. IPM has the potential to demonstrate that humans can reach the level of agricultural production needed to feed the 8 billion people expected to inhabit the planet in 2050, and still maintain harmony with the environment. If, through effective IPM, we can reduce the over 30 percent annual production losses to pests, we would be contributing an additional 750 million tons of food grains, enough to feed 1.8 billion people at an adequate level of 400 kg per year. To reach this goal there have been some remarkable achievements in the development of new environmentally benign control tactics that can replace more disruptive tactics. We have been less creative in the advancement of new strategic approaches. Areawide IPM is a recent example of what can be accomplished with a modest strategic shift. Sustainable agriculture, like IPM, also needs a strategic leap. Both IPM and SA seem to remain at level I of integration, i.e., a narrow focus on single crops or limited mixed cropping systems, within small agroecological units (small farms or microregions). Models that consider entire ecological regions are rare. When SA adopts the ecoregion as the fundamental planning unit, then IPM also will have reached level III integration, because at this level the two approaches to agricultural development will be indistinguishable.

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A NEW LOOK AT INSECT BREATHING

K. Sláma, Inst. of Entomology, Czech Academy of Sciences, Drnovská 507, 16100 Praha 6, Czech Republic; slama@entu.cas.cz.

INTRODUCTION

At the beginning of 20th century, a comprehensive textbook of invertebrate respiration by E. Babák demonstrated clearly that terrestrial arthropods were able to ventilate actively the tracheal system in response to hypoxia or accumulation of CO_2 . In 1920, however, a new theory of insect respiration was created by A. Krogh. He concluded that a simple passive diffusion of O_2 or CO_2 through the air-filled tracheal system could account sufficiently well for all respiratory requirements, without a need for active ventilation. This "diffusional theory" was accepted by most insect physiologists as a model of insect respiration for the whole 20th century. In 1927, Hazelhoff studied spiracular functions and found that Krogh's theoretical calculations about gaseous diffusion through spiracles were not practical, because spiracular valves of most insects and spiders were tightly closed for long periods. Later, the diffusional theory was tested and questioned several times, but there was no sufficient experimental evidence for its disproval (for more details and references see Sláma, 1999).

In 1976, I discovered the presence of special, periodically repeated pulsations in mechanical pressure of the haemocoelic body cavity. These extracardiac pulsations were produced by simultaneous contractions of abdominal somatic muscles, which caused positive pressure peaks in the haemocoele. The movements of body segments, associated with this "abdominal pressure pump", were rather small and invisible by a naked eye but still they were large enough to cause a bulk flow of gas through some spiracles that were just open (Sláma, 1984). It was also observed (Sláma, 1988), that spiracular valves pulsated selectively in synchrony with the upward or downward strokes of the pressure pulse, producing an actively regulated unidirectional stream of air. This type of active, "accordion-like", insect breathing was achieved by means of an autonomic, e. g. brain independent, cholinergic, neuromuscular system (*coelopulse*) driven by a nervous center in the thoracic ganglia of the ventral nerve cord (Sláma, 1988, 1994). The coelopulse system consists from thoracic and abdominal ganglia, lateral ganglionic nerves and perisympathetic neurohaemal organs. Its function depends on regulation of homeostatic balance in gas exchange and haemolymph circulation, which prevents water loss and respiratory acidaemia.

This contribution describes some recent advances in the study directed to elucidation of the role of the coelopulse system in insect breathing.

METHODOLOGY

The present topic has been restricted to immobile metamorphosis stages of

various endopterygote insects. The statements are based on a large amount of individual recordings with 96 species of Lepidoptera, 17 species of Coleoptera, 6 species of Diptera, 5 species of Hymenoptera, 2 species of Aphaniptera and 7 species of Neuroptera. The cardiac and extracardiac pulsations, O_2 consumption, CO_2 release, heartbeat and respiratory movements were monitored in these insects during the whole period of larval-pupal-adult transformation. With respect to rather small size of most investigated specimens, it appeared necessary to develop some novel, highly sensitive, electronic recording techniques. In addition, certain measurements required simultaneous monitoring of several physiological functions in one body. For example, extracardiac haemocoelic pulsations together with the heartbeat, respiratory movements together with the passage of air through individual spiracles, or continuous monitoring of O_2 consumption and CO_2 release. The description of the utilized differential transducers of haemocoelic pressure, thermographic cardiographs, position sensors, microanemometers or ultramicro-respirographs, that were used in these studies, would be beyond the scope of this abstract. However, some technical details required at least for understanding of the data in the Figures have been given in the text. A full description of the related methods can be found in my earlier publications (see Sláma, 1984-2000).

RESULTS AND DISCUSSION

The feeding larvae and adults of phytophagous insects show relatively simple respiratory adaptations. Their rate of O_2 consumption usually exceeds 500 µl $O_2/g/h$, the output of CO_2 is more or less continuous and, due to the dietary supply of water, these stages can freely breathe and ventilate the tracheal system. The situation changes substantially after cessation of feeding, when the retention of internal water becomes a major condition for insect survival. The nonfeeding stages generally keep spiracular valves tightly closed. Occasionally, they flash for a few msec, here and there and this is always associated with a brief gulp of air. This kind of respiratory scenario has been discovered long ago in diapausing saturniid pupae. It is known as the "passive suction inspirations".

It is generally assumed that the passive suction of insect body results from the decreased internal pressure due to continuous O_2 consumption, while CO_2 is dissolved in bicarbonate buffers of haemolymph and tissues. I have measured the haemocoelic pressure in immobile metamorphosis stages of a large number of insect species. Certainly, the internal body pressure of these stages is almost exclusively subatmospheric, including the soft bodied caterpillars, soft prepupae and soft pupae of various endopterygote groups. The relative pressure differences are rather small in larvae or pupae with soft, elastic integument (-100 to -

400 Pa), but some lepidopteran pupae with hard integumental case often develop negative haemocoelic pressures of several kPa below the local atmospheric values.

Under the described conditions of passive suction, air is inspired mechanically into the body whenever a spiracular valve opens. The factors affecting the velocity and volume of these intermittent inspirations are determined by relative difference between exterenal and internal pressures, by maximum aperture of the opening valve and by duration of the opening. The largest **instantaneous inspirations of 50 to 150 µl of air have been found in large pupae of saturniids. The inspirations are made by the left** and right thoracic spiracles whose valves alternatively open for some 200-300 msec., after a deep internal vacuum caused by complete closure of all spiracles for 15-30 min. The symptoms of passive suction respiration are absent in nondiapausing pupae of Coleoptera, Hymenoptera, Diptera-Nematocera and Neuroptera. I was also unable to detect the symptoms of passive suction in small diapausing pupae of Lepidoptera, in pupae enclosed within a hard puparial case of Diptera-Cyclorrhapha and generally in the adults of both Exopterygota and Endopterygota. The nondiapausing adult stages and larvae of exopterygotes exhibit frequent, periodically repeated extracardiac pulsations. Characteristic example of spiracular functions during a passive suction inspiration can be found in Fig. 1.

Fig. 1 shows the result of simultaneous anemometric recording of inspirations through 8 different spiracles (TR-right thoracic, TL-left thoracic, AL-2,4,7 left abdominal, AR-2,4,7 right abdominal) in diapausing pupa of *Manduca sexta*. The bottom trace shows synchronized record of "passive suction inspiration", which has been obtained indirectly, by recording contractions of terminal abdominal segments by a strain-gauge sensor mounted at the tip of abdomen. The characteristic, saw-tooth pattern of the bottom record has been associated with brief intermittent inspirations of air in 1-2 min. intervals.



The peculiar feature in Fig. 1 is that the inspirations of air proceed exclusively through the left throracic spiracle, while all other spiracles were kept hermetically constricted. Additional recordings with a substantial number of diapausing pupae of *Manduca* revealed that most of these pupae were able to show the pattern in Fig. 1 uninterrupted for 16 hours or more. Most of them used only TL as a master spiracle, although some used also the contralateral TR. After artificial occlusion of the functional TL, the pupa switched automatically to TR and, when this was also disabled, it switched successively to 2AL, then to 2AR, 4AL and so on. It is important to say that each of the consecutive spiracles opened at different intervals for different length of time, creating the saw-tooth pattern with different size of the teeth. This shows that there is a hierarchy of spiracular functions; each spiracle being programmed to whistle with a different sound. Originally, I thought that all pupae of *Manduca* could perhaps show the same spiracular hierarchy and thus could play identical spiracular music. This was true, however, only with respect to the thoracic, not the abdominal spiracles.

The exact physiological nature of the phenomenal, neurophysiological mechanism which is used by the coelopulse system for determination of the active master spiracles is still unknown. Obviously, it should be somehow related to the metameric, perisympathetic neurohaemal organs, whose axons lead to the spiracles. The method of indirect recording of changes in haemocoelic pressure from the tip of abdomen (see Fig. 1) has excellent practical implication for simple determination of pupal metabolic rate. The steady fall of the haemocoelic pressure during the suction inspirations is directly proportional to the rate of gas consumption, which can be easily recorded according to contractions of the abdominal segments.

The regular pattern of suction inspirations, as shown in Fig. 1, is very common in most developing or diapausing lepidopteran pupae, which have a compact integumental cover. By contrast, developmental stages of most other insect groups, including diapausing lepidopteran pupae of very small size, evolved a substantially different respiratory adaptation. They also keep spiracular valves closed for long periods of time, however, one of the thoracic spiracles remains incompletely constricted. In this case, the typical saw-tooth pattern is camouflaged by a constant stream of air into the thoracic tracheal compartment. The aperture

of the incompletely constricted, active spiracular valve is kept very small, so that the continuous bulk inflow of air is fast enough to prevent a possibility of the countercurrent diffusion and escape of the vital water vapour.

The most characteristic feature of the above described respiratory adaptation is that the exhausted hypoxic intratracheal gas has to be periodically renewed by actively regulated tracheal ventilation. This is executed mechanically by a coordinated interplay between the pulsations of spiracular valves and pulsations of the extracardiac abdominal pressure pump. The selective advantage of this type of breathing ,which is actively regulated by the coelopulse nervous systém, depends on minimalization of spiracular opening, e. g. reduction of water loss by avoiding gaseous diffusion between the tracheal system and the surrounding air. Paradoxically, this most common, widespread case of insect breathing appears to be in serious conflict with the mechanistic doctrine of Krogh. The reasons that most insects notoriously avoid to use diffusional principle and rather use active breathing is most probably again linked with prevention of water escape. It is also curious to imagine that insect physiologists trusted for such a long time into the diffusional doctrine, which most insects cautiously avoid to use.

The actively regulated breathing is common among developing stages of insects whose metabolic rate equals or exceeds 100 μ l of O₂/g/h. It occurs especially in insects of relatively small body size, which exhibit a generally hihger metabolic rate per unit of body mass. I am convinced that a respiratory water loss might be lethal to all very small insects within a few seconds, provided that they used diffusional principle of gas exchange. Unfortunately, the mechanical measures of active respiratory regulations in small insects are extremely delicate, being discernible only after use of the supersensitive electronic devices. For example, the periodically repeated ventilatory pulsations in a 10 mm pupa of a tineid moth have a maximum amplitude as small as 15 nm, and the associated changes of internal body pressure are smaller than 1 Pa (i. e. less than 0.1 mm of hydrostatic pressure). In larger specimens these measures are more pronounced, see Fig. 2.



Fig. 2 shows the result of differential anemometric recording from the anterior body compartment A (with spiracles on the rigid, 2nd to 4th abd. segments) and posterior compartment B (with spiracles on flexible, 5th to 7th abd. segments) in a pupa of *Galleria mellonella*. These pupae are missing functional thoracic spiracles so that the voluminous frontal part needs to be actively ventilated from the posterior abdominal spiracles. The mirror image traces of the two compartments in Fig. 2 reveal unidirectional inspirations of air through A, with simultaneous expirations from B. The frequency of air oscillations corresponds to the frequency of the extracardiac haemocoelic pulsations.

The described pattern of tracheal ventilation is rather common but not universal. The pupa of *Galleria* in Fig. 2, for example, was able to revert the flow of air in opposite direction and, curiously enough, it could deliberately alternate the forward and backward oriented ventilatory streams in short intervals of time. Moreover, recordings through individual spiracles revealed that the pupa could actually use only one or two master spiracles located at different part of the body. With these results I originally concluded that the function of extracardiac haemocoelic pulsations was only to serve for ventilatory movements. Later I found numerous instances, however, when vigorous extracardiac pulsations occurred with all spiracles closed. In this case the pulsations apparently did not serve for respiratory but circulatory functions. The differential, quite independent performance of individual spiracles during the extracardiac pulsation can be observed in Fig. 3.



Fig. 3 shows the result of anemometric recording through 4 spiracles (TL-left thoracic; 2AL, 3AL, 4AL- left abdominal) in a pupa of the chinese moon moth (*Actias selene*). We can see that the individual spiracles can be instantly opened or closed with the velocity that is at least equivalent or higher in comparison with the frequency of the current extracardiac pulsation. This relatively simple result shows that the nervous and neurohormonal mechanisms operating the spiracular valves can be fully synchronized with individual strokes of the abdominal pressure pump. It thus occurs to me that the phenomenal "accordion-like" type of active insect breathing represents an ultimate solution of evolutionary adaptations leading to insect survival under dry terrestrial environmental conditions. It is a pity that the study of such an important neurohormonal mechanism (coelopulse) has been hindered for a long time by orthodox beliefs into the diffusional doctrine.

The mechanism underlying the active insect breathing can be perhaps best portrayed by its comparison with the functions of an electronic microprocessor: The internal proprioceptive sense organs perceive the actual input signals about the momentary situation in gas exchange and convey these signals to the thoracic ganglionic center of the coelopulse system. The center then repairs the signalized excess or defficiency by increased ventilation of the concerned spiracles or by the increased circulation of the haemolymph.

A second established myth of insect respiration postulates that haemolymph is not involved in the transport of respiratory gases. This can be partly true with respect to transport of O_2 through the air filled tracheal spaces. The aerial transport is some 500million-fold faster in comparison with the penetration of oxygen through haemolymph or tissues. By contrast, the reciprocal transport of CO_2 to spiracles is highly problematic. The solubility of CO_2 in haemolymph or tissues is 36-fold greater than that of O_2 . The respiratory CO_2 is rapidly absorbed from its mitochondrial origin by carbonate buffers of haemolymph or tissues. The expected liberation of gaseous CO_2 into the tracheal system by means of simple diffusion would be associated with profound acidification of metabolizing tissues. Due to this, the carbonic acid of respiratory origin needs to be at first absorbed by the buffering capacity of the haemolymph. The bicarbonate ions are then transported to special loci of the tracheal system, where gaseous CO_2 is produced by enzymatic reaction with carbonic anhydrase. It has been recognized quite recently that insects with extremely high metabolic rate (*Galleria*) develop special carboniferous tracheal organs, which are specifically involved in periodic discharge of the concentrated CO_2 through a few selected spiracles.

The management of respiratory acidaemia is different in different species and developmental stages of insects. Nondiapausing pupae of most insect groups exhibit more or less continuous CO_2 output, which is apparently associated with a continuous supply of gaseous CO_2 from bicarbonate haemolymph buffers into the tracheal system, from which it is constantly released outside the body. This type of more or less continuous elimination of CO_2 and its transport into the tracheal system can be found in all pupae of Coleoptera and Hymenoptera. In *Tenebrio molitor*, for example, the pH reaction of the pupal haemolymph is constantly shifted towards acidic range of pH and the liberation of CO_2 is always continuous. Surprisingly, the strong extracardiac haemocoelic pulsations do not enhance the CO_2 output. In some other investigated models, however, the strong extracardiac pulsations may be absolutely essential for successful elimination of CO_2 from the body, which is illustrated by coordinated CO_2 elimination and extracardiac pulsation in Fig. 4.



Fig. 4 shows the result of simultaneous recording of extracardiac pulsations (lower trace from the strain-gauge sensor transducing abdominal contractions) and CO_2 output (upper trace from the flow-through IR sensor) in adult American cockroach (*Periplaneta americana*), which had been immobilised one day before recordings by decapitation. The dependence of CO_2 elimination on ventilatory function of the extracardiac pulsation is quite obvious. Moreover, the data in Fig. 4 leave no doubt that a perfectly coordinated function of the coelopulse system can take place in a complete absence of the entire cephalic nervous or neuroendocrine centers.

Our contemporary knowledge concerning CO₂ elimination from insect body is mostly based on results of IR based, flowthrough techniques. These techniques are very sensitive and practical, but they are usually blind with respect to short outpuffs of CO_2 in small specimens. In 1989, we investigated respiration of a small, 5mg, diapausing bruchid beetle, using a novel respirographic technique that was sensitive to pl amounts of O_2 consumption or CO_2 releease. We found that this miniature beetle produced curious respiratory microcycles, which were characterized by brief intermittent outpuffs of 30 to 40 nl of CO_2 in 3 min. intervals. The velocity of CO_2 elimination surpassed more than 30-times the rate of O_2 consumption. Later, we found these so called "Prague respiratory cycles" in a number of other stages and species, but especially in all instances where carbohydrate was the main source of metabolic fuel. The rate of CO_2 production was in this case usually equal or higher than that of O_2 consumption (aphids, aphidophagous Neuroptera, coccinellid beetles, food store beetles, ants and the like). In addition, we discovered the presence of similar microcycles of brief discharge of concentrated gaseous CO_2 from tissue buffers in Arachnida (ticks, pseudoscorpions and solifugae). We have recently realized that the "Prague respiratory cycles" were similar in nature with curious physiological cycles found in adult *Dytiscus* beetles by Babák in 1918. Although he did not realize, at that time, that the cycles could be associated with elimination of CO_2 , I propose to change the terminology and call these cycles as "the respiratory cycles is shown in Fig. 5.



Fig. 5 shows the result of respirographic scanning with a diapausing adult of *Chrysopa carnea* (Neuroptera) sitting on the wall of the respiratory vessel. The method is based on a constant volume, differential barographic principle. Volumetric changes associated with O_2 consumption and CO_2 output are recorded by means of an electronic transducer. The Babak's cycles in CO_2 elimination are manifested by periodically repeated, 30-50 nl deflections on the O_2 consumption curve (note that large perpendicular lines indicate electronic zeroing of the scanning system).

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The ability to vaporize and eliminate gaseous CO_2 from internal bicarbonate buffers is not uniform with respect to different groups of insects. The pupae of *Galleria*, for example, produce CO_2 in special carboniferous tracheal organs located selectively under spiracles of the proximal abdominal segments. Ants also produce and release CO_2 exclusively from tracheal sacs located at the base of the abdomen. By contrast, adult Neuroptera, like *Chrysopa* in Fig. 5, release CO_2 only from the thoracic, not from the abdominal body compartment. When I discovered the brief, selective outpuffs of concentrated CO_2 through some determined spiracles, I immediately imagined that this physiological adaptation would perhaps constitute a principal, though so far neglected, condition of insect survival in dry atmospheric environments. There are experimentally well supported indications that the periodically repeated discharges of gaseous CO_2 through some determined spiracles are also actively regulated by the neuroendocrine system (coelupulse) by means of the programmed activation of carbonic anhydrase. I regret to say that our knowledge about physiological functions of this very important enzyme, the carbonic anhydrase of insects, remains still poorly understood due to persistent belief into the Krogh's diffusion doctrine. When combined with respiratory functions of the metameric perisympathetic neurohaemal organs, these problems represents a real challenge for the new millenium.

CONCLUSIONS

Insects and some other terrestrial invertebrates evolved fascinating mechanism for active regulation of real breathing. The mechanism is mediated by an autonomic, cholinergic, neuro-endocrine system (coelopulse), whose centers are located in thoracic ganglia of the ventral nerve cord. The system regulates opening, constriction, or pulsation of individual spiraclular valves. This type of active ventilation of spiracles is fully synchronized with exteracardiac haemocoelic pulsations and other changes in internal pressure. The changes are produced by intersegmental abdominal muscles ("abdominal pressure pump"). The unused spiracular valves are always tightly closed, the respiratory acidaemia is usually restrained by periodic vaporization of CO_2 and its immediate elimination through some determined spiracles. Selective advantage of active regulation of insect breathing depends on reduction of respiratory water loss, elimination of dangerous respiratory acidaemia and survival under relatively dry atmospheric conditions.

Key words: Coelopulse system, Respiratory acidaemia, Spiracular functions.

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HYPOTHESES REGARDING GENITALIC EVOLUTION: AN UPDATE

W. G. Eberhard

Smithsonian Tropical Research Institute, and Escuela de Biologia, Universidad de Costa Rica, Ciudad Universitaria, Costa Rica E-mail: webe@biologia.ucr.ac.cr

Why is it that male genitalia tend to evolve rapidly and divergently in so many animal groups? An attempt will be made to summarize data and ideas from insects and arachnids that have appeared in the last 15 years that relate to various hypotheses (species isolation by mechanical lock and key; pleiotropy; male-female conflict of interests; cryptic female choice) that have bee proposed to answer this question. Major new developments include: the first detailed presentation of the male-female conflict hypothesis for genitalic evolution, and a general model of the possible role of male-female conflict in sexual selection (Alexander et al. 1997, Holland and Rice 1998); a major new test of the prediction made by some hypotheses that remating by females is associated with increased divergence between male genitalia (Arnqvist 1998); paternity and sperm transfer analyses which show biases favoring males with certain naturally occurring genitalic traits in three groups of insects (Rodriguez 1994, 1995, Arnqvist & Daniellson 1999, Daniellson & Askenmo 1999, Tadler 1999); additional data on genitalic mesh and behavior in a variety of groups; discovery of an apparently general trend in genitalic allometry that does not fit the predictions of some hypotheses (Eberhard et al. 1998); and indirect support for the female choice hypothesis from a considerable strengthening of support cryptic female choice in general (Eberhard 1994, Eberhard 1996). This indirect support includes the following: demonstrations that multiple genitalic contacts and copulations by the female (a prerequisite for the male female conflict and cryptic female choice hypotheses) is more common than previously thought (even in groups previously thought to be monandrous); realization that there are many female processes (at least 20) that can affect the chances that a given copulation will result in fertilization of a female's eggs; documentation from literature reviews and a survey study that courtship during and following copulation is extremely widespread among insects and spiders (and also, though apparently to a lesser extent, among scorpions - Peretti 1997); and the realization that the well-documented evolutionary trend for male seminal products to stimulate several female reproductive processes that benefit the male's reproduction is probably a result of either male-female conflict or sexual selection by cryptic female choice.

Related developments include: a careful demonstration that the character displacement in genitalic structures predicted by species isolation hypotheses does not occur in some spiders (Ware & Opell 1989); a possible explanation for the unusually consistent rapid divergent evolution and complexity of female as well as male genitalia in spiders, based on the unusual fact that the secondary male genitalia of spiders are completely lacking in innervation (Eberhard & Huber 1998); and documentation of receptors and nerve endings at sites in the female genitalia that are contacted by the male's genitalia in odonates and scorpions (Cordoba-A, 1999, A, Peretti ms).

Discriminating between the female choice and male-female conflict hypotheses is complicated by the fact that they make similar predictions in some contexts. One prediction associated strictly with the male-female conflict hypothesis, that species-specificity in genitalic structures will be associated with coercive (as opposes to luring) precopulatory interactions between male and female, is not born out by data from groups such as spiders (Huber 1998). Direct observation of the behavior of species-specific male genitalic structures that remain on the outside of the female during copulation is another, perhaps especially useful way to make critical distinctions. A concrete example in sepsid flies will be discussed in which the genitalic behavior and morphology give clear support to the sexual selection hypothesis and evidence against other hypotheses. Mapping of genitalic evolution on phylogenetic trees in groups in which the mechanical roles of male and female genitalic structures during copulation have been determined could also provide useful tests, because the male-female conflict and the female choice hypothesis predict different sequences of development of some types of structures.

Several continuing mysteries are associated with sperm. What is the functional significance of sperm gigantism and sperm polymorphism, and why does sperm morphology so often diverge rapidly? In the several groups in which the male genitalia do not reach the spermatheca but spermathecal morphology is nevertheless species-specific, are spermathecal traits related to sperm traits?. And how can one explain the elaborate divergent sperm of apparently strictly monandrous termites?

It is obviously dangerous to try to summarize the current state of a field in which one has proposed one of several currently competing hypotheses. For what it is worth, here is my current assessment. Both the lock and key and the pleiotropy hypotheses have been further weakened since they were last extensively discussed (and found inadequate) (Eberhard 1985, Shapiro & Porter 1989). The male-female conflict of interest hypothesis has been clarified, and has been supported indirectly by studies of the physiological effects of male semen on female <u>Drosophila</u> (Rice 1996); this interest hypothesis (along with the female choice hypothesis) is favored by the demonstrated association between female remating and rapid genitalic divergence. But several specific predictions made by the conflict hypothesis have failed in empirical tests.

The female choice hypothesis, by a process of elimination, is favored by these data, and is currently the strongest. This hypothesis has the practical disadvantage, however, of being very difficult to reject on the basis of testing its predictions. In particular, because of the variety of possible female choice mechanisms; it is very difficult empirically to check all of the possibly important effects that the hypothesis predicts that male genitalia may have on the female: it is thus empirically very difficult to rule out the possibility of female choice. It is possible, nevertheless, to search for predicted positive effects. Failure to find them will often not constitute definitive reason to reject the female choice hypothesis for a particular species; but if repeated tests of this sort fail to find positive effects, the hypothesis will be weakened. To date few direct tests of genitalic effects on female processes that have been published; several sets of results argue in favor rather than against the female choice hypothesis. If further direct tests also generally show predicted positive effects, the importance of the female choice hypothesis will be consolidated.

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THE ROLE OF SMALL-SCALE FARMERS IN STRENGTHENING LINKAGES BETWEEN BIODIVERSITY AND SUSTAINABLE AGRICULTURE

W. H. Settle¹ and M. J. Whitten²

- 1. Consultant to The FAO Programme for Community IPM in Asia, J1 Jati Padang Raya No. 38B, Jakarta 12540, Indonesia
- 2. Adjunct Professor of Zoology/Entomology, University of Queensland, St Lucia, QLD, Australia

Index Terms: sustainable agriculture, biodiversity, rice, vegetables, farmer education, participatory training

Introduction

The Green Revolution saw pesticides aggressively introduced on a vast scale throughout much of Asia, based mostly on the unexamined assumption of need and in the absence of an understanding of the ecology of the agricultural systems targeted. In Indonesia—in order to qualify for the Green Revolution rice "package" of credit, seeds, fertilizers and pesticides—farmers were required to follow strict recommendations for the use of all inputs, including calendar-based applications of insecticides. This model in which extension agencies are set up as a conduit for "inputs" is still the prevailing model in most of the developing world. The high-yielding varieties have, without question, increased productivity several fold, however the associated inputs of synthetic fertilizers and insecticides have without question led to a progressive deterioration of soil fertility, water quality, and human and environmental health.

This "input-driven" model for research and extension is a difficult one to change for many reasons, most obviously because it tends to promote financial linkages between chemical companies and government agencies. The input-driven model promotes economic self-interest among producers and distributors such that chemical companies and government agencies are profiting at the expense of the long-term well-being of farmers and their agricultural systems. The farmer, in this model, is viewed as merely one parameter in a production function, or a "market" for sales. While there may be debate on what exactly "sustainable agriculture" is—the model that predominates in much of the developing world today is surely an example of what sustainable agriculture is not.

The past 10-15 years have seen a concerted effort to try and substantially change the input-driven research and extension model. Specifically, participatory farmer education approaches, often under a bewildering array of names and styles, are increasingly seen as the tool of choice among non-governmental organizations (NGOs) as well as some of the larger development organizations. Although our experience is limited to Asia and Africa, we know that some of the very finest models of farmer-based education and research programs have been developed here in Latin America.

In this paper we would like to share a brief look at a model for farmer-participatory programs for Integrated Pest Management (IPM) for rice and vegetables in Asia that holds much promise as one alternative to the input-driven model. While IPM is ostensibly about crop protection, the programs we present here have necessarily taken on a larger scope of responsibility, including a full range of agronomic, economic, social and pedagogical issues.

IPM in its simplest form is a set of guidelines for farmers on how best to manage pests of a specific crop. Like any good management system IPM should be based on extensive experience, solid data and well-established theories, including a clear understanding of the ecological functioning of agroecological systems. However, in practice this has not always been the case. As a consequence we have the current situation around the world in which a multitude of highly diverse and often contradictory guidelines for IPM exist, often for the same crop (for a recent review see Ooi 2000)

In response to a major threat to their commercial interests, agrochemical companies in the 1990's attempted to take on the mantle of IPM or ICM (Integrated Crop Management). Most Industry advocates maintain that IPM is simply about reducing the amount of pesticides used in the system, usually advocating use of inappropriate Economic Threshold Levels (ETL) for pests and "pseudo-pests). Some of these ideas are illustrated by the suite of papers published by Ciba for the International Congress of Entomology in Florence, August 1996 where they equate IPM with a 'measured' reduction in pesticide use (Ciba 1996).

Plant protection for tropical rice has become a battle ground with respective parties attempting to retain the high ground for their respective positions vis-à-vis pesticides - and with all parties adopting IPM as their symbol. With the international legitimacy provided to IPM by the Rio de Janeiro Earth Summit in 1992, IPM has come to mean 'all things to all people' (Whitten 1996).

However, a closer look at the IPM programs promoted by the chemical industry show them to be input-driven and lacking any foundation of solid ecological thinking supported by good field data. While the chemical companies are capable of generating huge amounts of data (see Oerke, Dehne et al. 1994), there is no underpinning based on a coherent theory of how specific agroecosystems are structured and how they function. As a result, their experiments-no matter how abundant-are logically and methodologically flawed and their data and conclusions suspect because, in the absence of a coherent theory, data can be variously represented and misinterpreted (Rosenzweig 1995). To be realistic, the task of actually developing a sound understanding of the ecology of agroecosystems is no small task, and not one likely to be deemed worthy of investment by a large multinational concerned principally with "the bottom line" and mostly happy with the status quo.

The principal barrier faced by scientists interested in developing an ecologically-based agriculture is the same problem for those interested in understanding the ecology of "natural" systems-that is, the overwhelming diversity and complexity of these systems. Besides the formidable job of data acquisition and analysis, the task involves a difficult optimization problem: capturing the details of highly complex systems sufficient to explain the mechanisms of importance in the functioning of the systems, while developing conceptual models sufficiently simple to be understandable by a broad range of audiences. Scientists and extensionists taking on the task of addressing applied problems with a "sustainable" approach face the challenge of formulating their conceptual models in not just one, but a variety of forms that are appropriate for a variety of audiences, e.g., scientists in other disciplines, program administrators, government policy makers, and most importantly, farmers.

Biodiversity within agricultural systems

Much of the complexity of an ecosystem resides in its biodiversity, and it is precisely this biodiversity that is most negatively affected by input-driven agriculture. In addition to land clearing, specific practices that have impacts on biodiversity include: tillage regimes, drainage, crop rotation methods, multiple cropping methods, and pesticide and fertilizer use (McLaughlin and Mineau 1995). Suggestions to mitigate negative effects may range from simply "optimizing" inputs by cutting back on inefficient overuse of seed, fertilizers and pesticides, to employing fully organic practices involving zero synthetic inputs and minimal tillage regimes. Advocates at the two extremes of the input continuum engage in often lively debates, pitting organic agriculture against high-input agriculture.

Most experts in the field agree that agricultural intensification is necessary because the area of highly-productive arable land, worldwide, is limited and diminishing, and that only by increasing yields per unit area will we be able to meet the demands of a growing world population. The argument from the 'high-input' side, however, assumes that this agricultural intensification is of necessity tied to high-inputs and mechanization.

An earlier World Bank report questions this assumption (Srivastava et al. 1996) and introduces the term "agro-ecological intensification" in reference to the question of how agriculture can be intensified while enhancing biodiversity. The World Bank report suggests that: "the neglect of agro-biodiversity in the portfolios of lending and development organizations, as well as in treaties and conventions that deal with environmental conservation, is striking."

Vandermeer and Perfecto (1995), go further to say that: "we know as little about biodiversity in traditional tropical agroecosystems as we know about biodiversity in the tropical rainforests". They further state if important biodiversity exists in traditional systems, then transforming them into modern, intensively managed systems represents a potentially significant loss of biodiversity.

Whereas high species richness may be an end in itself from a conservationist's perspective, and intuitively appealing as a correlate to sustainable practices for agroecology in general, and crop protection specifically, the question still remains to what extent, and by what mechanisms biodiversity translates into more productive and sustainable systems and better pest control.

Rice fields on Java: a case study

The discussion that follows is based on work done over a five-year period on the island of Java in Indonesia (Settle et al. 1996). One might ask if it is even possible to develop useful conceptual models for pest control for something as geographically dispersed, complex and heterogeneous as, say, tropical rice ecosystems. For example, will knowledge gained on the island of Java have any bearing on a rice agroecosystem in West Africa? The answer to both questions is yes, and lies in the fact that ecological systems, even highly complex ones like tropical irrigated rice, tend to be structured by a very few key variables. Research over the past 20 years in applied ecology of managed systems shows that ecosystem dynamics in general tend to be organized around a small number of nested cycles, each driven by a few dominant variables (Gunderson et al 1995; Holling 1992).

Cereal monocultures in general and rice fields in particular are frequently viewed as the bottom rung on the biodiversity ladder. In fact there are good reasons to believe that as great a range in species richness exists across a continuum of habitat types for a single crop species, as between systems dominated by different principal crop species. For example, the diversity of arthropod species found in a swidden rice field in the forests of Borneo, or the fine-scale matrix of paddy fields on the island of Bali or Central Java, are far more rich in species than rice systems observed on the vast plains of North-west Java, Central Thailand or Southern China. Settle and colleagues found in the region of 835 morphospecies in samples from 12 locations for one season each on Java. The International Rice Research Institute (IRRI) estimates that one hectare of irrigated rice holds in the region of a thousand species of arthropods, probably placing it near the top of any list of agricultural systems for biodiversity (A. Barion, pers. comm.). The truth in the assumption that a tropical rice field is significantly less bio-diverse than say a coffee, tea, teak or oil palm plantation (Smith, 1996) or the traditional Javanese "Village gardens", (Vandermeer and Perfecto 1995) is likely to depend on which habitats for growing rice are observed for comparison.

Of course, from a purely crop-protection perspective the goal is not primarily the conservation of species, but rather the maintenance of pest populations at consistently low and stable levels, such that neither production nor profits are diminished. The question to which we return is to what extent does overall species diversity relate to this goal of low and stable pest populations?

Intrinsic mechanisms lead to low pest pressure in tropical rice

The past decade has seen an increase in serious efforts to look at tropical rice with the tools of the ecologist (Schoenly et al. 1996; Settle et al. 1996; Ives and Settle 1997; Schoenly et al. 1997; Schoenly et al. 1998). Settle and colleagues studied the structure and function of arthropod communities in Javanese rice fields. Their general conclusions are phrased in terms of the structure the foodweb structure in the irrigated rice system (Fig. 1).

From the time that rainfall or irrigation water floods a farmer's rice field prior to planting, organic matter, derived from residues of the previous crop cycle, allochthonous transport of organic materials in irrigation water, and the growth of various forms of algae and decaying weeds—provide energy and nutrients for a complex foodweb of micro-organisms and larger organisms in both the soil and the water column. At the base of this foodweb phytoplankton and various species of algae provide an important source of nutrients, feeding an array of aquatic plankton. Floating algal mats feed populations of shore flies (family Ephydridae) and several species of collembolans. Bacterial populations rapidly multiply as a result of the flush of nutrients. Bacteria are fed upon by both protozoans and rotifers, which in turn are fed on by various microcrustacea (dominated in our samples by the Branchiapoda), or directly consumed by the larvae of true midges (Family Chironomidae). The death of all these organisms cycles nutrients back to the bacterial populations, forming a "positive feedback loop" characterized by accelerating growth rates during the brief period in which water and sunlight are available.

Larval densities of chironomids often reach densities of tens of thousands per square meter within the first 30 days. Collembolans, chironomids and ephydrid flies represent approximately 28% of the total abundance of macroarthropods collected in 12 locations on Java, and are the dominant fraction of arthropod biomass found in the first 40 days. These detritus-feeding and plankton-filtering insects function to channel the high productivity of the below-water planktonic food web to an above-water array of generalist predators—principally the surface-dwelling predatory Hemiptera (Veliidae and Mesoveliidae) the ubiquitous wolf spiders (Family: Lycosidae) and various families of predacious beetles and flies.



Fig.1. Proposed foodweb for tropical rice ecosystems. Organic matter drives the development of high early-season populations of predators through parallel pathways: 1) microorganisms (zooplankton and phytoplankton) are fed on by filter-feeders (mosquitoes and midges), and 2) organic matter directly feeds detritous-feeding insects (Diptera larvae, Collembola, and some Coleoptera larvae). Each of three pathways dominates at different times of the season: microorganism/filter-feeders early-season; plant/herbivore mid-season, and detritivores post-harvest.

This ubiquitous, highly-abundant and well-dispersed source of alternative prey, emerging from the water very early in the rice-growing season, effectively "decouples" populations of generalist predators from the usual dependence on herbivore populations, and promotes the development of predator populations well in advance of the arrival of pest populations. Consequently, high rates of pest mortality from the very earliest part of the season ensues, minimizing the chance that pest populations will escape control and cause yield losses (Fig. 2a).

Support for the mechanism

Settle and colleagues tested this hypothesis experimentally by manipulating organic matter in test plots compared with low organic matter control plots, and were able to show significant and substantial positive responses by the detritivore, filter-feeder, and predator populations, both above and below the water (Fig. 3).

Seasonal samples often show high abundance of both predators and the complex of plankton-feeders and detritivores, while herbivore numbers are almost nil in comparison. Furthermore, early season insecticide applications can cause induced resurgence of chironomid populations as well as pest populations later in the season (Takamura 1993; Settle et al. 1996)—a strong indication that both groups are significantly suppressed by natural enemies (Fig. 2b).



Fig. 2. Seasonal dynamics of a rice field in West Java. A. An early-season peak in "neutrals" (detritivores and filter-feeders) at 30 DAT is mirrored by a rise in predator populations. Mid-season (50 DAT) predator populations again rise in response to the rise in herbivore populations. This early-season "boost" of predator populations is the major reason why yields in irrigated tropical rice ecosystems are rarely damaged by insect pests (in the absence of insecticides) B. When the system is disrupted by early-season pesticide use, classic pest "resurgence" is seen in the herbivore populations (mostly brown planthopper). Note as well resurgence in the "neutrals" populations. (after Settle et al., 1996).

Researchers in China reached similar conclusions through different experimental tactics, showing that eliminating midge and mosquito larvae—by using a highly selective *Bacillus sphaericus* insecticide—predator populations in irrigated rice were diminished, and pest populations were subsequently higher compared with untreated controls (Wu et al. 1994).

Recent studies in southern China using ELISA techniques have shown that chironomids represent up to 80% of the diet of spiders early in the season (Zhang Wenqing, Institute of Entomology and State Key Laboratory for Biological Control, Zhongshan University, Guangzhou, pers. comm. to W.H. Settle, September 1997).





The importance of ecological "context"

The mechanism described above suggests high levels of natural pest suppression can be brought about in tropical irrigated rice through the early season boosting of predator populations by abundant alternative prey, in turn linked to a highly productive aquatic foodweb. The degree to which this mechanism could be called a 'general' mechanism will depend, at the very least, on the degree to which the key functional groups are present in any location at the appropriate times in the season. We are suggesting this, in turn, will depend on large-scale historical factors in the ecosystem—what we would like to call the "ecological context" of a locale. This might include landscape characteristics (topography and soil), vegetational and seasonal planting patterns, water availability, overall toxic load (pesticides) and weather.

In brief (but see Settle et al. 1996; Ives and Settle 1997), experimental result and observations throughout the region suggest several hypotheses, including the following:

- 1. that organic matter amendments not only are essential for plant nutrition and soil health, but substantially boost levels of generalist predators in the system,
- 2. that the lower elements of the foodweb are ubiquitous—that is, bacteria, aquatic plankton, and even the chironomid midges, can be found in any rice field in the tropics (Asia and West Africa). In contrast, substantial variation can be seen in the upper-level elements of the foodweb (the natural enemies), which are correlated with large-scale factors of landscape, seasonal planting patterns and toxic load,
- 3. (specifically relating to #2): large-scale synchronous planting (greater than 500 ha) and long dry fallow periods (greater than 2 months) are correlated with: a) substantial reductions in species richness of predators and parasitoids, and b) delays in the return arrival of predators and parasitoids into the system after the long fallow period, thereby missing the early-season peak in alternative prey, and allowing pest populations to more easily escape control,
- 4. that early-season application of insecticides suppresses natural enemy populations, causing insecticide-induced pest resurgence (the literature on this is by now overwhelming).

But does greater biodiversity mean better pest control?

Substantial experimental efforts have been made to try and link a simple metric of species number to an overall measure of ecosystem functioning (e.g., Naeem et al. 1994; Tilman and Downing 1994; Naeem et al. 1995; Tilman 1996). What is clear is that such efforts are fraught with ambiguities linked to the inevitable existence of indirect effects and the "hidden variables" that confuse the interpretation of experiments (see Huston 1997, for an elegant analysis). As Huston concludes, the metric of species number is a simple concept that is distinct from the identities and behavioral properties of the species involved. In other words, the question "are more species better" is essentially unanswerable because, at scales larger than bacteria, it matters to a great extent which species you choose to look at.

We have tried to show that the issue is best approached by first asking what are the intrinsic mechanisms that support "good functioning" of the ecosystem (for our purpose, meaning consistently high levels of pest suppression), and how are these mechanisms affected by variations in the large-scale factors that underlie any ecosystem (the "ecological context").

Once having answered these questions we can then ask to what degree these specific mechanisms and large-scale factors correlate with species diversity. For our example of tropical rice we have evidence that the landscape characteristics, vegetational patterns, and chemical use patterns that lead to robust pest suppression (e.g., short dry-fallow periods, small-to-intermediate scales of planting synchrony, little or no insecticide use) are also positively correlated with species richness (Sawada 1993; Settle et al. 1996). Including, perhaps surprisingly, herbivore species richness.

We are suggesting that for the issue of crop protection—and we believe sustainable agriculture in general—we should avoid asking 'how many species is enough?', and focus instead on understanding the mechanisms and large-scale factors that constitute a robust and sustainable system. This has important operational implications in that farmers are unlikely to be able to quantify and manipulate complex arrays of species, but they are able to understand mechanisms and to a large extent are able to manipulate at least some of the key large-scale variables that directly contribute to a stable and robust system.

The role of farmers in managing their rice crop

Given the above, it should be distressing to discover that rice continues to account for more insecticide than any other crop in the world and that 80% of this amount is used in Asia. Yet after 30 years of "top down" and input-intensive approaches to research and extension, more than a generation of farmers have been caught up in a system that promotes fear and ignorance. The two most common perceptions among untrained farmers is a) that almost all the insects found in a crop will cause damage, and b) that all levels of damage translate into roughly equivalent levels of crop loss. The aggressive promotion of insecticide use in Asian rice led directly to massive outbreaks of pests—especially the rice brown planthopper *Nilaparvata lugens (Stal)*, yet because of the indirect nature of the causal mechanisms, and the inherent time delay between application and outbreak, farmers were not seeing the cause-and-effect relationship between insecticide use and pest outbreaks; hence, only adding to the conviction that pesticides were indeed needed. How to break such a cycle is the task faced by IPM in Asia.

Beyond Rice - IPM in vegetables and other crops in Asia

The ideal 'IPM' approach to pest and disease management in tropical rice paddies is sometimes described as 'informed nonintervention'. Rice, as a traditional crop with a history of cultivation of over 6000 years, has evolved a rich biota of invertebrates and micro-organisms. Understanding and manipulating the food web is the key to managing pests and diseases of rice. However, many important food (e.g. most vegetables) and fiber crops (e.g. cotton) grown in Asia are exotic to the region. Similarly, many of the pests and diseases of these crops are presumed not to be native to Southeast Asia (e.g. Diamondback moth, some thrips spp, and the leafminer, *Liriomyza huidobrensis*). Therefore it is common to find farmers using chemical pesticides as a component of IPM for vegetable and cotton IPM in Asia, and hence the term 'informed intervention'. Surprisingly, the indigenous biota can play a role in pest and disease management. For example, Shepard and colleagues estimated that in Indonesia the better use of the native biota could allow for a 75% reduction in pesticide usage without yield losses in a range of vegetable crops (Shepard, B. M. and E. F. Shepard. 1997). Indeed, enterprising IPM farmers in West Sumatra have isolated and cultivated a range of insect pathogens which they apply as bio-pesticides to various vegetable crops, thereby reducing pesticide dependency and usage greatly. These same IPM farmers have succeeded in manipulating the level of parasitism of the recently introduced leafminer, *Liriomyza huidobrensis*, by a native parasitoid, from more normal levels of 1-2% up to levels in excess of 80%. This intervention reduces the need to apply chemical pesticides for controlling *L huidobrensis*.

Examples of the use of the indigenous biota for controlling pests and diseases of vegetable crops and cotton can be found in the Proceedings of two recent workshops conducted in Asia (FAO Technical Report, 1998; CABI Biosciences/FAO Liriomyza Workshop Proceedings 1999). It would be unrealistic to say that vegetables, cotton and fruit crops could be grown economically and sustainable by small scale farmers in Asia without any use of chemical pesticides. But there is abundant evidence to support the claim that pesticide dependency and usage could be greatly reduced with significant economic, social and environmental benefit by these farmers. Greater knowledge about the existence and potential role of predators, parasites and diseases for controlling weeds, pests and plant diseases is needed; and this knowledge must be in the hands of the farmers. Recent IPM activities in Asia have shown that farmers can play a valuable role in creating, owning and sharing this knowledge with other farmers. The fact that many of the crops are relatively recent introductions seems only of secondary importance.

The evolution of Community IPM in Asia

The FAO Programme for Community IPM in Asia currently collaborates with some 12 Asian countries with the goal of training farmers in IPM. The program began in the early 1980s, but really began in earnest with a new model for farmer training in Indonesia in 1989. The program developed a farmer-training approach based on principles and techniques derived from adult, non-formal education (NFE). The NFE or "participatory" approach aims at helping farmers develop a broad range of skills related to agronomy, entomology, and critical thinking based on observation, experimentation, and the construction of conceptual models.

The objective is to put farmers in a position to make their own decisions based on an understanding of the ecological context and mechanisms underlying the functioning of their agroecosystems. Farmer training follows essentially the same path of discovery learning as followed by a researcher. By studying the field, asking questions, making systematic observations, discussing with others and coming together to test possible solutions, the IPM farmers develop real and practical knowledge based on fundamental scientific methods. IPM farmers have a saying: "the field is our book, go to the field to learn". This is far more than just a slogan, and represents an operational model that has proven highly successful.

Overall, the program has moved through four identifiable phases in development:

1) Farmer Field Schools (FFS). In the first stage, farmers in a village meet once each week for ½ day, over the course of an entire rice season (usually 12-14 weeks). The group consists of 25 farmers and a trainer. The observation field site is a simply a farmer's field, totaling around 1000 m². The group decides at the first meeting which half will be the IPM treatment, and which half the control, or "farmer practice" treatment. The latter is treated with insecticides, herbicides, and other management practices as per the usual practice for that area. Each week the farmers begin by breaking into small groups of five and spend the first hour in the field observing both treatment and control plots. Sweep net use by farmers is discouraged, rather farmers are encouraged to observe closely the life and activity in and around their paddy fields: in the mud, the water, on the water surface, on the plant, in the seedbeds, on the bunds, and eventually, in the stubble after harvest. Insects and spiders are collected by hand and placed into plastic bags to be brought back to a common meeting place. There, small groups construct representative drawings of the rice plant, including assessments of conditions of soil, water, weather, and the stage and needs of the plant (e.g., plant nutrient status). In addition, the captured insects are drawn in color on large blank newsprint, subsequently used for presentation to the larger group for discussion and decision making. The process encourages everyone to participate.

Other activities in the FFS often include:

- samples of aquatic plankton are taken in plastic bags and tubes for discussion and viewing,
- foodweb and energy-flow diagrams are constructed to discuss the structure and strength of rice ecosystems,
- studies of the effects of pesticides on natural enemies are carried out to show that pesticides are "poison" and not "medicine". The term "medicine" is commonly used in local languages around the world in place of "pesticide". This is a subtle but powerful (and incorrect) message,
- studies of plant compensation (via mechanical de-tillering and defoliation to simulate damage by insects). This is a critical point of which untrained farmers are often unaware. Early-season rice is highly tolerant of pest damage, with many varieties being able to incur from between 40-60% damage by insect borers and defoliators during the first third of the growing season, and as much as 10% loss by borers late season, without incurring yield loss (Shepard et al. 1990; Rubia et al. 1996),
- Studies on plant spacing, water control management, fertilizer choice and timing, seed cleaning, varietal selection, soil composition and methods of improvement
- insect "zoos", which compare pests caged on plants both with and without natural enemies (usually planthoppers and spiders), in order to show the effectiveness of natural enemies in controlling pests,
- various group-dynamic and team-building exercises.

Several important ideas farmers learn from the field training include:

- 1) that most of the insects they find in the IPM plot are either "neutrals" (a convenient term for plankton-feeders and detritivores) or natural enemies, very few are herbivores, and even fewer are pests,
- 2) that rice plant can compensate for a surprising degree of physical damage to leaves and stems with no loss of yield,
- that natural enemies can control populations of pests through predation and parasitism (but without natural enemies, pest populations build quickly), and
- 4) that insecticides are poisonous to natural enemies (and most other animals, including humans), and
- 5) that farmers are capable of doing their own experiments to answer important questions regarding farming.

On the social side, farmers learn:

- 1) how to do structured analyses of ecological, economic, and social problems,
- 2) how to work in a "facilitated" group discussion so that ideas are shared equally and no one person dominates,
- 3) how to do group planning exercises for season-long research and training activities.

The Farmer Field School approach, far from being an end-in-itself, seems to have led to a process of change driven, not by design from project management, but rather through an evolutionary process where the vision and creative potential of farmers, farmer-trainers and staff has been allowed to 'bubble-up' to create modifications in design, new materials for existing programs, and entirely new directions in program development.

2) <u>Follow-up Farmer Studies and Action Research Labs</u>. Starting in about 1991 a second stage in the program emerged when farmer FFS alumni solicited help in conducting follow-up farmer studies. In these studies groups of alumni farmers focused on issues of particular concern for their location. Examples include chronic stemborer problems, Golden snail, Seed bugs and tungro

virus. Some farmer groups chose to organize FFS on other crops (e.g., soybean and vegetables), while others chose to focus on specific studies. In especially difficult areas of chronic pest problems the farmers, together with program assistance, have developed Action Research activities. These are longer-term sets of studies geared toward helping farmers explore problems over several years and coming up with and carrying out action plans at the village-level and above. These studies are conceived of and carried out by alumni farmers with assistance by a project staff member who may live in the village, or visit periodically.

3) <u>Farmers-training-farmers</u>. The third stage has been the emergence of farmers-as-trainers. This happened at first quite spontaneously in Indonesia and was first noticed in 1991when alumni farmers in several districts were found to have organized training for neighboring farmers using local village funds for materials and transportation. The program staff immediately recognized the tremendous potential here, and formally began training farmers-as-trainers in 1993--now there are more than 25,000 farmers having spent at least one season training other farmers in Indonesia, with the number growing each year. Much of the training done by these farmers is financed by local IPM clubs, village funds, or sub-district and district-level government. In an increasing number of areas entire sub-districts have moved to self-funded IPM training by farmer-trainers with little or no financial support by the National Program.

4) <u>Farmer Networks and Community IPM</u>. Most recently we have witnessed a "fourth stage" –the emerge of networks of farmer-trainers within subdistricts, across subdistricts and across districts. Activities within these networks include farmer planning meetings, to develop strategies for training the remaining untrained farmers; to conduct farmer technical workshops, to plan and discuss the results of farmer studies; and meetings to develop strategies to influence local agricultural policy. This fourth stage we are calling *Community IPM*.

Results to date

Indonesia was the country in which the FFS model was first developed and the first country in which these additional evolutionary stages have emerged. Somewhere around 1,000,000 farmers have gone through an FFS in Indonesia. Vietnam is second having passed the 500,000 farmer mark. The China program started only in 1998, is showing remarkable growth. Overall in Asia somewhere around two million farmers have undergone at least the core FFS training. Critics state that this is still such a small number. The strategy, however, has never been to train every farmer, but rather to establish an IPM capacity in every farming community, and then to support lateral spread of IPM. This approach of follow-up and focused effort on farmer capacity development also creates pressure on the operational environment supporting pesticide use.

The model for farmer education presented here is not without controversy. There are individuals and institutions who feel the old models for extension, such as the Training-and-Visitation (T&V) system, were perfectly adequate. Similar approaches to the old T&V system can be seen today. Motivated by concerns for the cost of educating so many farmers, some promote the idea that "simple messages" transmitted through mass media will be sufficient to change the thinking and behavior of farmers. Our feeling is that this "ferment" of a collective global experience involving different approaches to farmer education is healthy and that in the long run, a diverse "toolbox" of proven methods will emerge as a core framework for extension models in this new century. Whereas the latter half of the 20th century was the time of the Green Revolution, we feel the 21st century must develop a "revolution" for farmer empowerment through education, and a farmer-based, bio-intensive agriculture.

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TICK-PARASITE INTERACTIONS AT THE HOST INTERFACE

P. A. Nuttall, CEH Institute of Virology and Environmental Microbiology, Oxford OX1 3SR, United Kingdom.

Ticks were once described as "..disgusting parasitic animals.." (Aristotle) but now they are considered "supreme pharmacologists." This change of attitude has arisen from a greater understanding of how ticks feed on the blood of their hosts, and how the pharmacological properties of tick saliva promote the transmission of tick-borne pathogens. Ixodid ticks in particular face one of the greatest challenges of all parasites. To survive, they must attach and remain feeding on a host for several days or weeks. The physical and chemical processes of feeding, and long duration of attachment, provoke host haemostatic, inflammatory and immune responses. Ticks counterattack with anti-haemostatic, anti-inflammatory and immunomodulatory substances secreted in their saliva. Included in this armoury are proteins that bind immunoglobulins, histamine, and serotonin, and various cytokine regulators that affect the production or activity of several cytokines, including interferons. As a result of the pharmacological activities of this rich cocktail of bioactive saliva molecules, the feeding pool within the skin becomes an immunologically privileged site. Any pathogens (viruses, bacteria, protozoa) transmitted by infected ticks into the feeding pool, or that are acquired by feeding ticks from infected hosts, will benefit from a supportive ecological niche created by the tick. Such a phenomenon, often referred to as 'saliva-activated transmission,' has been reported for several tick-borne pathogens. The challenge now is to determine whether this immunologically privileged feeding site can be destroyed, and pathogen transmission prevented. Index terms: ticks, blood-feeding, immunomodulation, vector-borne pathogen transmission.

RE-ASSESSMENT OF THE ROLE OF THE INSECT GUT MICROBIOTA

<u>R.</u> J. Dillon, Department of Biology and Biochemistry, University of Bath, Bath BA2 7AY, England. E-mail r.j.dillon@bath.ac.uk

The success of the Class Insecta in our world is beyond dispute. What is less acknowledged is the extent to which microorganisms contribute to this success. The intestinal tract of many insects has been shown to harbour a large diverse microbial community. Although we are now aware of mutualistic associations between a number of insect species and their extracellular gut microbiota (Tanada and Kaya, 1993), many species are known to contain a substantial microbiota whose impact on insect survival is unknown. Lysenko (1985) stated that the role of the normal insect microbiota has not been determined. There are still relatively few studies on the role of the normal microbiota of insects compared to their obligate pathogens, this is partly due to the difficulty in recognizing beneficial relationships. One area of progress is the contribution of microbiota to the nutrition of the host (Tanada and Kaya, 1993). Nutritional contributions may take several forms; improved ability to live on suboptimal diets, improved digestion efficiency, acquisition of digestive enzymes and provision of vitamins. The purpose of this paper is to reassess other subtle, but nonetheless potentially important, ways in which the gut microbiota benefits the insect host.

TERMINOLOGY

The lack of consensus on the terminology used to describe the insect microbiota reflects our ignorance about the stability and role of microbial communities in the gut of most insect species. Terminology is based on that of the intestinal microbiota of humans and domesticated animals (Savage, 1977). The criteria for inclusion of a microbial species as indigenous, or autochthonous include the following; always found in normal adults, colonize particular areas of the intestinal tract, colonize their habitats during succession in the young animal, maintain stable populations in climax communities in adults and associate intimately with the epithelium of the area colonized. In insects where there is a highly complex biota usually required for nutrition (see above) and the bacteria are passed from generation to generation, many of the criteria described for autochthonous microbiota in other animals are appropriate. Each species will presumably have a niche in the gut habitat and thereby contribute to the economy of the whole insect. An indigenous biota is present in all individuals of the species and maintains stable climax communities. However, apart from a few exceptions, the microbial colonization of most insect species has not been studied and the terminology is unclear. The assumption is that many species initially derive their microbiota from the surrounding environment such as the phylloplane of food plants or the skin of the animal host but the persistence of strains of the ingested species is unknown. Do strains of these species engage particular niches in the gut and colonize gut epithelia? Presumably they are not present in all members of the same insect species. The critical distinction is whether a microbial species is able to colonize the gut habitat in contrast to allochthonous (transient) microbes that cannot colonize it except under abnormal circumstances. Locusts (Schistocerca gregaria) derive their relatively simple microbiota from the ingested food plant, starved insects develop a larger population of gut bacteria than fed insects (Dillon, Vennard, Charnley, unpublished). Here the term 'locally indigenous microbiota' will be used to describe the microorganisms acquired by individual insects, which multiply within the gut, but are not necessarily present in all members of a single community. This term implies that a range of microbial species acquired from the external environment may occupy the same niche but allows that the microbial species involved may interact positively with the insect host.

Where a positive interaction between insect and microbe is identified the terms commensalism and mutualism are useful. Commensalism occurs where the microbe while doing no harm, benefits from the host but provides no advantage in return. Mutualism is a less flexible association where the microbe and insect mutually benefit each other. In practice there is a continuum between the two extremes, from a commensal, locally indigenous microbiota through to the total integration found between the host and intracellular prokaryotes in specialized cells such as mycetocytes. One example of the integration of bacteria with its host are the intracellular symbionts (genus Buchnera) of aphids which share common ancestory with aphid gut microbes (species of Enterobacteriaceae) and the bacteria ingested from the food plant (Harada, *et al*, 1996).

DIVERSITY OF THE INSECT GUT MICROBIOTA

It is now realized that we cannot culture the vast majority of microorganisms using traditional techniques. Molecular studies have revealed unrecorded microbial sequences in many natural samples to the extent that new kingdoms of life have been discovered in the Domain *Archaea*. The number of investigations of the diversity of the insect gut microbiota using molecular phylogenetic approaches is limited but we already have a glimpse of the information that this will reveal about the microbial diversity of the gut environment. Two thirds of clonally isolated 16s rDNAs from the gut microbiota of termites (*Reticulitermes speratus*) had less than 90% sequence identity with known bacterial species (Ohkuma and Kudo, 1996). Ten of these clones failed to show close similarity with any recognized bacterial phyla.

In situ hybridisation with species specific rRNA probes provides a complementary approach to cloning for the characterization of gut microbiota. Fluorescently labelled probes can be used to visualize phylotypes, establish morphology and determine number and spatial arrangement of cells. Fluorescently labelled probes were used to survey gut microbiota of five cricket species (Santo Domingo *et al.*, 1998a). Species that are difficult or currently impossible to cultivate were detected eg. *Bacteroides* and *Prevotella*

spp. and species of Archaea, the probes were able to detect changes in the profile of the microbial community due to dietary changes. Fractionation of microbial DNA according to guanine plus cytosine content was used to give an overall measure of microbial community composition and structure in the cricket (Acheta domesticus) hindgut (Santo Domingo et al., 1998b). The cricket microbiota provides a supply of fermentation products to the insect. Changes in the insect diet resulted in the emergence of a new microbial community structure together with changes in the microbial fermentation activity. These results show that fundamental shifts in the microbial profile can occur even in insects with an indigenous mutualistic biota.

NON-NUTRITIONAL ROLE FOR MICROBIOTA A) COLONIZATION RESISTANCE

The most important beneficial function of the indigenous intestinal microbiota in humans and domesticated animals is their ability to withstand the colonization of the gut by non-indigenous species including pathogens and therefore prevent enteric infections (Berg, 1996). The term colonization resistance (CR) is used to describe this function. The notion that this sort of function might be widespread in insects has received scant attention. Several approaches have been used to study colonization resistance. Insects whose resident microorganisms have been suppressed by antimicrobial agents are compared with insects containing an undisturbed microbiota. Alternatively, germ free insects are compared with their conventional counterparts or insects associated with one or two bacterial species. These studies can only be undertaken in insects with a non-obligatory microbiota unless specialized diets are used. Use of antimicrobials has a number of drawbacks. Apart from toxic effects towards the host even a broad antimicrobial regime may be overcome by resistant microorganisms. Some insect species such as locusts can be reared free from extracellular microorganisms using surface sterilized eggs and kept in sterile isolated environments. This system enables the production of gnotobiotic (defined biota) insects where bacterial species can be eliminated or reintroduced and population An isolator system, based on that developed for rearing gnotobiotic animals, was used to study the changes monitored. colonization resistance of the locust gut microbiota (Charnley et al., 1985). Another approach to the study of colonization is to use bacteria containing molecular markers (eg antibiotic resistance, Murphy et al., 1994).

Locusts (Schistocerca gregaria) contain a relatively simple locally indigenous microbiota (Hunt and Charnley, 1981) located primarily on the hindgut cuticle. Axenic locusts were reared in an isolator system on y-irradiated dict (Charnley et al., 1985) The insects were able to breed through several generations and there was no obvious nutritional requirement for a microbiota; indeed axenic locusts were physiologically comparable to conventional insects.

Colonisation resistance of the locust gut microbiota was implicated in the inability of fungal entomopathogens to germinate and infect via the conventional locust gut (Dillon and Charnley, 1986ab, 1988, 1991). Axenic insects were susceptible to fungal infection. Antifungal phenolic compounds detected in the gut fluid or frass of conventional locusts were absent from the axenic locusts. The phenolic compounds inhibited germination of 10 species of insect pathogenic and plant pathogenic fungal species. Moreover the phenolics were present in concentrations sufficient to account for the antifungal activity of the gut. Hydroquinone, 3,4 dihydroxybenzoic acid and 3,5 dihydroxybenzoic acid were identified. Similar antifungal activity has been located in the gut of seven other Orthopteran species. Monoassocation experiments of axenic locusts with a commonly isolated bacterial component of the microbiota, Pantoea (Enterobacter) agglomerans resulted in the appearance of one of the antifungal phenolics and established germination inhibitory activity in the gut fluid (Dillon and Charnley, 1995). The presence of only one of the three phenolics detected in conventional locusts suggests that several bacterial species cooperate in their production. A wider role for these antimicrobial phenolics in colonization resistance is suggested by the finding that they are selectively bactericidal; the indigenous species were able to survive in comparison to other species.

A few studies have examined the impact of the gut microbiota on the establishment of human pathogens and parasites in their insect vectors. Gnotobiotic insects (Greenberg et al, 1970) were used to provide evidence of the bacterial pathogen-suppressing ability of the microbiota of Musca domestica and Lucilia sericata. Erdmann et al, (1987) suggested that aromatic metabolites of the gut bacterium Proteus mirabilis are involved in the suppression of allochthonous bacteria in Calliphorid larvae. The possibility that CR is involved in suppressing medically important parasites such as Plasmodium and Leishmania in their Dipteran vectors has been discussed (Pumpuni et al, 1996; Dillon et al, 1996). The transmission of Chagas' disease by its vector provides the first example of a gut bacterium that has been genetically modified to provide CR towards a parasite (Durvasula et al., 1997). The role of the tsetse fly midgut microbiota in promoting trypanosome development (Maudlin and Welburn, 1994) will not be considered here.

B) SEMIOCHEMICAL PRODUCTION

Some insects sequester plant compounds for use directly as pheromone components or make minimal modifications to a dietary precursor (see review Tillman et al., 1999). The production of pheromone components by bacteria in the insect gut has also been inferred in a number of studies but conclusions were based solely on their ability to produce the relevant compound in vitro. Alternatively they have used antibiotic treatment to link the microbiota to pheromone production. Given the shortcomings of this approach in studies on gut microbiota (see earlier) it is not surprising that subsequent studies demonstrated an insect origin for the compounds.

Nolte *et al.* (1973) suggested that bacteria in the digestive tract of the locust *Locusta migratoria migratorioides* convert lignin to locustol (5-ethylguaiacol), a pheromone involved in aggregation. Subsequent studies failed to isolate locustol (eg. Fuzeau-Braesch *et al.*, 1988). Considerable advances have been made in the last 10 years in understanding the process that causes solitary locust populations to turn gregarious. There is interplay of visual, tactile and chemical stimuli (Byers, 1991; Pener and Yerushalmi, 1998). Pheromone involvement in attraction, group cohesion and transformation of locusts has been studied (Pener and Yerushalmi, 1998). Some of the pheromone compounds that modulate locust behaviour are phenolic compounds released from the insect faeces (Fuzeau-Braesch *et al.*, 1988; Obeng-Ofri *et al.*, 1994). These compounds do not elicit the gregarization process but seem to function as cohesion pheromones. The phenolic compounds guaiacol and phenol are the predominant electrophysiologically active components released from juvenile and adult faecal pellets of the locust *Schistocerca gregaria* (Obeng- Ofri *et al.*, 1994), adult male pellets also contained phenylacetonitrile. Phenylacetonitrile is probably derived from cuticular glands, but the origin of the other phenolics is unknown. In view of the finding that gut microbiota are involved in the production of related phenolic compounds in locusts the possibility that the gut bacterial biota were involved in the production of components of the locust cohesion pheromone has been recently investigated (Dillon *et al.*, 2000).

Volatile compounds collected from faecal pellets from conventional adult and juvenile locusts contained guaiacol and phenol. In contrast, there was a marked absence of guaiacol-like odour emitted from axenic locust faecal pellets compared to conventional locust pellets. GC-MS analysis revealed that the difference in odour was indeed due to the absence of guaiacol and the low level of phenol detected in volatiles collected from axenic faecal pellets (Dillon et al., 2000). The monoassociation of the bacterium P. agglomerans with newly hatched axenic locusts, subsequently reared on γ -irradiated diet, resulted in the detection of the 2 phenolics in 5th instar larvae although phenol was already present at a low level. These results indicate a bacterial origin for guaiacol and a proportion of the phenol. This is supported by experiments that demonstrated the ability of three species of locust gut bacteria (including P. agglomerans) to produce guaiacol and phenol directly from axenic faecal pellets in vitro. Microbial production of guaiacol was not a universal attribute. Guaiacol was not produced by Serratia marcescens (Enterobacteriaceae), a locust pathogen, or by locust gut enteroccocal species (Dillon, Vennard and Charnley, unpublished). A role for bacteria derived aromatics in other locust species is likely since guaiacol, and phenol were the main compounds detected from three species of locusts and their faecal pellets with guaiacol being the major product in each case (Fuzeau-Braesch et al, 1988). Veratrole, which was detected in previous studies, was not detected. Differences in the profiles of phenolic volatiles might be attributable to variations in the species composition of the gut microbiota. The fact that some of these aromatic compounds are microbially derived might account for variations in the results obtained from previous studies - the gut microbiota of lab-reared locusts will vary widely in both population size and diversity depending on the diet and rearing conditions. Bacterial fermentation continues in the faecal pellet after being voided from the insect. Continuation of aromatic volatile production by bacteria within the faecal pellets will depend on the availability of precursors and the moisture content of the pellet. Thus the duration of pheromone component release from faecal pellets surrounding locust roosting sites will depend partly on external environmental factors.

Knowledge of the bacterial origin of the aromatic compounds enables us to explain the variation in amounts of compound released from different ages of locusts. Lower quantities of aromatic compounds were produced in young adults in this study confirming the observations of the two previous studies (Fuzeau-Braesch *et al.*, 1988; Torto *et al.*, 1994). The hindgut cuticle is the site of the main bacterial population and during moulting it is renewed and the bacterial population declines (Hunt and Charnley, 1981), young adults will therefore contain a reduced population of bacteria which correlates with the fall in guaiacol and phenol production observed at this stage. Periods of starvation may change the composition and total population of bacteria and this would influence the amount of pheromone produced. The intriguing possibility that changes in the metabolism of the gut microbiota are linked to changes in the pheromonal profile is being investigated.

The precursor for guaiacol synthesis in faecal pellets must either be a component of the plant material or an excretory product of the insect. The former is indicated, as guaiacol production was dependent on the diet; considerably more guaiacol was present when conventional locusts were fed fresh wheat seedlings than the freeze-dried, γ -irradiated grass. Incubation of the locust diet with bacteria resulted in only minor amounts of guaiacol or phenol, indicating that digestion of the plant material in the locust gut is required for production of guaiacol by the bacteria. The most obvious precursor for guaiacol synthesis lignin-derived vanillic acid (4-hydroxy-3-methoxybenzoic acid) which is detected in the faeces of both axenic and conventional locusts (Dillon and Charnley, 1988, 1995). Microbial transformation of vanillic acid to guaiacol is via loss of a carboxyl group by the action of an inducible decarboxylase (Dillon, Vennard and Charnley, unpublished). Consistent with this, we found guaiacol was released by three species of locust gut bacteria from glucose/peptone broth cultures containing vanillic acid. Furthermore faecal pellets from conventionally reared insects fed filter paper impregnated with vanillic acid solution yielded large amounts of guaiacol (Dillon *et al*, 2000).

Locusts possess a locally indigenous microbiota composed of species commonly encountered in their environment, in particular the phylloplane biota on food plants (Hunt and Charnley, 1981). Guaiacol production by vanillic acid decarboxylation is an attribute of some plant and soil saprophytes (Crawford and Olson, 1978) which will be ingested with the food plant, so locust faecal pellets will always contain guaiacol though the bacterial species producing it may differ. The flexibility in the association

between the locust and its microbial partners was predicted by Jones (1984) who suggested that insects should evolve mechanisms to minimize the adverse consequences of mutualist loss by reduced reliance on single microbial species.

Bacteria colonizing the insect plant food may be adapted to deal with aromatic compounds and these plant-inhabiting strains may be selectively enriched in the gut environment. Microbial communities adapt through extensive transfer of degradative genes. Although we know that transconjugation between bacterial strains occurs in insect guts (eg.Watanabe *et al.*, 1998), the extent to which this may occur within the insect gut community or on the food source prior to ingestion by the insect is unknown.

Behavioural responses to microbial metabolites associated with insect frass have been reported for other insect species. *Klebsiella* oxytoca and *Bacillus* spp. produce the volatile alkyl disulphides present in the faecal pellets of the leek moth (*Acrolepiopsis* assectella; Thibout et al, 1995) which serve as kairomones to attract the parasitoid *Diadromus pulchellus* to the moth host. These also appear to result from the action of the bacterial enzymes on plant precursor molecules. It is intriguing to note that guaiacol was implicated as a kairomone for another parasitoid *Microplitis demolitor*; though the origin of the compound in the faeces of the soybean looper host (*Pseudoplusia includens*; Ramachandran et al, 1991) was not determined.

CONCLUSIONS,

The gut microbiota is regarded as a valuable metabolic resource for insects on sub -optimal diets but apart from this, most relationships between insects and their microbiota remain undefined. Studies with gnotobiotic locusts suggest that the microbiota confers previously unexpected benefits for the insect host. Microbial transformation of plant secondary compounds in an insect gut and adaptation by the host to use the resulting common metabolites are unlikely to be processes unique to locusts since seven other Orthopterans also have antimicrobial phenolics in their gut fluid. These findings have potentially wide implications for our appreciation of insect-microbe-plant tritrophic interactions.

The importance of colonization resistance of the gut microbiota in other animals is well documented though progress in establishing the mechanisms involved are hampered by the overwhelming complexity of the gut microbiota. Unequivocal demonstration of cooperative effects of the gut microbiota requires the use of rigorous quantitative microbiological methods using *in vivo* models and this has also restricted the work on insects. Insects are often used to establish principles which are common to all animals; perhaps the most famous being Pasteurs' demonstration of disease transmission using silkworm larvae as a model system. In view of the relatively simple microbiota of insects such as locusts, they can be used to establish the principles of colonization resistance which will be of relevance to work on colonization resistance in other animals. Furthermore, there is much interest in the role of the human gut microbiota in carcinogen metabolism and the production of naturally occurring compounds which may prevent tumour formation. One putative suppressor of tumour formation is also a bacteria- derived compound found in the locust gut.

The studies with locusts provide evidence for a *moderately* mutualistic association between the locust and its microbiota. The bacterial community of the locust gut is adapted to metabolize plant allelochemicals into antimicrobial compounds with increased activity against allochthonous microbes and provision of pheromonal compounds. This dual benefit for the insect suggests a closer degree of integration between the locust and its microbial community than was previously suspected. Surprisingly, this has not resulted in the development of an obligately mutualistic association; instead the locust has minimized the consequences of mutualist loss by not relying on a single microbial species.

ACKNOWLEDGEMENTS.

Keith Charnley and Viv Dillon for discussions and critical comments. Chris Vennard for lab support and BBSRC (UK) for financial support.

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Index terms: Schistocerca, intestine, bacteria, symbionts, pheromone.

NEURAL DEVELOPMENT DURING EMBRYONIC AND METAMORPHIC DEVELOPMENT IN INSECTS

L. P. Tolbert, ARL Division of Neurobiology, Univ. of Arizona, P.O. Box 210077, Tucson, AZ 85721-0077, USA, e-mail tolbert@neurobio. arizona.edu.

INTRODUCTION

Why study the development of insect nervous systems? Beyond satisfying sheer curiosity, knowledge of insect neural development holds the hope of revealing novel and specific paths for biologically sensitive intervention to protect or to control specific populations of insects. Furthermore, for developmental biologists, insects offer a rich source of material. The development of the nervous system in insects follows different paths, depending on the life history of the species, yet many of the cellular and molecular mechanisms underlying neural development appear to be common across disparate insect species, and even common between insects and mammals (see Arendt & Nubler-Jung 1999). Individual species variations confer particular experimental advantages to the investigator using insects. For all of these reasons, recent years have seen a huge research effort to understand neural development in insects.

Unable to review all of insect nervous system development in a one-hour presentation, I will provide a very selective review. I will focus on the growing understanding of the importance and nature of cellular interactions in insect neural development. The nervous systems of certain insects have been excellent systems in which to study these interactions. *Drosophila melanogaster*, a superb organism for genetic studies, has been used to great advantage to reveal the cellular and molecular bases for developmental influences in the peripheral and central nervous systems. Large holometabolous insects, such as the hawkmoth *Manduca sexta*, have different advantages; for instance, developing sensory and central neural structures are readily accessible throughout a major postembryonic wave of development (during the metamorphosis of the larva to the adult), when the animal is large and hardy, readily amenable to surgical manipulations. *Manduca*, besides being useful for cellular studies, also has been especially useful for studies of the molecular bases of hormone action, a special type of long-range cellular interaction, in neural development (Levine et al. 1995).

Insect nervous systems develop along widely differing timetables, depending on the life stages of the species. In this review, I will provide background on embryonic development and metamorphosis of the nervous system, but will focus mostly on intercellular interactions that play key roles no matter what the timetable, no matter what the extent of postembryonic reorganization, of the developing nervous system. I will go into most depth on intercellular interactions during development of the antennal system in *Manduca*.

EMBRYONIC DEVELOPMENT

Investigation of the development of the nervous system during embryonic development in insects has a long history and has been reviewed many times. The central nervous system, or CNS, arises from the ventral ectoderm of the embryo (Bate 1976, Doe & Goodman 1985). Regularly spaced cells in the ventral ectoderm enlarge and bud off, into the interior of the embryo, in clusters that form the primordia of the ganglia and brain. These cells then undergo a stereotyped set of mitotic divisions to produce neurons; the lineage of many of the uniquely identified neurons in the grasshopper and in *Drosophila*, is known completely, and is invariant from individual to individual. Soon after neurons are born, they begin to extend axons along specific paths toward their targets (see Bastiani et al. 1985). Once they reach their targets, they form synapses, and the specific neural substrates for behavior are elaborated.

METAMORPHIC ADULT DEVELOPMENT

After hatching, the nervous system continues to change. In species that do not undergo metamorphosis, the changes are likely to be subtle, mostly in response to input, falling under the rubric of "experience-dependent plasticity."

In hemimetabolous insects, such as grasshoppers and crickets, each molt involves the production of new sensory neurons, which then must send axons into the CNS to carry their input. This continuous addition of new sensory neurons and the challenge of integrating them into the animal's neural circuitry has been studied extensively in the cercal system of the cricket (Murphey 1985). In grasshoppers, Arbas (1983), among others, showed regressive as well as progressive changes.

In holometabolous insects, the larval nervous system produced during embryogenesis is much more dramatically altered during metamorphosis to produce an adult nervous system that includes some components of the larval system and some entirely new components (Levine et al. 1995). The overall shape of the CNS is modified, under the control of the *Broad complex* genes in *Drosophila* (Restifo et al. 1995). Best understood in *Manduca*, some of the larval circuitry undergoes extensive reorganization, involving regression and subsequent new growth of dendrites and axons. This reorganization occurs under the control of the ecdysteroid hormones (Truman 1996, Weeks & Levine 1990).

In addition to reorganization of larval structures, new cells and circuits are added to the adult nervous system to accommodate adult-specific functions. Imaginal disks give rise to new appendages, with new sensory neurons and with new muscles to be innervated by motor neurons in the CNS. New neurons are born in the CNS and either become incorporated into existing circuitry, or make new neural centers (e.g., Sorensen et al. 1991). The visual and antennal systems have been studied in most detail. I will focus on the antennal system, below.

INTERCELLULAR INTERACTIONS IMPORTANT IN NEURAL DEVELOPMENT

How do only certain ectodermal cells acquire a neuronal fate? How do new neurons acquire a specific identity? How are neural circuits formed and modified? As in the developing nervous systems of all species with complex nervous systems that have been studied, molecular details are still sparse, but interactions between cells are being understood to be critical for normal development in insect nervous systems. Here, I will discuss some of the major types of interactions, and provide examples of work addressing the underlying mechanisms for the intercellular influences. The experiments cited will come from studies of insects with many different life patterns, in part to make the point that mechanisms appear to be broadly similar.

In the part of the ventral ectoderm made competent to give rise to nervous system by the action of "proneural" genes, lateral inhibition determines which cells will become nervous system and which will remain in the ectoderm. Interactions between the products of the "neurogenic" genes *Notch* and *Delta* have been shown to be involved in this lateral inhibition and are being studied in detail (Anderson & Jan 1997).

Once cells have delaminated from the ectoderm, they acquire specific fates; that is to say, they become specified to give rise to specific sets of cells (see Jan & Jan 1994, Skeath 1999). That some of this specification is accomplished via cell-cell interactions was revealed elegantly by, who used laser ablation methods to kill neuronal precursors in grasshopper embryos, to see whether new cells would replace their progeny. Whether the intercellular interactions trigger "master" regulatory genes that control large sets of genes encoding cellular properties, or whether smaller sets of genes are turned on individually is not known. Recent studies, however, have identified genes that specify unique cell fates in *Drosophila* (Doe & Skeath 1996).

After neurons have adopted a specific fate, they begin to express their cell-specific characteristics. Most noticeable among these is the trajectory of the axon and choice of synaptic target. Axon extension is very complex and involves recognition of and reaction to many dozens of molecules in the environment.

Growing axons, tipped by actively exploring growth cones, may respond to molecules deposited by other cells into the extracellular space, and to molecules on the surfaces of other cells, as well as to soluble molecules released by other cells (Auld 1999, Garcia-Alonso 1999, Van Vactor & Lorenz 1999). Glial cells play special roles in the guidance of early axons (Klambt et al. 1999). Work in *Drosophila* (e.g., Harrelson & Goodman 1988) has led to a comprehensive understanding of families of cell-surface molecules that play roles across phyla.

Development of synapses has been shown to involve two-way interactions between pre- and postsynaptic elements. The developing neuromuscular junction has been used to great advantage in this area (Keshishian et al. 1996), in large part because pre- and postsynaptic partners can be identified at the level of the individual cell.

THE ANTENNAL SYSTEM AS A MODEL SYSTEM FOR STUDIES OF NEURON-GLIA INTERACTIONS

The developing antennal, or olfactory, system offers excellent opportunities for the exploration of intercellular interactions during neural development. Studies in several laboratories have shown the antennal (olfactory) system of the moth *Manduca sexta*, in particular, to be an advantageous system for detailed study of the interactions among neurons and between neurons and glial cells that lead to the creation of olfactory synaptic glomeruli, which are common to both vertebrate and invertebrate species, and, more recently, of the neuron-glia interactions important in axon guidance.

This system is useful for developmental studies for a number of reasons. Olfactory receptor neurons (ORNs) and their postsynaptic targets arise independently during postembryonic development, and are located at some physical distance from each other, allowing the two populations of neurons to be manipulated independently with ease (Schneiderman et al. 1986). The antennal (olfactory) nerve is long from the earliest stages, and is convenient for imaging. Within the CNS, neurons and glial cells are born at different times, so that interference with glial proliferation does not affect neuronal proliferation (Oland et al. 1988). Although the number of cells involved is generally much smaller, cellular organization of the primary olfactory center in *Manduca* is strikingly similar to that of vertebrate olfactory bulbs (Boeckh et al. 1990, Hildebrand & Shepherd 1997), in that it is organized into discrete glomeruli that contain the synapses of olfactory receptors and their target neurons.

CELLULAR ORGANIZATION OF THE MATURE ANTENNAL SYSTEM IN MANDUCA SEXTA:

The ORNs have their cell bodies in 2cm-long paired antennae, and their axons project via the antennal nerve to the brain. In addition to other ORNs, male antennae have ORNs specialized to detect the female's sex pheromone (Kaissling et al. 1989).

The 330,000 axons (Oland & Tolbert 1988) of the ORNs of each antenna terminate in about 64 glomeruli of the ipsilateral antennal lobe of the brain (Rospars & Hildebrand 1992). In the male, the axons of the ORNs responsive to female sex pheromone describe a separate dorsal "macroglomerular complex" (Christensen & Hildebrand 1987). The "ordinary" glomeruli present in both sexes are arrayed in roughly a single layer around a coarse central neuropil. Antennal-lobe neurons branch in the glomeruli, and one major class of neuron, the projection neurons, project an axon out of the antennal lobe to higher centers in the protocerebrum. All glomeruli are surrounded by glial-cell borders (Tolbert et al. 1983; Oland & Tolbert 1987; Rössler et al. 1998).

DEVELOPMENT OF THE ANTENNAL SYSTEM:

The ORNs of the antennae and their targets, the antennal lobes, arise during metamorphosis. The antennae arise from imaginal disks that evert and begin to develop at the onset of metamorphosis. ORNs are born during stages 1 and 2 of the 18 stages (each roughly one day long) of metamorphic adult development

(Sanes & Hildebrand 1976). Almost immediately they extend axons, which begin to reach the brain at stage 3. ORN axons continue to grow into the brain from ever more distal antennal segments until about stage 9. The antennal lobe develops essentially *de novo* during metamorphosis (Kent 1985) from 5 neuroblasts that divide throughout larval life to produce the three clusters of neurons of the adult antennal lobe (Sorensen et al. 1991). By stage 2 of metamorphic development, neurons of the antennal lobe are postmitotic; they extend neurites into a small neuropil which is ensheathed by a continuous border of glial cells. As the first ORN axons begin to arrive, they pierce the glial border and encircle the neuropil, just beneath the layer of glia, before terminating in a fringe (Oland & Tolbert 1987; Oland et al. 1990). From late stage 5 through stage 6, ORN terminals elaborate and segregate into nodular "protoglomeruli", which become enveloped by glial cell bodies and processes. The neurites of antennal-lobe neurons reach outward to overlap with the axon terminals (Oland et al. 1990, Malun et al. 1994), and synapses are formed in large numbers (Tolbert 1989).

INFLUENCE OF ORN AXONS ON DEVELOPMENT:

Hildebrand et al. (1979) observed that if antennal ORN axons are prevented from innervating the antennal lobe during development in *Manduca*, the resulting lobe lacks glomeruli. We found that, without ORN input, development is abnormal beginning as soon as antennal axons would normally have begun to reach the brain (Oland & Tolbert 1987). Glial cells remain restricted to a rim surrounding the neuropil, and that neuropil is composed of neurites of antennal-lobe neurons that branch diffusely, rather than in glomerular tufts (Oland et al. 1990).

Even more intriguingly, Schneiderman et al. (1986) and, more recently, Rössler et al. (1999) used antennal transplantation to show that the male-specific ORN axons of male antennae have the ability to induce a macroglomerular complex in a genetically female host antennal lobe. The axons from the transplanted male antenna induce some female antennal-lobe neurons to send a neurite branch into a macroglomerular complex, and these neurons now respond to female sex pheromone, clearly indicating a strong influence of antennal axons on development of target neurons.

NEURON-GLIA INTERACTIONS IN GLOMERULUS DEVELOPMENT:

Taking advantage of the fact that glia proliferate later than neurons in the antennal system, we reduced the number of glial cells, while maintaining apparently normal numbers of both antennal and antennal-lobe neurons, to ask whether glial cells act as intermediaries in developmental interactions between ORN axons and antennal-lobe neurons (Oland et al. 1988, Oland & Tolbert 1988, Baumann et al. 1996). When glial numbers are reduced significantly, ORN axons begin to form protoglomeruli, but the protoglomeruli dissipate before the neurites of antennal-lobe neurons grow out to meet them; the resulting neuropil lacks glomeruli, and closely resembles that of lobes that develop in the absence of ORN axons. On the other hand, the few glial cells that remain undergo the changes in shape and position seen in glia in normal lobes, indicating that they are responding to ORN axon terminals to describe "protoglomeruli" upon entering the antennal lobe (Oland et al. 1990), glial cells are required to stabilize the protoglomerular organization of the axon terminals while the neurites of antennal-lobe neurons grow out to meet the axons.

What are the molecular substrates for this neuron-glia interaction? We (Krull et al. 1994a) found evidence for the existence of tenascin-like molecules on the surfaces of the glial cells in the antennal nerve in the antennal-lobe neuropil during ORN axon ingrowth and glomerulus formation. Tenascin in other systems can inhibit the growth of axons, so, in a second set of experiments (Krull et al. 1994b), we tested the responses of antennal-lobe neurons to purified mouse CNS tenascin as a substrate for neurite outgrowth in culture and found that many antennal-lobe neurons avoided growing on the purified tenascin. These findings taken together support the idea that tenascin-like molecules on glial cells might constrain the growth of the neurites of certain antennal-lobe neurons in the developing glomeruli, although further work in this area is needed.
NEURON-GLIA INTERACTIONS IN SORTING AND TARGETING OF ORN AXONS:

In ongoing studies of the molecular mechanisms by which ORN axons find the appropriate target glomeruli, we have discovered that glial cells play a key role in sending ORN axons to the correct target glomeruli. We have found that a subset of the ORN axons in *Manduca* strongly expresses molecules likely to be identical to, or closely related to, the *Manduca* form of fasciclin II during the period of glomerulus development. Fasciclin II, a member of the immunoglobulin superfamily (Harrelson & Goodman 1988), is a well documented cell adhesion molecule, known to play roles in guidance of axons in the developing grasshopper (e.g., Bastiani et al. 1987) and in *Drosophila* (Grenningloh et al. 1991). In situ hybridization and immunocytochemical experiments indicate that scattered ORNs in the antenna of *Manduca* express fas II (Higgins et al. 1998). Serial reconstructions reveal that fas II-expressing ORN axons terminate in a reproducible subset of glomeruli. The fas II-positive axons are scattered singly or in small bundles throughout the nerve until they reach a glia-rich zone, at the entrance to the antennal lobe, where axons abruptly change their trajectory and sort into glomerulus-specific, fas II-positive or -negative bundles (Rössler et al. 1999).

This finding led us to ask whether ingrowing ORN axons must interact with the cluster of glial cells that they encounter at the entrance to the antennal lobe in order to be able to sort into glomerulus-specific fascicles. Using the same paradigm as used previously to reduce the number of glomerulus-associated glial cells, we reduced the number of glial cells in the glia-rich axon sorting zone, and found that fas II-positive axons no longer sorted into fascicles based on their expression of fas II or terminated in the appropriate part of the antennal lobe (Rössler et al. 1999). Thus, glial cells appear to be essential to the sorting of ORN axons into bundles destined to terminate in specific glomeruli, just as they are essential to the stabilization of forming glomeruli.

CONCLUSIONS

A great deal is known about the development of the insect nervous system. In recent years, the critical importance of intercellular interactions has been recognized, and the molecular underpinnings of these interactions are being elucidated. Because neural development across disparate species involves solving many of the same problems, many cellular and molecular mechanisms being characterized in insects are being found to be very similar to those underlying nervous system development in other invertebrates and invertebrates. Thus studies in other species can inform us about likely mechanisms in insects, and studies in insects will continue to play an important role in helping to elucidate development in less accessible mammalian systems.

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INSECT-PARASITOID INTERACTIONS

M.P. HASSELL

LXII

Department of Biology, Imperial College at Silwood Park, Ascot, Berks SL5 7PY, UK.

For much of this Century, insect ecologists have questioned what determines the abundance and patterns of fluctuation of insect populations. This talk deals with one of the major factors affecting the dynamics of insects - parasitism by insect parasitoids and attempts to review how our understanding of the dynamics of host-parasitoid interactions has advanced over the past 20 years or so. Parasitoids are amongst the most abundant of all animals, comprising some 10% or more of all metazoan species. They have been popular subjects for ecological study for a variety of reasons. First, their importance in biological pest control progra mes has stimulated a large amount of empirical and theoretical work seeking to identify and quantify the attributes that enhance the effectiveness of parasitoids as pest control agents. Second, the study of host-parasitoid population dynamics has greatly benefited from the way that parasitoids make ideal subjects for the development of relatively simple population models. This is mainly because there is only one stage, the adult females, that search for hosts, and because the act of finding a host is then normally followed by oviposition. The success in finding and attacking hosts therefore closely defines parasitoid reproduction. Consequently host-parasitoid models can have a much simpler structure than corresponding predator-prey models in which all predator stages may attack prey with different effectiveness, and reproduction is less closely defined by prey consumption. This close link between parasitoid searching behaviour and reproduction has also made parasitoids a popular group amongst insect behavioural ecologists and those seeking to reveal how features of individual behaviour can affect population dynamics. Finally, many species of parasitoids and their hosts can readily be cultured in the laboratory, and this has greatly increased the amount of empirical information on parasitoids under controlled conditions. There are thus several published time series for host-parasitoid interactions obtained from laboratory microcosms, and many laboratory studies have explored the ways that various factors affect parasitoid efficiency. One product of the long tradition of studying the population dynamics of insects has been the number of long-term field studies that have accrued, most of which show conspicuous fluctuations in population size, but without any longterm trends in average abundances. The mechanisms for persistence in such examples, however detailed the study, have tended to remain elusive. In particular, there has often been no clear indication that density dependence is operating, whether caused by natural enemies or other factors, and ecologists have long disagreed over the implications of this. People have argued over definitions, over whether or not density dependence is needed for population persistence, over the frequency with which density dependence occurs in natural systems and over the best ways to detect density dependence and identify regulated populations. This talk reviews some familiar basic models for the dynamics of host-parasitoid interactions. These have been refined in many ways: (1) by including such factors as host density dependence, generalist natural enemies and density dependent parasitoid sex ratios, (2) by exploring the effects of age-structure on hest-parasitoid interactions formulated in continuous time and therefore with overlapping generations, (3) by examining how parasitoids may affect the dynamics of multispecies systems, and (4) by determining how spatial patchiness and other forms of heterogeneity at a wide range of scales, from local populations to metapopulations, may affect population dynamics.

Index terms: Dynamics, Spatial heterogeneity, Density dependence

INSECTS FOR STUDYING FUNDAMENTAL PROBLEMS IN BIOLOGY

<u>M. Locke</u>, Department of Zoology, University of Western Ontario, London, Ontario, Canada, N6A 5B7, e-mail mlocke@juliam.uwo.ca

The organism - Insect or Cell - directs me to problems, questions that need to be answered - segmental gradients in the epidermis, the nature of the cuticulin envelope that bounds all cuticles, organelle specific sequences of autophagy in the fat body, tracheal systems that look as though they might be lungs, ferritin that has a different distribution from that in vertebrate cells, cuticle secretion that serves as a model for directed transport. I have opened boxes of problems that I shall never be able to empty. This lecture tells you about them in the hope that they may interest you enough to research them further. For example: When a biologist looks at an organism he is immediately struck by the regularity of its proportions. How this growth is coordinated in different parts to create a sensible design is a much neglected problem. The mechanism by which coordination is brought about can be shown in the adaptive growth of the tracheal system. Tracheal systems are branched tubes that allow air to diffuse from the spiracles to terminal tracheoles in the tissues. Variable growth of the terminations is reflected in growth of the main branches to keep the cross-sectional area of the diffusion pathway constant at different levels of branching. This implies that information on how much to grow is transported cell-to-cell from the terminations to the main trunks, a conclusion that has been confirmed by surgical experiments. Experiments on other tissues, such as the fat body, also suggest that cell-to-cell communication for coordinated growth may be a general phenomenon. Insect biology is dominated by the properties of the cuticle, the most neglected aspect of which is the study of the cuticulin envelope. The cuticulin envelope, like the corresponding structure in bacteria, defines a compartment external to the plasma membrane. In bacteria, the compartment is involved with transport and protection, in insects it is the space within which the rest of the cuticle is deposited. Current experiments explore the nature of the cuticulin envelope. In conclusion, in honour of V.B.Wigglesworth, I remind you of his views on administration. He thought that the prime purpose of science administrators should be to encourage research. "Anyone who has tried both, knows that administration is immeasurably easier than research" he said. Scientists know this. They also know that all of the wealth and wellbeing of modern man depends on it. How then does it come about that modern man is, for the most part, scientifically illiterate. Coverage of science is miniscule in the National Newspapers of the world and the coverage itself is often scientifically illiterate. Does it matter if most of the population, including those who think of themselves as the elite of society politicians, lawyers, business executives, managers - are scientifically illiterate? It matters because these illiterates have hijacked decision making processes that affect all of us. Think of the crew of the spaceship challenger. They were sent aloft to explode because managers overruled scientists on a simple matter of the safety of the O rings sealing the fuel supply lines. The cult of management, the dictatorship of the manageriate, governed by the bottom line, is dangerous to all of us and to the world at large. These scientific illiterates have also hijacked the flow of money for their own remuneration. Research skills are much rarer than management skills. Scientists are highly selected, first from High School to get into University Science programs, then to do Graduate and Postdoctoral work, and for the very best, if they are lucky as well as able, a scientific career. Compare the money earned by that highly select group called scientists with that paid out to business executives. Nobel Prizewinners earn a fraction of that which thousands of top business executives award to themselves. This is more than an injustice, it is a most serious problem. Human survival depends on science and scientists. Unless the very best brains are recruited into science, unless these top brains have the resources to be fully employed, and unless they have a greater role in decisions arising from the implementation of their findings, those implications that affect humanity, the human species will not survive.

WHITEFLIES REVISITED

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D. Gerling, Department of Zoology, Tel Aviv Univ., Ramat Aviv 69978 Israel Fax- 972 3 6407830 voice 6408611, e-mail <u>DANGR@post.tau.ac.il</u>.

Scientific advances are continually being made. Every scientist knows this and likes to "revisit", in order to share the excitement of new findings with his colleagues. But why have whiteflies been chosen as the group to be revisited? The eternal race for increased fitness [the ability to leave more viable and reproductively effective progeny relative to the abilities of other individuals or populations - (Price 1996)] has led to the emergence of new and better-adapted forms of life. Once detected, it is of special interest to learn in what way such forms stand out and how their traits contribute to greater fitness. Whiteflies, or Alevrodidae, have been known and studied for over 250 years. The research conducted reflects the changes in their economic status and advances in biological theory and scientific methodology. During the last 100 years, two whitefly species, the greenhouse whitefly [Trialuerodes vaporariorum] and the tobacco or sweetpotato whitefly [Bemisia tabaci] seemed to differ from other economic species in defying attempts at classical biological control and have become economic pests of worldwide proportions. During the past 15 years, B. tabaci has caused damages sometimes reaching \$500 million or more per year (Perring et al 1993). Concomitantly, B. tabaci races and biotypes were found. The most prominent one, biotype 'B', showed increased fitness in relation to the former 'A' biotype. It eventually replaced it in extensive regions, and has been described as a separate species: B. argentifolii. The increase in fitness of biotype 'B' and its greater economic importance, have been accompanied by a rise from about 830 publications since Gennadius' description of B. tabaci in 1889 through 1985, to about 3150 from 1985 till 1998. Thus, our body of information, which once concentrated upon whitefly taxonomy and behavior, has been supplemented with studies on whitefly control, host plant relationships, physiology, molecular biology, natural enemies and tritrophic interactions. Therefore, the new biological and physiological information recently uncovered in whiteflies warrants revisiting. Gerling (1990) and Byrne and Bellows (1991) reviewed many of the findings concerning whiteflies in general, whereas Gerling and Mayer (1996) and Henneberry et al (1998) discussed Bemisia. Relying on this fact, I shall only present here some results of recent research that contribute to our understanding of fitness-enhancing strategies: whitefly relations with competitors and natural enemies, the physiology of whiteflies in relation to their environment and the emergence of *Bemisia* as a major pest.

TRITROPHIC RELATIONSHIPS

Whiteflies (Aleyrodidae, Homoptera) have winged, free-flying adults. Their eggs are inserted into the leaf tissue by means of a pedicel. The hatching crawler settles in the proximity of the oviposition site following a search for a suitable location into which to insert its mouthparts and reach the phloem veins from which its feeds. All four nymphal instars, following the settling of the crawler, spend their life in the same location, reinserting their mouthparts into the leaf tissue following each molt. The fourth instar is usually short and transforms into a so-called pupal stage during which the scale-like nympn transforms into the winged adult that emerges through a slit in the dorsum of its shed exoskeleton.

Whiteflies have arrhenotokous reproduction. Unfertilized eggs produce males. Sex ratios are often close to 1, but may be biased towards either sex. Dispersal is through adult flight leading to landing on new host plants. Being small, whiteflies depend upon air currents for transportation. They often fly only short distances, but marked adults have been found seven kilometers from their point of origin (Byrne 1999).

The leaves upon which whitefly nymphs live are also a substrate for other phytophagous insects, the whiteflies' competitors, as well as the roaming grounds of predators and parasitoids, the whiteflies' natural enemies. Additionally, whitefly feeding removes nutrients from the plant and induces biochemical reactions that are unique to injured plants (Inbar et al 1999a,b). It is interesting to examine if and how defense of whitefly nymphs against natural enemies and antagonism *vis a vis* competitors materialized, considering that the only mobile stages of the whiteflies are the adults and crawlers.

Interspecific territoriality in whiteflies can materialize directly, morphologically and/or physiologically, or indirectly through the plant. Morphological features with possible territorial functions in whiteflies include: a powdery wax produced by the adults, and often also covering their places of residence and oviposition upon the leaf; and waxy spines and/or protrusions on the immatures. The quantities of both of these, and the numbers or size of the latter may vary among different species and conditions. In addition, whitefly nymphs may be transparent, white, brown or black.

Such features indicate considerable expenditure in extra-corporal structures (e.g. Guershon 1997), whose cost-benefit relationship should be examined in direct association with all three trophic levels. Few such studies have been performed, but they nevertheless indicate a consistent trend in their functional morphology.

Ovipositing females of the ash whitefly, Siphoninus phillyreae, deposit a typical circle of wax. When developing on Crataegus aronia this wax prevents another homopterous leaf feeder, the tingid Stephanitis pyri, from approaching the area of whitefly development, leaving clear-green regions surrounding the latter. Experimental evidence for direct defense against natural enemies was produced by Guershon and Gerling (1994). The exuviae of the nymphs of Aleyrodes singularis, developing on Lactuca serriola, remain on the nymphs and are piled on top of one another. In addition, the mother female, following oviposition, remains upon the patch on which her progeny develop, frequently shaking powdery wax from her wings to create a permanent waxy cover that prevents parasitoid females, except those of Encarsia inaron, from walking on or mounting these nymphs.

Exclusion experiments in the field showed that even *E. inaron* was able to parasitize fewer hosts in the presence of wax than in its absence. The case of *A. singularis* is of particular interest since it implies parental care by the female. This is further supported by observations that the female physically attacked parasitoids and predators that visited the patch.

Spiny protrusions, in varying quantities, have long been known to exist on whitefly nymphs (Mound 1963). By creating artificial tomentosity on smooth leaves, Guershon (1997) has experimentally shown that the nymphs show individual variability in the propensity to become spiny (or smooth). He also showed that nymphs upon tomentose leaves possess more spines than those on smoother leaves with spineless nymphs found on glabrous leaves. An adaptive explanation for this relationship comes from studies on foraging behavior by adults of the coccinellid predator *Delphastus catalinae*. On tomentose leaves, they prefer to attack spineless vs. spiny nymphs. Associative learning enhanced this trait, making it more explicit in experienced beetles.

In addition to the dorsal spines, many whitefly species secrete a waxy fringe around their margins and waxy filaments over most of their body or parts of it. These waxy "ornaments" may become very elaborate, creating a maze of wax on and around the insect. In some species, like *Aleurodicus dispersus* and *Lecanoidues floccossimus*, the wax covers large sections of the leaf, and has been observed hampering parasitoid movements. Moreover, the parasitoid *Encarsia hispida* that successfully attacks *A. dispersus* on which the wax does not encircle the whole nymph, is unable to reach and parastize *L. floccossimus*, in which the wax ring surrounds the nymph completely (E. Hernandez-Suarez personal communication). Since parasitoids of the genus *Eretmocerus* must reach the margins of their host nymph in order to insert the ovipositor under its margins, it is tempting to speculate upon the defensive values of the "fringe extension" in preventing parasitoid attacks. Unfortunately, no experimental evidence has been forwarded to support or refute this or other hypotheses. Neither has an explanation been forwarded to the fact that many of the whitefly nymphs exhibit the most elaborate protrusions only during the pupal stage, whereas the younger nymphs, which are the targets of parasitoid attack, are hardly ornate. Thus, significance of whitefly investment in wax and structural modifications, and their relationship with fitness, are only starting to unravel.

Insect-plant interactions were shown to induce the production of putative protective proteins in the plants, such as chitinases, peroxidases and lysozymes. The magnitude of induction for each defensive protein varies among insect species and different plant species. Inbar and co-workers (Inbar et al 1999a) showed that adult feeding, oviposition and larval survival were reduced by 26.5%, 47.7%, and 30.7% respectively in the leafminer *Liriomyza trifolii* feeding on plants infested by *B. tabaci*. However, *B. tabaci* remained unaffected by changes in plants caused through feeding of *B. tabaci*, *Helicoverpa zea*, or *L. trifolii*. Additional experiments (Inbar et al 1999b) examined feeding of the looper *Trichoplusia ni* on collard leaves infested with whitefly nymphs vs. uninfested ones. Development of their larvae was 20.8% slower and relative growth rate was reduced by 18% on whitefly infested vs. control leaves. Young larvae were also found more often on the nymph-free adaxial (top) side of the leaf than on the underside on which the nymphs were present. Finally, field survival to pupation was only 4% for larvae feeding on whitefly-infested plants, vs. 18% on whitefly free plants. These results may indicate that the feeding mechanisms of *B. tabaci* avoid contact with the induced plant defensive chemicals. However, since the whitefly induces formation of products that adversely affect its competitors, its immunity can be seen as a mechanism conferring competitive advantage in utilizing food resources, and possibly increasing its fitness.

WHITEFLY PHYSIOLOGY AND BEHAVIOR

Studies of *B. tabaci*, and other whitefly species that feed on annuals, have concentrated upon features that enable them to survive and multiply in their ever-varying environment. The main constraints in such environments are: constant changes in plant suitability, a need to shift from one, wilting, host plant species to another several times a year, and the selective pressures imposed by human agricultural practices. The great increase in whitefly populations and ranges, attesting to their successful adaptation, have led to studies elucidating some of the physiological and behavioral mechanisms underlying whitefly biology.

Physiological changes in the developing whiteflies, that are detectable both morphometrically (Byrne and Houck 1990) and in the egg loads and levels of vitellogenins, (Isaacs and Byrne 1998), indicate that whiteflies can "read" the worsening host plant quality and choose a different metabolic pathway during their immature development. Presumably the emerging adults, now with different wing dimensions, less commitment to egg production and less of an egg load, will make better migrants with better chances of arriving at a suitable host on which to establish further generations.

Host plant choice also poses intriguing dilemmas. Bernays (1999a) argued that polyphagous insects, like *B. tabaci*, face difficulties in choosing host plants that stem from shortcomings in their sensory and nervous systems. The difficulties are expressed as changes in behavior of the landing adult and in the relative number of eggs laid on different host plants when choice vs. no choice replicates are compared (Bernays 1999b). These behavioral patterns indicate better success when attacking an agricultural crop (a monoculture) than a mixed natural stand of plants.

Being weak flyers, whiteflies are dependent on air currents. They may have little influence on their direction of movement, and cannot be precise in the choice of their landing site. There is thus little active choice prior to contact with the plant, after which the insect may remain on the plant or desert it for another (Gerling and Lindenbaum 1991). The phase between landing and feeding cannot be completed before the whitefly has adapted to the new host plant that is often heterospecific with the previous one. Behavioral aspects of this phase, in which new plant features have to be adapted to, have been dealt with by several workers (van Lenteren and Noldus 1990) and I shall not discuss them here. However, recent work has also shown the need for, and the existence of enzymatic adaptability, without which polyphagous plant feeding insects would face difficulties.

Each plant species mobilizes specific types of sugars in the phloem. Cotton plants mobilize sucrose, while cucurbits mobilize galactose-containing sugars such as raffinose, or stachyose. Whiteflies, being phloem feeders, need to break down these different sugars in order to utilize them as well as to dispose of excess sugars by changing them into other oligosaccharides such as trehalulose (Salvucci et al 1997). When migration occurs from squash or melons that use raffinose and stachyose, to cotton that uses sucrose, the insect must also shift its metabolic pathway, using different enzymes for sugar breakdown. By moving whitefly adults from cotton to squash plants and examining honeydew production, it was possible to show that after as little as three hours, they were able to utilize the new sugars for nutrition (Salvucci and Gerling, personal observations).

The outdoor distribution of Bemisia includes mainly countries with desert climates in which temperatures throughout the summer can exceed 40°C. Adaptation to such conditions, and especially protection of soluble proteins from heat-induced aggregation and inactivation, is vital. In whiteflies, the mechanisms for coping are not associated with evaporative cooling, due to their minute size, which renders them too vulnerable to desiccation. Alternative methods include remaining on the lower leaf surface, which under dry weather conditions may evaporate water and thus lower ambient temperatures near the leaf (Lu et al 1997). Whiteflies also synthesize heat-shock proteins (Hsp) in response to heat stress (Salvucci 2000). In addition, Salvucci and coworkers (Salvucci et al 1999, Wolfe et al 1998) have shown that *Bemisia* accumulate the polyhydric alcohol sorbitol, when exposed to temperatures in excess of about 30°C. Recently, Salvucci (2000) has shown that when whiteflies were conditioned at 40°C, they showed greater heat-tolerance than did unconditioned individuals that were kept at 25°C. Relying on the findings of Wolfe et al (1998) that sorbitol levels increased 15-27-fold (to about 0.5M) in heat-stressed whiteflies, he argued that sorbitol accumulation protects whiteflies during heat stress in a similar manner shown for trehalulose protection of yeasts. Since sorbitol levels can only be raised when the insect is actively feeding from the plant, the mechanism of heat resistance begins when the whiteflies are on the plant and is affected by a combination of their location (underneath the leaves), Hsp and raised levels of sorbitol. The latter is mainly active when the whiteflies are feeding on healthy, non-stressed plants, whereas Hsp gain importance when the plants are in poor health. It remains to be examined if loading with sorbitol prior to migration helps whiteflies to resist the high temperatures that may prevail en route to the new host plants.

THE BEMISIA COMPLEX

From its first description, *B. tabaci* has been reputed to reach high populations (Gennadius 1889). Following reports in the 1920-1930s from India and Israel (Husain and Trehan 1933, Sachs 1994), it later appeared as a pest of vegetables and cotton in numerous places in the Old World including the Sudan and Egypt. Between 1970 and 1980 unexplained increases in whitefly populations were reported [Turkey about 1974, Israel 1976/7 (Sachs 1994) and the Sudan about 1979 (Dittrich et al 1990)]. The extensive cotton fields produced millions of whitefly, which, especially following cotton defoliation, moved to other field crops and vegetables. Massive insecticide applications followed, with the inevitable result of resistance build-up and a general failure to cope with the increasing whitefly problems. Dittrich et al (1990) attributed part of the problem to hormoligosis, i.e. the ability of insecticide-resistant *B. tabaci* individuals to increase their oviposition rates several folds when under insecticidal stress. Since then *B. tabaci* has been recorded, sometimes as a very severe pest, in most locations of the Old World in which climatic conditions permit its existence.

In the Western Hemisphere, *B. tabaci* was first reported in 1894, but aside from being a vector of cotton leaf crumple, it was rarely of economic importance prior to 1975 (Henneberry et al 1998). From the mid-1980s on, it started to increase its host plant range and to cause new physiological disorders. Concurrently, unusually high populations developed in California and Arizona and suspicions arose as to the identity of the *Bemisia* species or variety at hand. Several years of study (Henneberry et al 1998) have resulted in the description of a second species, *B. argentifolii*. The validity of the specific status given to the so-called "type B" *B. tabaci* on the basis of mating incompatibility studies and morphological characterization as well as on molecular examination (Bellows et al 1994), is still unsettled, although its distinctive characteristics are well recognized (De Barro 2000, Henneberry et al 1998).

During the last 10 years the range of *B. tabaci* has continued to spread, making it a serious pest in vegetables and field crops in many previously uninfested, South American and Far Eastern countries (Hilje, 1998, Sumalde and Salinas 1999). Thus, Gennadius' prediction that this insect species has the potential of becoming a very damaging pest has fully materialized.

At present, studies on *B. tabaci* bifurcate. On the one hand, the appearance of host-associated races, new biotypes and possibly new species indicates active changes in the process of speciation. Therefore, with its ca. 100 year known history, it offers an interesting subject for the study of possible short-term evolutionary changes. On the other hand, it is one of the most damaging pests known, and prevention of present and future damage is of paramount interest in the agricultural world.

The changes in the taxonomic status of *B. tabaci* might have resulted from recent mutations, selection on existing types, or both. Whatever the case, we could have expected multiple biotypes and strains to exist since its morphological variation has long been recognized (e.g. Mound 1963), resulting in over 10 synonyms of *B. tabaci* presently known (Henneberry et al 1998).

Principal factors contributing to the rapid process of specialization, and possibly speciation, are also recognizable:

1. The extensive geographic and host-plant ranges can lead to allopatric development of differences. For example, the "non-B" biotypes found in Spain (De Barro et al, 2000), may have developed in isolated conditions in relation to the ubiquitous 'A' or other biotypes that were or are typical to the Mediterranean region. Sympatric strain developments in *B. tabaci* that are plant-associated have been reported by Legg (1996). Whiteflies from cotton and sweetpotato did not colonize or survive on cassava, while the

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reciprocal arrangement, with the whitefly from cassava on cotton, showed limited colonization of the cotton. However, their adults, emerging from cotton, retained the ability to colonize cassava, confirming the genetic basis for this discrimination.

2. Genetic factors, including: a. The extensive whitefly populations forming isolated subgroups that could have led to segregation. b. The nature of whitefly populations, rising to extremely high numbers and then declining to few individuals due to the absence of suitable host plants, inclement weather, or insecticidal treatments, suggesting a "flush-crash cycle" mechanism (Carson 1968). Thus genetic drift following a bottleneck could change the genetic structure of the population and enable natural selection to act on the new genomic compositions. c. The arrhenotokous haplodiploid sex determination mechanism favors rapid evolution since the deleterious recessives are rapidly selected out of the population in the halploid males (Price 1996).

3. Human activity, driving the process of specialization further. We supply large quantities of uniform, stable food sources and apply insecticidal pressures. These, in turn, lead to the formation of very large whitefly populations, resistance buildup, and to processes like hormoligosis generating, again, large populations that differ somewhat from the parental ones.

4. Finally, new technologies, especially those employing molecular genetic methods (e.g. PCR) enhance our recognition of genetic specialization by enabling us to differentiate among strains that were previously indistinguishable.

It may be worth speculating on the interface between changes occurring to *B. tabaci* and its status as an agricultural pest, i.e. "what are we to expect, and what can we do about it"?

Except for the transmission of viral diseases, the history of *B. tabaci*-associated problems usually repeats itself. Extreme population outbreaks cause extensive damage that even the most frequent and sophisticated insecticide and management techniques fail to control. A few years later the problem abates somewhat, resulting in a more stable, controllable condition that, in contrast with the outbreak phase, is open to IPM technology. This process is reminiscent of the developments that take place following establishment of an invading species. An explosive stage, in which the invader can take advantage of its novel capacity to exploit untamed local resources, is followed by a more balanced stage, in which local resistance, including natural enemies, host plant defenses and climatic constraints materialize. The new population level reached is typical of the local conditions under which it has developed. If we relate to the *B. tabaci* biotypes and strains as invaders, we should expect that, following the outbreak phase, it will stabilize in different crops and conditions at different levels, depending upon climate, host plant availability and suitability, and pest management practices

This reasoning leads to the following practical conclusions:

1. We can expect severe, widespread and hardly controllable outbreaks in the first few years following invasions. These usually cannot be handled by the growers alone and must be dealt with at the state or national level in cooperation with the growers. At this phase a different approach must be taken towards the initial "invasive stage outbreaks" vs. the later "stable stage outbreaks" (Gerling, 1996).

2. It is critical that management, including employment of natural enemies, be implemented as soon as viable. This is especially important since the chances for resistance build-up already at the "invasive stage outbreaks" are substantial, and the resistant populations will be carried over to the "stable stage outbreaks" hampering IPM attempts in the future.

3. The mere discovery and description of new biotypes has little value unless the relationship to functional traits is elucidated as a lever for better biological, ecological and agricultural understanding, leading to better management.

ACKNOWLEDGEMENTS

I am indebted to many colleagues for their help and advice, in particular: to Ms. N. Paz, and to Drs. J. Brown, (Univ. of Arizona). P. DeBarro, (CSIRO, Canberra, Australia), I. Denholm (Rothamstead Exp. Sta. UK) M. Guershon, and D. Wool (Tel Aviv Univ.), D. Hendrix, T.J. Henneberry and M. Salvucci (UDSA, Phoenix, AZ USA), Estella Hernandez-Suarez (ICIA- Tenerife- Spain), M. Inbar, (Haifa Univ.) B. Roitberg (Simon Frazer Univ. Canada), and J. Rosenheim (Univ. of CA USA).

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- Index terms: Bemisia, Encarsia, Eretmocerus, tritrophic interactions, honeydew

ENTOMOLOGY FOR THE THIRD MILLENNIUM -SCIENTIFIC AND TECHNOLOGICAL CHALLENGES

Manfred Kern, Aventis CropScience, Industrial Park Höchst, K 607, D-65926 Frankfurt/Main, Germany Fax: ++49 (0)69 305 7342, E-mail: manfred.kern@aventis.com

Address:

Introduction

You are all familiar with the rather odd question reporters always ask players immediately after the game before leaving the field: "How did you see the game?" The only sensible answer, of course, would be: "Quite well, I was taking part." What the player while still struggling for breath - is expected to give is a preliminary analysis of the course of the game. Although I am not a sportsman, and this has not been a game, the situation I find myself in here is rather similar.

At the breathless end of what was for me personally a great entomological and educational experience, I can only give a provisional analysis: I am still trying to order the impressions made on me by the contributions to this XXI International Congress of Entomology here in Brazil at Foz do Iguassu.

As a scientist in the area of applied entomology, working in the industry for the crop production company Aventis CropScience, I trust you will believe me when I say that it is a very great honour and an extraordinary challenge to be invited here, to outline the hemimetabolic and holometabolic developments in insect science, and the visions, future tasks, missions and "entomological utopia" of the twenty-first century. This is not a simple task.

What better way to do this than try to "think" or "behave" like an insect? Just like the insects, I will now try:

- to communicate with you,
- to sting and bite you, though certainly not to kill you or paralyse you,
- to get on your nerves, but also to amuse and entertain you,
- to fascinate you and set you buzzing with ideas, and, if you like, to help you develop insect wings for a flying start into the new millennium.

World famous entomologists

All scientific entomological knowledge has grown out of the painstaking work of generations past and present.

There is no need for me here to draw up a list of all eminent entomologists separately - all the Fabres, von Frischs, Buthenands, Uvaroys, Nabokovs, Dethiers, Osamus, Wigglesworths, Gilberts, Wilsons, Nüsslein-Volhards and the rest.

Let it be sufficient to express our gratitude that they approached insects in the right way, and had the ability and wisdom to grasp the essentials about insects in a rapidly changing world and to impart them to us.

I think this is the right time and place to thank all those entomologists from whom we received our basic knowledge, and to honour them with a round of applause.

May I ask you all to stand? ---- Thank you very much!

An applied entomologist

Entomologically speaking, my own "egg phase" started with the study of "Brain ageing in insects - insects as model organisms to prolong life span"; insect brain structure and functions, entomo-neurophysiology, and biochemistry of insects was my profession. During my "hemi-/holometabolic development" I worked in the field of pest control, looking for new selective insecticides, analysing new modes and mechanisms of action, contributing to the field of entomo-neuropharmacology, analysing mechanisms of selectivity and pesticide resistance, working with insect pathogen fungi, and discovering synergisms of genetically engineered plants and insecticides.

During the time I devoted myself to basic and applied research in IPM and ICM, I was able to learn more about a wide range of very different agricultural production methods in almost fifty countries, from wheat, rice, soybean, tea and vegetables to coffee and cacao.

The aim of my work was sustainable dematerialisation, enhancement and optimisation of agricultural production.

During all these years I have watched, analysed and killed a lot of insects, such as tobacco hornworms, *Manduca sexta;* blowflies, *Calliphora erythrocephala*; silkmoths, *Bombyx mori*; honey bces, *Apis mellifera*; coffee berry borers, *Hypothenemus hampei*; tobacco budworms, *Heliothis virescens*; leaf cutting ants, *Atta sextens*; lace wings, *Chrysopa carnea*; paper wasps, *Polistes erythrocephalus*; cotton boll weevils, *Anthonomus grandis*; Colorado potato beetles, *Leptinotarsa decemlineata*, etc. - all of them highly astonishing and fascinating organisms!

Behind all this work, there is a cardinal imperative which will continue to be valid in the twenty-first century: a bio-ethical examination and evaluation of all tests carried out on insects and of all measures taken to control them.

Entomologists in the twenty-first century will very certainly have to develop bio-ethical standards! They will be called upon to find ways of applying the entomological sciences for improving the quality of life, especially in the context of the human right to sufficient food.

World food security and insects

In fact, the quality of life is the focal point we have to face when we talk about the role of insects, the safeguarding the world's food supplies. Today, during the hour or so taken up by the closing lecture of the XXIst ICE, the world population will have increased by another 7,000 people.

There is no escaping the fact that "food and safeguarding of food supplies" is a topic which will continue to increase in importance. The number of conferences held on the subject has increased threefold since 1994, with 400 to 500 per year and the tendency pointing upwards. The central question is: "How can we feed the future world population sustainably and in keeping with human dignity?"

Let us take a look at the factors "requirements" and "consumption" up to 2025 (2050). Round about 1850 the number of people on this planet was approximately 1 billion, and during 1999 the number reached 6 billion. Mean estimates indicate that by 2025 the world population will have risen to more than 8 billion. However, this numerical increase is not the main problem for future world food supplies and the safeguarding of these supplies; a much greater impact will be had by rapid economic growth in the key regions of our planet. This economic development will very quickly alter world eating habits and increase total food consumption - first of all regionally, and then throughout the world.

A look at the increases in calorie consumption will reveal significant regional differences. Consumption today in the Western world is around 3,400 kilocalories per head and day. The increase here over the next 25 years is hardly worth mentioning: 3,470. At the same time the average global calorie consumption rate will increase from 2,700 to 3,000. Here is where the great challenge lies. To make this clear, let us take Asia as a whole - China included - where the calorie consumption will rise from 2,400 kilocalories per head and day to 2,880 by the year 2025. This means that about 50 percent of the world population is moving over from low calorie consumption to a more nutritious dietary level, though still not up to Western standards.

And if we now look at the food requirements and food production of the world as a whole, we will find that we have a slight "surplus". The word "surplus" suggests that we already have more than enough. But this is not so: at the moment only 0.26 percent more food is being produced than is actually consumed. And this without even allowing for the fact that we are still a long way from eliminating the hunger of 0.84 to 1.2 billion people in the world today.

Our first priority must be to create the technical basis for producing as much calorie and energy-rich food as is needed throughout the world. We must bear in mind that over the next thirty to fifty years world food requirements will more than double, and this will make it necessary to double - and even treble - agricultural production and supplies. At the same time, we will have to compensate for reduced farmland areas, water shortages and the switch from plant-based to meat-based diets.

In the next thirty years we will have to produce more food worldwide than over the whole of the last 10,000 years. And we will have to do all this in a sustainable and environmentally compatible way. "Meeting the needs of the present without compromising the ability of future generations to meet their own needs" is our guideline for sustainable development written in the Brundtland commission report in 1987.

The need for food creates a relationship between human beings and the environment, and insects are here the key organisms. Insects can survive very well without us, but we - like most other terrestrial organisms - would be lost without them.

In the USA, for example, the annual value of pollination by honey bees has been estimated at 6.7 billion dollars. When a mite plague spread among bee colonies in America at the end of the nineties, agricultural yields went down immediately. This is just one example of how we hardly notice insects in everyday life, and only start to realise the role they play when they are disappearing or have already disappeared.

On the other hand, it must not be forgotten that the principal occupation of an insect, especially of a caterpillar, is eating. Anything else it does is connected with its metamorphosis, is subservient to the function of procuring food. Most species feed on plants and live in the open, but some tunnel into the leaves, into the fruit, or into the stem or wood. Other species feed on seeds, stored grain, and cereal preparations.

Yudelman et al. (1998) have reviewed the estimated annual losses from pests on 50% of the crop area world wide, especially in rice, wheat, barley, maize, potatoes, soybeans, cotton, and coffe. Pre-harvest losses were due to insects (15%), pathogens (13%), weeds (14%) and additionally 10% by post harvest losses. Without pest control the overall world wide losses from pests were as high as 50%.

Entomologists in the twenty-first century will be under an obligation to answer the following questions: "What must we do, what must we try to achieve, what actions must we take, and what constructive changes must we make in order to keep a sound balance between world food security and a functioning environment?"

For this reason I would like to draw your attention to the Rio Conference of 1992 on Sustainable Development, Agenda 21, Chapter 16, on the subject of biotechnology. Chapter 16 expressly propagates gene technology. Although it refers only to biotechnology, the wording in this context is invariably used in the sense of gene technology. "Biotechnology is the integration of the new technologies emerging from modern biotechnology with the well established approaches of traditional biotechnology.

Biotechnology, an emerging knowledge-intensive field, is a set of enabling techniques for bringing about specific man-made changes in deoxyribonucleic acid (DNA), or genetic material, in plants, animals and microbial systems, leading to useful products and technologies."

In view of the tasks confronting a sustainable future agriculture, genetic engineering combined with improvements in conventional production technologies will make a decisive contribution to the production of more food and raw materials on a sustainable basis and on already available farming areas. Basic and applied entomology has a special obligation to meet these challenges and find appropriate solutions.

Climate change, pests and beneficials, biodiversity

Climate change will have significant implications for the regional flora and fauna, with insects as poikilothermic organisms being amongst the first species to respond to change.

The present geographic propagation of pests is substantially limited by temperature. Insect populations at present confined to the tropics will most likely spread towards middle latitudes when the atmosphere warms up. A significant northward move in Europe at an average rate of 20 - 50 km/year is estimated by Kozar, F. (1997). Warmer climates generally offer better possibilities of wintering and lead to a higher density of population, earlier presence of populations and an increased risk of invasion by migratory insects. Higher atmospheric CO₂ concentrations increase the carbon assimilation of plants and modify the carbon distribution pattern, and qualitatively and quantitatively the secondary plant ingredients. The increase in bound carbon in a plant causes a reduction of the nitrogen concentration. The result is that nitrogen may become more and more a limiting factor for the development of insects. In economically important species, this will finally lead to an increased uptake of biomass. Considerable yield reductions due to increased damage by insects loom up in agriculture.

Quite different reactions to the impending climatic change are to be expected in view of the biological and physiological/biochemical diversity of the pests and the complex relationships within the systems "crop plant – pest – beneficial". The following effects are most likely to occur in pests and beneficials, independent of the host, due to an increasing climatic change:

1. Various changes in the geographic propagation of pests and beneficials

- 2. More rapid development and an increased number of generations
- 3. Prolongation of the development season
- 4. Modification of the interaction "plant noxious organism beneficial".

Insect-dependent plant pollination will also change as a result of climatic changes and thus also the productivity of plants. Climatic changes do not only have effects on local and regional food chains, but even on complete food systems. Such changes will affect the biodiversity of some regions.

Important fields of work and tasks of entomology in the twenty-first century may be derived from these briefly outlined interrelated topics:

An important part of the work of entomologists will be to analyse the habits of plants, pests and beneficials and their interactions in various agricultural ecosystems, paying attention to factors such as CO_2 , CH_4 , N_2O , O_3 , temperature, and effects on biogeography and biodiversity.

Biodiversity and insects

"The preservation of biodiversity is a common concern for mankind" (Convention on Biological Diversity, Rio de Janeiro, 1992).

The Rio de Janeiro Convention on Biological Diversity was a milestone on the road to sustainable conservation of the earth's genetic resources. The preservation of biodiversity is an essential prerequisite for the future development of the earth as a viable habitat. It is therefore an objective worth pursuing in its own right. New insights into processes and structures, and genes of animals and plants, will also help us to find new ways of combating disease, safeguarding the food supply of the world's growing population and protecting the environment. The preservation and sustainable utilisation of the diversity of species is of vital importance for the interests of all mankind, for the countries which supply these resources and, last but not least, for the health and food industries.

Let me give you an example to illustrate the importance of preservation: One single Peruvian peasant who cuts down rain forest to feed his family and then moves on from one patch to the next as soon as the nutrients in the soil have been used up, will destroy trees and insects of more species than are native to the whole of Europe. And he will go on felling trees as long as he cannot earn his living in any other way.

"Biodiversity can be rescued from the grindstone of poverty only if we can find new potential uses for already cleared land and for the remaining intact areas. We must look for new methods to make better use of the yield potential of natural habitats - without involving their destruction - and to encourage the invisible hand of the free market economy to grow a green thumb. The search has already started" said by E.O. Wilson (1997). Protection of global biodiversity areas, conservation of biodiversity on arable land and safeguarding of the biodiversity potential of crop plant species are key areas of biodiversity, sustainable agriculture, sustainable development and, ultimately, of a sustainable socioeconomy.

By 2015, pests and diseases will be controlled largely by genetic methods (Delphi '98). Within the next couple of years entomologists will have to prove that the widespread application of biotechnology has no significant adverse effects on the preservation of genetic diversity or biodiversity in the agricultural sector. This is one of the key responsibilities of entomologists in future.

Nobody today can possibly say what a particular beetle might have been useful for if it still existed today. Simply the fact that it survived over a very long period of time made it something special - after all, 99 percent of all other species had already become extinct before it.

During the process of evolution, many forms of life - some breathtaking, some very unobtrusive - have developed and survived into our own times. As Gleich et al. (2000) have demanded, we should never sacrifice any of them except under sheer force of circumstances. They are our vital capital for the future, for an intact environment and the foundation of its dynamism.

Parasites and pathogens - the plagues of the future

In future more than half of the world's population will be living closely packed together in mega-cities of 10 to 25 million people, and since human parasites and their vector organisms have by no means reached the end of their evolution, we have to assume that future generations will be confronted with massive onslaughts of parasites and pathogens, both old and new, with ever more finely-tuned molecular methods for overcoming immune barriers and control methods.

Half of the world's population lives under the threat of insect-borne diseases.

At the present time more than 12 million human beings are afflicted by leishmaniasis, according to estimates of the World Health Organisation, and more than 350 million people live in risk areas. The number of new infections is about 2 million per year, tendency rising.

Vectors such as mosquitoes and ticks transmit diseases to hundreds of millions of human beings, and the number of mortalities associated with these infections exceeds 1 million each year and perhaps as many as 2.5 million. But malaria control, for example, is not a profitable market, which is why very few financial resources are available for research in this field.

Advances in biotechnology, including mapping the genome of the malaria parasite, point to a possible malaria vaccine. But it will need a private-public cooperation to take the right course.

Nanotechnology and insects

In the early days of entomology scientists observed insects under natural conditions, collected them, described them, named them and classified them. Later on, entomologists started to learn more about insects by analysing the interior of insects, i.e. they studied the organisms in vivo. In the century which has now just ended they learned to examine them in the test tube, i.e. in vitro. In future they will investigate insects with the aid of the computer, in silicio, so to speak.

Scientists will systematically analyse natural functional principles in order to exploit them commercially. Material specialists and chemists, architects and automobile constructors will be looking into nature's toolbox. And they will do this because insects show what can be achieved given a good power source, sophisticated controls, superlative materials and 350 million years of evolution.

The "nano era" of the twenty-first century will also revolutionise, or evolutionise, entomology. Biochips will be expressed in insects, and with the aid of nanotechnologies, i.e. nanoelectronics, nanomechanics, nanobiology, nanomanufacturing, nanocontrol and nanomicrology, it will be possible to construct mechanical insectoids, hybrid cockroach robots and ant robots. Crawling robots and "intelligent spare parts" which will make life easier for handicapped people (controllable "running" plates and cups).

At the same time as we are advancing our knowledge of the macro-world, we are also engaging in unremitting exploration of the micro-world. After undergoing the "catalysis" of modern science and technology, certain notions that used to be looked on as wild tales are now confronting mankind "as if coming to life". Some of man's fantasies are to manufacture extremely small-scale electrical machinery that can only be seen under a microscope, an "intelligence chip" that could be transplanted into the brain of an insect, or a "remote controlled submarine".

We will have the responsibility of ensuring that all these things do not become a knife "cutting both ways" and threatening social stability. "Microscale electromechanical insects" or "modified insects" should never be used as nanotechnology weapons"!

Entomology/Gen(e)tomology

Another challenge lies in the creation of genetechnology-based entomology. In fact, entomology in the twenty-first century will bear the title "Gen(e)tomology". The large number of highly diversified insect species, the successful evolution of insects, their enormous adaptive potential, their many different survival strategies, their immensely efficient communication systems, and their highly organised society formation will become key fields for molecular biology and gene technology in the future. Transgenic strains of arthropod vectors will become commonplace. We will also be in a position to create and produce new insect species.

Just imagine the scope of possibilities: one thousand grams of DNA (dissolved in one cubic metre) would have a larger storage capacity than all computers which have ever been built, or about 100 billion times the storage capacity of our brain. Thirty grams of DNA work one hundred thousand times faster than the fastest computers we know today (Kaku, 1998).

The genetic code of life is a gigantic biological manuscript that we have scarcely yet begun to examine or decode.

Plenary Lectures

"Drosophila - completely decoded" was the great headline at the beginning of the year 2000. This means that we now know the 13,601 genes of each separate cell and also those for the development from egg to adult fruit-fly.

Let me describe the great amount of work that still lies ahead: Molecular biologists will be responsible for the process of gene and genome cloning, sequencing and the expression of the genome. Entomologists will be needed in the field of expression, for instance to express DNA (chips) (transcriptones), and to analyse the consequences of a treatment or a stress on gene expression. Furthermore, they will analyse the proteins (proteomics) and various metabolites (metabolomes) in an insect cell (which will be the basis for any patents), and last but not least carry out functional analyses of gene networks (phenomics or better 'physiomics'). An important goal will be to determine the function of a gene, *in silicio*, in *vitro* and *in vivo*.

What will we have to establish?

1. Genetic maps, for identifying and localising traits on the chromosomes.

2. Cytological maps, for visualising chromosomes and bands corresponding

to traits and for localising genes on the DNA.

3. *Physical maps*, describing the complete nucleotide sequences.

Genomic research will enable us to identify and validate new targets for insecticides, and to determine the mode of action of active ingredients. It will also place us in a position to identify new genes and gene functions to enable us to discover and validate new traits for seed improvements.

With the aid of gene technology, we will obtain insects which are able to produce drugs, probiotics and essential products.

At the beginning of the next century a diverse range of novel molecular DNA markers will be available for entomological investigations. Both DNA and protein markers have revolutionized the biological as well as the entomological sciences; they have enhanced many fields of study, especially ecology, taxonomy, population biology, insecticide resistance and pest control. A review article is given by Loxdale, H.D. and Lushai, G. (1998).

End of 1999 Wimmer, E., Berghammer, A. and Klingler, M. in Germany succeeded for the first time in developing a universal marker gene that was to function in all insect species. Demonstrated in the fruit fly and yellow mealworm beetle as examples, the eyes of transgenic animals fluoresce green due to the introduction of this marker gene. The universal suitability of this marker gene is based on the fact that it is activated by a regulatory mechanism, which has been generally expressed throughout the animal kingdom. An exciting new field has been opened.

In this case also, it may be stated that insects remain an endless source of both theoretical and applied interest in the field of molecular markers.

Entomology - key science of the twenty-first century

Let us, like the insects, direct our eyes forwards and try to gain an overall panorama of the future.

If biology, as many people believe, becomes the "key science" of the twenty-first century, entomology will fulfil a pioneer function and occupy a top position. It is important to get this over clearly to the public as a whole.

Holistically trained and holistically thinking entomologists will be in a position to furnish the knowledge necessary for solving tomorrow's problems and for achieving a sustainable healthy environment.

But at this point I must draw your attention to a very important area of future entomological research: "Endangered Species: Doctoral Students in Systematic Entomology". By 2017, as Howell Daly wrote in 1995, there will be hardly any doctoral students carrying out studies in insect systematics in the United States of America and Canada, and there will also be hardly any insect systematists. This development is very disturbing and must be stopped, particularly since in the new century insect systematics will be decisive for cataloguing and promoting biodiversity.

Entomologists will no longer be "dreamy egocentric individualists" or specialists in the "left legs of cockroaches", but will be indispensable, sought after and, I would proudly add, fully recognised men and women.

It will be our responsibility to point out suitable ways for young people. Our decisive contribution must be to devote special attention to long-term financial support mechanisms to allow basic science to continue growing in an international environment marked by sharp competition and the call for immediate results.

Some entomologists are of the opinion that the Internet will completely replace scientific journals. It is true that the Internet has advantages of which almost everyone is aware and it certainly helps to "democratise" information. All the same, I am convinced that even in the future peer reviewed journals will continue to be of vital importance for entomology. They will do much to minimise or prevent the publication of frivolous or false research results, scientific misinterpretations and faulty ecological and economic decisions which may have worldwide consequences.

We all know that science is knowledge which is stored, multiplied and passed on; that an entomologist who is unable to give an account of his scientific work to a 15-year-old pupil is an impostor, and that the words of Krass and Landois as early as 1895 will continue to remain valid in the twenty-first century: "A scientist is doing his job properly only if he pursues his particular line of study in depth, and at the same time contributes to the spread of scientific knowledge throughout the population." In this spirit, we, as entomologists, must not shrink from using well-made insect comics or even science fiction - such as LEXX, the "super insect" - as a vehicle.

Plenary Lectures

"Serendipity" and "mavericks" in entomology

We must admit that rationality in scientific research is not everything. We should make full use of the opportunities opened to us by random discoveries. This will increasingly become an attribute of entomologists in the twenty-first century.

Therefore we should always welcome creative unconventional thinkers, or "mavericks", who notice what others overlook, who perceive, absorb and wonder, who ask questions and reflect, who question the status quo, break with familiar habits and take a sceptical look at things, who venture, risk and act, who foresee, search and discover, and who have a feeling for "how everything works".

It will be our task to collect all information available, in the natural world, in the laboratory, in experiments and via the Internet. If we ultimately succeed in bringing about new qualities and future solutions, it will be thanks to our ability to regain information by reconstructions and model calculations, and by re-combining information. We must enter into a new symbiosis between modern technologies and nature.

We entomologists will need an optimistic holistic vision of what the future can be, and we must develop holistic sciences. We will continue to extend the boundaries of our knowledge at an ever-growing rate. Our motto should be: "Venture courageously to the uttermost limit of necessity". No better time to start than now, at the beginning of the new millennium. And finally, quite apart from the scientific challenges for entomology in the coming century, let us never lose our eye for the beauty of insects and of the world in which these creatures - and we ourselves - live. Now that this XXIst ICE here in Fos do Iguassu is about to close, let us take a look together at the picture "Niña del Campo" of the Spanish artist Guillermo Silva Santamaria. Its fascinating profusion of colour, its striking lightness and its youthful carefreeness are things well worth taking back home with us for the coming millennium.



LXXIV

ABSTRACT BOOK I - XXI-International Congress of Entomology, Brazil, August 20-26, 2000

[0001] PHYTOSEIIDS AS MANIPULATORS OF SEX: *WOLBACHIA*, PARAHAPLOIDY AND GENOMIC IMPRINTING

<u>M. A. Hoy</u>, Dept. of Entomology and Nemaiology, University of Florida, P.O. Box 110620, Gainesville, FL 32611-0620, USA

Populations of the predatory mite *Metaseiulus* (= *Typhlodromus* or *Galendromus*) occidentalis Nesbitt (Acari: Phytoseiidae) exhibit partial reproductive incompatibility. This has been confirmed to be due to the presence of *Wolbachia*, a microbial endosymbiont that is transmitted transovarially. *Wolbachia* has been proposed as a potential drive mechanism for inserting genes into populations because *Wolbachia*-infected females can produce progeny when mated with infected or unifected individuals. The incompatible crosses (unifected females mated with infected individuals. The incompatible crosses (unifected females) produce fewer eggs than normal, shriveled eggs, and a highly male-biased sex ratio. This phenotype is due to the unusual genetic system (parahaploidy, but sometimes called pseudoarthenotoky) of *M. occidentalis*. *M. occidentalis* females can produce progenent as diploids. Male embryos lose haif their chromosomes during embryonic development as are eliminated are paternal in origin. The loss of the paternal chromosome set must be due to some form of genomic imprinting, but the nature of this has not been resolved.

Index terms: Metascinlus occidentalis, Phytoselidae, Wolbachia, genomic imprinting

[0003] HOST IMMUNE RESPONSE TO SARCOPTES SCABLEL AND INDUCED IMMUNITY

L.G. Arlian & <u>M.S. Morgan</u>, Dept. of Biol. Sciences, Wright St. Univ., Dayton, OH, 45435 USA.

Sarcoptes scabiei mites burrow in the epidermis of mammalian hosts and induce both a humoral (1h2) and cell-mediated (1h1) immune response in the infested host. A previous infestation or immunization with extracts of house dust mites induces protective immunity in a majority of hosts. Hosts that exhibit protective immunity exhibit stronger Th1 and weaker Th2 responses than hosts that do not exhibit resistance. The dominant cells in the dermal infiltrate during a protective immune response are neutrophils and mononuclear cells which appear coincidentally with the appearance of many Langerhans cells (LCs) in the epidermis. Monoclonal antibody studies of canine scables skin biopsies show that the mononuclear cells contain a large representation of CD4+ cells. This population of CD4+ cells consisted of both T-helper cells and neutrophils and the large increase in their density during challenge infestations suggests they play a key role in the successful immune response that results in resistance to subsequent scables infestations. Neutrophils may function as antibodydependent cytotoxic cells to kill mites or disrupt their reproduction. The high prevalence of LCs in the epidermis suggests they play a key role in the initiation of the immune reaction and antigen presentation. Some naive T-cells (CD45RA+) and cytotoxic T-lymphocytes (CD8+) also infiltrate scabietic lesions but no B-lymphocytes (CD21+) were found in the dermal Keratinocytes may be a major source of IL-1 that stimulates the infiluates. immune/inflammatory reaction since we have found that keratinocytes up-regulate secretion of these cytokines in response to scables mites. Likewise, production of IL-6 and IL-8 by fibroblasts was up-regulated in response to products from scabies mites. These cytokines stimulate the release of IL-1 by keratinocytes co-stimulated by scabies mites Index terms: scables mites, resistance, humoral response, cell-mediated, cytokine studies

[0002] COLD RECEPTORS ON THE BODY SURFACE OF THE TROPICAL BONTTICK AMBLYOMMA VARIEGATUM

P. M. Guerin, A. Widmer, M. Vlimant & P.A. Dichl, Institute of Zoology, University of Neuchâtel, Rue Emile-Argand 11, 2007 Neuchâtel, Switzerland, E-mail patrick.guerin@zool.unine.ch.

Ticks make use of thermal cues in addition to other sensory modalities for survival. Amblyomma variegatum possesses warm and cold receptors in each of two long poreless sensilla at the tip of each of the foreleg tarsi. These appendages are employed by ticks while searching for a host. Now we have discovered cold recentors scattered over the body surface of A. variegatum. Ultrastructure investigations reveal that all of these sensilla have a terminal-pore structure and contain a tubular body in addition to five receptor cells. The cell we suspect to be the cold receptor is much bigger than the others and possesses two ciliary bodies giving rise to two outer dendritic segments. These dendritic segments are invaginated proximally and then branch extensively within two sets of sensilla. The first set is comprised of 20 sensilla that are 10µ long and concentrated bilaterally on a non-sclerotized section of cuticle on either side of the basis capitulum. The second set of 8-10 slightly longer sensilla occurs around each eye. The other 100-120 terminal-pore sensilla containing cold receptors are much longer than the others and are scattered over the rest of the body. The latter sensilla are characterised by the fact that the outer dendritic segments of the big receptor cell are neither invaginated nor branched. Electrophysiological responses from these cold receptors were recorded using an airflow switching device that delivered different T° shifts to the preparation. The responses of these receptors show the highest gain to small drops of temperature, still clearly responding to a ΔT° of 0.02°C. Evidence from behavioural tests will be provided to show how these receptors contribute to survival of A. variegatum.

Index terms: Amblyomma, thermoreception, cold receptor, behaviour, sensory physiology

[0004] ECDYSTEROID SYNTHESIS AND ACTION IN THE IXODID TICKS

L.H. Chen, L. O. Lumas, P. C. Turner & H. H. Rees, School of Biological Sciences, University of Liverpool, Life Sciences Building, Crown Street, Liverpool, L69 7ZB, UK

Ecdysteroids (moulting hormones) were initially characterised in insects and are involved in the regulation of moulting and metamorphosis as well as reproduction. Similarly, ecdysteroids in ticks have been suggested to function in the regulation of moulting, salivary gland degeneration, pheromone production, and aspects of reproduction. It has been demonstrated that epidermal tissue of the soft tick, Ornithodoros parkeri, was capable of synthesising ecdysteroids. We have identified that the integument of the adult ixodid tick, Amblyomma hebraeum was able to synthesise ecdystercids in vitro. The synthesis was stimulated by a neuropeptide hormone originated from synganglian tissue (central nervous system) with possible involvment of a cAMP second messenger system, analogous to the known prothoracicotropic hormone-prothoracic gland endocrine axis of insects. In insects, ecdysteroids act in target tissues by binding to their receptor (EcR), thereby forming a functional receptor complex. This complex is a heterodimer of two proteins, EcR and ultraspiracle (USP), which in turn, binds to the upstream regulatory elements of the early target genes and regulates their expression. The products of the early genes subsequently function as transcription factors that can activate many late genes, which are believed to relate to the regulation of many of the above mentioned physiological processes. EcR and USP are members of the nuclear hormone receptor superfamily. These proteins have common structural features and some domains, such as the DNA-binding domain and ligand-binding domain, are highly conserved. Using an RT-PCR method employing degenerate primers designed on the basis of these highly conserved domains, we have cloned cDNAs for EcR and USP from the female ixodid tick, Amblyomma hebraeum. With these cDNAs as probes, we analysed tissue distribution and developmental profiles of the receptors in relation to the changes in the ecdysteroid titres. This has opened up a way for us to characterise molecular mechanisms of ecdysteroid action in this species of tick.

Index terms: Ticks, Amblyomma hebracum, ecdysteroid, hormone, receptor

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[0005] A NOVEL ANTI-INFLAMMATORY FACTOR IN THE SALIVA OF THE LONE STAR TICK AMBLYOMMA AMERICANUM

A.S. Bowman¹, J.S. Tucker² & <u>I.R. Sauer</u>², ¹Dept of Zoology, Univ. of Aberdeen, Tillydrone Ave, Aberdeen AB24 3TZ, SCOTLAND, E-mail a.bowman@abdn.ac.uk; ²Dept of Entomology and Plant Pathology, Oklahoma State University, Stillwater, OK 74078, USA.

Ticks remain attached to naïve hosts for unusually long periods without eliciting a host immune or inflammatory response capable of rejection. Factors in tick saliva facilitate the tick's vectorial ability by dampening the host immune response, thus, allowing ticks to remain attached for extended periods and allowing pathogens to be introduced into an immunocompromised environment. We have identified an activity in tick saliva that inactivates the pro-inflammatory lipid mediator platelet-activating factor (PAF). In mammals, PAF is deactivated by the enzyme PAF-acetyl hydrolase (PAF-AH) that cleaves the acetyl group from the sn-2 position resulting in the biologically inactive lyso-PAF. An homolgous activity (tPAF-AH) was detected in the saliva of seven ixodid tick species from four genera. The specific activity in Amblyomma americanton saliva is ca. 2000x that detected in sheep plasma and is present throughout the feeding cycle. (PAF-AH is Ca2+, EDTA, dithiothreitol and 5'5'-dithbis(2-nitrobenzoic acid) insensitive, thus, more akin to secreted mammalian PAF-AH than the intracellular form. The tPAF-AH was inhibited by PMSF and pbromophenacylbromide indicating the involvement of a serine and histidine residue in the catalytic mechanism. The tPAF-AH is heat-stable up to 85°C and maintains 75% maximum activity over the pH range 4.5 - 11. Isolation of the tPAF-AH yielded an active fraction of 125kDa on both FPLC size exclusion column and native gels. The band dissociated upon boiling to form a band ca. 57kDa. Amongst the many actions of PAF is its ability to cause platelet and neutrophil aggregation and the recruitment and degranulation of monocytes, neutrophils, cosinophils and basophils. The tick's ability to deactivate locally formed PAF in the feeding lesion would appear vital to the successful completion of a bloodmeal and may also play a role in pathogen transmission.

Index terms: platelet-activating acetyl hydrolase, PAF, lipid mediator, Amblyomma americanum

[0006] PROSTAGLANDINS IN TICK SALIVARY GLAND PHYSIOLOGY

<u>LR. Sauer</u>¹ & A.S. Bowman², ¹Dept. of Entomology and Plant Pathology, Oklahoma Sta. University, Stillwater, OK, 74078, USA, E-mail jrs4864@okstate.edu; ²Dept. of Zoology, Univ. of Aberdeen, Aberdeen AB24 2TZ, Scotland, UK.

Tick salivary glands and saliva contain extremely high levels of prostaglandin E_2 (PGE₂) and PGF_{2a} which are likely important in tick feeding. Data also demonstrate that PGE₂ functions as a local hormone in ixodid tick salivary gland physiology. A PGE₂-specific receptor was identified in the salivary gland plasma membrane that exhibits a single, high affinity PGE₂ binding site, is saturable, reversible, specific for PGE₂ and is coupled to a cholera toxinsensitive guanine nucleotide regulatory protein. PGE₂ directly activates phospholipase C and stimulates inositol triphosphate (IP₃) formation in dispersed salivary gland acini and stimulates an efflux of Ca²⁺ from pre-labeled salivary glands. Functionally, PGE₂ stimulates release of salivary gland anticoagulant protein in preference to PGF_{2a} or the thromboxane nalog U-46619 in accordance with their respective binding affinities for the PGE₂ receptor. I'MB-8, an antagonist of intracellular IP₃ receptors inhibits PGE₂ stimulated secretion of salivary gland protein in a dose-dependent manner, suggesting that PKC is a regulator of Ca²⁺ dependent exocytosis. The results support the hypothesis that PGE₂ stimulates secretion of ick salivary gland protein via a phosphoinositide signaling pathway, mobilization of ntracellular Ca²⁺ and activation of PKC.

ndex terms: exocytosis, protein kinase C, calcium

[0007] GENETIC SIGNATURES OF DISPERSION

M. Navaias, Inst. Nat. Res. Agronomique, Centre de Biol. et Gestion des Populations, Lab. de Modélisation et Biol. Evol., 488, rue Croix de Lavit, 34090 Montpellier, France, E-mail navajas@ensam.inra.fr.

Dispersal is an important parameter that often escapes direct observation in natural populations. It is however of paramount importance to properly account for this parameter in order to understand species evolution and adaptation. Population genetics theory predicts that variations of neutral allele frequencies in space can provide a reliable indirect measure of the amount of genetic exchange, and thus of individual migration inside a species. Predictions of levels of dispersal can be made based on the biology of a species, that can then be tested in the field using these indirect methods. Based on examples from the literature, I review several features (residence status, natural vs. agricultural, host range, etc.) of phytophagous arthropods having an influence on population genetic structure. The different methods commonly used to quantify genetic variation and infer gene flow at different scales are presented. Taking as an example the cosmopolitan spider mite Tetrancyhus urticae I show how different genetic markers and sampling schemes can reveal the genetic structure and allow inference of individual dispersal at different geographic and temporal scales. Combined results on mitochondrial COI and nuclear ITS ribosomal DNA sequences of a worldwide sample of T. urticae show a great homogeneity of the species, associated with relatively recent range expansion events. However, on a fine geographic scale and using nuclear gene allele frequency variations, a strong pattern of isolation by distance over relatively short distances is obvious. These results are not contradictory, but rather concern different temporal scales in the evolution of the species.

index terms: gene flow, genetic markers, genetic structure, tetrancyhus urticae

[0008] DISPERSAL AND SPREAD OF EXOTIC PHYTOSEHDS IN AFRICA

J. S. Yaninek¹ & R. Hanna², ¹USDA Coop. State Res. Ed. Ext. Service, 1400 Independence Ave., Washington D.C. 20250-2220, USA E-mail syaninek@reeusda.gov; ²Intern. Inst. Trop. Agr., PHMD, IITA Benin Station, 08 B.P 0932, Cotonou, Benin, E-mail rhanna@cgiar.org.

The establishment of three exotic phytoseiid predators of the cassava green mite, Mononychellus tanajoa (Acari: Tetranychidae), in Africa provided a unique opportunity to evaluate the dispersal and spread of deliberately released natural enemies. *Neoseiulus idueus* was released in 1989. established in one site each in Benin and Kenya, never spread beyond a 50 m radius from the release fields. Typhlodromalus manihoti, also released in 1989, has been recovered in 145 field sites in Benin, Burundi, Ghana, and Nigeria. T. manihoti dispersed at a rate of 3.3 km per year covering an area estimated at 4,300 km2 after 7 years in West Africa. Typhlodromalus aripo was first released in October 1993 in Benin, West Africa and subsequently recovered from more than 1000 field sites in 19 countries through 1998. It spread at a rate of 12.5 km in the first season, and up to 200 km per season thereafter to cover an estimated 900,000 km2 in 4 years. All three species use herbivore-induced infochemicals to locate prey patches and persist as long as sufficient prey are available. However, N. idaeus require prey for both development and reproduction, and disperses away from cassava in search of new prey patches as M. tanajoa densities decline. Both Typhlodromalus predators are capable of exploiting a range of prey and non-prey diets including plant-provided exudates for juvenile development and increased longevity during periods of prey scarcity, but eventually require prey for optimum reproduction. This increased predator persistence helps suppress colonizing and incipient pest populations, yet maintain a "stream" of dispersers in search of M. tanajoa prey for oviposition. These results revealed a relationship between prey exploitation strategy, ability to use indirect host plant defenses, propensity to disperse, and the rate of spread that should warrant additional attention by the biological control community.

Index terms: Mononychellus tanajoa, exotic phytoseiids, dispersal, spread.

[0009] PREDATOR DISPERSAL AND PREY-EXPLOITATION STRATEGIES

B. Pels & M. W. Sabelis, Inst. for Biodiversity and Ecosystem Dynamics, Univ. of Amsterdam, Kruislaan 320, P.O. Box 94084, 1090 GB Amsterdam, The Netherlands, Email pels@bio.uva.nl.

We studied the impact of dispersal of predators on local predator-prey dynamics in systems that are characterised by overexploitation of prey. Based on a caricature, two types of dispersal strategies can be distinguished: the Killer-strategy in which predators do not disperse from patches with prey, and the Milker-strategy in which continuously part of the predators leave, even when the patch still contains many prey. Once all prey have been eliminated, both Milkers and Killers are expected to disperse instantaneously. Theory predicts that Killers are selected for, when local predator populations are started by multiple founders, whereas Milkers are selected for when the number of founders is sufficiently low. To test which of these dispersal strategies occur in wild populations of predatory arthropods, we carried out replicated experiments on local dynamics and dispersal in a system consisting of bean leaves, herbivorous mites (Tetranychus urticae) and various field-collected strains of predatory nuites (Phytoseiulus persimilis). We found that the predatory mites indeed tend to drive local prey populations to extinction. We also observed consistent differences in dispersal behaviour of two predator strains that were measured in detail. In one strain predators did not disperse until after extermination of the local prey population, but in the other the adult females started to disperse earlier, *i.e.* when there were still prev available. In agreement with theory, the earlier predator dispersal was associated with a longer interaction period, a larger prey population and a larger production of dispersing, adult female predators. Finally, it was observed that not all predatory mites leave instantaneously once prey have been eliminated. Dispersal occurred over a period of 10 days since all prey were eliminated (Pels and Sabelis 1999). Follow-up experiments showed that, in absence of prey, a part of the juvenile predators turn to cannibalism whereas other juveniles disperse. The dispersers probably avoid being eaten by larger conspecifics, whereas the cannibals continue to feed and may mature and mate before they leave the arena. Since P. persimilis reproduces by pseudo-arthenotoky (i.e., males and females develop from fertilised eggs), dispersing juvenile females first have to find a mate before they can start laying eggs. We hypothesise that dispersal after prey elimination is part of a size-dependent cannibalism and mate-finding game.

Index terms: Phytoseiulus persimilis, predator-prey interaction, cannibalism.

[0010] DISPERSAL OF AN EMERGING INFECTIOUS AGENT: POTENTIAL ROLE OF MITES

M. A. Houck, Dept. Biol. Sci., Texas Tech University, Lubbock, TX 97409-3131, USA, Email MAHOUCK@ttu.edu.

Hantavirus pulmonary syndrome is an often-fatal disease, thought to be transmitted exclusively by rodents. Previously, no arthropod vector had been implicated. We report the first evidence of Bayou hantavirus-specific RNA from chiggers and a tick collected from wild-caught rodents and from a free-living predatory stage in the chigger life cycle. While the tick host was hantavirus-positive, the chigger hosts were hantavirus-negative, suggesting that chigger infection was trans-stadially transmitted. The recovery of hantavirus-specific RNA from a free-living stage in the chigger life cycle indicates that mites may contribute to the long-term ecological persistence of the virus. I hypothesis that rodent-todent transmission is through aerosol routes while rodent-human cycling occurs through the agent of arthropod vectoring. Index terms: hantavirus, coevolution

[0011] THE ROLE OF HERBIVORE-INDUCED PLANT VOLATILES IN DISPERSAL AND FORAGING OF PHYTOSEIID PREDATORY MITES

M. W. Sabelis, Sect. Pop Biol., Univ. of Amsterdam, Kruislaan 320, 1098 SM Amsterdam, The Netherlands, E-mail sabelis@bio.uva.nl.

Herbivory is known to induce the production of volatiles in the plant. These signals are thought to betray herbivores to their predators, which are then attracted or arrested near the plant under attack. Evidence for involvement of herbivore-induced plant volatiles in predator recruitment is largely based on experiments with olfactometers designed to demonstrate a response to odors, not to elucidate the behavioral mechanisms used to locate the source. Since the mechanisms underlying orientation may well operate at a spatial scale beyond that considered in the lab, experiments are required to unravel the tactic and kinetic responses in carefully designed laboratory experiments at a larger scale and to assess the responses under more realistic (greenhouse, field) conditions. We discuss experiments showing the role of odor-conditioned anemotaxis, tactic/kinetic responses to odor gradients, odor-conditioned landing and take-off responses, as well as the role of hunger, associative learning and innate responses in predatory mites.

Index terms: behaviour, foraging, infochemicals, phytoseiid mites, predators, tritrophic interactions

[0012] EVOLUTION OF PARASITISM IN THE ASTIGMATA: THE ROLE OF PHORESY

M. A. Houck, Dept. Biol. Sci., Texas Tech University, Lubbock, TX 97409-3131, USA, Email MAHOUCK@ttu.edu.

Astigmatid mites specialize in the ecological exploitation of ephemeral habitats. Successful navigation among these temporary habitats is through cultivation of associations with other organisms (=phoresy). Phoresy plays a proximate ecological role in the dispersal of astigmatid mites among habitats that are temporally and spacially limited. Not all life stages in the astigmatid life cycle are capable of phoresy however. A heteromorphic deutonymph (=hypopus) arose early in the evolution of the Astigmata (plesiomorphic) and radiated among astigmatid lineages. Only the astigmatid deutonymph is morphologically equipped for phoretic dispersal. Since successful dispersal, during times of ecological stress, depends on the navigational success of the deutonymphal stage alone, this imposes key selective forces on the deutonymph to coevolve with specific phoretic hosts having shared ecological requirements. As will be developed, phoresy has the ultimate potential of providing a transitional mechanism for providing a free-living ancestral disperser a means to assume a parasitic (or mutualistic) role, within an evolutionary time scale. Parasitic (or mutualistic) interactions mitigate the historical pressures to disperse among temporary habitats and provide a more integrated and stable alternative for persistence within an ecological and evolutionary community. This presentation summarizes eighteen years of research on the exploration of a biological model organism (Hemisarcontes corremani) to illuminate the required steps of transition from an independent life-style to a parasitic life style in the Astigmata, through the application of a phoretic intermediate. Data and inference from several sources will be integrated to argue this point: biochemical, behavioral, and morphological.

Index terms: Astigmata, coevolution, Hemisarcoptes

[0013] PHYLOGEOGRAPHY OF RHOMBOGNATHINE MITES

H. Abé, College of Bioresource Sciences, Nihon Univ., 1866 Kameino, Fujisawa, Kanagawa, 252-8510 Japan, E-mail: acari@brs.nihon-u.ac.jp.

The Rhombognathinae, a subfamily of marine mite family Halacaridae, consists of four genera: Isobactrus, Rhombognathus, Rhombognathides, and Metarhomoo-gnathus. A morphology-based phylogenetic analysis implied that Rhombognathus was the earliest derived genus, and thereafter Isobactrus, Rhombognathides, and Metarhombognathus were derived successively. Rhombognathus and Isobactrus have cosmopolitan distribution, whereas Rhombognathides and Metarhombognathus have limited trans-Atlantic distribution In these mites, long distance dispersion across the deep oceans is hardly probable, because they are benthic animals inhabiting the coastal area in the oceans and do not have the floating stage in the ontogenetic development. Therefore, it is expected to explain their worldwide distributional patterns with reference to the continental drift. Each rhombognathine lineage was assigned on an area cladogram of the six major continents by the Drooks parsimony method. In the reconstructed area cladogram, the continents of Eurasia and North America constituted a sister-group and the common stem that indicates Laurasia bore the lineages of Rhombognathides, Metarhombognathus and the most recent common ancestor of both genera. The basal stem of the area cladogram, which represents the super-continent Pangaea, held the lineages of Rhombognathus, Isobactrus, the most recent common ancestor of both genera, and the common ancestor of the subfamily. This geological event can be traced to the late Palaeozoic Era of about 220 to 280 myr ago. Taking a branching process of a lineage into consideration, several evolutionary scenarios underlying the phylogeny and geographical distribution of rhombognathine mites will be outlined on the basis of the historical legacy of interactions among their ancestors and habitation.

Index terms: Acari, evolution, Halacaridae, continental drift, vicariance.

[0015] DAMAGE CHARACTERIZATION OF *OLIGONYCHUS YOTHERSI* (ACARI: TETRANICHIDAE) TO ERVA-MATE (*ILEX PARAGUARIENSIS*) (AQUIFOLIACEAE)

L.F.A. Alves,¹ R.C. Oliveira², D.L.Q. Santana³ & C.J. Moraes⁴, ¹UNIOESTE/CCBS, R. Universitária, 2069, Cascavel/PR, Brazil, CEP: 85814-116, E-mail: hag@unimidia.com.br; ²UEL, Dept. de Agronomia, C.P. 6001, 86051-970, Londrina, PR, Brazil; ³Embrapa/CNPF, Colombo, PR, Brazil; ⁴ESALQ/Univ. de São Paulo, Dept. Entomologia, Fitopatologia e Zoologia Agrícola.

The mites are very important pests in many culture. In the last years these arthropods have been frequently observed in Brazil and Argentine associated to reduction on the production of leaves of the erva mate. However, there are few studies about these pests. This observation were carried out in a erva mate commercial plantation, near to the Campus of Unioeste at Cascavel, State of Paraná, Brazil. The observation began at September of 1999, after the budding. It was observed that the mite distribution was heterogeneous on the area. The damaged plants showed new leaves with small purple punctuation on the dorsal face that were concentrated on the central nervure and mainly near by the basal region of the leaves. The punctuation growing larger forming necrotic areas. After some days the damage leaves became wrinkled with the border turning down. It was observed some depression on surface of leaves with a grate number of the mites in all life stages, besides exuviae and most webs. The mites affected the leaves development and the most infested ones (15 to 20 mites/leave) were smaller than non infested or less infested leaves which at the time drops off. There were a direct relation to the damage and the production because in the most infested and damage plants were 90 to 100% of premature defoliation with reduction of weigh of biomass.

[0014] BASES FOR AN ACARICIDE RESISTANCE MANAGEMENT PROGRAM OF *BREVIPALPUS PHOENICIS* (ACARI: TENUIPALPIDAE) TO THE ACARICIDE DICOFOL IN BRAZILIAN CITRUS

E. B. Alves, C. Omoto & C. R. Franco, Depto. de Entomologia, Fitopatologia e Zoologia Agrícola. Escola Superior de Agricultura "Luiz de Queiroz", Univ. de São Paulo, Av Pádua Dias 11, 13418-900, Piracicaba, SP, Brasil, E-mail ebalves@carpa.ciagri.usp.br.

The phytophagous mite Brevipalpus phoenicis is one of the most serious citrus pest in Brazil, because it transmits citrus leprosis virus. Failures to control this mite, especially with the acaricide dicofol have been reported. Because of constant selection pressure with acaricides, the evolution of resistance in B. phoenicis could be one of the major factors affecting the efficacy of this product. Basic information for the implementation of a resistance management program of *B. phoenicis* to the dicofol was collected in this study. A residual bioassay technique was used to characterize the responses of susceptible (S) and resistant (R) strains of B. phoenicis to dicofol. The estimated LC50s for the S and R strains were 7.44 µg of dicofol / mL of distilled water [ppm (A.I.)] (95% CI 6.74 - 8.23) and 422.45 ppm (A.I.) (95% CI 369.41 - 482.80), respectively. The resistance ratio derived from LC₅₀₅ was about 57-fold. Based on this difference, discriminating concentrations between 32 and 100 ppm (A.I.) were defined for monitoring dicofol-resistant mites. Then, fitness cost associated with dicofol resistance in B. phoenicis was evaluated under laboratory conditions. Initially, we conducted cage studies to evaluate the dynamics of resistance in populations of B. phoenicis with 20, 50 and 80% of dicofol-resistant mites. The frequencies of resistance were estimated monthly in a 6-month period with a discriminating concentration residual bioassay of 32 ppm (A.I.). The resistance revealed to be unstable; that is, the frequency of dicofol-resistant mites declines significantly in the absence of selection pressure. Life-history studies of S and R strains were evaluated. No difference in the egg-adult developmental time was detected between strains. However, significant differences were found in the longevity and fecundity of mites. The mean longevity of S and R strains were 31.4 and 21.7 days, respectively. The fecundity of R strains was about 51.5% of the S strain. And lastly, studies of cross-resistance relationships between dicofol and other acaricides recommended in citrus were evaluated in B. phoenicis to find alternative products for managing dicofol-resistant mites. S and R strains were tested against fenbutatin oxide, propargite, fenpyroximate and bromopropilate. Dicofol-resistant B. phoenicis showed positive cross-resistance to bromopropilate and negative cross-resistance to fenpyroximate. No cross-resistance was detected between dicofol and the acaricides fenbutatin oxide and propargite.

Index terms: fitness cost, cross-resistance, chemical control

[0016] EFFECT OF NUTRIENTS ON THE FLAT MITE, *BREVIPALPUS PHOENICIS* (ACARI:TENUIPALPIDAE) AND ON COFFEE RING SPOT VIRUS TRANSMISSION IN THE COFFEE (*COFFEA ARABICA*) CULTURE

R.C. de Andrade & O. Nakano, Escola Superior de Agricultura "Luiz de Queiroz" ESALQ - USP - Piracicaba - SP - Brazil, Postal Box 09. Zip code 13418-900 e-mail reandrad@carpa.ciagri.usp.br

The flat mite has caused damages in coffee plant because it transmits a virus that causes leaf and fruit falls. A trial was carried out with the variety Red Catuai to check the influence of coffee plant nutrients on spider mite and, consequently on the disease, in July, 1999. The experimental design was completely randomized block, with 5 replications. The treatments were: 1- control; 2- Boron (Boric Acid); 3- Sulphur (Kumulus-S); 4- Zinc (Zinc Chloride); 5-Boron plus Sulphur; 6- Boron plus Zinc; 7- Sulphur plus Zinc; 8- Boron plus Sulphur plus Zinc; 9- Liming. The plots were shaped by 7 plants being used the 3 central plants for evaluation and they were spaced 0,80 m and the rows were spaced 4 m apart. The fertilization was based on soil analysis. The evaluations were realized on 10 leaves/plant and the number of leaves with injured , injuries per leaf and flat mite vere counted. The results allowed to conclude: a) there were fewer occurrence of the symtoms at the treated with Sulphur plus Zinc and with only Zinc; b) the smallest spider mite number happened in the treatments with Sulphur.

Index terms: virouse, boron, zinc, sulphur,

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[0017] HOUSE DUST MITE (DERMATOPHAGOIDES PTERONYSSINUS) MORTALITY IN OCCUPIED BEDS AND HEATED AND UNHEATED CARPET

<u>J.R.H. Andrews</u>¹, M. Cunningham², A. Pike¹, S. Wood¹ & M. Hearfield², ¹ School of Biological Sciences, Victoria University of Wellington, PO Box 600, Wellington New Zcaland, E-mail john.andrews@vuw.ac.nz; ² Building Research Association of New Zcaland, Private Bag 50908, Porirua, New Zealand.

Psychrometric measurements from occupied beds suggested that unfavourable temperature and humidity conditions for mites may occur in some parts of the bed, leading to some mortality or a stimulus to escape to more favourable areas. Temperature and humidity conditions recorded from the bed were simulated in a programmable incubator and the effects on mite mortality noted. Although the temperature and humidity in the upper layers of the bed appeared unfavourable, according to steady state literature data, experimental simulations conducted over 72 -hour and 7 day periods showed little or significant decline in mite numbers, compared with controls. This suggests that mites can survive unfavourable cyclic periods, although variable conditions elsewhere in the bed would offer a more amendable haven if required. Psychrometric measurements taken from another significant dust mite habitat, curpet, showed that mottality under normal conditions was not significantly different from ideal steady state controls, but carpet beated to 50°C for one hour and two hour periods showed significant reductions in mite numbers. The implications for control are discussed. Index terms: *Dermatophagoides pteronyssinus*, beds, cappets, mortality

[0018] LIFE HISTORY PARAMETERS AND FUNCTIONAL RESPONSE PHYTOSEIULUS PERSIMILIS ON TETRANYCHUS URTICAE

¹<u>M. H. Radii</u>, ²J. Landeros & ¹A. E. Flores, ¹Autonomus University of Nuevo Leon, AP. 391. San Nicolas, Nuevo Leon, 66450, México, E mail mbadii@ccr.dsi.uanl.mx; ² Autonomus Agricultural University of Narro, Saltillo, Coahuila, México.

Life history of and life table parameters for Phytoseiulus persimils Athias-Henriot (Phytoseiidae) on different stages of the two-spotted spider mite, Tetranychus urticar on excised pieces of bean leaves located on circular acrylic discs (3 cm diameter) were studied under laboratory conditions of 28 \pm 2° C, 60 \pm 8% RH and 12:12 L:D Photoperiod. Data for life history and life table analyses were generated on the basis of a cohort of 37 females resulting from 100 eggs placed individually on study arenas. The methodoloy of Birch was used to generate the growth and longevity parameters. The following parameters were obtained in this study. The raw reproductive rate (RRR) of 42.59 dauthers per female per generation in the absence of any mortality, the net reproductive rate (Ro) of 41.12 dauthers per female per generation, the finite rate of increase (I) of 1.51 dauthers per female per day, an aproximate rate of increase (re) of 0.44 dauthers per female instantly and an intrinsic rate of natural increase (rm) of 0.41. Some longevity parameters were also produced as follows: a duration of cohort (T_c) of 8.41 days, a generatin time (T_g) of 9.10 days and a doubling time (T2) of 1.70 days. The functional response of the the gravid female predator on increasing densities of different stages of its prey was anlyzed under similar conditions of life history test based on Holling's disk equation. Different densities of 1, 2, 4, 8, 16, 32, 64 and 100 eggs and larval stages were used individually as pery items, in the case of proto and deutonyphs, densities of 1, 2, 4, 8, 16, 32 and 64 and for prey females densities of 1, 2, 4 and 8 individuals per arena were utilized for this study. Each density was repeated 15 times. The instantaneous rate of discovery (a) and handling time (Th) of this predator on different life stage of the prey were estimated using the model of Woolf Transformation, at the end of 2, 4, 6, 8, 10, 12 and 24 hours. The functional response of P. persimilis on immature stages of T. urticae was of type II, while in the case of the femle prey a linear line was obtained. There was no significant difference between the observed and expected functional response on any and all stages of the prey. The prey stages most severely attacked by the female predator were egg with a mean of 52.37, larva with an average of 63.07 (the highest) followed by the nymphal stages with a mean of 32-7 and finally the stage least attacked by the predator was the prey female with an average of 6.93 individuals per day.

[0019] FUNCTIONAL RESPONSE OF *PHYTOSEIULUS PERSIMILIS* ON *TETRANYCHUS URTICAE* ON THREE DIFFERENT ROSE VARIETIES

¹<u>M. H. Badii</u>, ²J. Lauderos & ¹A. E. Flores, ¹Autonomus University of Nuevo Leon, AP, 391. San Nicolas, Nuevo Leon, 66450, México, E mail mbadii@ccr.dsi.uanl.mx; ² Autonomus Agricultural University of Narro, Saltillo, Coahuila, México.

The two-spotted spider mite, Tetranychus urticae Koch (Tetranychidae) is the principal pest of the agricultural crops in the glasshouse. Mexico is the second major exporting country of roses in Latin America. The control of the two-spotted spider mite in the glasshouse has become quite difficult due to the development of resistance of this mite pest to the chemical pesticides, the destruction of natural enemies and the phytotoxicity caused by some of these synthetic compounds. A valid alternative to the unintelligent and unilateral use of miticides for the control of the two-spotted spider mite is the employment and sound utilization of biological control agentes. Phytoseiulus persimilis Athias-henriot (Phytoseiidae) has been tried with excellent results as the regulating agent against the population of this mite pests. Therefore, a study was designed to test the functional response capability of this predaceous nuite species on increasing densities of its prey, the two-spotted spider nuite. In the northeastern region of Mexico, there are basically three varities of the rose, namely, Royalty, Starlite and Parco which are exported to the foreign countries. In experiments under laboratory conditions i.e., 28 ± 2°C, 60 ± 10 % RH and a 24 hr. L period regim, The functional responses of the gravid femañes of P. persimilis were investigated. Only egg stages of T, urticae were used as previtem. To test the functional response, the egg stage of the prev were placed on the exsciezed pieces of different varieties of rose at increasing densities of 1. 2, 4, 8, 16, 32, 64 and 100. Each density was replicated 15 times. The number of the eggs attacked by the predator were counted at the end of 2, 4, 6, 8, 10, 12 and 24 hours. The Woolf transformation model was used to generate the functional response parameters, i.e., the instataneous rate of discovery or attack coefficient ('a), and handling time (Th) for each of six exposure periods. The parameters, then were used in the model of Holling in order to generate the expected number of prey items attacked by the predaceous mite species. The functional response curve was of type II, according to holling, for all cases. The highest values of the attack coefficient were obtained for the predator at the end of 4 hr expousre time for all three rose varities. In the case of handling time, the highest values were also obtained at the end of 4 hr time period for the two varieties of Royalty and Starlite, however, for the Pareo variety the maximum value was generated at the end of 6 hr epocure period. Comparing all around functional responses, there were no difference between the expected and observed functional response curves, furtheremore, the values of the attack coefficient as well as handling time were basically the same for all three rose varities.

[0020] FUNCTIONAL RESPONSE OF THE PREDACEOUS, *EUSEIUS IIIBISCI* ON IMMATURE STAGES OF TWO-SPOTTED SPIDER MITE, *TETRANYCHUS URTICA*E

M. H. Badii¹, E. Hcrnández² & A. E. Flores¹, ¹Autonomous University of Nuevo Leon, AP. 391, San Nicolas, Nuevo Leon, 66450, Mexico, E-mail mbadii@ccr.dsi.uanl.mx; ²Programa Moscamed, SAGAR-CONASAG. AP. 368, Tapachula, Chiapas, 30700, Mexico.

Strawberry is the most important cash crop in the central region of Mexico. The two-spotted spidet mite, *Tetranychus articae* Koch is the most relevant economic pest and in fact the key pest of starwberry in the "Bajia Region", central valley of Mexico. Strawberry farmets have relied mainly on synthetic organic miticides to control this mite pest species, and this pactice has significantly increased the cost of the production of this crop in Mexico. Since strawberry is basically cultivated for exportation and due to the strict standards of pesticides residue guidelines set by the the importing countries, there is an urgent need to mange this nuite pest by alternative methods such as biological control. Eusius hibisci (Chant) is the most common predaceous mite species associated with the tow-spotted spider mite, on strawberry in the central region of Mexico. Although the species belonging to the genus of Euseius basically posess type III life history style, i.e., general pollen feeders, some studies have suggested their important role in the biological control of the spider mites. Therefore, the objective of this research was to determine the predaceous capacity of this predator on the prey species by means of the functional response, to the varying densities of eggs, larvae and protonymphs of the two-spotted spider mite as well as the combination of the larval stage of this prey and the pollen of Ligustrum ovalifolium Hassk. In order to verify the consistency of the results and for omparative puposes, several functional response models were used. The functional response on all stages tested was type II. The functional response parameters , i.e., The instantaneous rate of disacovery or attack coefficient ('a) and handling time (Th) for this predator species attacking different immature stages of the two-spotted spider mite were estimated by means of Holling's disk model, Rogers' equation, Livdahl and Stiven's model and non-linear regression cueve. The highest value of 'a and the lowest value of Th were obtained for the predator feeding on egg stage, while the contrery results were obtained when protonymphs were offered as food. Using the Jack-Knife method, the mean values for the papameters of functional response were generated and compared among all the functional response models. There were no significant differences among the mean values for each paramteres among four models, However, there was a marked tendency to overestimate the parameters with Rogers' model. The results indicated a relative tendency to consume higher number of prey egg stage followed by the laraval and finally the nymphal stage. Using pollen simultaneously with prey laraval stage as food, decreased the consumption of the latter stage by as much as 20%.

[0021] ASSESSMENT OF PUBLIC HYGIENE INSECTOACARICIDES IN RUSSIA

E.I. Bakanova, S.A. Roslavtseva & N.Yu. Bakanova, Research Institute of Desinfectology, 117246, Nauchny proezd, 18 Moscow, Russian Federation, *Moscow State Lomonosov University, faculty of Economics, Moscow, Russian Federation, e-mail: elena_bakanova@mail.ru.

Synanthropic crawling and flying insects, mites and ticks represent one of most important problems, since they can contaminate food with bacteria, transmit diseases and cause human allergies. During the past eight years there was an increase in applying of different insectoacaricides to control synanthropic pest species in Russia. All the means were analysed by three criterias: formulations, methods of applications and target organisms. The major formulations are containerized aerosols, water based ready-to-use insecticides, wettable powder, soluble powder, tablets and granules, emulsion, micro-, suspoemulsion concentrates, flow formulations, microcapsulated formulations, chalks, gels, bait stations, sticky traps, vaporizer mosquito liquid, electric heaters with mates, creams, lotions, shampoos etc. The largest market shares belongs to the following formulations - containerized aerosols (22,5 %), powders (9,1 %), bait stations (6,6%), emulsion concentrates (5,6%), electric heaters with mates (5,1%), chalks (4,9%). Leading methods of application are liquid sprays. For the last two years an interest to microcapsulated formulations raised. There are trends to the growth of low helth and environmental risk assessment means to pest control. It's different kinds of baits and sticky traps. Most the producing means controlled the following important pests of public hygiene: common houseflies, german and oriental cockroaches, ants, mosquitoes, bedbugs, fleas, head- and bodylice, mites and ticks. During the same two years there was decreasing of the amount of pediculicides but repellents and acaricides were increasing. Ticks Ixodes persulcatus is the main vector of two important tick-borne diseases: tick-borne encephalitis and Lyme borreliosis. It is recommended on the high epidemiological risk recreational areas to make the treatments with "Baytex 40% w.p." (1 kg/ha).

[0023] PLAN OF SAMPLING OF *DICHOPELMUS NOTUS* (ACARI, ERIOPHYIDAE) IN PARAGUAY-TEA ORCHARDS

L. A. Chiaradia^U & J. V. Neto², ^UCPPP/Epagri, Box 791, CEP 89801-970, Chapecó, SC, BR, E-mail: chiaradi@epagri.rct-sc.br; ^UUNOESC, Box 747, CEP 89800-000, Chapecó, SC, BR, E-mail: jvn@unoesc.rct-sc.br

This research had the objective of proposing a sampling plan for the mite Dichopelmus notus (Acari, Eriophyidae) in paraguay-tea (Ilex paraguariensis) orchards, a plant used to industrialize tea and other drinks. This pest causes shoot death and tan leaves with posterior fall. The following factors of the behavior of the mite in the orchards were considered: three tree heigth (upper, medium and lower) and two canopy depth (internal and external). These factors were analyzed through the model of blocks in factorial structure. The samples were taken biweekly from February to May of 1999 in orchards with eight years old conducted in an arrangement of 2,5 x 4,0 m between the trees. The orchard was located in Chapecó West of Santa Catarina, Brazil. The experimental unit was constituted by one tree. Each date 18 leaves were collected from ten trees, being six leaves per height and three per depth. The mites counting were carried out in the Laboratory of CPPP/Epagri with esterioscopic microscopic with fourty magnificence. The effects of heigh and depth were considered fixed, while blocks (trees) and leaves were taken as aleatory to obtain the mathematical hopes of the medium squares. Starting from the experimental model was obtained the stimactor of the variance of the general mean and of the components of the variances associated with aleatory effects. Determination of the number of trees (k) and the number of leaves (l) recommended for sampling was observed by the combination among k and l that turned minimum the variance of the mean. Results suggest that for rational estimation of the number of mites in paraguaytea orchard with a standard error until 10%, it is necessary to sample three leaves from 110 trees, from lower and medium parts of the trees. Idex terms: paraguay-tea, tan mite, sampling.

[0022] BIOLOGY OF *TETRANYCHUS DESERTORUM* (ACARI: TETRANYCHIDAE) ON PAPAYA TREE AND ITS OCCURRENCE IN PROTECTED ENVIRONMENT

T. M. M. G. Castro^t & M. R. Vieira¹, ¹Dept. Of Biology, Unesp. P. O. Box 31, 15385-000, Ilha Solteira, Sp, Brazil, e-mail marineid@bio.feis.unesp.br.

The occurrence of Tetranychus desertorum in papaya tree was researched on Improved Sunrise Solo Line 72/12 and Baixinho de Santa Amália varieties, in three situations: natural environment and two screened with mesh of 2 x 2 mm and 2 x 1 mm, providing a incidence of solar radiation reduction of 30% and 40% respectively. In this assay, the species only occurred in screened, with upper populations that mesh 2 x 2 mm on Improved Sunrise Solo variety. The biology of this tetranychid on the two varieties, was carried out in Petri plates using leaves discs with 2,5 cm diameter, on a moisten cotton layer with destilated water. The plates were kept to 25.4 ± 0.32 °C, relative humidity of $70.8 \pm 0.84\%$ and 10 hours photophase. In this condition, the duration of the period from egg to adults for female was 8.2 ± 0.27 days on Improved Sunrise Solo and $8,0 \pm 0,05$ days on Baixinho de Santa Amália, which the female depositing 55,0 \pm 6,54 eggs in 14,25 days (4,1 \pm 0,45 eggs/day) and 54,7 \pm 4,12 eggs in 17,0 \pm 1,51 days $(3,6 \pm 0,34 \text{ eggs/day})$, respectively. On Improved Sunrise Solo variety, the life table of fertility's parameters were: intrinsic rate of increase (rm) of 0.23, finite rate of increase of 1,26 individual per female per day, mean generation time (T) of 16,37 days and net reproductive rate (Ro) of 43,39, while on Baixinho de Santa Amália the values were 0,21, 1,23 individual per female per day, 16,88 days and 37,55, respectively. Index terms: screened, varieties, life table of fertility, net reproductive rate.

[0024] FLUCTUATION OF *BREVIPALPUS PHOENICIS* (ACARI, TENUIPALPIDAE) IN CITRIC ORCHARD IN CHAPECÓ, SC

L. A. Chiaradia ^u, L. C. de Souza^v & José Maria Milanez^u, ^uCPPP/Epagri, Box 791, CEP 89801-970, Chapecó, SC, BR, E-mails: chiaradi@epagri.ret-sc.br and milanez@epagri.rct-sc.br; ^uStudent of Agronomy Course, UNOESC, Chapecó, SC, BR.

Brazil is the biggest Citrus productor in the world with annual production around 20,000,000 ton. The mite Brevipalpus phoenicis transmit the leprosys citrus disease, a virous that causes damage in the sugar oranges trees, and requires permanent pest control that increase the production cost and environmental problems. To study the fluctuation of this pest and its interference with environmental factors one experiment was conducted in an orchard located in Chapecó, West of Santa Catarina, Brazil. This study started in August 1997 and his datas is until July 1998 (however this research will continue for more two years). With six years old trees variety 'Valence' on Poncirus trifoliata conducted with 4.0 x 6.0 m between trees, had 2,5 m heigth. The samples were taken biweekly with "sweeping" method that consisted of the all fruit bark observation, mainly fruits with "scab" disease, remainder fruits and early fruit, looking three fruits from twenty trees. When with no fruits, shoots and leaves with insertion at terminal portion by sixty branches of canopy internal were sampled. The samples were made in the orchard using lens with ten magnificence and one squar centimeter by fixed camp. The preliminary results showed that B. phoenicis ocurred during all period with large infestation from September to December. The monthly rain total and air humidity had few interference on the mite fluctuation. The total monthly maximum temperature mean (U3) was the factor with more interference on the pest infestation and the analysis correlation accused value of 0,72, with 0,007 significance level and resulted in the equation $\hat{U} = -42,28 + 3,73 U_3$ with linear regression analysis.

Index terms: Citrus, leprosys mite, fluctuation, environmental interference

[0025] IGG BINDING SITES IN THE SALIVARY GLANDS AND CEMENT CONE OF AN IXODID TICK

L. B. Coons & M. Rothschild, Dept. of Microbiology & Molecular Cell Sciences, Life Science Bldg. Univ. of Memphis, Memphis TN 38152 USA.

IgG binds to the secretory granules of a, d, e and g type cells in *Dermacentor variabilis* salivary glands. The a, d, and e type secretory granules occur in fed and unfed ticks of both sexes; but g type secretory granules occur only in fed males. Previous studies have shown that e type granules are shed into basolateral spaces that are contiguous with the hemocoel. The contents of these granules may be involved in binding host IgG in the hemocoel. IgG also binds to the cement cone that surrounds the tick's mouthparts during feeding. Previous studies have shown that the cement cone and both d and e type secretory granules have similar immunoreactive polypeptides, indicating that these granules may contribute a component of the cement cone. In f cells, host IgG undergoes transcytosis into the saliva . We suggest that this IgG binds to sites in the cement cone where it acts to shield the parasite from the host's immune system during feeding.

Index terms: Dermacentor variabilis, Ixodidae, Host IgG

[0027] EAR MITES OF GOATS IN BRAZIL

J. L. H. Faccini, Depto. Parasitologia Animal, Univ. Federal Rural do Rio de Janeiro. Seropédica, RJ, 23890-000, Brasil, E-mail faccini@ufrrj.br.

An overview of the relationship between ear mites and goats in Brazil is presented. Two species have been diagnosed: Psoroptes cuniculi and Raillietia caprae. Both are cosmopolitan but data gathered in Brazil and elsewhere suggest that the first species is much more common than the second. Diagnosis of mite infestation has been carried out either by swabbing or flushing the ear canals of hosts. The latter is the better method as it allows quantification of the intensity of infestation. Mixed infestations may occur. Prevalence and intensity of infestations in both species of mites appear to be independent of age and sex of the host. Surveys, carried out in northeastern, southeastern and western Brazil, have shown that average herd prevalence of *P. cuniculi* ranged from 73%, 76% and 89%, respectively, whereas intensity of infestation ranged from 71-1237, 76-229 and 259-934 mites/goat, respectively. In southcastern Brazil, prevalence and intensity of infestation of R. caprae ranged from 31-100% and 2-27 mites per goat, respectively. Breeds of goats such as Saanen, Toggenburg, Anglonubian, Alpine and Moxotó (native) appear to be highly susceptible to infestation with R. caprae, but further research is needed to confirm such data. Population structure of each species is quite different. In P.cuniculi all stages of the life cycle are found in the ear canals whereas in R. caprae nymphs are absent. It is suggested that part of the life cycle of R. caprae occurs in the environment. The pathogenesis of parasitism has not been fully clarified, but one may infer, based on morphology of the chelicerae of both species, that otitis is caused by invasion and colonization of mite-feeding lesions by common bacteria which live in the ear canals of goats. Clinical parasitosis is rare, although typical lesions of otitis are frequently found during necropsy of parasitized goats. From the epidemiological point of view, these animals are an important source of intra and interherd mite transmission. Transmission of both species to sheep pastured together with goats might occur under certain circumstances, so that sheep may also be a source of mite transmission. A strong association, between R. caprae and pathogenic mycoplasmas for goats has been observed under natural conditions in southeastern Brazil.

Index terms: Psoroptes cuniculi, Raillietia caprae, Acari, epidemiology

[0026] STUDIES ON INFECTION MECHANISMS OF THE FUNGI BEAUVERIA BASSIANA AND METARIHIZIUM ANISOPLIAE ON HYPOTHENEMUS HAMPEH USING FLUORESCENCE MICROSCOPY AND SCANNING ELECTRON MICROSCOPY

<u>F. Delgado¹</u>, P.E. Vélez¹, E. M. Giraldo¹ & Y. López¹, ¹Disciplina de Entomología. Centro Nacional de Investigaciones de Café (Cenicafé).Chinchina, Caldas, Colombia. E-mail fefdelb@cafedecolombia.com Fax: 0968-506630. A.A 2427.Manizales. Caldas. Colombia.

Among the several pests that attack coffee crop (Coffea arabica), the most serious for colombian coffee growers is the coffee berry borer (Hypothenemus hampei). So far the use of entomopathogenic fungi B. bassiana and M. anisopliae are considered to control this insect pest of economic importance. We have studied infection mechanisms of both B. bassiana and M. anisopliae on adults of H. hampei and cuticle fragments by light fluorescence microscopy and scanning electron microscopy (SEM). The infection seems to involve the following events: (1) adherence of the spores to the cuticle (2) germination of spores and growth of the mycelium on cuticle surface (3) penetration of germinative tubes into the cuticle (4) extensive lateral development of hyphae followed by strong degradation of the cuticle layers. Labelling with Calcofluor White suggests that cuticle penetration and colonization mechanisms by both B. bassiana and M. anisopliae are closely related to enzymatic hydrolisis and mechanical pressure. Germinative tubes of B. bassiana and M. anisopliae can penetrate at any place of the H. hampei cuticle, although the most frequently penetration site is the insect abdomen close to the adherence site of the spores. A fissure is produced on the cuticle surface after penetration of the germinative tube into the insect. These observations bring further insights into the infection mechanisms of both fungi on H. hampei and on the localization of fungal spores and their penetration site on the insect cuticle. Spores localization, germination, mycelium growth and development of these fungi were observed from 48 h to 12 days after inoculation on growing media containing fragments of H. hampei cuticle using fluorescence microscopy and SEM.

Index terms: Entomopathogenic fungi, Coffee berry borer, conidial attachment, microscopy

[0028] THE FOOD WEBS OF ARTHROPOD COMMUNITIES IN *NEPENTHES* PITCHERS: WHERE DO HISTIOSTOMATID MITES FIT IN?

N. J. Fashing, Dept. of Biology, P. O. Box 8795, College of William & Mary, Williamsburg, VA23187-8795, USA, E-mail Norman.Fashing@wm.edu.

Many terrestrial plant species possess morphological attributes that collect and retain water, and these bodies of water often house communities of arthropods. Termed "phytotelmata". they have been lauded as excellent subjects for testing community theory since they are natural microcosms that are easily manipulated, provide for replication and contain relatively few species. In this regard, the fluid-filled pitchers of Nepenthes make excellent subjects and have received a great deal of attention in recent years. The trophic relationships of insect inhabitants are relatively well known, but those of the mite inhabitants remain largely uninvestigated. Although individually small, mites attain high population levels in pitchers and are important competitors of larger inhabitants. An understanding of the trophic relationships of mite inhabitants is therefore essential to an understanding of community dynamics. Three species of histiostomatid mites inhabit Nepenthes pitchers in northern Queensland, Australia, and studies emphasizing functional morphology of mouthparts via scanning electron microscopy reveal differences in feeding behaviors. Typically, histiostomatid mites possess non-chelate, flattened, serrated chelicerae, as well as a very long, flagella-like, terminal seta on each pedipalp. The long pedipalpal setae beat in a manner that creates a vortex in the fluid medium, thereby drawing small particulate matter and microorganisms toward the mouth where they are raked in by alternate protraction and retraction of the chelicerae. Zwickia (near) guentheri has typical mouthparts and utilizes this mode of feeding. Zwickia (near) nepenthesiana has short rather than long pedipalpal setae, and its chelicerae are stout and blade-like rather than serrated. It is not adapted for filtering particulate matter and microbes from the fluid and probably feeds by cutting (slicing) pieces of tissue from decaying insects. While Cruetzeria sp. has rake-like chelicerae, it lacks long pedipalpal setae. This genus is unique among astigmatic mites in that it is adapted for swimming. Rather than using the action of long pedipalpal setae to draw small particulate matter and microbes to the mouth region, members of this genus rapidly swim at an angle to the substrate keeping it in contact with their chelicerae. The chelicerae act as "brushes" to stir up small particulate detritus and microbes from the surface of decaying insects. The "suspended" matter is then funneled into the mouth by the forward movement. Cruetzeria sp. and Z. (near) guentheri gather microbes and small particulate detritus from the fluid, thereby competing with mosquito larvae. Z. (near) nepenthesiana, however, feeds directly on decaying insects and competes with sarcophagid, phorid and ceratopogonid larvae. Index terms: Zwickia, Cruetzeria, Acari, functional morphology, mouthparts

[0029] SETAL POLYMORPHISM WITHIN AND BETWEEN STASES IN AN ALGOPHAGID MITE INHABITANT OF WATER-FILLED TREEHOLES

N. J. Fashing, Dept. of Biology, P. O. Box 8795, College of William & Mary, Williamsburg, VA23187-8795, USA, E-mail Norman.Fashing@wm.edu.

A manuscript is now in press describing a new genus of Aigophagidae, members of which are obligate inhabitants of water-filled treeholes in a semitropical rainforest in Queensland, Australia. One of the two described species exhibits an interesting polymorphism in regard to the morphology of dorsal setae. In non-dispersing (= homeomorphic) inumature instars as well as adults, setae se, c3, and c2 are similar in that they are hair-like, however the morphologies of all other dorsal setae vary between stases with none being hair-like in immatures Larvae even exhibit intra-stase variation, with some individuals having stout setae with relatively long biserrations, others having long, bipectinate setae, and yet others with a setal morphology in between. Non-larval stases exhibit only slight intra-stase variation for any given seta. As setae are compared between immature instars, a progression is observed from the long, bipectinate and/or bushy setae of the larvae to the shorter, biserrate and lanceolate setae of the tritonymphs. In adults, setae si, c1, c2, c3, cp, d1, d2, and e1 become short and hair-like, Those few adult setae that retain a biserrate condition with short barbs (f2, h_1,h_2,ps_1 and $ps_2),$ are much shorter relative to body length than in early immature instars. It is postulated that the longer, bipectinate and/or biserrate dorsal setae of the immatures function as a deterrent to predators. The algophagid mites share the treeholes with predatory arrhenurid and ascid mites, as well as with predatory tanypodine midge larvae and the predatory tadpoles of a frog. Although such setal morphology could potentially offer protection to adult as well as immature instars, it would also have a negative effect during copulation. Males of algophagid species are approximately the same size as females and mount dorsally during copulation, facing in the same direction as the female, and overlapping her to a great extent. If enlarged, bipectinate dorsal setae were present, they would undoubtedly hold the male away from the female and interfere with copulation. This seems a logical explanation for the transition from the relatively long, stout, bipectinate setae of larvae to the primarily short, weak, hair-like setae of adults. It is interesting that the second species of algophagid found in the treeholes retains greatly enlarged pectinate setae in adults as well as homeomorphic nymphs, however, it has evolved a different strategy to prevent interference during copulation. The enlarged dorsal setae are lost early in the adult stage through abscission

Index terms: Algophagidae, Acari, copulation, Australia

[0030] SPACIAL AND TEMPORAL DISTRIBUTION OF CALACARUS HEVEAE ON RUBBER TREES IN BRAZIL

N. J. FERLA¹, O. BONATO² G. J. MORAES DE¹, H. J. SCOMPARIN³, C. C. FRANCHECHI¹, ¹Esalq, Depto. De Fitopatologia, Entomologia E Zoologia Agrícola, C. P. 11, 13418-900, Piracaba, São Paulo, Brazil; ²ird (Ex-Orstorn), França; ²embrapa Meio Ambiente, C.P. 69, 13820-000, Jaguariúna, São Paulo, Brazil; ³ Plantações E. Michellin, C.P. 80, 78700-090, Itiquira, Mato Grosso, Brazil; ⁴ Triânguto Agro-Industrial, C.P. 42, 78250-000, Pontes E Lacerda, Mato Grosso, Brazil: E-Mail Ferla@Carpa.Ciagri.Usp.Br

Three eriophyid species (Acari: Eriophyidae) are found on rubber trees in Brazil: Calacarus heveae, Phyllocoptruta seringueirae and Shevtchenkella petiolula. The former is the most important, for rusting the leaves and causing premature leaf drop. The objective of this work was to analyze the distribution of C. heveae on the plant, selecting the most representative sampling stratum and studying the dynamics of the mite population during one growing season. The study was conducted at Itiquira and Pontes e Lacerda, in the State of Mato Grosso. The most susceptible clones were selected for study in each site, PB 260 (10 years old) in the former and IAN 873 (12 year old) in the latter. Ten trees were randomly selected in each field, at least 20 m from field margins. No chemical treatments were done in those areas during the time the study was conducted. The trees were divided into 3 strata: basal, medium and apical. From September 1998 to August 1999, monthly samples consisting of 3 leaves from each stratum of each of the pre-selected plants were collected, taking them to the laboratory for examination. Mite density was analyzed with ANOVA and proportions of mites was analyzed with Friedman's test. In both sites, the proportions of infested leaves in the different strata were statistically similar. At Itiquira, the average mite density in the basal stratum was significantly higher or lower than that at other strata in only 4 sampling dates. At Pontes e Lacerda, this parameter was not significantly different between strata. At Itiquira, the proportion of mites in the basa! stratum was significantly higher or lower than that in the median stratum in 5 sampling dates; it was higher than that in the apical stratum in one sampling date and lower in another sampling date. At Pontes e Lacerda significant differences were found in just one sampling date, when the proportion of mites at the apical stratum was significantly lower than that on other strata. The amplitude of the proportions of infested leaves and of the number of mites per leaf was lower in the medium stratum, indicating that this should be the stratum selected for samplings of populations of C. hevene. The peak of the population of C. hevene occurred in December at both sampling sites, but in Itiquira it was cousiderably higher.

Index terms: Calacarus heveae, rubber tree, Hevea brasiliensis, populational dynamic

[0031] MODEL FOR OPTIMISATION OF THE WORKRATE OF AIRBLAST SPRAYERS ON CONTROL OF *BREVIPALPUS PHOENICIS*

M. C. Ferreira^{2,3} & T. Matuo^{2,3}, ²Dept. Fitossanidade, Univ. Estadual Paulista-Campus de Jaboticabal, ³E-mail: mdacosta@fcav.unesp.br; ⁴E-mail: matuo@fcav.unesp.br. Project supported by FAPESP.

Cost of pest control is responsible for one third of the total production cost of citrus in Brazil. This high cost is due mainly to citrus leprosis mite (Brevipalpus phoenicis, Geijskes 1939) that usually is lodged in sites difficult to be reached by the spray. This demands traditionally very high rates for spraying. Therefore is very important to improve the working capacity of the sprayers in order to reduce costs. Studies regarding to operational capacity of these types of sprayers are scarce. The aim of this study was to conduct field measurements and establish the validity of a mathematical model and apply it in simulation studies determining systems for optimisation of the operational capacity of airblast sprayers for citrus minimising the production costs. Comparing estimated figures with data observed in the field it was verified that the model is valid, presenting correlation coefficient ranging from 0.83 to 0.99. Using the simulation model it was verified the feasibilityin increasing the performance of the sprayer reducing costs. We concluded that proposed simulation model is valid and is suited to conduct simulations that afford reduction in production costs through changes in operational attitudes as well as changes in he sprayers. A software named FiSiCoM was developed that allows to compare situations such as reduction in spray volumes and changes in the other application parameters. The use of simulations can show the best situation for economically carry out the spray operations in minimum time. Nevertheless the information that leads to a better way to spray are very scarce, for example, the basic knowledge in reducing spray volume maintaining the same efficacy. This is certainly a research field that is needing more efforts in order to allow more rational procedures in pesticide application, lowering costs as well as reducing environmental impacts.

Index terms: simulations, spray technology, sprayer, pest control, citrus mite

[0032] MODEL FOR REDUCTION OF THE COSTS AND ENVIRONMENTAL IMPACTS ON THE CONTROL OF *BREVIPALPUS PHOENICIS*

M. C. Ferreira^{2,3} & T. Matuo^{2,3}, ²Dept. Fitossanidade, Univ. Estadual Paulista-Campus de Jaboticabal, ³E-mail: mdacosta@fcav.unesp.br; ⁴E-mail: matuo@fcav.unesp.br. Project supported by FAPESP.

More than 50% of mitecides used in Brazil is for the control of citrus leprosis mite (Brevipalpus phoenicis, Geijskes 1939). Excessive spray volume carrying large amounts of chemicals is responsible for such figure. Traditionally very high spray volumes, sometimes higher than 10,000 L/ha, is used due to the difficulty in reaching mites located in the inner part of the canopy and in chinks offruits and branches. This fact causes undesirable wastage of resources and environmental impact. In the present study a simulation was performed using the mathematical model in order to estimate the economy reached using an improved filling procedure and a lower spray rates. In the filling procedure using transfer of already prepared spray solution are included the costs of an auxiliary crew (one tank car driver and one assistant) and costs of the tank car. Conventional spraying for mite control spraying to only one side of the machine using 19 L of spray solution per tree in 8 x 4 m planting scheme considering the yield of 35.7 t/ha reaches the operational cost of US\$ 30.56/ha not considering the costs of the chemicals. In the other hand, considering the improved filling procedure using transfer of already prepared spray solution and applying 12 L per tree in 7 x 3.5 m planting scheme and considering the same 35.7 t/ha the application cost will be US\$ 10.28/ha, i.e. one third of the conventional spraying. Improved filling procedure combined with lower spray rates provide saving in resources, mainly water, as well as less contamination leading to create mere stable and sustainable agri-ecosystem. Thus, research on reduction of spray volume to more effective pest control as well as improved operational capacity of sprayers are very important factors in Brazilian citriculture.

Index terms: simulations, citrus leprosis mite, sprayer, spraying, pest control

[0033] KETOENOLE: A NEW CHEMICAL GROUP TO THE MITES CONTROL IN THE CITRUS CULTURE

A. C. P. Florim¹ & <u>O. Nakano¹</u>, ¹Dept. of Entomology, Fitopatology and Agricultural Zoology, Univ. of São Paulo - ESALQ/USP, Av. Pádua Dias 11, P. O. Box 9, Piracicaba, São Paulo, Brazil.

The citrus culture is usually aimed by several pests, which can cause beyond repair damages when found in favorable conditions to its development. Among the dangerous and frequent pests, it's possible to remark the mites action, that also becames resistent to the conventional acaricides. Meaning to avoid the promotion of this resistance evolution it's recommended to manage the pest varying the acaricide group. Meanwhile, even though we find several acaricides available, most of them belongs to the same chemical group, making it harder to create a rotary scheme of different groups. So we can say that the emergence of this new group, the Ketoenole, represented by BAJ 2740, formulated at 240SC, is providing another option to the acaricide management. This acaricide acts over all the mite development stages, and also acts as an ovicide. It presents low oral and dermal toxicity, is not aggressive to the eyes and skin and, when on the soil or in the aquatic system, degrades quickly. Depending on the time it's been applied, presents low effect over other predators mites, is non toxic to the bees and birds, being compatible to the entomophatogenic fungus and beneficial insect, and besides has not presented any crossing resistance to the world comercialized products. The BAJ 2740 was tested in the field conditions over Brevipalpus phoenicis, Phyllocoptruta oleivora and Panonychus citri populations, in different dosages (10;15 and 20 ml/100L H_2O). It's been verified that any dosage used was very efficient to control the concerning mites. The evaluations were realized from the third up to the 75th day after application (DAA), depending on the mite species. The evaluation consisted of counting the mites found on ten alcatory fruits per parcel with 40 fruits/treatment. Those are the results: B phoenicis, high efficiency from the 15th DAA up to the 75th DAA; P oleivora, over 90% efficient from the third DAA up to the 45th DAA; and P citri, over 90 % efficient from at third DAA and 100% efficient after the 15th DAA.

Key words: Ketoenole, acaricide, citrus.

[0034] INTERACTION OF TICK SALIVA WITH THE HOST IMMUNE MECHANISMS AND ITS SIGNIFICANCE FOR PATHOGEN TRANSMISSION

N. Fuchsberger¹, P.Kocáková¹, V.Hajnická², M. Slovák³, M. Labuda³ & P.A. Nuttall⁴, ¹Inst. Virology, Slovak Acad. Sci., 842–45 Bratislava, Slovakia, E-mail virufuxo@savba.k; ² Institute of Preventive and Clinical Medicine, Limbova 14, 83301 Bratislava, Slovakia; ³Institute of Zoology, Slovak Academy of Sciences, Dubravska 9, 84306 Bratislava, Slovakia; ⁴ CEH Institute of Virology and Environmental Microbiology, Oxford, OXI 3SR United Kingdom

Ticks are of great medical and veterinary importance not only as haematophagous ectoparasites infesting humans and domestic animals, but also as vectors of a wide variety of pathogenic organisms. Ixodid ticks are obligate blood-feeders in all their life stages. In contrast to other haematophagous parasites, the contact between an ixodid tick and its host lasts for days or even weeks. During the prolonged feeding period, the salivary glands increases in protein content. Feeding provokes host haemostatic, inflammatory and immune responses. Therefore, ticks counterattack with anti-haemostatic, anti-inflammatory and immunomodulatory substances. We demonstrate the differences in protein patterns of different tick species (Ixodes ricinus, Haemaphysalis inermis, Dermacentor reticulatus, Rhipicephalus appendiculatus, Amblyomma variegatum), differences in patterns at different stages of feeding, differences between sexes and collaboration of both sexes during feeding. The salivary glands are also the primary means for transmission of tickborne pathogens. Such pathogens exploit the immunomodulatory activities of tick saliva. This phenomenon is known as Saliva activated transmission (SAT). We demonstrate the promotion of virus growth by tick SGE in an animal-free system. We demonstrate the interaction of tick SGE with host immune mechanisms namely with the interferon system, with natural killer cells, and with chemotaxis. We demonstrate the interaction of tick saliva with the host cytokine network at the levels of both production and action.

[0035] MITE POPULATIONS IN RELATION TO CYDIA POMONELLA CONTROL IN THE ALTO VALLE DE RÍO NEGRO Y NEUQUÉN (ARGENTINA)

 $\underline{\rm H.}$ Giganti, G. Dapoto & M. Bondoni, Fac. C. Agrarias - U.N.C. , C.C. 85–8303 Cinco Saltos (R.N.) Argentina. E-mail: hgiganti@uncoma.edu.ar.

Apple tree is the most important crop in Alto Valle de Río Negro y Neuquén, and *Cydia* pomonella (L.) is the key pest. The chemical control determine different changes in other species those wich reach population densities above economic damage threshold. Four plots were observed for to look about the evolution of Tetranychidae (Acarina) with different *C* pomonella control modes manage as follow: from 1994/95 to 1996/97: a) neglected, 1994/95 to 1997/98: b) recently implanted, for organic crop, c) with regional usual chemical treatments and in 1997/98: d) pheromone disruption. Since october to march once a week, 40 leaves were taken out of 10 trees in each plot, from wich the nites were extracted by Berlese method. Results show that plots a), b) and d) increase populations more that plot c) at the end of spring and begining of summer, but they do not reach economic damage threshold. The peaks of phytophagous, mainly *Panonychus ulmi* Koch, are controlled by predators and a narrow phytophagous/predator relation is obtained until the end of cycle. In plot c) graphics do not show trends and in spite of the pesticide pressure it has a small but prudent population of *Neoseiulus californicus* (Mc Gregor), the main predator.

Index term: Tetranychidae, Phytoseiidae, Cydia pomonella control, apple tree, Argentina.

[0036] EFFECTS OF CILLORPYRIFOS AND TEFLUTHRIN ON LUMBRICUS TERRESTRIS

<u>R. Giménez</u>, **A. B. Della Penna & E. Odello**, Cátedra de Terapéutica Vegetal, Facultad de Agronomía, Univ. de Buenos Aires. Av. San Martín 4453, (1417) Buenos Aires, Argentina, E-mail: rgimenez@agro.uba.ar

This essay was carried out in order to evaluate the ecotoxicity of the insecticides Chlorpyrifos and Tefluthrin on the earthworm Lumbricus terrestris L., using the Daniel funnel test, following the guidelines of the International Organization of Biological Control (IOBC). This is a laboratory test to measure side effects of pesticides on L terrestris. The earthworms were collected from a soil free of pesticides from the Ap horizon at the Faculty of Agronomy field. It was placed in recipients with sterilized soil, under fully dark and 12°C conditions by 5 days, and was fed with dried clover leaves. Only juveniles earthworms were used: then those with a live biomass higher than 1,5 g / individual and without clitelum were used, and putted into the experimental unity (Daniel funnel's) with ten dried leaves of Trifolium repens L. over the soil surface. The treatments sprayed in the surface of the funnels were: To= standard, with water; T1= negative standard, with 30 mg/l chloroacetamid solution (L; 97,37%); T2= Chlorpyrifos (EC; 48%) 5 liters/ha and, T3 = Tefluthrin (EC; 5%) 2 liters/ha. A hand spray were use, with drops of 150 micrometers and covering a surface of 70 drops/cm². The experimental design was a DCA with 10 replications. During the 15 days of exposition the following variables were analyzed: weight variation, the individual activity measured by the withdrawn leaves; and mortality of earthworms. ANOVA and Tukey test were used for the statistic analysis. The increase of weight of the earthworms was similar in all the treatments. The activity, measure as the dairy number of leaves withdrawn, showed that there were no significant differences between the treatments. The L. terrestris survival was affected only by Chloroacetamid, drug used like negative standard, in that case it showed that the 80% of the individuals dead during the 15 days of exposition.

Index terms: insecticides, side effects, non-target, ecotoxicology, earthworms

[0037] LIFE TABLES OF THE RED MITE, *EOTETRANYCHUS LEWISI* (ACARI: TETRANYCHIDAE)

M. P. González-Castillo¹, M. T. Valverde² & T. M. Pérez³, 1.- Instituto Politécnico Nacional, CIIDIR, U. Dgo, A. P. 112, Vicente Guerrero, Dgo, C.P. 34890, México, Becario de la COFAA-IPN. E-mail: marypgoca@hotmail.com. 2.- Lab. Esp. de Ecol., Fac. de Ciencias. UNAM. Cd. Univ. C.P. 04510, México, D.F. 3.- Lab. de Acarol. Int de Biol. UNAM. A. P. 70-153, C.P. 04510, México, D.F.

The red mite, Eotetranychus lewisi shows a worldwide distribution and may live on a number of host plants, including the peach tree. This mite may colonize the leaves of peach trees causing severe damage to the peach production in several regions of México. Mite populations in Zacatecas and Durango, México occur from march to september each year. The aim of this study was to describe the life cycle of E. Lewisi and to build a life table for a population of this mite kept under controlled conditions in order to evaluate demographic variables such as stage-specific mortality and fertility, and analyze its potential for population growth. The work was carried out at the Entomology laboratory of CHDIR-IPN, in the Mexican State of Durango during 1997. Mites were kept at a temperature of 27 ± 2 °C, a relative humidity of 70 \pm 10 % and a 12:12 hr photoperiod. Starting with eggs that were followed closely, the life cycle of E. Lewisi was described including the duration of each stage and the total longevity of males and females. Stage-specific mortality was recorded and fertility was measured; this allowed us to build a life table from which population growth estimates were calculated, in particular, net reproductive rate (Ro), intrinsic rate of population increase (r_m) , generation time (T) and finite rate of increase (λ) . Female were able to oviposite from the 18th day after emergence; each female produced an average of 22 eggs. According to the fertility and survival records of our life table, E. Lewisi may produce a 4-fold population increase each generation. The generation time, which may be interpreted as the average time elapsed between the birth of parents and the birth of their offspring, was 12.54 days. The intrinsic rate of population increase (rm) was 0.114 and the finite rate of population growth (λ) was 1.12. The moment of highest population growth was when females were between 23 and 25 days old, which coincided with the moment of highest oviposition decreased after day 26. The potential for population increase of E. Lewisi is high. This may contribute to the fact that it is usually considered a pest. Yet, it is important to study the demographic behavior of this mite under natural conditions since, for instance, mortality factors in the field must be much stronger than under controlled conditions. In any case, this study has allowed us to address fundamental aspects of the biology of E. Lewisi both from the point of view of its life cycle and its demographic potential. Key words: damage, peach tree, population.

[0038] EFFECTS OF CASSAVA CULTIVAR ON ABUNDANCE OF EXOTIC PHYTOSEIID MITES IN AFRICA

R. Hanna¹, D. Ojo¹, J. S. Yaninek², M. Toko¹, D. Gnauvossou¹ & A. Onzo¹, ¹Intern. Inst. of Trop. Agric., PHMD, IITA-Benin Station, 08 B.P. 0932, Cotonou, Benin, E-mail r.hanna@cgiar.org; ²USDA Coop. State Res. Ed. Ext. Service, 1400 Independence Ave., Washington D.C. 20250-2220, USA, E-mail syaninek@rceusda.gov.

The establishment of the exotic phytoseiid mite Typhlodromalus aripo on cassava in Africa has generally provided excellent biological control of cassava green mite Mononychellus tanajoa, and has resulted in substantial increases in cassava yields. Typhlodromalus aripo inhabits the apex of cassava shoots during much of day and forages on cassava leaves during the evening and night hours. Cassava provides shelter, prey as well as non-prey food such as exudates for the maintenance of T. aripo populations. In field surveys throughout the areas where T. aripo has been established, we have observed at times large differences in T. aripo abundance among cassava cultivars that differed in the level of shoot apex 'hairiness'. In an initial attempt to understand the relationship between cassava cultivars and T. aripo, we set up a common experiment with 6 cassava cultivars, 3 with 'hairy' apices and 3 with 'glabrous' apices. Mite abundance and several cassava apex characteristics were evaluated on 4 occasions over a 12-months period. Abundance of both M. tanajoa and phytoseiid predators varied considerably between sampling periods, as expected, and among cultivars. 'Hairy' cultivars had significantly higher hair density and hair length on the midrib, vein, and venule of immature leaf tissue in the cassava shoot apex. Mononychellus tanajoa densities were higher during the dry season on 'glabrous' compared with 'hairy' cultivars. Moreover, T. aripo abundance was positively correlated with hair density on the midrib, veins and venules of immature leaf tissue in the cassava shoot apex, despite lower abundance of M. tanajoa on the hairy' cultivars. Under the conditions of the experiment, none of the cultivars suffered substantial M. tanajoa damage. The utility of these findings for developing tactics to enhance M. tanajoa biocontrol and in cassava improvement programs will be discussed. Index terms: Mononychellus tanajoa, Typhlodromalus aripo, shoot apex surface

[0039] BIOLOGICAL CONTROL OF *OLIGONYCHUS PERSEAE* (ACARI: TETRANYCHIDAE) ON AVOCADO: EVALUATING THE EFFICACY OF VARYING RELEASE RATES AND RELEASE FREQUENCY OF *NEOSEIULUS CALIFORNICUS* (ACARI: PHYTOSEIIDAE)

M. S. Hoddle, Department of Entomology, Univ. of California, Riverside CA 92521, USA. E-mail: mark.hoddle@ucr.edu.

Three different release rates and timings of the phytoseiid Neoseiulus californicus were evaluated for Oligonychus perseae control on avocado trees in a commercial orchard in southern California, USA. Densities of natural enemies and O. perseae were monitored on trees for 34 weeks that were treated with either one, two, or three releases of 500, 1000, or 2000 N. californicus, or two applications of 5% narrow range (NR) 415 insecticidal oil. Predator releases were made when 50% (release one), 75% (release two), or 95% (release three) of sampled leaves were infested with one or more motile O. perseae. Densities of O. perseae on trees treated with N. californicus or oil were compared to control trees that received no treatments for O. perseae suppression. Release of a minimum of 2000 N. californicus per tree was necessary to significantly reduce O. perseae densities in comparison to control trees. Releasing 1000 N. californicus twice or 2000 N. californicus once provided O. perseae control similar to oil treatments and to trees treated with cumulative releases totaling more than 2000 predators per tree. This result indicated that releases totaling more than 2000 N. californicus per tree did not substantially improve O. perseae control and the cumulative number of predators released per tree is more important than the number of times N. californicus is released for controlling O. perseae. index terms: Persea americana

[0040] THE CAPTURE EFFECT OF PREDACEOUS MITE AMBLYSEIUS ORIENTALIS TO THE RED MITE PANONYCHUS CITRI AT DIFFERENT TEMPERATURES

S. O. Hu, M. Gan & M. H. Li, Dept. of Biological Science and Engineering, Nanchang Univ, Nanchang 330047, Jiangxi, China, E-mail hsqlqlw@public.nc.jx.cn

Panonychus citri is an important injurious mite in citrus orchard, affecting both the quality and quantify of orange trees. Amblyseius orientalis is a effective natural enemy on *P.citri*. The capture effect of *A.orientalis* on the phytophagous mite *P.citri* was dealt with five temperatures with seven density of *P.citri* in the laboratory (Tab 1). The results showed that the function response of *A.orentalis* to *P.citri* all accorded with Holling's II equation at different temperatures. The mathematical model and maximum predation of *A. orentalis* to *P.citri* showed at different temperatures (tab 2).

Index terms: Holling's II equation, mathematical model, maximum predation

[0041] THE CARBOHYDRAZES OF THREE ACAROID MITES (ACARI: ACARIDIDA) – PRELIMINARY RESULTS

<u>J. Hubert</u> & E. Ždárková, Research Inst. of Crop Production, Drnovská 507, Praha 6, 161 06, Czech Republic. E-mail hubert@hb.vurv.cz.

Feeding habits of the most abundant acaroid mites in stored grain in the Czech Republic were assessed by measuring carbohydraze activities in the mites. The enzymatic activities were measured in the whole body homogenates of Acarus siro, Lepidoglyphus destructor and Tyrophagus putrescentiae. The mites were reared on yeast and wheat germs diet in darkness at 25°C. The enzymatic activities against starch, amylopectin, cellulose, cellobiose, saccharose, maltose, lichenan and trehalose were tested by a saccharogenic method, detecting glucose as the reaction product. The S-Test using specific chromolytic substrates (Institute of Chemistry® Bratislava, Slovakia) was used for the amylase and laminarinase assays. The spectrum of digestive enzymes was similar in all studied species. The amylase, isoamylase, maltase, saccharase and laminarinase activities were always detected. The activity splitting cellobiose was detected in L. destructor only. The activities splitting cellulose, lichenan and trehalose were not detected in neither species using the saccharogenic method. The proportions of laminarinase in all observed species and cellobiase in L. destructor were low in comparison to other carbohydrases. Amylase, isoamylase and maltase activities strongly prevailed on saccharase in A. siro and T. putrescentiae. The proportion of saccharolytic activity was higher than maltase and isoamylase on L. destructor, but lower than amylase. The enzymatic equipment of the studied mites indicates that the digestion of storage polysaccharides is more intensive than digestion of the content of fungal cells and plant cell walls. A possible interpretation of the enzymatic equipment for understanding of feeding habits of the studied species is discussed. The work was supported by grant COST OCNA.50. Index terms: Astigmata, digestive enzymes, feeding habits

[0043] THE EFFECT OF STARVATION ON METABOLIC RATE AND MICROANATOMY OF GALUMNA ELIMATA (ACARI: ORIBATIDA)

<u>J. Hubert¹</u> & V. Šustr², ¹Research Inst. of Crop Production, Drnovská 507, Praha 6, 161 06, Czech Republic E-mail hubert@hb.vurv.cz, ²Inst. of Soil Biology, ASCR, Na sádkách 7, České Budějovice, 370 05, Czech Republic.

Starved oribatid mites Galumna elimata were reared in sterilised plastic vials containing moistened zeolite at 25 °C in 12:12 photoperiod. The control group was reared on bark covered by the green bark algae (Desmococcus viridis) under the same conditions. The physiological parameters such as mortality, weight, oxygen consumption and digestive enzyme activity (amylase, trehalase, and cellobiase) were recorded in both groups after 21 days. The microanatomical observation of the digestive tract was done after 21 and 42 days. The weight of starved individuals significantly decreased while the water content in the body tissues increased. The mortality of individuals was significantly higher in starved groups than in the controls. Oxygen consumption of starved mites was lower. The activity of amylasc showed significantly higher variability in feeding individuals than in starved ones. A similar trend was also observed in trehalase and cellobiase activities but the results were not significant. The starved individuals usually had no food in the gut. Mucoid droplets produced from the caeca and salivary glands filled the gut, but some guts were empty without mucoid substances. All parts of the gut (mesenteron, colon and rectum) of control individuals were filled with food boli. These boli contained algal cells. The granulation and thickness of mesenteral cells were reduced after 42 hours. The secretion activity of caecal cells was observed after 21 days of starvation, however the activity was reduced in comparison with control mites. The reproductive organs were also influenced by starvation. The vesiculae seminales were without spermatic cells in starved males. A possible interpretation of starvation under the outdoor conditions is discussed.

Index terms: Cryptostigmata, mites, respiration, amylase, gut

[0042] THE FOOD INTERACTIONS BETWEEN THREE ACAROID MITES (ACARI: ACARIDIDA) AND SOME MICROMYCETES

J. Hubert¹, E. Ždárková¹ & A. Kubátová²¹Research Inst. of Crop Production, Drnovská 507, Praha 6, 161 06, Czech Republic. E-mail hubert@hb.vurv.cz ²Department of Botany, Faculty of Science, Charles University, Benátská 2, Praha 2, 128 01, Czech Republic.

The 8 fungal species used for this study (Mycocladus corymbifer, Eurotium amstelodami, Aspergillus versicolor, A. montevidensis, A. niger, Cladosporium cladosporioides, Alternaria alternata, Penicillium aurantiogriseum) were isolated from stored poppy seed. The micromycetes were offered as food to 3 acaroid mites (Acarus siro, Lepidoglyphus destructor and Tyrophagus putrescentiae). After 3 days of feeding all fungal species were reisolated from both the body surface and the digestive tract of the mites. Some bacteria together with fungi were also isolated. The bacteria occurred on the surface of mites and inside their bodies but were not observed on plates, which were not infested with fungi. Mites consumed the fungal species differently. For instance all tested mites rejected A. niger. Also the voracity of mites differed. T. putrescentiae consumed fungi most intensively and the rate of growth of its population was highest. The microanatomy of the guts of acarid species showed different levels of digestion of the consumed fungi. The results were compared with the enzymatic equipment of the observed species and discussed. The work was supported by grant NAZV Czech Republic, No. EP 9138/99.

Index terms: Astigmata, fungi, feeding, microanatomy, gut.

[0044] THE PREDATORY MITE NEOSEIULUS CALIFORNICUS: ITS POTENTIAL AS A BIOCONTROL AGENT FOR THE FRUIT TREE RED SPIDER MITE PANONYCHUS ULMI

<u>R. L. Jolly</u>, Dept. of Entomology & Plant Pathology, Horticulture Research International, East Malling, Kent, ME19 6BJ, UK, E-mail rebecca.jolly@hri.ac.uk.

The predatory phytoseiid mite, Neoseiulus californicus, is not native to the UK. However, it has been released on several occasions in previous years and has been found on apple, strawberry, blackcurrant and hop where it appears to be overwintering. Previous releases were allowed based on a spurious synonomy with a native species. In fact, the literature on this group is confused. A study of the morphological features, including SEM examination of the chelicerae, has clarified species differences and resolved synonomies. The ability of N. californicus to undergo diapause was determined. It was found that two strains of N. californicus differed in diapause propensity, and it is possible that they may have originated from different parts of the world. Field studies have examined the overwintering potential of N. californicus in artificial refuges. Although less abundant than native species, it appeared to be overwintering as succesfully. There has been no previous study of N. californicus as a biocontrol agent of Panonychus ulmi. An investigation into the effect of prey type on developmental time of the immature stages showed that N. californicus developed as rapidly on P. ulmi as on the two-spotted spider mite Tetranychus urticae. Neoseiulus californicus developed more rapidly than the native predatory phytoseiid Typhlodromus pyri. Index terms: Neoseiulus californicus, Panonychus ulmi, biocontrol, diapause.

[0045] LIFE TABLES OF ACARUS SIRO (ACARI, ACARIDAE) ON SEVEN DIFFERENT DIETS

N. Kilic¹ & S. Toros², ¹ Dept. of Plant Protection, Agric. Faculty, Univ. of Trakya, 59030, Tekirdag, TURKEY, E-mail:tzfbitkikoruma@superonline.com ² Dept. of Plant Protection, Agric. Faculty, Univ. of Ankara, 06100, Ankara, TURKEY.

The grain mite Acarus siro is a common and serious pest of stored food products. In this study, life tables were constructed on selected 7 diets (wheat flour, corn flour, rice flour, wheat starch, corn starch, powdered milk and yeast) for investigating the effects of these materials on the rate of reproduction capacity and population growth of A. siro. The mite were produced separately for every diet in micro-cells at 25 ± 1°C and 75 ± 5 % R.H. The highest Ro and rm values calculated on the yeast diet were 97.59 female/female/life and 0.221 female/female/day. (Table 1). Mean generation time was also the shortest (20.73 days) in this diet. This indicated that the most suitable food among the test materials was yeast. The lowest values of Ro and rm were obtained on rice flour (1.23 female/female/life, 0.005 female/female/day). These data indicated that rice flour was not appropriate food for A. siro. The mite completed its development very slow on rice flour and reached to the adult stage after a mean generation time of 45.52 days. On wheat flour and powdered milk R_0 values were 26.03 and 33.94 female/female/life and r_m values were 0.124 and 0.125 female/female/day, respectively. The rm values of wheat flour and powdered milk were not significantly different from each other which means both of these foods are suitable for A. siro feeding. R. and r. values were obtained low on corn flour, wheat starch and corn starch and these foods were found unsuitable for A. siro because of prolonged generation time and decreased reproduction rate

Index terms: Acarus siro, diet, life table, intrinsic rate of increase

[0047] TETRANYCHUS EVANSI – A NEW CHALLENGE TO SMALL-HOLDER TOMATO GROWERS IN SOUTHERN AFRICA

M. Knapp¹ & S.W.S. Luchen², ¹Int. Centre of Insect Physiology and Ecology (ICIPE), P.O. Box 30772, Nairobi, Kenya, E-mail: mknapp@icipe.org; ²Nat. Irrigation Res. Station, Private Bag S-3, Mazabuka, Zambia.

Tomato growers in southern Africa (Zimbabwe, Mozambique, Namibia, Malawi, Zambia) have experienced increasing problems with red spider mites in the last years. In most countries the species involved were usually misidentified as Tetranychus cinnabarinus or T urticae. Recent identifications of material collected in the region show that T. evansi is causing the problems. T. evansi is specialized on Solanaceae: introduced to southern Africa. probably from South America and expending northwards. Only few natural enemies have been found so far (Phytoseiidae, Anthocoridae, Staphylinidae) and identifications are in progress. Results of surveys conducted in Kenya and Zambia clearly show the impact of different spider mite species on tomato production. In Kenya T. evansi is not yet present and we usually find T. urticae on tomato. Only 1% of the Kenyan farmers considered red spider mites as one of their two most important problems in tomato growing. In Zambia the corresponding figure was 27%. Asked more specifically about most important pest and disease problems, 16% of the Kenyans mentioned red spider mites; the corresponding figure for Zambia was 89%. The current control approach is purely use of chemicals, 42% of the Kenyan farmers and 97% of the Zambian farmers apply pesticides for red spider mite control. Many of these chemicals are highly toxic broad-spectrum insecticides and some of them have only limited activity against mites. In Zambia the most common control agent is monocrotophos (49% of farmers applying pesticides) followed by antitraz (39%), and cypermethrin (10%). In Kenya acaricides are more commonly used. Dicofol is used by 42% of the farmers who apply pesticides, followed by bifenthrin (18%) and cypermethrin (16%). Integrated pest management and classical biological control are discussed as alternative strategies to control T. evansi in southern Africa.

Index terms: Tetranychidae, tomatoes, IPM

[0046] A FAUNISTIC INVESTIGATION ON THE MITE SPECIES OF STORED PRODUCTS IN TEKIRDAG PROVINCE

N. Kilic¹ & S. Toros², ¹ Dept. of Plant Protection, Agric. Faculty, Univ. of Trakya, 59030, Tekirdag, TURKEY, E-mail:tzfbitkikoruma@superonline.com ² Dept. of Plant Protection, Agric. Faculty, Univ. of Ankara, 06100, Ankara, TURKEY

Mites which are pests of stored products damage and taint cereals and attacking the germ thus affecting the viability of grain. 27 different stored products (grain and grain products, rice and its products, sunflower seed, animal feed and its raw material, corn starch, sweepings etc.) were collected from storehouses in Tekirdag province. 536 samples out of 1140 were infested with mites and the average rate of infestation was obtained as 47.02 % in the province. Except corn starch all kind of stored products were found as infested with the mites. Results of survey showed that 13 harmfull mite species from five families belong Astigmata were determined. They included Acarus siro, Tyrophagus putrescentiae, T. similis, Aleuroglyphus ovatus, Rhizoglyphus callae, Suidasia nesbitti, S.medanensis, Glycyphagus domesticus Lepidoglyphus destructor, Blomia freemani, Gohieria fusca, Chortoglyphus arcuatus, Dermatophagoides farinae. Five species from one family belong Prostigmata and three species from two families belong Mesostigmata were regarded as beneficial mites, namely Cheyletus eruditus, C.malaccensis, C. trouessarti, Acaropsis sollers, Eucheyletia taurica, Blattisocius tarsalis, Proctolaelaps pygmaeus and Androlaelaps casalis casalis. S. medanensis, B. freemani and E.taurica were new records for Turkish fauna. Among harmful species A. siro, L. destructor and T. putrescentiae were found as the most common species and their infestation rates were estimated as 68.28 %, 53.17 % and 16.31 %, respectively. However T. similis and R. callae were determined as the most rear species (0.01 % and 0.06 %, respectively). C.eruditus and C.malaccensis were found to be as the most common beneficial species with 55.75 % and 42.26 % infestation rates, respectively whereas E.taurica was the most rare species with 0.01 % infestation rate.

Index terms: stored product mites, harmful species, beneficial species, infestation rate

[0048] INVESTIGATION OF THE MECHANISMS OF ANTI-COMPLEMENT ACTIVITY IN IXODES TICKS

C. H. Lawrie & P. A. Nuttall, NERC Institute of Virology and Environmental Microbiology, Mansfield Road, Oxford, OX1 3SR, U.K., E-mail: charles.lawrie@zoo.ox.ac.uk.

Ticks and tick-borne pathogens are a major drain upon worldwide agricultural resources as well as representing significant veterinary and medical problems. The ability of a tick to feed successfully on a host relies upon the ability of the tick to overcome the inflammatory and immune responses of that host. The complement system plays a central role in the orchestration of these host responses. Anti-complement activity has been described in the salivary glands and saliva of *Ixodes* ticks directed against the alternative pathway of complement. We have investigated the mechanisms of anti-complement activity in the salivary gland extract (SGE) of the European Lyme-disease vector *Ixodes ricinus*. We tested the effect of SGE upon various components of the complement activity in *Ixodes* ticks. Index terms: *Ixodes ricinus*.

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[0049] CHECKLIST OF MITES FROM MOSO BAMBOO IN FUJIAN, CHINA

J. Z. Lin¹, Z. Q. Zhang², Y.X. Zhang¹, Q.Y. Liu³ & J. Ji¹, ¹Institute of Plant Protection, Fujian Academy of Agricultural Sciences, Fuzhou, 350013 China; E-mail zyxlj@pub3.fz.fj.cn; ²Landcare Research, Private Bag 92170, Auckland, New Zealand; ³Laboratory of Forest Protection, Fujian Forestry Bureau, Fuzhou 350002, China.

This paper gives a report of 45 species of mites from the moso bamboo (*Phyllostachys pubescens*) in Fujian province, China. They belong to 23 genera in 9 families. Some of the Tetranychidae (e.g. *Aponychus copuzae* Rimando and *Schizotetranychus nanjingensis* Ma et Yuan) and Eriophyidae (e.g. *Aculus bambusae* Kuang), either alone or in mixed populations, cause serious injury to the moso bamboo in Fujian.

Index terms: Acari, pest, natural enemy, bamboo, Phyllostachys pubescens

[0051] MORPHOLOGICAL DIFFERENCES IN AQUATIC AND TERRESTRIAL SUBANTARCTIC ALGOPHAGUS SPECIES (ACARI: ASTIGMATA)

<u>D. J. Marshall¹</u>, B. M. OConnor² & P. J. A. Pugh³. ¹School of Life and Environmental Sciences, Univ. of Durban-Westville, Durban, South Africa; ²Museum of Zoology, Univ. of Michigan, Michigan, U.S.A.; ³British Antarctic Survey, Cambridge, U.K.

The Algophagus mite complex on the sub-Antarctic Prince Edward islands comprises at least five morphologically and ecologically distinct species. Three species (A. antarcticus antarcticus, A. a. laticollaris, and A. semicollaris) occur in inland or supralittoral pools, and two (Algophagus sp. 1 and sp. 2) in water films covering supralittoral beach boulders or in edaphic habitats. Principal morphological differences of the species are, sizes and proportions of the idiosoma and legs. Morphometric analyses of females suggest that the legs, claws and apodemes are functionally related to habitat, showing an aquatic/ terrestrial dichotomy. The aquatic species (A. antarcticus antarcticus, A. a. laticollaris, and A. semicollaris) have proportionally longer legs, spines, and claws, features which are probably important in maintaining an upright position in water and allowing easy passage through filamentous algae. On the hand, the stout legs, relatively close apodemes, and small thick claws of the terrestrial species (Algophagus sp. 1 and 2), seem important for crawling over solid surfaces and through dense soil media. Being comparatively close to the midline in the terrestrial species, apodemes I and II allow, via an increased leg muscle mass, more effective and direct leg muscle action. Additionally, the distal position, enlargement, and extension of setae e and pon leg II in the terrestrial species may contribute to the grip on solid surfaces.

[0050] INTERSPECIFIC PHYSIOLOGICAL DIFFERENTIATION IN MARINE AND TERRESTRIAL *HALOZETES* SPECIES (ACARI, ORIBATIDA)

<u>D. J. Marshall</u>¹, S. L. Chown², R. Mercer² & C. J. Klok², ¹Dept. of Zoology, Univ. of Durban-Westville, Durban, South Africa; ²Depart. of Zoology and Entomology, Univ. of Pretoria, Pretoria, South Africa.

Species of the mite Halozetes at sub-Antarctic Marion Island are either marine or terrestrial (two species of each). We were interested in knowing to what extent the physiology of the marine species differs from that of the terrestrial species, and by implication whether this has a role in habitat separation. Experiments were performed to determine particularly 1) tolerance of exposure to dry air, 2) tolerance of continuous submergence in freshwater and seawater, and 3) lower and upper lethal temperature limits of the mite species H. marinus devilliersi (marine), H. marionensis (marine), H. belgicae (mainly supralittoral but referred to here as terrestrial) and H. fulvus (terrestrial). Some comparative physiological features, such as rate and tolerance of water loss, and tolerance of submergence in freshwater and seawater, suggest a physiological basis for the exclusive marine existence of the marine species, but do not explain the exclusive terrestrial existence of the terrestrial species (particularly that of H. fulvus). For example, the terrestrial species controlled water loss better and survived for longer in dry air than the marine species, but there was no significant difference among the species in their levels of tolerance of freshwater or seawater submergence. Although lethal temperature limits differed between the marine and terrestrial species, generally being lower at the low temperature limits (c. -15 DC) and higher at the upper temperature limits (c. 43 C) in the terrestrial species, temperature limits of all the species showed no correspondence with present-day habitat temperature extremes (for example the seawater temperatures vary between 2 and 8 C). Those aspects of physiology which were similar among the species, or clearly not related to habitat (submergence tolerance, supercooling points, lethal temperature limits), indicate a broad based generic tolerance physiology, which may be important for the persistence of Ilalozetes in adverse and changeable (at least within a geological timeframe) antarctic environments, by offsetting the seemingly limited capacity within the genus for specific adaptation and speciation. Index terms: mites, sub-Antarctic, physiology

0052] THE UNIQUE INSECT BIODIVERSITY OF THE KLAMATH/SISKIYOU MOUNTAIN REGION IN NW USA; CHALLENGES FOR INVENTORY AND CONSERVATION

<u>A. R. Moldenke¹</u>, B. G. Marcot², D. DellaSala³ & N. Rappaport⁴, ¹Dept of Entomology, 2046 Cordley Hall, Oregon State University, Corvallis, OR 97331-2907; ²US Forest Service, 1221 SW Yamhill St., PO Box 3890, Portland, OR 97208-3894; ³World Wildlife Fund, 116 Lithia Way – Suite 7, Ashland, OR 97520; ⁴Forest & Range Experiment Laboratory, USDA Forest Service, Albany, CA. E mail: moldenka@bcc.orst.edu

This region has long been recognized as of extreme significance botanically. Escape from glaciation, diversity of geologic substrates combined with varied relief, and location at the interface of mesic vs. xeric biomes should have rendered this region as unique entomologically as botanically. Though scattered literature supports this hypothesis, a careful documentation of the endemic levels of arthropod biodiversity needs to be undertaken. The World Wildlife Fund, the Forest Service (land owners) and entomologists from Oregon State University are collaborating in a unique attempt to define and protect the ecological processes arthropods participate in, preserve biodiversity hot-spots and premiere taxa, while permitting economic utilization of the forest resources as a sustainable long-term resource. The three most critical management concerns center on ancient-forest stands, riparian habitats and the adequacy of buffers, and unique habitats. Relict ancient taxa representative of the transcontinental forests before mountain orogeny split the continent in two characterize this region (i.e., Tricholepidion gertschi (Thysanura) endemic to CA; Cryptocercus punctulatus (communal Blattaria) amphi-continental distribution). Beta diversity is driven by habitat heterogeneity and recent adaptive radiation (i.e., Amaurobiidae (Araneae)). Additionally, taxa with limited mobility have spawned localized geographic isolates as they recolonized the Pacific Northwest since glaciation (i.e., Pleocominae (Scarabaeidae), Caseyidae (Diplopoda)). Though the vast majority of taxa inhabiting the region is widely distributed geographically, endemicity is likely to be relatively high. With adequate inventory a system of protection can be implemented before this ecosystem is more heavily impaired. Index terms: palacoendemic, adaptive radiation

[0053] PARASITIC AND MUTUALISTIC RELATIONSHIPS BETWEEN ASTIGMATID MITES AND BEES OR WASPS IN JAPAN

K. Okabe¹ & S. Makino², ¹ Kyushu Res. Cent., Forestry & Forest Prod. Res, Inst., 4-11-16 Kurokami, Kumamoto 860-0862, Japan, e-mail kimikook@ffpri-Kys.Affrc.GO.JP; ² Forestry & Forest Prod. Res. Inst. Matsunosato 1 Kukisaki, Ibaraki 305-8687, Japan, e-mail makino@ffpri.affrc.go.jp.

There are some species of mites associate with bees or wasps in Japan. The common relationship is phoresy in which mites depend on hosts for transfer. However, the nature of the relationship between the mites and the hosts is not always clear. We surveyed some astigmatid mites for their association with hosts. Sennertia sp. was only found on adults of the common carpenter bee Xylocopa apendiculata. It is morphologically specialized to attached to the host for phoresy though detailed observations were not made. Kuzinia spp. were commonly found attaching to bumblebees (Bombus spp.) in the field. They sometimes become pests in artificially reared nests. The mites are suspected cleptoparasitc because they probably feed not on the host but on pollen stored by the host. A winterschmidtiid mite was specifically attached to the eumenid wasp Anterhynchium flavomarginatum, which nests in tube-like structures. The immature mite seemed to feed on various fungi and debris in larval host cells whereas the adult female was suspected to suck hemolymph of the larva or pupa. Therefore, we hypothesize that the relationship between the juvenile mite and the host is mutualism or commensalism while the female mite is purely parasitic. Observations on collected nests in different seasons revealed the followings. The number of adult mite females per host cell was one or very rarely two. A large number of deutonymphs aggregated on a prepupal host and overwinter. Once the host pupated, the deutonymphs became active, then quickly moved from pupal skin to the adult body during host eclosion. Seventy percent of wasps associated with the mite were males in Kyushu in 1999. Because the mite can produce progeny only in a nest of the host, those mites finding themselves on the male may transfer to the female, which is the only sex to nest, during mating. The mite should also be adapted to release itself from the female body while the host is engaging in nesting activities.

[0055] OVICIDE ACTION OF BAJ 2740 (SPIRODICLOFEN) AND PEROPAL (AZOCYCLOTIN) 250 WP AND 500 FW ON CITRUS LEPROSIS MITE BREVIPALPUS PHOENICIS

C.A.L. Oliveira¹ & M.L. Oliveira¹, ¹Depart. de Fitossanidade, FCAV/UNESP, Jaboticabal, 14870-000, Brazil, E-mail: amadeu@fcav.unesp.br

The efficiency of the spirodiclofen, azocyclotin and cyhexatin on eggs of Citrus Leprosis Mite was evaluated in a bioassay conducted in the Acarology Laboratory at the FCAV/UNESP, Jaboticabal, SP. The experiment was carried on a controlled-environment room, at 25 C°, 55-60% RH and photophase of 14 hours. Fruits of citrus cv Pêra-Rio were used, presenting 6 cm of diameter on the average, defined by a tanglefoot barrier. From a population of B. phoenicis, 20 females were transferred to each fruit, maintained at a period of 4 days for oviposition. After that period the females were eliminated, and only eggs were left on the fruits, approximately 100 for treatment. The bioassay was in a randomized block design, with 6 treatments in 7 blocks. Each fruit was constituted as an experimental plot. The spary volumes were expressed in g or ml of the product formulated by 100 L of water: BAJ 2740 240 FW at 10 and 15 ml, Peropal 250 WP at 100g and 500 FW at 50 ml; Hokko cyhexatin 500 WP at 50 g and a check. Spraying on the fruits was applied by a tower of Potter, at 2nd per fruit. The percentage of ovicide efficiency of each product was evaluated after 7 and 11 days of the application, based on the percentage of the egg hatching on the check less the percentage of the egg hatching on the treated fruits, divided by the percentage of the egg hatching on the check, times 100. The products evaluated were highly efficient as ovicides in the control of B. phoenicis, presenting the following percentage of efficiency: BAJ 2740 240 FW at 10 and 15 ml, 100% at 7 and 11 days after spray application; Peropal 250 WP and 500 FW, 96.4 and 100% at 7 days and 96.7 and 100% at 11 days; and Hokko cyhexatin 500 WP, 89.7c 90.7 at 7 and 11 days after spray application.

Index terms: Citrus sinensis, chemical control, mitecide, Tenuipalpidae,

[0054] EFFICIENCY OF BAJ 2740 (SPIRODICLOFEN) 240 FW AND PEROPAL (AZOCYCLOTIN) 250 WP AND 500 FW IN THE CONTROL OF CITRUS LEPROSIS MITE IN CITRUS ORCHARD

C.A.L. Oliveira¹ & M. L. Oliveira¹, ¹Dept. de Fitossanidade, FCAV/UNESP, Jaboticabal, 14870-000, Brazil, E-mail: amadeu@fcav.unesp.br

The Brevipalpus phoenicis mite, vector of the virus of the citrus leprosis (CitLV) is one of the major pest in the system phytosanity management in citrus orchards. Aiming to evaluate the mitecides action of BAJ 2740 240 FW and Peropal 250 WP and 500 FW, two field trials were conducted, in 1998 and 1999, respectively located at Olímpia (trial 1) and Bebedouro (trial 2), State of São Paulo, important citrus regions in Brazil. Both experiments were installed in orange orchards cv Pêra-Rio, with 8 and 12 years old. A randomized block design with 4 replications was adopted. Each experimental plot consisted of three citrus tree, considering as useful tree the central one. In trail 1, there has been installed the following treatments, whose spray volumes are expressed in g or ml of the product formulated by 100 L of water: BAJ 2740 240 FW at 20 and 40 ml; Peropal 250 WP at 100 g and a check. In trial 2, there has been tested: BAJ 2740 240 FW at 10, 15 and 20 ml and Peropal 250 WP at 100 g and 500 FW at 50 ml and a check. Spraying was performed in June, 16, 1998 and August, 10, 1999, respectively, to trials 1 and 2, using a spray gun with D6 nozzle, pressure of 300 p.s.i., applying 10 L of spray solution per tree. Population assessment was counted before and after the spray solution applications, 10 fruits from each tree were sampled. The mites were removed from the fruits by means of a mite-brushing machine and counted under a stereoscopic microscope. The results of trial 1 evidenced that, BAJ 2740 240 FW at 20 and 40 ml presented high control efficiency on B. phoenicis, with 100% of reduction of mite population 128 days after spraying, and Peropal 250 WP at 100 g presented efficiency of 98.5%. In trial 2, it was verified, after 72 days of spraying, reductions of 100% for BAJ 2740 at all the dosage rate tested and at 91 days reductions of 99.5, 100 and 100% at dosage rate of 10, 15 and 20 ml, while for Peropal 250 WP and 500 FW were verified reductions of 88.7 and 73.6% at 72 days and 30.3 and 14.6% at 91 days, respectively.

Index terms: Brevipalpus phoenicis, Citrus sinensis, chemical control, mitecide.

[0056] CONTROL OF PHYLLOCOPTRUTA OLEIVORA IN CITRUS WITH SPIRODICLOFEN AND AZOCYCLO'IIN

C.A.L. Oliveira¹ & M.L. Oliveira¹, ¹Depart. de Fitossanidade, FCAV/UNESP, Jaboticabal, 14870-000, Brazil, E-mail: amadeu@fcav.unesp.br

The citrus rust mite is considered one of the major pest in citrus orchard in Brazil, due to the damages that it caused on fruit. Besides the qualitative damages, the mites cause quantitative yield reductions, and their control have been through the use of mitecides, that should be efficient and selective to assist to the necessary requirements for an appropriate management. The present work evaluated the mitecide action of spirodiclofen (BAJ 2740 240 FW) and azocyclotin (Peropal 250 WP and 500 FW) in the control of P. oleivora in citrus orchards. The experiment was carried out in a citrus orchard cv Pêra-Rio, 17 years of age, planted in the spacing of 7 x 6 meters, located in Bebedouro, State of São Paulo. A randomized block statistical design was adopted, with 6 treatments and 4 replications. Each experimental plot consisted of three citrus trees, having been considered as useful, the central one. The spraying volumes were expressed in g or ml of the product formulated by 100L of water: BAJ 2740 240 FW at 10, 15 and 20 ml; Peropal 250 WP at 100g and 500 FW at 50 ml and a check. Spraying was performed in November, 11, 1998 in morning period, at 31.9°C, 61.5% RH and wind speed of 6.4 km/h, using a spray gun with D6 nozzle, pressure of 300 p.s.i., using 2000 L of spray solution/ha. The pH of the water determined by occasion of the application was of 5,8. Population assessment was counted before and after the spraying, it has been collected 15 leaves, which were conditioned in paper sacks and immediately transported to the Acarology Laboratory at the FCAV/UNESP, Jaboticabal, SP, for evaluation. The samples of each plot were submitted to a mite-brushing machine and the mites were counted under a stereoscopic microscope. The results evidenced that BAJ 2740 240 FW at 10, 15 and 20 ml were highly efficient in the control of citrus rust mite *P. oleivora*, presenting reductions of 97.6, 100 and 99.3%, respectively after 40 days of spraying. Peropal 250 WP and 500 FW were inferior to BAJ 2740, presenting reductions of 71.7 and 66.9%. Peropal formulation FW was superior to WP in the control of the P. oleivora.

Index terms: Eriophyidae, chemical control, Citrus sinensis, citrus rust mite.

[0057] MITECIDE ACTION OF SPIRODICLOFEN AND AZOCYCLOTIN ON POLYPHAGOTARSONEMUS LATUS ON CITRUS

C.A.L. Oliveira¹ & M.L. Oliveira¹, ¹Depart. de Fitossanidade, FCAV/UNESP, Jaboticabal, 14870-000, Brazil, E-mail: amadeu@fcav.unesp.br

The broad mite P. latus, is an important pest of many plants cultivated that are attacked specially in their new parts and fruits. Its occurrence on citrus in Brazil, has been more intense on Tahiti lemon, due to its several flowerings during the year, however, it has also been infesting sweet orange orchards. Its damage is more evident on fruits, is characterized by a decoloration or opaqueness, manifested later as silvering of the surface. The aim of this work was to evaluate the mitecide efficiency of spirodiclofen and azocyclotin to control mites in a citrus orchard ev Pêra-Rio, 17 years of age, planted in spacing of 7x6 meters, located at Bebedouro, State of São Paulo. The adopted statistical design was a randomized block with 6 treatments and 4 blocks. Each experimental plot consisted of 3 citrus trees, considering as useful plant, the central one. The treatments, whose spray volumes were expressed in g or ml of the product formulated by 100L of water were: BAJ 2740 240 FW at 10, 15 and 20 ml; Peropal 250 WP at 100 g and 500 FW at 50 ml and a check. Spraying was performed in November of 1998, in the morning period, 32°C, 62% RH and air speed of 6 km/h, using a spray gun with D6 nozzle, pressure of 300 p.s.i., using 10 L of spray solution/plant. The pH of the water used in spraying was 5,8. Population assessment was counted in the field trials, before and after spraying, with a magnifying glass in 10 new fruits, random chosen around the top of the plants. The results showed that BAJ 2740 240 FW at 10, 15 and 20 ml and Peropal 250 WP and 500 FW at 100g and 50ml, respectively, were highly efficient to control P. latus on citrus, presenting 100% of reduction of the mite population at 20 days after spraying, occasion in that was closed the population assessment due to the accentuated decrease in the check treatment.

Index terms: Tarsonemidae, chemical control, Citrus sinensis.

[0059] OCCURRENCE OF LATENT MITE PEST AFTER BIOLOGICAL CONTROL OF DOMINANT SPIDER MITE BY INTRODUCED NATURAL ENEMY AND EFFICIENCY OF INDIGENOUS PHYTOSEILD MITE

<u>Mh. Osakabe,</u> Dept. of Plant Protection, National Agriculture Research Center, 3-1-1 Kannondai, Tsukuba, Ibaraki 305-8666, Japan, E-mail mhosaka@narc.affrc.go.jp.

To control Tetranychus urticae, Phytoseiulus persimilis was released on commercially cultivated strawberries in a plastic greenhouse in western Japan in 1999. This resulted in good control of the mite pest. However, leaves of the strawberry were infested with Eotetranychus asiaticus after harvesting of the fruit (Teramoto, personal conununication) although strawberry had not been known as a host plant of this mite. E. asiaticus did not occur, however, on strawberries in another plastic greenhouse cultivated by the same farmer where P. persimilis was not released. It appeared that the use of P. persimilis as an agent of the biological control of T. urticae actually caused the occurrence of E. asiaticus. The efficiency of P. persimilis to control E. asiaticus was studied in laboratory experiments. Five adult females of E. asiaticus were placed on a detached strawberry leaf (3 cm sq.) and those of T. urticae were done on another detached leaf. After six days, these leaves were linked together by a small piece of filter paper soaked with water, and three adult P. persimilis females were then introduced to each leaf. T. urticae was quickly consumed and eliminated by the predator, which also preyed on E. asiaticus. However, several eggs or individuals of E. asiaticus survived the predation. As P. persimilis reproduced very few eggs and its offspring rarely grew to adults when they fed only on E. asiaticus, the predator was extinct after T. urticae was eradicated. Consequently, the E. asiaticus population again increased on the leaf. It was therefore assumed that the occurrence of E, asiaticus in the above greenhouse resulted from the feeding habits of P. persimilis. In the next experiment, the efficiency of two indigenous phytoseiid mites. Amblyseius californicus and A. womersley were tested using the same procedure. A. californicus exterminated E. asiaticus 24 days after its release, but reproduced very few eggs. The observed control effect was assumed to be due to immigration and attack by this predator that fed on T. urticae and increased. A. womersley, in contrast, preved on and exterminated E. asiaticus as it did on T. urticae. Moreover, this predator reproduced well on the leaves infested by both species of spider mites. Consequently, A. womersley is assumed to be the most efficient natural enemy of E. asiaticus.

Index terms: Eotetranychus asiaticus, Phytoseiulus persimilis, Amblyseius californicus, Amblyseius womersleyi, strawberry

[0058] ACTION OF THIAMETHOXAN ON THE POPULATION DYNAMICS OF THE BROAD MITE *POLYPHAGOTARSONEMUS LATUS* ON COTTON AND ITS SELECTIVITY TO PREDATOR MITE *EUSEIUS CONCORDIS*

C.A.L. Oliveira¹, R.L.B. Fontes¹, A.L. Matioli¹ & M.L. Oliveira¹, ¹Dept. de Fitossanidade, FCAV/UNESP, Jaboticabal, 14870-000, Brazil, E-mail: amadeu@fcav.unesp.br

The broad mite is an important pest of several crops in Brazil, responsible for significant quantitative and qualitative reductions of cotton yield. It has been evaluated, in field conditions, the action of thiamethoxan, that is not a mitecide, on the populacional assessment of broad mite, once, some chemical products applied on the crop causes an increase in mite population. It also has been evaluated, in laboratory, the selectivity of thiamethoxan to E. concordis, because it has been considered the more frequent predaceous mite on cotton crop. The field trail was conducted in a cotton crop or IAC-22, in a experimental area at the FCAV/UNESP, Jaboticabal, SP, Brazil, in 1998. The statistical analyses was performed in a randomized block design with 4 treatments in 6 blocks: thiamethoxan (Cruiser 3 g p.c. /1.0 kg seed); thiamethoxan (Actara WG 25 to 200 g p.c. /ha) and deltametrina (Decis 25 EC at 400 ml p.c./ha) both applied in spraying and a check. Each plot consisted of 6 lines of 15m. After spraying, populacional assessment of broad mite was carried out, and it was sampled two leaves of the top of 10 plants in the central lines of each plot, and the damages caused to the leaves were evaluated through a visual scale of notes that varies from 0 to 3. In laboratory, it was carried on a bioassay to evaluate the selectivity of thiamethoxan (Actara WG 25) to E. concordis for 1, 1/2, 1/4 and 1/16 and 0 of the recommended rate (200g p.c. /ha), 10 times replicated. Spraying was performed using a tower of Potter, applying 2 ml of the spray solution for each Petri dish containing 5 disks of cotton leaves, with 2,5 cm of diameter, on a cotton layer soaked in distilled water. After dryer the disks, it has been realized the transfer of two mites to each leave disk. The mites were fed during the bioassay with pollen of Typha sp. The thiamethoxan in the seed treatment (Cruiser) and sprayed (Actara) and, deltametrina (Decis) didn't cause populacional increases of P. latus on cotton crop. The thiomethoxan presents selective action to the predator mite E. concordis, causing reductions of 15.4, 23.1, 15.4 and 0% considering 24 hours after transferring the mites. Index terms: Tarsonemidae, phytoseiid, Gossypium hirsutum, ressurgence.

POPÚLATION ON CORN AT BAIXO ALENTEJO (PORTUGAL)
M. M. Pereira¹ & A. M. Mexia², ¹Escola Superior Agrária de Beja, Praceta Rainha D. Leonor, 7800-Beja, Portugal. E-mail: mmpereira@mail.pt; ²Instituto Superior de Agronomia,

Tapada da Ajuda, 1399 - Lisboa, Portugal.

[0060] FIELD EVALUATION OF SPIDER MITES (ACARI: TETRANYCHIDAE)

The spider mites Tetranychus spp. are maize pests in some areas of Europe and have the potential to develop high populations that may result in significant yield reductions. Feeding damage is therefore cumulative; mite feeding reduces chlorophyll content of leaves and may interfere with vascular tissue. In 1998, a field survey was conducted, at Baixo Alentejo (Portugal), in order to evaluate abundance and spatial distribution of mites in 3 maize fields. These maize fields were sampled on a weekly basis, from tassel to grain-filling growth stages, when maize is the best host for mites and their densities can increase rapidly. Each field sampling consisted of 3 groups of fifty leaves randomly selected and removed from each third of the plants (lower, middle and upper thirds); the samples, identified with the field, date and the third of plant sampled, were carefully observed at laboratory under a dissecting microscope; the number of mites (females and males) per leaf and the number of infested leaves were recorded. The average rate of plant damage was also determined, for each field under study, and for each plant third, using a 1-10 rating scale: 1= 1-10 % of the leaf area damaged by mite feeding to 10= 91-100 % of the leaf area damaged. Maize growth stage was recorded each week. The abundance and the within-plant distribution of these spider mites were described and the average plant damage rating was determined for each field. Index terms: Tetranychus spp., spider mites, population intensity, damage, maize.

[0061] DAMAGE AND POPULATION DISTRIBUTION OF BREVIPALPUS PHOENICIS ON GUAVA FRUIT, PSIDIUM GUAJAVA

<u>M. J. Quirós-González</u>¹ & N. C. Poleo¹, ¹University of Zulia, Agronomy Faculty, Museum of Arthropods, MALUZ, Núcleo Agropecuario, Maracaibo, Zulia State, Venezuela. E-mail: mquiroz@luz.ve.

Brevipalpus phoenicis is an important pest of guava in Zulia State. Venezuela, This study was conducted to determine the qualitative damage and distribution of B. phoenicis on guava fruit. From February to December 1998, 5 to 10 fruits/15 plants were harvested every 14 days for mite counting and damage observation. The damage and populations start very early with the fruit formation, about 10 days old. Mite Populations fluctuate on the fruit during 140 days of total fruit development. Two separate populations were observed, one at the apical end of the fruit, between the sepals (or remaining flower parts) and at the base of the sepals; while the other population establishes at the base of the fruit. Degree of damage were distinguished using a qualitative scale on each part, it was observed that the highest degree of damage (Grade 3=Severe) is reached first at the apical end of the fruit than at the base of the fruit. The mean number of mites are significantly different between the apical y basal ends. The population of mites at the apical end is always higher, up to 3 times, compared with that of the base of the fruit. B. phoenicis strategically prefers the apical end where the females find refuge at the innerside of the sepals (oldest fruit tissue) to lay the eggs, once the sepals food is depleted they and the future larvae and nymphs move to the concavities and tissues that surround the base of the sepals which is a meristematic kind of tissue. The mite populations that establish at the base become from females that walk from the nearest leaves and twigs and remain there for feeding. Exact location and initial timing for damage of the pest ensure the management success

Index terms: Tetranychoidea, Tenuipalpidae, False Spider Mites, Flat Mites

[0062] LABORATORY STUDIES ON THE LIFE HISTORY, POST-EMBRYONIC SURVIVAL AND OVIPOSITION OF THE PREDACEOUS MITE *CYDNODROMUS* SP. [ACARINA: PHYTOSEIIDAE] ON DIFFERENT KINDS OF FOOD SUBSTANCES

<u>S. Ragusa¹</u>, R. Vargas² & R. Asbach², ¹Istituto di Entomologia Agraria, Viale delle Scienze, 90128 Palermo, Italia. email: ragusa@unipa.it; ²INIA, Centro Experimental de Entomología La Cruz, Casilla 3 La Cruz, Chile. email: rvargas@lacruz.inja.cl

The effect of different kind of foods (pollen and prey) on development of *Cydnodromus* sp was determined in laboratory conditions. Biological parameters of *Cydnodromus* sp varied when different kind of foods were provided. From 50 to 62% of the individuals reached adulthood on *Oxalis* sp. and *Agrostis* sp. Postembryonic development was not successful on *Acacia* sp., *Carpobrotus* sp., *Citrus limon, Convolvulus* sp., *Cynodon* sp., *Pluchea* sp. and *Ricinus* sp. When *Cydnodromus* sp. fed on *T. urticae* and *P. citri* 100% of the inmature stages reached adulthood. The oviposition and longevity were observed on *Oxalis* sp., *Agrostis* sp., T. urticae and *P. citri*. It is discussed the potential use of these results in Integrated Mite Management programes.

Index terms: Phytoseids, Pollens, T. urticae, P. citri.

[0063] HOST RESISTANCE TO INSECTS AND MITES IN ZOYSIA SPP. FOR URBAN LANDSCAPES

J. A. Reinert & M. C. Engelke, Texas A&M Univ. Res. & Ext. Ctr., 17360 Coit Road, Dallas, TX 75252-6599, USA, E-mail j-reinert@tamu.edu.

Various species of Zoysiagrass (Zoysia matrella and Z. japonica) originating in the Orient are in use as durable turfgrass around the world for landscapes. Genetic plant resistance to pests including insects, mites and diseases is an effective, economical and environmentally sound control strategy and should be a major component of every turfgrass management program when resistant cultivars are available. In our program at Texas A&M University, Dallas, TX. USA, many cultivars and genotypes of Zoysia have been evaluated for pest resistance (insects, mites and diseases) and for low cultural input landscape grass. Resistance has been identified to fall armyworm (Spodoptera frugiperda) in the genotypes 'Cavalier' and DALZ8501. Resistance to tropical sod webworm (Herpetogramma phaeopteralis) was identified in Cavalier, DALZ8501, 'El Toro' and 'Korean Common'. Cavalier also expressed high resistance to the differential grasshopper (Melanoplus differentialis) which migrates into landscapes during drought years, and Cavalier and 'Diamond' provided resistance to tawny mole crickets (Scapteriscus vicinus). Additionally, DALZ9006, DALZ8516 DALZ8508 and 'Emerald' exhibited a high level of resistance to the host specific zoysiagrass mite (Eriophycs zoysiae). Several Zoysia genotypes have been identified with multiple pest resistance. Four new Zoysia cultivars (Diamond, Cavalier, Crowne, Palisades) with insect or mite resistance and other stress resistances have been released to the Turf Industry. In particular, Cavalier exhibits resistance to all four of the chewing insects evaluated.

Index terms: Spodoptera frugiperda, Herpetogramma phueopteralis, Eriophycs zoysiac, Scapteriscus vicinus, Melanoplus differentialis

[0064] POPULATION DYNAMICS OF *BREVIPALPUS PHOENICIS* ON DIFFERENT CITRUS VARIETIES IN BRAZIL: I - INFLUENCE OF CITRUS LEAF MINER INJURIES

J. C. V. Rodrigues¹ & O. Bonato², ¹ Centro de Energia Nuclear na Agricultura, Univ. de São Paulo, C. Postal 96, 13400-970 Piracicaba, SP, Brazil. E-mail: jevrodri@pira.cena.usp.br. / Centro de Citricultura –Inst. Agron. de Campinas; ² IRD (ex ORSTOM), EMBRAPA Meio Ambiente, C.P. 69, 13820-000 Jaguariúna, SP, Brazil.

Brevipalpus phoenicis (Acari: Tenuipalpidae), the vector of 'Citrus Leprosis Virus', is considered as a key-pest and periodic inspections are recommended for its control. The citrus leaf miner (CLM), Phyllocnistis citrella (Lepidoptera: Gracillariidae), was reported in São Paulo State region (Brazil) in March 1996. During its developmental process, this microlepidoptera mines the adaxial and abaxial surfaces of newly formed leaves. Because of their altered morphology, leaves can become a refuge and reproduction places for small insects and mites. The objective of this work was to compare the percentage of infestation of B. phoenicis between non-infested leaves and leaves infested by CLM in the region of São Paulo (Brazil). Then, 9 sweet-oranges varieties were examined: 'Valência' (1), 'Pêra-Rio' (2), 'Lima' (3), 'Bahia' (4), 'Seleta' (5), 'Barão' (6), 'Natal' (7), 'Lima verde' (8) and 'Hamilin' (9), and one of 'Persia Lime' (10), all grafted on *Citrus limonia*. The experimental design was, for each variety, randomised blocks of 12 plants of two years old. Six plants were infested with 30-40 infected adult females of B. phoenicis/plant. The six non-infested ones were kept as control and received periodic pesticide treatments. Mite populations were monitored monthly from August 1997 to August 1998. At each sampling procedure, 4 leaves without and 4 leaves with CLM injuries were collected at random inside of each infested plant and 8 mature leaves were collected for each plant belonging to control. In the laboratory, the presence of B. phoenicis (eggs, immatures and adults) were observed under binocular. For all varieties at all sampling dates no mites were found on control. Statistical analyses revealed significant differences between CLM infested plants and non infested ones The observed percentage of leaves with B. phoenicis was significantly greater on CLM infested plants of all varieties except for 'Pêra-Rio' (2) and 'Persia Lime' (10) (P <0,05, Sinal tests). The number of mites recorded was significantly higher on CLM infested leaves than on non infested ones, for all varieties except 'Seleta' (5) (P <0,05, Sinal tests). These results indicated that the introduction of a new element inside a complex system like citrus orchard can lead important implications from a pest management point of view. In our case the new element, i.e., CLM, can indirectly enhance mite infestations and thus shift the system equilibrium and finally increase disease damages.

Index terms: Leprosis mite, Phyllocnistis citrella, 'Citrus Leprosis Virus', pests interactions

[0065] POPULATION DYNAMICS OF *BREVIPALPUS PHOENICIS* ON DIFFERENT CITRUS VARIETIES IN BRAZIL: II - INFLUENCE OF CITRUS VARIETY

J. C. V. Rodrigues^{1*}, O. Bonato² & N. L. Nogueira¹, ¹ Centro de Energia Nuclear na Agricultura, Univ. de São Paulo, C. Postal 96, 13400-970 Piracicaba, SP, Brazil. E-mail: jevrodri@pira.cena.usp.br. / * Centro de Citricultura –Inst. Agron. de Campinas; ² IRD (ex ORSTOM), EMBRAPA Meio Ambiente, C.P. 69, 13820-000 Jaguariúna, SP, Brazil.

In 1997, was estimated US\$ 75 million to mitecides acquisition by Brazilian citrus farmers for the control of leprosis mite, Brevipalpus phoenicis. This mite is vector of 'Citrus Leprosis Virus' and is a polyphagous and cosmopolite specie. Many physical and environmental factors interact to influence the likelihood of a mite and plant disease outbreak. Among these factors that contribute to mite dynamics the nutrition afforded by the host plant and its relative susceptibility or resistance to the mites. The objective of this work was to compare the infestation of B. phoenicis on differents citrus varieties in the Piracicaba region of São Paulo (Brazil). Then, 9 sweet-oranges varieties were examined: 'Valência' (1), 'Pêra-Rio' (2), 'Lima' (3), 'Bahia' (4), 'Seleta' (5), 'Barão' (6), 'Natal' (7), 'Lima verde' (8) and 'Hamlin' (9), and one of 'Pérsia Lime' (10), all grafted on Citrus limonia. The experimental design was, for each variety, randomized blocks of 12 plants of two years old. Six plants were infested (June 1996) with 30-40 infected adult females of B. phoenicis/plant. The six noninfested ones were kept as control and received periodic pesticide treatments. Mite populations were monitored monthly from August 1997 to August 1998. At each sampling procedure, 4 leaves without and 4 leaves with CLM injuries were collected at random inside of each infested plant and 8 mature leaves were collected for each plant belonging to control. In the laboratory, the presence of B. phoenicis (eggs, inunatures and adults) were observed under binocular. For all varieties at all sampling dates no mites were found on control. Statistical analyses by Kruskal-Wallis Tests in dates from infested plants revealed significant differences among varieties: (A) The mite number/infested leaf was great on (3, 9,8)>(4,1,6)>10>2>5>7 varieties, (B) the mite number/infested plant was great on (3, 9,8)>(4,1)>6>10>(2,5,7) varieties, and (C) the observed percentage of infested plants was 3>(9,8,4,1,6)>(10,2,5,7) (P≤0.001). On the other hand, the observed percentage of infested leaves/infested plants was not significantly different (P≤0.07) among varieties. The (3) variety showed the maximum value on (A), (B) and (C), however this variety has not showed the maximum leprosis disease index, what can be indicating distinct resistance mechanism on citrus varieties to mite and leprosis virus. The variety factor should be consider in citrus IPM programs that have leprosis mite as a key-pest.

Index terms: Leprosis mite, sweet orange, 'Citrus Leprosis Virus'

[0066] INVESTIGATIONS OF THE SOIL DWELLING PREDATORY GAMASINA MITES (ACARI, MESOSTIGMATA) IN LATVIA

I. Salmane, Inst. of Biol., LU, LV-2169, Salaspils, Latvia, e-mail: incis@email.lubi.edu.lv

Material collected from the diverse habitats in the territory of Latvia (Eastern Europe) was investigated. The highest species diversity was found in the salty coastal meadows. Driftline (washed ashore material), xerophytic and hygro-mesophytic habitats were investigated here and 85 Gamasina species recorded. All the selected habitats showed high diversity of Gamasina mites, altogether giving about 1/3 of Gamasina species known in Latvia. Among the coastal meadow habitats as the richest in species were stated hygro-mesophytic habitats with 62 Gamasina species. In the xerophytic and driftline habitats 46 and 40 species, respectively, were found. As the most frequent species in coastal meadows were stated Holoparasitus excipuliger, Pergamasus vagabundus, Hypoaspis praesternalis, Hypoaspis aculeifer and Cheiroseius borealis. Sixteen species here were recorded for the first time in fauna of Latvia. Comparison with inland meadow fauna was made. About 1/3 of the species were found in both coastal and inland meadows, but they differed by the structure of dominance. Along the sea coast of Latvia 113 Gamasina species were recorded. As the most diverse were found driftline habitats with 60 Gamasina species. Thirty-five species were collected from the primary and yellow dunes. Primary dune habitats were stated as the poorest with only 22 Gamasina species. Thinoseius spinosus, Halolaelaps balticus, Halolaelaps incisus, Parasitus halophilus and Veigaia nemorensis were found as the most numerous in the seashore habitats. Thirty-four species from the seashore habitats were stated for the first time in fauna of Latvia. Sampling was made in the pine forest stands of different age and altogether 40 Gamasina species were recorded. The oldest pine forest stand (150-200 years old) was the richest in Gamasina species. Thirty species were registered here, as well as the number of specimens here was the highest. The middle-age stand (60-80 years) and the youngest one (40-50 years) had 25 and 22 Gamasina species, respectively. Only 14 species most of them known as ubiquitous were stated as common for all three pine forest stands. The most abundant Gamasina species in the pine forest soils were determined Veigaia nemorensis and Parazercon sarekensis. Some case study in the beech forest soils also was made and 15 species were determined here. From them the most frequent were Veigaia nemorensis, Pergamasus vagabundus and Pergamasus lapponicus. Altogether about 170 species were registered from the investigated habitats in Latvia, thirty-six of them were recorded as new for fauna of Latvia.

Index terms: Veigaia nemorensis, coastal habitats, forest soils, species diversity

[0067] POLIPHAGOTARSONEMUS LATUS (ACARI: TARSONEMIDAE) DAMAGES IN "ERVA-MATE" SEEDLINGS

D. L. O. Santana¹; L. F. A. Angeli² & P. S. B. Pucci³, ¹ Embrapa Florestas, Estrada da Ribeira, Km111, Colombo, PR. C. P. 319, 83411-000 - Colombo - PR francis.santana@bbs2.sul.com.br ²Dept. Zool. UFPR, C. P. 19020, 81531-990, Curitiba, PR. ³Dept. Física. UFPR, C. P. Curitiba, PR.

It was observed in march 1999 a soaring of Poliphagotarsonemus latus mite in "erva-mate" (Ilex paraguariensis Hill.) seedlings in a nurserys located in São Mateus do Sul, Paraná State, Brazil. A sample of 300 seedlings of "erva-mate" was transferred to the glasshouse conditions and observed during three consecutive months. One part of this sample was maintained free of mites by chemical control, while the other was infested and the symptoms were observed. P. latus cause damage preferentially in young leaves. A few mites were found on leaves located in the half height position on the plants. It was rare to find mites in old leaves. In average, were observed 11,4 mites per leaf and at maximum 51 individuals/leaf. One week after infestation young leaves became wrinkled followed by an unequally growth of nervure with give the leaves an orange peel appearance. Afterwards the leaves fall or they became leather like with a slightly bronze colour. The upper part of the crown is the most damaged and when the attack is sever, only a few leaves remained. At the end of three months leaves were collected, oven dried and weighed. On average, infested plants loose 42% of the total biomass. Recovery of strongly attacked plants were observed two weeks after chemical control, with the development of new leaves. Deformed leaves were not able to recover. Index terms: Ilex paraguariensis pests, mite

[0068] NEW SPECIES OF ERIOPHOID MITES FOR WORLD FAUNA OCCURRING ON ORNAMENTAL PLANTS IN POLAND

<u>G.M Soika</u> & G.S. Labanowski, Research Institute of Pomology and Floriculture, 96-100 Skierniewice, POLAND.E-mail: gsoika @ insad.isk.skierniewice.pl

Up till now in Poland about 100 species of eriophyoid mites on ornamental shrubs and trees were found. Observations carried out during 1995-1999 in ornamental nurseries and Botanical Gardens showed on trees and shrubs 57 species of eriophoid mites new for Polish fauna including 18 species new for world fauna. Among species new for science only six were described and illustrated: Rhinophytoptus platani Boczek & Shi, 1995 on Platanus occidentalis L., Vasates viburnifoliae Boczek & Shi, 1995 on Viburnum lantana L., Epitrimerus taxifoliae Labanowski, 1999 on Pseudotsuga taxifolia Britt. and Phyllocoptes piceae Soika, 1999 on Picea abies Karst., Aculus cytisi Labanowski on Cytisus x praecox Bean 'Hollandia' and Tetra caraganae Soika on Caragana arborescens Lam. Other 12 identified species of eriophoid mites remains for description in short time: Aceria sp. nov. on Aesculus x carnea Hayne and Berberis thunbergii DC. 'Aurea', Aculops sp. nov. on Syringa vulgaris L., Aculus sp. nov. on Fagus sylvatica L., Anthocoptes sp. nov. on Fraxinus excelsior L., Calepitrimerus sp. nov. on Crataegus laevigata DC. and Quercus robur L., Cupacarus sp. nov. on Fagus sylvatica, Epitrimerus sp. nov. and Eriophyes sp. nov. on Crataegus laevigata, Johnella sp. nov. on Quercus cerris L., Tegontus sp. nov. on Ligustrum vulgare L.

Index terms: Eriophyoidae, coniferales, decidious, trees, shrubs,

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[0069] INTERNATIONAL COOPERATION IN THE INSECT INVENTORY, THE INBIO EXPERIENCE IN COSTA RICA

<u>A. Solís</u>, Instituto Nacional de Biodiversidad, Apartado 22-3100, Santo Domingo de Heredia, Costa Rica. E-mail: asolis@inbio.ac.cr

As in most of our countries in Central and South America, the entomofaunistic knowledge in Costa Rica is poor. Historically we can separate the effort for getting entomological knowledge in 3 general phases: First, "The Biologia Centrali-americana phase" (1876 - 1912), coordinated by Frederick Godman y Osbert Salvin. In this phase the work was done with specimens gotten from European expeditions, mostly from British people, and the number of described species in this period showed a significant increase. Next, "The Sporadic work phase" (1913 -1989), period basically scattered of personal efforts from international experts, mostly from USA, and the rate of the species description was relatively low. Finally, the "INBio's Inventory of Insects phase". It started with INBio (1989 - 2000) but it is also part of the global boom about the conservation and biodiversity. This phase was initiated with the British collaboration (NHM) and simultaneously and afterward was followed up with a punctual collaboration mostly from USA, Mexican, Canadian, and European taxonomists with the development of inventory methodologies very particular. In 1994-97 into the "All Taxa Biodiversity Inventory" project and later into the "Development of the knowledge and the sustainable use of the Biodiversity" project, were established Working Groups in Coleoptera, Hymenoptera, Diptera and Lepidoptera, as part of a redesign of strategies process. Personnel of INBio, national universities people, and international expert entomologists integrated these groups. The mission of these groups was the design of strategies of inventory into 5 Conservation Areas. The general objective defined was "Decrease the lack of information about the insects, and make this information available to the people of Costa Rica and the rest of the world, for a rational use, and for the conservation and development". We are right now in the implementation phase of the strategies. We are showing to the world the collection work, infrastructure, processes, and methodologies accumulated through the last 10 years. We are making available the parataxonomists system, the data base information capture system, the bar code system, and an adequately curated and accessible collection, presented in a physical and computerized way. Also, a information publication system for facilitating the work of the international resourse denominated Taxasphere. We have established some agreements and have achieved some products.

Index terms: Neotropics, Biodiversity, Taxasphere.

[0071] REPELLENCY OF GREEN ONION TO THE TWO-SPOTTED SPIDER MITE

G. Tito, <u>N.E. Sánchez</u> & M. Theiller, Centro de Estudios Parasitológicos y de Vectores, Univ. Nacional de La Plata, CONICET, 2 N° 584 (1900) La Plata, Argentina. E-mail cepave@museo.fcnym.unlp.edu.ar

Alternative cropping systems may improve or replace conventional management practices relying on chemical pesticides as the only control tactic. The association of green onion (*Allium cepa*) with strawberry crop in commercial greenhouses of La Plata showed reductions in *Tetranychus urticae* Koch (Acari: Tetranychidae) populations, one of the most serious arthropod pests affecting strawberry. Associated plants may affect an individual's ability to find the host plant. Encountering a nonpreferred host may increase the probability of a faster or further emigration, increasing the likelihood of leaving the crop. Moreover, allelochemical factors present in non host plant may act as repellents that direct herbivorours away from plants. The objective of this study was to investigate whether or not green onion has a repellent effect on *T. urticae*. The experiment was conducted using glass containers (5 cm wide by 25 cm long by 5 cm deep). One leaflet belonging to a strawberry plant growing in a pot was inserted into holes at two opposite facing walls of the containers. One cut

strawberry leaflet infested with 30 T. urticae individuals was placed on the floor at one end. Two treatments were evaluated : 1) Green onion: the floor and the walls at the end of the container where the infested leaflet was placed, were rubbed with green onion sap. 2) Control: with no green onion sap. Each treatment was replicated 50 times and the containers were placed randomly in an experimental greenhouse. After 24 hours, the number of individuals on each leaflet at both ends of the containers were counted. The data were square-root transformed and analysed by ANOVA. T. urlicae emigration was significantly affected by treatment. The number of individuals colonizing the leaflet at the opposite end to where the infested leaflet was placed was higher in the green onion treatment (F= 5.05; df =1,78; P< 0.03), while in the control a higher number colonized the closest leaflet (F= 4.37; df=1,78; P< 0.04). The number of individuals that did not colonize any leaflet was higher in green onion treatment, although the differences were not significant (F= 0.4; df= 1,78; P> 0.53). We believe that these results are related to volatile allelochemicals present in green onion that produce an effect of repellency to T. urticae, leading to higher levels of emigration. Further chemical analysis will increase our understanding of the effect of green onion on T. urticae abundance and the feasibility of the association as a potential management tactic. Index terms: Tetranychus urticae, Allium cepa, repellents, alternative cropping systems.

[0070] TOXIC AND MUTAGENIC EFFECTS OF A FEW CARBAMATE PESTICIDES ON SILKWORM BOMBYX MORI

<u>G. Subramanya¹</u>, Hiriyanna & S. A. Deepak, ¹Department of Studies in Sericultural Science, University of Mysore, Manasagangotri, Mysore-570 006, India. E-mail: Subramang@hotmail.com

Several carbamate pesticides are widely used to control fungal diseases during silkworm culturing and mulberry cultivation. In the present investigations four carbamate pesticides were selected namely Dithane M45, Benlate, Bavistin and Captan witch were very commonly used fungicides to eradicate fungal diseases of silkworm and mulberry. The stress has been laid on the utilization of silkworm *Bombyx mori* for environmental toxicity and mutagenecity. In view of this, the above pesticides were analysed for their effects by administering the pesticides through different methods to silkworm. The mutagenic effects of the pesticides were analysed through dominant lethal and specific locus test. Different sub-lethal concentrations of 100 ppm to 800 ppm were used. The results have revealed that at higher concentrations all the four pesticides produced toxic effects and dominant lethals. Contrary to this, only Dithane M-45 revealed the tendency to produce mutations at *pe and re* locus at higher concentration. The importance of the pesticides in Sericiculture with a stress on the utilization of silkworm *Bombyx mori* as test system to screen environmental toxicants and mutagens are discussed.

Index terms: Silkworm, Bombyx mori, Dominant lethals, Specific locus, toxicity

[0072] POPULATIONAL FLOTATION OF ACARI EDAPHICS ON TILLAGE AND NO TILLAGE SYSTEMS IN THE AREA OF DOURADOS – MS

<u>M.H.P.Vieira</u>¹, H. R. Santos², P. E. Degrande² & W. D. Fernades¹, ¹DEB/CEUD/UFMS, Caixa Postal 322 CEP-79825-070, Dourados-MS, E-mail: mhveira@zaz.com.br. ²DCA/UFMS, Caixa Postal 533 CEP: ídem, Dourados-MS, E-mail: hrsantos@ceud.ufms.br.

This work was carried out in field and in the laboratory of Entomology of the NCA/UFMS, in Dourados, MS. The main objective was to study the to dinamic populacional of mites, in proper agricultural soils for the production of grains and hadlings under the systems of no tillage and tillage. The experiment was conducted driven entirely under an experimental accidental outline, in an outline fatorial 24 x 2, with three repetitions. The field collections were made from July 1996 to June of 1998, being used of the of Berlese funnel (modified). For the extration of mites, the soil samples were placed in the same position for seven days. After identified, with base in the obtained results, we get to the conclusion that, the accentuated falls of the population were attributed to the implantation of cultures in the system of tillage, with drastic effects in function of the methods of preparation of the soil. There are indications that the fall observed in the population under the system of direct plantation á factors abióticos is associated. The largest pick populacional can be possibly attributed to unbalances provoked by the herbicids application and larger indexes pluviometrics happened in the corresponding period. The population of mites in the system of no tillage was larger than in the system of tillage. Sazonalidade didn't influence the number of the edaphic population of organisms.

Index terms: Population, mites, tillage no tillage

[0073] STABILITY ANALYSIS IN A CLASSICAL PREDATOR-PREY MODEL: EXAMPLE OF CASSAVA MITES SYSTEM

A. C. S. Vilcarromero¹, T. Ohishi¹, <u>O. Bonato</u>^{2,3}, ¹DENSIS/FEEC/Unicamp, C.P. 6101, 13083-970, Campinas, São Paulo, Brasil; ²IRD (ex-ORSTOM), França; ³Embrapa Meio Ambiente, C.P. 69, 13820-000, Jaguariúna, São Paulo, Brasil, E-mail : angela@densis.fee.unicamp.br.

Phytophagous mites belonging to Tetranychidae family are one of the major constraints for cassava crop. Among them, the cassava green mite Mononychellus tanajoa is the most economically important in South America where it comes from, and in Africa where it was accidently introduced in the 1970ies. In Brazil, M. Tanajoa is most abundant in the Nordeste region and high yield losses (untill 50% of dry matter) are reported. Ecological and biological studies suggested that phytoseiid mites would be the most approriate predators to control M. Tanajoa. The objective of this work was to analyse the stability of a predator-prey model with special reference to cassava system where M. Tanajoa is the prey and Typhlodromalus aripo the predator. T. aripo, native from Brazil, is a phytoseiid frequently found in association with M. tanajoa in brazilian cassava fields. Besides, in the context of M. tanajoa control programmes, this predator was recently released and established with success in Africa. Our study consisted to analyse mathematically the effect of changing the functional response in the predator-prey Rosenzweig-MacArthur type model: dH/dt = rH (1-H/K) - aPF(H) and dP/dt = sP + bPF(H), where H and P = populations of prey and predator, respectively, t = time, a, b, r, s = constants, F(H) = functional response. Four functional responses were choosen: 1) Ivlev (1961): $F(x) = b \cdot (1 - exp(-a \cdot x));$ 2) Holling (1959): $F(x) = a \cdot x/(1 + a \cdot T \cdot x);$ 3) Rosenzweig (1971): $F(x) = a \cdot x^{s};$ 4) Takahashi (1964): $F(x) = a \cdot x^{2}/(x^{2} + b^{2})$. Numerical simulations were done to show qualitative differences between functional responses. Mathematical analyses of equations allowed interpretation of numerical results and exploration of structural stability. Use of functional response (2) gave numerous oscillations showing high sensibility to parameters used. Function (3) also showed numerous oscillations and/or extinction of populations. From a mathematical point of view these two functions are inapropriate to represent interactions between predator and prey because populations never reach an equilibrium or extinguish. The adequate functions would be (1) and (4). They showed little oscillations but they stabilize very quickly. From a mathematical point of view, the function (4) would be the best one because stability was reached faster. However, numerous biological studies have shown that no or little predatory mite species display trophic interactions leading to behave as function (4) shows. Therefore, from both biological and mathematical point of view, the functional response (1), the Ivley model, seems to be the best for representing interactions.

Index terms: sensibiliy analysis, functional response, M. tanajoa, T. aripo

[0074] NUMBER OF PREY NECESSARY FOR COMPLETING DEVELOPMENT OF CHEYLETUS ERUDITUS (ACARINA: CHEYLETIDAE.)

E. Zdárková & P. Horák, Res. Inst.Crop Production, Drnovská 507, 161 06 Prague 6, Czech Republic, E-mail: Zdarkova@hb.vurv.cz.

Biological control is a part of the integrated pest management of stored food mites. The predator used is *Cheyletus eruditus* (Schrank). In order to optimise the technique it is desirable to have all relevant information about this species. It is already known that (1) *C. eruditus* is resistant to low temperature and organophosphates, (2) it does not develop at temperatures below 12°C, (3) the length of its development lasts from 18 to 164 days depending on temperature, and (4) it prefers slowly moving prey species to fast moving ones. However, not much is known about its voracity. The aim of the present research was to fill this gap. Fifty larvae of C. eruditus were fed either by eggs, larvae, protonynphs, tritonymphs or adults of *Acarus siro* from hatching to the adult stage. No food related differences in the lengths of development of the predators were evident as far as the number of prey specimens consumed was concerned; individual developmental stages consumed prey of corresponding sizes. Larvae predominated in the food of all stages, while adults were consumed least frequently. The eggs were also eaten in spite of the fact that the predators prefer moving prey. Females that fed on adults and tritonymphs laid most eggs. Index terms: *Acarus siro*, biological control, voracity

[0075] NOTE ON A NEW LAELAPTID MITE FROM SHANXI PROVINCE, CHINA (ACARINA: LAELAPTIDAE)

<u>L-T. Zhang</u> & H.-J. Zhang, Dept. of Vector Biol. & Control, Inst. of Microbiol. & Epidemiol., 20 Dongdajie Str., Fengtai D., Beijing 100071, P. R. China, E-mail Zhangjt@nic.brni.ac.cn.

A new laelaptid mite collected from Yicheng County, Shanxi Province, northern China in Nov. 1995 off Apodemus speciosus is herewith described as follows: Laelaps shanxiensis sp. nov. Diagnoses: Allied to Laelaps nuttalli but is distinguishable by the following characters: 1) the distance between VI₄ longer than that of VI₁; 2) S₈ is as 2/3 long as S₇; 3) the sternal plate is pretty long with a deep concave at its posterior margin. Female: Elliptical in shape, 723 um long and 550 um width. Dorsal plate 696 um long aud 528 um width, almost covered over the dorsal part with 39 pairs of acicular setae. S & is as 1/2 long as M 11. Terminal part expanded of pilus dentilis of digitus fixus of chelicera with an acuminate apex, much similar to that of Laelaps turkestanicus. Middle anterior margin of sternal plate slightly narrowed(122 um long), and 165 um in length at the place of St 2, with a deep concave at the posterior margin, the top line of this concave reached the base of St 3. Apex of St $_1$ not reached the posterior margin of sternal plate, while that of St $_2$ extended beyond the margin. A pair of metasternal plate located at the place between the coxae of leg III and leg IV. Epigynial plate 310 um long, with an extreme width at the base line of VI 3 (119 um). The distance between VI 1 110 um, much longer than that of VI 1 (80 um). Metapodal plate ovoid in shape, 8~9 pairs of epithelial setae on the ventral epithelium. Anal plate 156 um long and 140 um width. Adanal setae located at the posterior margin line of anal pore with apexes reaching the base of postanal seta. A spiniform seta and an acicular seta set on the coxae of leg I, leg II and leg III, with the acicular seta located at the anterior margin of the coxa, while only an acicular seta set on the coxa of leg IV. Holotype, female, collected from Yicheng County of Shanxi Province, northern China in Nov. 1995 off Apodemus speciosus, deposited in the Collections Hall of the Institute of Microbiology and Epidemiology, Academy of Military Medical Sciences, PLA, China.

Index terms: Laelaps sherriensis, New species, Diagnostic characters

[0076] CAUSES OF MITE PEST OUTBREAKS IN BAMBOO FORESTS IN FUJIAN, CHINA: ANALYSES OF MITE DAMAGE IN MONOCULTURE VERSUS POLYCULTURE STANDS

<u>Y. X. Zhang¹</u>, ZQ. Zhang², L. X. Tong³ Q.Y. Liu⁴ & M.G. Song⁵, ¹Plant Protection Institute, Fujian Academy of Agricultural Sciences, Fuzhou 350013, China, E-mail: zyxlj@pub3.fz.fj.cn; ²Manaaki Whenua -Landcare Research, Private Bag 92-170, Auckland, New Zenland; ³Yongan City Forest Protection Office, Yongan, Fujian, China; ⁴Fujian Forest Protection Office, Fuzhou, China; ⁵Yanping District Forest Protection Office, Nanping, Fujian, China.

Damage caused by the phytophagous mites Schizotetranychus nanjingensis Ma & Yuan, Aponychus corpuzae Rimando and/or Aculus bambusae Kuang to the moso bamboo (Phyllostaychs pubescens) was examined for ten pairs of mono culture versus polyculture forests at six locations in Fujian, China. Mite damage in the monoculture forests (35%) was on average twice as high as that in the polyculture forests (17.5% < the injury level of 20%). The relative contribution of each mite species to total damage varied among sites, but Ap. corpuzae was the dominant pest at all sites except one, where S. nanjingensis was the major pest. Polyculture forests overall had more predatory mites than monoculture forests. Mite damage was inversely correlated with the altitudes of individual forests across sites. These results are discussed in light of ecological theories on the effects of plant diversity on animal abundance and suggestions for possible measures to control pest mites on bamboo in Fujian. Index terms: Acari, bamboo, outbreak, plant diversity, pest control. [0077] POTENTIAL OF AMBLYSEIUS CUCUMERIS (ACARI: PHYTOSEIIDAE) AS A BIOCONTROL AGENT AGAINST SCHIZOTETRANYCHUS NANJINGENSIS (ACARI: TETRANYCHIDAE) IN CHINA

<u>Y. X. Zhang¹</u>, Z. Q. Zhang², J. Z. Lin¹ & J Ji¹, ¹Institute of Plant Protection, Fujian Academy of Agricultural Sciences, Fuzhou 350013, China, E-mail: zyxlj@pub3.fz.fj.cn; ² Landcare Research, Private Bag 92170, Auckland, New Zealand.

The predatory mite Amblyseius cucumeris (Oudemans) was studied in the laboratory to evaluate its potential as a biocontrol agent against the spider mite Schizotetranychus nanjingensis Ma & Yuan, a pest of the moso bamboo in Fujian, China. When fed S. nanjingensis females and eggs, the life cycle of A. cucumeris (developmental time from egg to egg 7.68 days for the first generation and 7.80 days for the second generation) was as long as its life cycle on its normal diet in the laboratory, Tyrophagus putrescentiae (Schrank) (7.84 days) at 27-28°C. Adult females of A. cucumeris started to lay eggs at the age of 3 days with a daily rate of 1-4 eggs (average of 2.2) over a period of 7-18 days and a total fecundity of 35.8 (14-47) eggs. The number of prey consumed by predators increased with prey density and the number of eggs produced was directly correlated with the number of prey consumed. Female predators (6 versus 3 per day at 9 prey per leaf). A. cucumeris females were unable to invade intact webnests of S. nanjingensis but were able to invade and liked to stay and lay eggs in broken nests with existing openings or holes.

Index terms: Acari, spider mites, predatory mites, biocontrol, bamboo

[0078] SCARAB LARVAE - A WORLDWIDE PEST PROBLEM

A. C. Bellotti¹, D. Peck¹, ¹Integrated Pest and Disease Management, CIAT, A.A. 6713, Cali, Colombia, E-mail A.Bellotti@cgiar.org, E-mail D.Peck@cgiar.org.

Soil dwelling arthropods are among the most destructive and troublesome of agricultural pests. Although research has intensified in recent years, and knowledge of the biology, behavior and ecology has improved, there is still a lack of information on the damage and management of soil insects. White grubs, the larval stage of certain scarabaeids (Fam: Scarabaeidae) are important soil welling pests that damage a wide range of crops throughout the tropical and temperate regions of the world. Crop damage is reported from North, South and Central America, Africa, Europe and Asia, as well as Australia and New Zealand. Damage is manifested by grubs feeding on the roots of numerous plant species causing plant degradation and death of young plants and seedlings: Adult beetles can feed on plant foliage which may contribute to yield loss. The white grub complex, especially in tropical ecosystems, is characterized by considerable species richness. In Colombia more than 575 species, belonging to 107 genera, have been recorded, and 22 species have been identified as agricultural pests. Similar species diversity is also reported from Panama, Brazil and Mexico. Worldwide, the most important genera include Phyllophaga, Cyclocephala, Costelytra, Anisoplia, Melolontha, Lipidiota, Ligyras, Hypopholes, Holotrichia, Phytalus, Dermolepida and Amphimallon. Despite their importance, there is a dearth of information on economic damage to agricultural crops due to white grubs. There are literature reports of yield losses on surgarcane (28 to 39%), beans (70 to 80%), potatoes (40 to 60%), maize (30 to 50%), sorghum (27%), asparagus (12 to 15% damaged spears), peanut (50%), roses (10 to 20%), rice (20 to 25% plant loss), cassava (95% loss in stake germination); damage to sugarcane by cane grules in Australia has been estimated at 10 million dollars annually. Additional crops reported as damaged by white grubs include to mator, grape, citrus, wheat, barley, pastures, onion, cotton, sunflower, coffee, and numerous fruits, vegetables and ornamentals. Toxic soil pesticides are frequently used by rural farmers to control grubs; these applications have been linked to soil and water contamination and human health problems, especially in developing countries. Index terms: Phyllophaga spp., white grubs, crop damage, yield loss.

[0079] TAXONOMY AND BIOLOGY OF THE SCARABAEIDAE

<u>M. A. Morón</u>, Departamento de Entomología, Instituto de Ecología, A.C. P.O. Box 63, Xalapa, Veracruz 91000, MÉXICO, E-mail moron_ma@ecologia.edu.mx.

Chafer beetles and their larvae, known as white grubs, are well known around the world. Some white grub species cause damage to the roots of a wide range of crops in many regions. Most of the injurious species are included in the genera Melolontha, Rhizotrogus, Phyllophaga, Holotrichia, Schizonycha, Brahmina, Lepidiota, and Costelytra (Melolonthinae) or Anomala (Rutelinae). Studies on the species taxonomy, larval identities, detailed life histories, food preferences and reproductive behaviour are scarce and sparse or incomplete and inaccurate. Field data from 1960 to the present indicate that white grubs constitute a major pest of food and industrial crops, rangelands, forests, and recreational areas in nearly all parts of the world. However, the patchy distribution of white grubs and sporadic nature of damage, each 3-5 years, makes it difficult to convince farmers or technicians to take adequate control measures when they are needed. Apparently, some species have a wide host range including both crop and weed species, as well as a wide ecological and geographical range. Severe damage frequently occurs in maize, potato, sugarcane, peanuts, beans, chili-pepper, sweet-potato, carrot, cabbage, onion, pastures, and ornamental flowers. One of the main problems in management of white grubs is the great diversity of species. For example, more than 340 species of Phyllophaga have been described from Mexico and Central America. They are distributed in 8 subgenera, and 44 groups of species. The high number of Phyllophaga species represent nearly 60% of the Melolonthinae species found in the region. It is certain that the relatively low number of species reported from some countries is mostly due to lack of information. The coexistence of several species from one or more genera in a site must influence the results from any control action. Unfortunately, species diversity is rarely taken into account in reports of control of white grubs. Great diversity of species, found in every biome, clearly indicates that scarabs are still going through a diversification process, and in many cases taking advantage of the agricultural monocultures that humans have established. For each species identified as a pest, there are 16 others that could potentially substitute for it as plant pests. Apparently, these beetles are using only 13% of their adaptive potential on cultivated plants. The list of host plants of larvae and adults of Melolonthinae larvae and adults include species from at least 57 plant families. Thus, to meet the challenge of these pests there is a need for precise identification of the species included in the white grub complex. There is also an urgent need for information on their life cycles, food preferences, natural enemies and other factors that limit their spread and influence their response to different control techniques. Index terms: White grubs, Melolonthinae, pests, biology, taxonomy

[0080] LARVAL BEHAVIOUR IN THE SCARABAEIDAE

<u>M. G. Villani</u>, Department of Entomology, NYSAES, Cornell University, Geneva, NY 14456, USA, email: mgv1@nysaes.cornell.edu

Movement patterns of Japanese beetle, Popillia japonica Newman and European chafer Rhizotrogus majalis (Razoumowsky) grubs as influenced by gravity, host plant position, and external disturbances were studied in laboratory soil-turfgrass microcosms. Second instal grubs through third instars just prior to pupation were monitored using radiographic techniques. Neonates were monitored using destructive sampling. Results indicate significantly different movement patterns between species and among age groups. The development stage of the grub had a large effect on Japanese beetle grub behavior and a measurable, if lesser effect, on European chafers. All life stages of European chafers and all stages of Japanese beetle, except neonates and post -overwintering third instars, displayed a downward movement in response to disturbance. Neonate Japanese beetles showed little movement while post-overwintering Japanese beetles moved upward when disturbed. European chafers of all age classes displayed random vertical movement with some arrestment in or near sod. Pre-overwintering and post-overwintering third instar chafers showed less dramatic arrestment behavior than other instars tested. Second instar Japanese beetles behaved similar to European chafers, however, third instars behaved very differently. All third instars except those tested in late winter and early spring showed some inate downward movement in the soil microcosms. Japanese beetles tested in late winter displayed random movement with some arrestment in sod while those tested in early spring exhibited upward movement and arrestment in sod. Fluctuations in temperature had little impact on the position of European chafer grubs, in contrast, Japanese beetle grubs moved from the upper root zone downward with the onset of cooling soil (14° C) and returned to the surface as temperatures increased. Radiographs of soil blocks containing third instar grubs indicated that both species respond to simulated irrigation and drought. Individual grubs moved upward after the addition of moisture in dry soils.

Index terms: scarab, grub, soil insects, movement, behavior

[0081] TOWARDS THE MANAGEMENT OF SCARAB BEETLES WITH SYNTHETIC SEX PHEROMONES AND OTHER SEMIOCHEMICALS

W. S. Leal, Dept. Entomology, University of California, Davis CA 95616, USA, Email: wsleal@ucdavis.edu

Most of the research programs concerning the identification of pheromones and other semiochemicals with potential application for scarab beetle management have focused on the subfamilies Cetoniinae, Melolonthinae, Dynastinae, and Rutelinae because of the economic importance of these groups as agricultural and/or turt pests. In addition to the identification of male-released aggregation pheromones for a few dynastines, various female-released sex pheromones have been identified in rutelines and melolonthines. Utilizing pheromone blends that consist of just a few semiochemicals or even a single constituent, closely related scarab species in Japan have attained separate chemical communication channels and reproductive isolation. Chiral pheromones play a pivotal role in the isolation of Popillia japonica and Anomala osakana, which share the same habitat in parts of the Japanese archipelago. The Osaka beetle produces and responds only to (S)iaponilure, the activity of which is completely inhibited by the presence of (R)-japonilure, the sex pheromone of the Japanese beetle. Examination of the olfactory perception in scarab beetles demonstrated that most scarab beetles cannot detect nonnatural enantiomers of their chiral pheromones (enantiomeric anosmia) and that the agonist-antagonist effect of the enantiomeric pheromones is more the exception than the rule. The synthetic pheromones and other plant-derived semiochemicals can be used to monitor the level of scarab populations as well as for quarantine. Although there is no direct evidence that the application of pheromones has an effect on suppressing scarab populations, some pheromone systems have been used in Japan for pest control.

Index terms: Anomala osakana, Popillia japonica, Rutelinae, Melolonthinae
100821 NATURAL ENEMIES OF THE SCARABAEIDAE

A. Jackson, AgResearch, PO Box 60, Lincoln, New Zealand. Email T. jacksont@agresearch.cri.nz.

Beetles of the Scarabaeidae often occur at high densities providing abundant resources for predators, parasites and pathogens. Vertebrate predators, mammals and birds, can consume high numbers of insects, but will often cause more damage than the insects themselves while searching through the soil. Flocks of birds, such as starlings, can be an indicator of high densities of scarab larvae below the ground. In cultivated land, improved grasslands and amenity turf, invertebrate predators of scarabs are usually rare, but these may be more common in old natural grasslands. Scarabaeids can be parasitised by scoliid and tiphiid wasps and tachinid flies. Levels of parasitism are highest at grassland/forest margins, which has led to the suggestion that planting of appropriate trees in agricultural land could increase the impact of parasitoids on scarab pest populations. While predators and parasitoids generally have only a localised impact on scarab populations, the impact of pathogens can be far greater. Scarabaeids are hosts to a wide range of nematodes and insect diseases, including a number of species which are only known from this insect family. Nematodes of the genus Psammomermis have a world-wide distribution, but are only found as parasites of scarab larvae. The bacteria Paenibacillus popilliae and Serratia entomophila and the Oryctes virus are only infective to scarabaeids and have been used in pest management of this group. The occurrence of a large number of pathogens, many of which are family and even species specific, reflects the evolution of this family for more than 200 million years in the microbially-rich soil environment Natural enemies often respond to their hosts in a density-dependent manner. Suppression of scarab natural enemies together with their hosts by the use of broad-spectrum insecticides has frequently led to pest resurgence. Where cropping practices and environmental management have led to outbreaks and high densities of scarabs, management to exploit the benefit of natural enemies should be an integral part of IPM systems.

Index terms: predator, parasite, pathogen, disease, density-dependence

[0084] MANAGEMENT OF RHINOCEROS BEETLES IN MALAYSIA

M. B. Wahid¹, R. Moslim¹, T. Jackson², T. R. Clare², N. Kamarudin¹, S. R. A. Ali¹ & N. Barlow², ¹Palm Oil Research Institute of Malaysia (PORIM), P. O. Box 10620, Kuala Lumpur 50720, Malaysia, E-mail basri@porim.gov.my: ²AgResearch, P. O. Box 60, Lincoln, New Zealand.

Major replanting programmes since 1985, as well as changes in agricultural practices and the need to comply to environmental regulations has elevated the status of Oryctes rhinoceros from that of an occasional to a key pest of oil palm in Malaysia. These changes include zero-burning technique of land clearing for replanting, under-planting of new palms within old ones which will be killed and left to rot in-situ within two years, and application of empty fruit bunches (EFB) as a partial source of nutrients. Population studies indicate that the under-planting technique supported the highest population of rhinoceros beetles (39,000 grubs/hectare) compared to felled poisoned palms (17,000 grubs/hectare) and shredded trunks (9,000 grubs/hectare). This information can lead to a more rational management of the rhinoceros beetles. Various methods have been integrated in the management of this pest. These methods involve cultural, chemical, pheromonal, and microbial control. Cultural control involves maintaining a good sanitation, the planting of leguminous cover crops and the removal of adults from the palm crown by a hooked piece of wire. Chemical control using carbofuran and cypermethrin is adopted in the prophylactic treatment of immature palms. Pheromonal control can only be adopted in areas where the population is relatively low (<5 adults/night/trap). Current emphasis is on the development of Metarhizium and Oryctes rhinoceros virus (OrV) as biological control agents of these beetles. Molecular technique has been used in the characterization of both pathogens. Of four isolates of Metarhizium examined, two were highly pathogenic. A suitable formulation of *Metarhizium* has been developed for the control of rhinoceros beetles. PCR analysis of rhinoceros adults from 30 estates in Malaysia revealed a widespread occurrence of OrV. Subsequent strain analysis of this virus using the restriction endonuclease reaction revealed the presence of three strains of OrV. The pathogenicity of the virus has been confirmed by histopathological examination of the mid-gut of the beetle. Cell-culture and bioassay techniques are being developed so that the most virulent strain can be selected for subsequent field release and control of rhinoceros beetles. All data will eventually be incorporated into a discrete model that is aimed at monitoring and predicting the fate of released virus in the field.

Index terms: Oryctes rhinoceros, Metarhizium, microbial control.

[0083] ERADICATION OF A SCARAB PEST FROM A NATIONAL WILDLIFE REFUGE

M. G. Klein¹, C. M. Mannion², A. Asquith³, N. Hoffman⁴ & W. S. Leal⁵, ¹ USDA, Agric. Res. Serv., 1680 Madison Ave., Wooster, OH 44691, USA; ² Univ. FL, TREC, 18905 SW 280th St., Homestead, FL 33031, USA; Kauai National Wildlife Refuge, PO Box 1128, Kilauea, HI 96754, USA; Dept. Interior, FWS, Midway Atoll NWR, P.O. Box 29460, Honolulu, HI 96820, USA; Dept. Entomol., Univ. CA, Davis, CA 95616 USA

The "Emerald Beetle", Protaetia pryeri, (Coleoptera: Scarabaeidae: Cetoniinae) is a serious pest on the Midway Atoll National Wildlife Refuge. Beetles were probably introduced from China-Japan in the early-mid 1900s. Favorable larval habitat in organic matter under ironwood trees, Casuarina equisetifolia, and lack of natural predators, probably exacerbated by eradication of rats, allowed beetle populations to explode. Beetles inhabit both main islands, and create guarantine concerns about their movement to the main Hawaiian Islands. Beetles also destroy fruits and flowers (tomato, papaya, okra, corn, hibiscus, grapefruit) in island gardens, and are a nuisance by landing on, and clinging to, visitors. During 1999 investigations were started on the beetles biology, an attractant for adults, and an insecticide to control larvae. There is one generation per year on Midway. Adults fly from May to October, and may be present in low numbers even longer. Adult emergence likely takes place over several months. Larvae are very highly correlated with ironwoods, with few in turf areas, and even fewer associated with shrubs or the beach community. Since ironwoods are not native vegetation, they are being killed with a herbicide and cut down when dead. Fewer larvae were found under recently killed trees, and very few were found past the drip line of living trees. Larvae break down the organic matter in fallen ironwood needles, and have created vast areas of frass up to 12+ inches deep under some trees. Although previous cetoniid attractants did not capture P. pryeri adults, several were excellent attractants for carpenter bees, Xylocopa sonorina, the primary pollinator on the island. However, L-Isoleucine Methyl Ester (LIME), a pheromone component for certain melolonthids, attracted over 400 Emerald Beetles to a Japanese beetle trap in a day. Preliminary tests indicate that ca. 20 mg of LIME will last at least one week, and that traps near the ground with plastic bags replacing the standard canisters can increase the captures of beetles. Following application in June, the insecticide MACH2 killed 94-100% of P. pryeri larvae by October. The availability of an excellent adult attractant, an effective insecticide, and the removal of ironwood trees which create larval habitat, gives us the chance to develop an IPM program for eradication/suppression of the Emerald Beetle on Midway.

Index terms: Scarabaeidae, Protaetia, IPM, Xylocopa, lures, traps, MACH2

[0085] IPM OF SCARAB PESTS IN SOUTH AMERICA

R. Alzugaray, INIA La Estanzuela, CC 39173, 70.000 Colonia, Uruguay. e-mail: rosario@inia.org.uy

Many scarab species are important pests of crops and pastures in South America. The larvae feed on the roots of major crops such as potatoes, corn, wheat, barley, oats, soybeans, sugar cane, rice and cultivated pastures. Most scarab pests are endemic species and can be found among the roots of grasses in native pastures. In the southern cone of South America, the natural pasture and forest ecosystems have been highly modified by introduction of livestock and agriculture after colonization. Burning of tall grasses, transformation of woodland into prairies, introduced animal and plant species, different types of dung, and the disappearance of native plant and animal species have all modified the environment. The increase of grazing pressure has made scarab feeding evident in pastures and the disturbance produced by agricultural practices has converted natural living organisms into pests. The problems of scarabs are greatest in crops following pastures. The subterranean habits of the larvae, together with the difficulties of sampling these species, has resulted in relatively few identified species and a scarcity of biological studies. IPM strategies vary depending on the crop and the scale of production. These include timing and nature of agricultural practices such as crop rotation, no-till cropping, date of planting and residue management. Application of insecticides to the soil has been a common practice, with consequent effects on soil and water contamination. Seed treatment with insecticides has been adopted in recent years, in crops such as wheat and corn, reducing the dose of chemicals and the cost of control as well as diminishing environmental contamination. Biological control may be considered as the only applicable method of control in pasture ecosystems. In surveys for natural control agents a number of pathogens have been isolated from scarab larvae, including several species of Metarhizium, Cordyceps sp. and Beauveria sp. Bacillus popilliae has been detected in natural infections of Phyllophaga species. M. anisopliae has been cultured and tested as biological control agent in several countries. Parasitic nematodes, insect predators and parasitoids and some viruses are known as natural enemies of different species of scarabs. However, there are no biocontrol programs currently adopted in farm conditions. Index terms: South America, scarab pests, IPM

Symposium and Poster Session

[0086] DETECTING EXOTIC PESTS: THE SCIENCE AND PRACTICE OF SAMPLING WHEN THE ECONOMIC THRESHOLD IS ONE

D. R. Lance, USDA-APHIS-PPQ, Otis Plant Protection Center, Bldg. 1398, Otis ANG Base, MA 02542, USA, E-mail david.r.lance@usda.gov.

Regulatory surveys for agricultural pests of quarantine significance are designed to detect and delimit incipient populations of exotic insects and/or to provide data that can be used to assess risk associated with export of commodities. Detection trapping, in particular, is carried out to demonstrate to a country and/or its trading partners that populations of an exotic species have not become established within the area in question (often the entire country). Surveys to detect introductions of tephritid flies into the mainland U.S. are among the largest, best organized and most expensive insect trapping programs in the world. Despite this, a lack of a basic understanding of how the trapping and pest systems function has, over the years, led (1) to inadequacies in survey design or execution that resulted in expensive and politically unpopular area-wide eradication programs, and (2) to a controversy over the possible existence of resident populations of Mediterranean fruit fly, Ceratitis capitata, in California. Indeed, the probabilistic nature of trapping makes it impossible to prove absolutely that an area is pest-free, but a relative degree of assurance can be developed through a sound understanding of sensitivity of the detection survey. Specifically, the probability that populations of various sizes will be detected (at least one insect will be found) can be estimated based on the relationship between distance to a trap and the probability of catching an individual insect. Examples are given in which releaserecapture and related techniques were used to develop distance-capture functions, and simple probability equations were then used to compute working estimates of detection sensitivity given different sampling efforts. Pronounced variation distance-capture functions was observed at different locales, confirming the potential influence of such factors as the state of the insect, weather, habitat structure, and local availability of food, mates, and host plants. To optimize the design of a detection survey, this basic understanding of how the detection technology functions must be juxtaposed with information from pest-risk assessments. That information can include, for example, the pest's potential geographic range (based host availability and climate), the risk of introduction, host-plant quality and density in the surveyed area, ease of eradication from an area, and even human demographics. Regulatory agencies are increasingly pressured to detect populations of invasive pests while they are small enough to eradicate with environmentally friendly tactics. To that end, incorporation of information on trapping sensitivity and pest risk assessment is essential for the design and optimization of detection surveys

Index terms: regulatory entomology, detection systems, detection protocols

[0087] METHODS FOR ESTIMATING THE SENSITIVITY OF DETECTION TRAPPING SYSTEMS

A. J. Sawyer

ABSTRACT NOT RECEIVED

[0088] USE OF A DATABASE AND GEOGRAPHIC INFORMATION SYSTEM TO MONIFOR A FRUIT FLY ERADICATION PROGRAM

AW Meats, P Gleeson & <u>AD Clift</u>, Fruit Fly Research Centre, School of Biological Sciences, A08, The University of Sydney, New South Wales 2006, Australia, E-mail clifta@agric.usyd.edu.au.

The exotic fruit fly Bactrocera papayae Drew and Hancock was first detected in North Queensland, Australia in October 1995. The extent of the infestation was surveyed during October/November 1995 and an eradication program started by December of that year. The last wild flies were caught in July 1997, area freedom claimed in August 1998 and eradication declared in May 1999. The Pest Quarantine Area comprised 70,000 km² north of 19°00'S and east of 144°15'E, with up to 3000 male lure traps using methyl eugenol as the lure. The successful eradication program was assisted by the use of the database Microsoft Access[®] and the Geographic Information System (GIS) Arcview[®]. The unique designation code and Global Positioning System (GPS) location of each trap was entered into a Location Table within the data base. The trap catch and trap clearance date for each trap clearance was entered into a different Table within the database, with the unique designation code linking the two tables. The GIS could plot the location of each trap onto a map grid, with overlays showing World Heritage Rainforest, agricultural land use, settlements and/or elevation. It was therefore possible to directly map, at any given date, the distribution of B papayae, locations where trap catches exceeded any given number per fortnight and changes in these distributions with time. Spatial analysis of initial trap catches provided indirect evidence of how the infestation established as a series of separate foci in urban areas before a more widespread distribution was achieved. Analysis of subsequent catches provided direct evidence of the dynamics of the eradication process whereby the population collapsed into another series of foci, which could then be targeted for intensive treatment. Methods for location of breeding sites and risk analysis of predictions of local eradication events were also developed using GIS data. Index terms: Bactrocera papayae, database, GIS, GPS, eradication.

[0089] QUALITY ASSURANCE IN LARGE-SCALE DETECTION TRAPPING PROGRAMS

B. J. Taylor¹, ¹Pest Detection/Emergency Projects, California Department of Food and Agriculture, 7845 Lemon Grove Way, Lemon Grove, CA 91945, USA, E-mail: btaylor@cdfa.org.

Large-scale trapping programs for insect pests are being utilized to justify: the pest-free status of exporting countries; the validity of agricultural quarantines of importing countries; the delimitation of exotic pests; and the feasibility of eradication programs. These trapping programs must be both biologically sound and economically feasible. Quality assurance of these programs must be based on sound biological principles as well as good management and supervisory practices, including proper training of employees, written training materials, accurate record keeping, consistent follow-up, observation of work, real-life experiences, achievable standards, independent evaluation, and effective discipline. Programs must also ensure appropriate quality when purchasing traps and lures through standards and field bioassays. Unique to insect trapping programs is the requirement of employees to identify target pests. Supervisors must be willing to monitor employees' performance using in-field observation of the employee's work and "seeding" traps with the target pest. Program evaluations must be performed on a regular basis using global evaluation techniques. Individuals having expertise in the detection of the target pests, the respect of the program administrators, the ability to recommend and implement appropriate changes and submit their findings to funding authorities, should perform these A trapping program without standards and regular quality assurance evaluations. inspections will not justify the pest status ratings that the program may be seeking and will fail to detect exotic pests in a timely manner.

Index terms: employee standards, supervision, training, trap seeding.

[0090] OBTAINING INTERNATIONAL CONSENSUS AND APPROVAL ON DETECTION TRAPPING EQUIPMENT, PROTOCOLS, AND PROCEDURES

<u>R. R. Heath</u>, United States Department of Agriculture, Agricultural Research Service, South Atlantic Area, Subtropical Horticulture Research Station, 13601 Old Cutler Road, Miami, FL 33158-1334 USA, E-mail miarh@ars-grin.gov.

Every day, new discoveries to protect agriculture from pest insects are made. Unfortunately, very few are developed to a point where the discovery would be considered as new technology that should be transferred to action programs. While the process of the "learning experience" is useful for developing strategies for obtaining consensus and approval on detection trapping equipment, protocols, and procedures, it is seldom accomplished. The conundrum involved in the "learning experience" related to the technology transfer of most discoveries is neutralized by the effort required to make it transpire. Consideration of impact, patent ability, validation, and consensus are arduous and complex. Because the process of advancing new technologies can be arduous, the scientist can be disadvantaged in their research effort realizing that the technology transfer adventure may never come to fruition. International recognition of new technologies requires supplementary effort. How technology transfer happens; the fusion and fission of science and politics, and the tactics needed will be presented. Examples of several technologies that were developed, including fruit fly attractants and sweetpotatoe weevil attractants, which are being used to protect agriculture will be presented to illustrate the technology transfer process.

Index terms: Technology Transfer; Detection Systems; Detection Protocols

[0092] POLLINATION AS A PROBLEM: AN INTEGRATED APPROACH IN ECOSYSTEM HEALTH FROM AGRICULTURE TO CONSERVATION OF NATURE

P. G. Kevan, Environmental Biology, University of Guelph, Guelph, Ontario N1G 2W1, Canada

Pollination is a process central to the functioning and sustainability of all but a few terrestrial ecosystems. Much pollination depends on animals, especially insects. The crucial role of pollinators in the reproductive biology of flowering plants, and the central importance of floral resources for pollinator populations enmeshes two major components of global diversity, productivity, and biomass. Because of the increasing levels of environmental stress faced by pollination systems (habitat destruction, fragmentation, pollution, etc.), an ecosystemic approach should be taken. The log-normal relationship between diversity and abundance has become recognized as reflecting ecological and evolutionary interactions between organisms that share ecological roles. This relationship for guilds or taxocenes of pollinators scems to be disrupted in stressed situations, and butterflies stressed by habitat destruction. Thus, a way of examining the health of pollinator communities is presented along with evidence for the potential value of using the log-normal relationship of diversity and abundance in assessing ecosystem health in nature, forestry, and agriculture.

[0091] THE INTERNATIONAL POLLINATORS INITIATIVE

B. F. S. Dias¹ & A. Raw², 1. Ministry of the Environment, Brasilia, Brazil; 2 University of Brasilia & Santa Cruz State University, Ilheus, BA, Brazil

The importance of the sustainable use of biological diversity for society is clearly demonstrated in the pollination of crops by animals. At least one-third of the world's food production relies on insects visiting the crops' flowers so that the plants can produce seeds and fruits. The total value of this pollination service worldwide is estimated at US\$ 67 billion annually. By far the greatest part of the pollinating service is provided by many species of bees which are responsible for the pollination of some 75 % of the world's crops. There is also an enormous dependence of plants on insect pollinators in natural habitats. The numbers of pollinator species are said to be declining. The estimated crop loss through lack of pollination for 30 crops is cited at US\$ 54.6 billion per year. Presumably the declines are linked to the use of agrochemicals, disease and habitat damage; the latter resulting in losses of nest sites and alternative food plants. The problem of varroatosis on honeybees demonstrates the risk involved in relying on a single species. However, there is insufficient information on the insects' taxonomy, their roles as crop pollinators, how serious the problem is and how it might grow. We urgently need convincing information in all these areas. An international workshop in São Paulo (1998) produced clear messages over the identification of the problem and what, in general terms, needs to be done to begin to resolve it. The International Initiative on the Conservation and Sustainable Use of Pollinators was proposed from the meeting. Capacity-building for taxonomy should be linked to the effective implementation of the Convention on Biological Diversity. We need more information on the pollination requirements of plants. A comprehensive monitoring programme is needed to collect data on changes in the sizes of populations of species of pollinators so that we may evaluate the scope and seriousness of the problem. Varroatosis has made it clear that native pollinators need be managed for the service they can provide and agricultural practices should be designed to incorporate the protection and the sustainable management of these insect populations. Few species of wild bees have been managed for the pollination of crops. A call is made for international cooperation on pollinators conservation and sustainable use.

[0093] TOWARDS AN INTERNATIONAL PROGRAMME ON POLLINATORS AND THEIR ROLE IN ECOSYSTEM RESILIENCE

R. Krell, T. Putter & P. Kenmore, FAO, Rome, Italy, email: Rainer.Krell@fao.org

Pollination of crops has received attention only in some agricultural systems and regions. However many producers even in those regions do not regard pollinators as important for improved production. Some studies exist on the natural and managed pollination of agricultural crops, but far less has been done on the impact of pollinators in natural ecosystems and little is known about most pollinator species and their relationships with their plants. The decline of natural pollinators in intensive agriculture and urbanized areas has consequences on agricultural production and most likely also on natural ecosystems. Pollination is as basic as sunlight in assuring primary food production for all organisms in the terrestrial food chain. Thus natural diversity of pollinators is essential for ecosystem maintenance as well as for global food security. With growing concern over biodiversity, increasing understanding of pollinator-plant relationships, and annual pollination benefits to global agricultural crop production of at least US\$ 50-60 billions, pollinators are gradually being given more attention. The International Workshop on the Conservation and Sustainable Use of Pollinators in Sao Paulo, Brazil in 1998 clearly demonstrated the need for globally coordinated efforts and human resources and knowledge to deal with pollination and pollinators adequately. Already existing initiatives are making important contributions, but a global effort for a coordinated international programme will unite forces and create the focus required to improve integration of pollination in agricultural management and other conservation practices, to work on the most urgent research needs, and also to create opportunities to involve other players at different levels - decision makers, agricultural extensionists, nature conservationists and land-use planners. Including pollinators in conservation thinking requires a different approach to habitat preservation, like the inclusion of disturbed habitats for specific pollinator requirements. These changes in approach alone will contribute considerably to ecosystem stability. Pollinator diversity and individual pollinator species have very high potential as indicators of biodiversity and ecosystem health. FAO has a well established data collection and distribution system. Inclusion of relevant pollinator data in the large ECOPORT plant database can be used to establish a global pollinator support system. Gathering and disseminating this information, building expertise and general awareness for improved agricultural production and production security while assuring ecosystem diversity and sufficient reproductive capacity will be the prime results of a global cooperation Establishing pollinators as important indicator species could be another programme. outcome. Under the umbrella of an international organisation, with the initiative of the various institutions and interested experts, an international programme on pollinators has all the elements of rapid progress and success.

ABSTRACT BOOK I - XXI-International Congress of Entomology, Brazil, August 20-26, 2000

[0094] ARE POLLINATOR NUMBERS DECLINING OR FLUCTUATING NORMALLY ?

G. W. Frankie & S. B. Vinson, University of California, Berkeley, CA, USA

Concern about the suggested worldwide decline of pollinators has raised questions among researchers over whether there is a general global decline, if it is only local or if recorded declines are just natural fluctuations in pollinator populations. Other questions are over the most appropriate methods to study the phenomenon. The situation has provoked lively discussion over possible causes of decline and whether any of the long list of these possibilities can be altered so as to reverse downward population trends of pollinator numbers. In Costa Rica, we have monitored species diversity and frequency of bees in two nearby study areas in what was dry forest. The numbers and species of bees have been recorded at the flowering leguminous tree Andira inermis for 28 years at one site near an evergrowing rural community, and for the 10 years at the other in modified wooded savanna. Substantial declines in bee species diversity and frequency have been documented at both sites. At the first, habitat destruction through human development around the Andira trees is the most obvious cause of the decline. The causes at the second are not so clear and a combination of unusual weather factors, high natural bee mortality, and habitat fragmentation may be contributing to the decline of the bees' numbers.

[0096] THE STATUS OF POLLINATORS IN EUROPE

<u>J. Banaszak</u>, Institute of Biology and Environmental Protection, Pedagogical University in Bydgoszcz, 30 Chodkiewicza St., 85-064 Bydgoszcz, Poland, E-mail lednica@wsp.bydgoszcz.pl.

In the climatic conditions of Europe the most important for the pollination of plants are the representatives of Apoidea superfamily. Compared with other parts of the world, Europe is the best known continent as far as bee species diversity is concerned. The composition of fauna has been regularly researched for at least 150 years and the existence of over 1250 species of wild bees has been identified. Local lists of species, made for the majority of European countries, have proved a great success of the last decade of the XX century. Increase in crops, especially in forage crops (alfalfa, red clover) became the focus of interest, which brought about first estimates of apoids density in the crops after II World War. Whereas it was only in the eighties when density in natural ecosystems was first estimated and proper methods worked out. Research on the resources of pollinating insects must be considered as top priority; it constitutes one of the main achievements in the contemporary apidology. It became the basis for research on bee ecology in a landscape aspect, and in future will allow for objective estimate of changes in fauna. First regular studies of changes in bee fauna in long term cycles have already been undertaken (e.g. in Poland). The basic source of information about endangered species are quite common red lists and red data books of animals, bees included (Germany, England, Poland, etc.). The paradigm of protection by law of bees as well as other insects and its efficiency is quite controversial. Many countries still do not have any legal regulations concerning protecting Hymenoptera. Under the rules for conservation of wild bees, the main stress is put on preserving their natural habitats - fauna refuges by means of preserving or creating the structure of landscape based on ecological rules. Other measures taken to protect bee populations included breeding wild bees and their reintroduction to a landscape or breeding for agricultural purposes etc. New problems appear as a result of the development of bombiculture and breeding of other wild bees. Freedom of hybridization of honey bee races makes maintaining the purity of traditional local races difficult and genetic protection of honey bee populations necessary.

Index terms: pollinators, Apoidea, Europe, diversity, density, protection of bees

[0095] INSECT POLLINATION IN AUSTRALIA – CURRENT ISSUES AND DIRECTIONS FOR THE $21^{\rm ST}$ CENTURY

C. L. Gross, School of Rural Science and Natural Resources, University of New England, Armidale NSW, Australia

Insect pollinators in Australia include moths, butterflies, ants, flies, beetles and some 2,000 species of native bees, the latter including a significant and diverse assemblage of Colletidae and Halictidae (short-tongue bees). Australian vascular plants number c. 18,000 species of which 80% are endemic. Pollination ecology in Australia has developed from a descriptive phase at the turn of the century to studies in the 1980s that focussed on issues of evolutionary ecology. In the last decade conservation has been a focus of some research although there is much to be done. Insect pollination is poorly researched in Australia. However a number of initiatives have started to database the identity of floral visitors. The impact of the introduced honeybee on the native biota has generated much interest although very few researchers have actually investigated the impact of honeybees on the fitness of plants and/or their native pollinators. Recently bumblebees were introduced to Australia and there are growing concerns about their potentially adverse effects on the native biota. Honeybees may be seriously contributing to the success of weeds in Australia in both natural and agricultural systems and studies are urgently required to examine this. Moreover the incursion of bumblebees into Australia may exacerbate the weed problem, particularly in those species with poricidal anthers, e.g. Solanaceous taxa. Australia has a very high incidence of threatened plant species (c. 23%) and it is unknown for almost all of these rare taxa whether or not pollination failure has contributed to their rarity. Even less is known about the conservation status of their pollinators. The importance of insect pollinators at the community level is virtually undocumented although available evidence suggests that Australian rainforests rely heavily on insects for pollination services. Finally the global decline in insect pollinators has not generated the concern in Australia that it should partly because (1) honeybee populations are healthy, (2) because baseline data of insect pollinators are lacking and (3) there is virtually no recognition among the general public of the importance of native bees, let alone other insects, as pollinators.

[0097] THE STATUS OF POLLINATORS AND BIODIVERSITY IN ASIA: AN OVERVIEW

<u>A.J. S. Raiu,</u> Dept. Environmental Sciences, Andhra University, Visakhapatnam - 530 003 Andhra Pradesh, India

Asia has a large variety of climates and ecosystems with a wide range of plant and animal species. However, the pressures on the poor to meet their essential needs (food, fuel wood and fodder) and the elite's desire to accumulate wealth and maintain socio-economic power are major factors causing the continuing destruction of forests and diminishing forest resources and their biodiversity to the extent of disrupting the ecological balance. Many forests are now fragmented which has resulted in losses of many plant: pollinator relationships. However, forest fragments may still have adequate pollinator and plant diversity. The value of pollinators has been recognised since the dawn of agriculture, but measures for their conservation and management in wildlands have been considered only The Rio Convention is instrumental for the conservation of pollinator recently. biodiversity. India has identified pollination ecology as a major area for research and recognised the value of pollinators in conserving biodiversity. Detailed studies on pollination ecology and on pollinators of agricultural and non-agricultural plants are being conducted to analyse the interactions between native pollinators and their native host plants. In Japan, populations of many species of native pollinators are declining or have become dependent on introduced plants as their native hosts disappeared. In urban areas, the greatest numbers of pollinator insects are in public gardens and parks with less plant diversity. Excellent work is being conducted in Israel to discover the roles of pollinators in maintaining plant diversity. Indonesia, Malaysia, China and other countries have pollination projects. Environment warming is influencing the reproductive cycles of pollinators. Pesticides, insecticides, etc. reduce the numbers of pollinator species. Pollinator numbers also decline due to losses of nest sites and native host plants through cultivation, urbanization and the burning of their habitats. The published information on pollination ecology of native species in Asia mostly comprises lists of pollinators of plant species, but does not provide information on the status of pollinator species in a study area or on the entire ecosystem of a region. Investigations on the status of pollinators must take into full consideration the importance of the sustainable availability of forage plants for larvae and adults, the availability of nest sites, the influence of climatic factors, etc. This information is required to plan measures for the effective conservation and management of pollinators of wild plants and hence sustain biodiversity in natural and manmade habitats.

[0098] NOR'IH AMERICAN POLLINATORS AND HABITAT FRAGMENTATION: DURABLE BEE FAUNAS AND THE PROMISE OF SMALL RESERVES

J. H. Cane, Bee Biology & Systematics Laboratory, Logan, UT, USA

Few studies directly address the consequences of habitat fragmentation for communities of invertebrate pollinators, particularly for bees; the most important group of pollinators. The present studies define fragments by remnant patches of floral forage or living woody vegetation, and not by bees' nesting substrates. Several of the studies conclude that such habitat fragmentation is broadly deleterious, but overlook native species in their own data sets that proliferate more in fragments than in intact habitats. Several other studies find the densities of native bees at flowers increase in larger remnants relative to intact habitats, with little change in species richness but with marked shifts in species composition and relative abundances. Bees are typically well-adapted to habitats wherein their nesting substrates and floral resources are both patchily distributed and spatially dissociated. provided that the coarseness of such pattern does not exceed their flight vagility. Furthermore, many bee species occupy or even require habitats of intermediate successional stage or modest disturbance. Perceptive future studies of habitat successional stage or modest disturbance. fragmentation and bees will account for and evaluate fragmentation, alteration, and loss of nesting habitats, and not just patches of food plants. Inasmuch as floral associations, floral specializations and nesting habits of bees are typical attributes of species, or at most, subgenera, authoritative determinations of specimens to these levels is an essential prerequisite for any biologically meaningful interpretation. Studies must also anticipate and accommodate the statistical problems that attend bee community or pollinator guild samples. For bees, broadly deleterious habitat fragmentation may need to be extensive to overcome their flight vagilities, dispersal abilities and orientation capabilities. Given the sheer area of intervening matrix that must be rendered inhospitable in order to fully isolate fragments from outside bee foragers and immigrants, such scenarios might be better relegated to cases of habitat loss, not fragmentation. Conversely, the prolonged persistence of substantial diversity and abundance of native bee communities in some habitat fragments and reserves of even moderate size gives hope for practical solutions. If selection, design and management can address bees' foraging and nesting needs, networks of small reserves should be able to sustain considerable pollinator diversity and their ecological services.

[0100] HOST PLANT RESISTANCE TO *BEMISIA TABACI* AND OTHER WHITEFLY SPECIES, AND ASSOCIATED VIRUSES

<u>A. C. Bellotti¹</u> & F. Morales², Integrated Pest and Disease Management, Cassava Entomology, CIAT, A.A. 6713, Cali, Colombia, E-mail A.Bellotti@egiar.org, ²Virology, CIAT, A.A. 6713, Cali, Colombia, E-mail F.Morales@egiar.org.

Host plant resistance (HPR) to whiteflies in cultivated plants is rare. At CIAT, in Colombia, more than 5000 cassava varieties have been evaluated for resistance to Aleurotrachelus socialis. Several varieties have been selected for high levels of resistance. Nymphal mortality on the cassava variety MEcu 72 reached 72.5%. Greenhouse and fields studies showed that A. socialis feeding on resistant clones had less oviposition, longer development periods, reduced size and higher mortality than those feeding on susceptible ones Whitefly resistant cassava varieties are being evaluated for release to farmers in Colombia. Different breeding populations have been obtained from crosses between resistant and susceptible cassava genotypes. Using AFLP's, bands co-segregating with resistance to A. socialis have been found. These bands are being sequenced to generate SCAR's markers, which will be used for the identification of resistant materials in breeding programs. The search for genetic resistance to plant geminiviruses has been a long and frustrating process. The intra-specific genetic variability present in the main cultivated plant species affected by whitefly-transmitted geminiviruses, does not confer immunity to these pathogens. The common bean (Phaseolus vulgaris) is attacked by different whitefly-transmitted geminiviruses, such as Bean golden mosaic virus, Bean dwarf mosaic virus and Bean calico mosaic virus. Of over 20,000 common bean accessions screened for resistance to BGMV, none has shown immunity to this geminivirus. Similar results have been obtained for other cultivated plant species, such as cassava, tomato, pepper, cucurbits, cotton, etc., attacked by geminiviruses. This situation has forced plant breeders to search for sources of resistance to geminiviruses in related species. Resistance to one of the most severe geminiviruses affecting horticultural crops, Tomato yellow leaf curl virus (TYLCV), has only been found in wild Lycopersicon species. The first commercial resistant tomato cultivar released. TY20, came from a cross between L. esculentum (the domesticated tomato) and the wild species L. peruvianum. In the case of common bean, considerable progress has been made by exploiting various mechanisms of resistance identified in different races of P. vulgaris. The pyramiding of the genes responsible for the observed resistance mechanisms, has resulted in the selection of bean cultivars possessing high levels of geminivirus resistance. Index terms: Cassava, Beans, A. socialis, geminivirus.

[0101] ECOLOGICAL CONSIDERATIONS FOR MANAGEMENT OF A MULTIPLE-CROP PEST

A. Pauw, W. Bond, S. Johnson & F. Field, Department of Botany, University of Cape Town, Cape Town, South Africa

[0099] HABITAT FRAGMENTATION AND ITS CONSEQUENCES FOR PLANT-

POLLINATOR MUTUALISMS IN SOUTH AFRICA

South Africa, and in particular the Cape, is world renowned for its high levels of plant diversity and endemicity. Also unique are the very high levels of specialization in plant pollinator relationships. In contrast with the Northern Hemisphere, where specialized pollination systems are rare, South African plants often depend on a single pollinator or small group of related pollinators. For this reason, there is concern over the dramatic decline of specialized pollinators in recently fragmented habitats. In the high altitude grasslands of the KwaZulu-Natal Province, plants depending on hawkmoths, long-tongued flies and solitary bees set significantly fewer seeds in landscapes fragmented by exotic pine plantations. Similarly in the Cape shrublands, oil-collecting bees (Melittidae) and tangle-winged flies (Nemistrinidae) were extinct from several small nature reserves. These reserves protect the last remnants of endangered lowland vegetation and are surrounded by urban sprawl and agriculture. Here, seed production in plants without pollinators varied from zero in some allogamous orchids to 100% in facultatively selfpollinating Iridaceae. However, the consequences of decreased seed-set on plant populations are not obvious, because they are determined by the degree to which the plant species depends on seeds for reproduction and persistence. For example, plants that reproduce clonally via underground runners or extra bulbs may persist despite zero seed production, but initial results indicate that these persistent populations experience a loss of genetic diversity. Demographic studies of clonal orchids and non-clonal amaryllids have been initiated to elucidate the real consequences of pollinator extinction for these divergent life histories. The balance of evidence suggests that the conservation of many South African plants depends on the conservation of their pollinators, however, pollinator conservation is hampered by the lack of basic information on pollinator life cycles and nesting requirements.

P.C. Ellsworth¹, J.C. Palumbo², S.E. Naranjo³& S.J. Castle³, ¹Dept. Entomology, Univ. of Arizona, Maricopa Ag. Ctr., 37860 W. Smith-Enke Rd., Maricopa, AZ, USA 85239; Email: peterell@ag.arizona.edu; ²Dept. Entomology, Univ. of Arizona, 6425 W. 8th St., Yuma, AZ, USA, 85364; ³USDA-ARS, Western Cotton Research Lab., 4135 E, Broadway, Phoenix, AZ, USA, 85040.

Whiteflies (*Bemisia* spp.) are important pests of numerous crops all over the world. Their polyphagous nature, especially in the recently-identified strain (B. tabaci, Strain B) or species (B. argentifolii), has elevated the importance of understanding the ecological contexts where they are most pestiferous. With the exception of protected agriculture (e.g., glasshouses), Bemisia whiteflies are major pests limited mainly to tropical, subtropical. arid, and semi-arid crop production regions of the world. One common thread among these diverse biomes is the lack of harsh winter conditions. Occasional field outbreaks in more temperate regions of the world are often associated with spatially and temporally local efflux from protected environments. Thus, there are ecophysiological constraints on the range of this insect that include an array of abiotic parameters governed mainly by low temperatures. Bemisia whiteflies are freezing intolerant with little ability to survive subzero temperatures of short duration. They have no distinctive overwintering life stage or any capacity for diapause. Another shared characteristic of Bemisia-endemic regions of the world is a year-round growing environment. Bemisia whiteflies cannot live away from living plants for any length of time. Thus, in addition to the ecophysiological constraints, Bemisia dynamics are also subject to the host ecology and phenology present in the system. Regions of the world that report significant outbreaks of Bemisia whiteflies also tend to have a sequence of strategically important whitefly plant hosts year-round. The year-round ecology of this pest includes seasonal dynamics, overwintering ecophysiological constraints, host-mediated development and mortality differences, movement, host temporal and spatial availability, and control dynamics. The latter component is the factor that is most influenced by grower action, but long-term, growers will need to also consider the manipulation of these other components of Bemisia seasonality to ensure successful management on any particular target crop. Thus, management systems for Beniisia must consider the intercrop dynamics and crop ecology of large areas. "Avoidance," in its broadest sense, is the foundation of integrated pest management (IPM). Investigation of the seasonal ecology of this pest should lead to more ecologically stable IPM strategies that are wholly integrated within multiple crops over large areas.

Index terms: Whiteflies, *Bemisia tabaci, Bemisia argentifolii*, integrated pest management (IPM), overwintering, seasonality, areawide management.

[0102] CONSERVATION AND EVALUATION OF NATURAL ENEMIES IN IPM SYSTEMS

<u>S. E. Naranjo¹</u> & W. A. Jones², ¹USDA-ARS, 4135 E. Broadway Rd, Phoenix, AZ 85040, USA, Email snaranjo@ix.netcom.com; ²USDA-ARS, 2413 E. Hwy. 83, Weslaco, TX 78596, USA, Email w-jones@pop.tamu.edu

Evidence from many of the agricultural systems affected by Bemisia tabaci (= B. argentifolii) suggests that natural enemies are an important component of natural control. Maximization of the effects of natural enemies should form the foundation of modern pest management systems. However their integration into IPM has been hampered in many systems by a poor understanding of the overall impact of natural enemies on pest population dynamics and the interaction of their impacts with other control tactics. The relative effects of aphelinid parasitoids (Eretmocerus and Encarsia spp.) on Bemisia have been characterized in a number of cropping systems by measuring percentage parasitism. Clear geographic as well as host plant-related patterns have been identified. Still, great care must be used in relating such measures to pest population control. Predation is less well understood because of measurement difficulties; however, serological and other techniques have helped to identify key predator species in several cropping systems and it is clear that a large number of generalist predator species attack Bemisia. The impact of pathogens is poorly known in most systems. Conservation of natural enemies in IPM systems depends on a number of factors. The greatest impediment to conservation biological control in IPM systems for most crops are insecticides. Toxicological studies have been conducted on various parasitoid and predator species attacking Bemisia. These studies have revealed potential direct and sublethal impacts, but it is difficult to extrapolate findings to the field. Controlled field studies in some cropping systems have also been used to characterize the gross effects of insecticides; however, such studies can overlook behavioral and more long-term effects. More selective insecticides are available in some systems and may contribute significantly to conservation of natural enemy abundance and activity. Ultimately, many interacting mortality factors impact the population dynamics of Bemisia in IPM systems and it is critical that we examine the contribution and potential of natural enemies within this context. We highlight field life table studies that have been conducted to identify and quantify sources and interactions of mortality forces within alternative IPM systems in cotton in the southwestern USA. We discuss strengths and limitations, and suggest the life table approach as a paradigm for evaluating and developing conservation biological control programs for all affected crops.

Index terms: Bemisia tabaci, Bemisia argentifolii, biological control, predators, parasitoids, life table, insecticides

[0103] INTERNATIONAL AND NATIONAL RESEARCH PROGRAMS FOR THE DEVELOPMENT OF *BEMISIA* IPM SYSTEMS

<u>P.K. Anderson¹</u>, T. J. Henneberry² & M. R. Vilarinho³,¹CGIAR Whitefly IPM Project, CIAT, A.A. 6713, Cali, Colombia, Email p.anderson@cgiar.org, ²USDA-ARS, Phoenix, Arizona, USA, Email thenneb@asrr.arsusda.gov, ³Embrapa/Cenargen, Cx Postal 02372, Brasilia-DF, Brazil, Email vilarin@cenargen.embrapa.br

In the United States, at the end of the 1991 growing season, it was apparent that unacceptable losses in cotton and vegetable field crop production, as well as ornamental and vegetable losses from whiteflies in glasshouse cultures, were being experienced in California, Arizona, Texas, and Florida. A five-year sweetpotato whitefly (SPW) national research and action plan was developed. The need for "stop gap" control measures was Standardized experimental procedures, data collection protocols, report urgent. preparation, and results exchange systems were established for a national testing program of promising chemicals, natural products, microbial insecticides and improved application resistance management program (IRM) was also established. Over 30 federal and state experiment station scientists, in 8 states, were involved in the overall program. The results have provided the basis for highly effective SPW chemical control and ongoing SPW-IRM. A complete management system for SPW is a goal for the currently operational 2rd five-year plan. Throughout the Tropics, whiteflies are causing devastating losses on a broad array of food security and income-generating crops. In response, the project on "Sustainable Integrated Management of Whiteflies as Pests and Vectors of Plant Viruses in the Tropics" was initiated in 1997 by the Consultative Group on International Agricultural Research (CGIAR), as one of the projects within the Systemwide Program on IPM. The CGIAR Whitefly IPM Project is structured into 6 sub-projects that operate in 30 countries in Latin America, Africa and Asia. The Project focuses on: 1) whiteflies as pests in Tropical highlands; 2) whiteflies as vectors of plant viruses in mixed cropping systems of the low-to-mid-altitude Tropics; and 3) whiteflies as pests and vectors of plant viruses in cassava. The principal objective of Phase 1 (1997-1999) has been to generate a more comprehensive characterization of these whitefly problems to provide the foundation for a basic research program on whitefly pest and disease dynamcis, and IPM component testing, during Phase 2 (2000-2003).

Index terms: Bemisia tabaci, whiteflies, United States, Latin America, Africa, Asia

[0104] IPM OF BEMISIA TABACI IN AUSTRALASIA

P. J. De Barro¹, F. Driver², I. D. Naumann², S. Schmidt², J. Trueman² & J. Curran², ¹CSIRO Entomology, PB 3 Indooroopilly, QLD 4068, Australia, paul.debarro@brs.ento.csiro.au; ²CSIRO Entomology, GPO Box 1700, Canberra, ACT 2601, Australia; ³ Research School of Biological Sciences, Australian National University, Canberra 0200, Australia.

Bemisia tabaci biotype B was first discovered in Australia in October 1999. This lead to the initiation of a wide array of research aimed at helping Australian producers prepare for and manage the whitefly. Key elements to the first phase (3 years) of this research was to determine the diversity of parasitoids already present that may be of use against the pest. This work led to the development of easy to use keys for the various species found. In addition, the phylogenetic relationship of world populations of B. tabaci was investigated. Here, the research aimed at determining where Australia's indigenous B. tabaci fitted in terms of the world fauna. As part of this work a rapid screening protocol was developed to enable the exotic and indigenous biotypes to be distinguished. This work was then broadened to investigate the distribution of B. tabaci across the Pacific Island Countries with the aim of assessing the likelihood of further incursions of exotic biotypes. Another key component of the research was assessing the potential of five parasitoid species already present in Australia. This concluded that, Eretmocerus mundus (Australian Parthenogenetic Form) offered the best potential for control. Research also determined the efficacy of insecticides currently available, the insecticide resistance profile of the B biotype and the registration of more effective products. The interaction between the indigenous and exotic forms of B. tabaci was also investigated, as were the damage thresholds for at risk crops such as tomato. The research is know focusing on developing field management protocols and in screening for resistance to tomato geminiviruses that are beginning to move southwards towards our major tomato growing regions. In Asia, Australia, AVRDC and cooperating scientists in Bangladesh, Indonesia, Nepal, Philippines, Sri Lanka and Vietnam are part of the Consultative Group on International Agricultural Research initiative on whitefly IPM (Sustainable Integrated Management of Whiteflies as Pests and Vectors of Plant Viruses). The program is being convened through the International Centre for Tropical Agriculture. This programme is gathering baseline data on the biotype/host plant/geminivirus interaction.

Index terms: Australia, Asia, biological control

[0105] IMPLEMENTATION AND ADOPTION OF IPM SYSTEMS

<u>I. L. Martinez-Carrillo¹</u>, P. C. Ellsworth², L. Hilje³ & R. Ausher⁴, ¹INIFAP Calle Norman Borlaugh Km. 12 Cd. Obregón, Sonora. México: ²Dept. Entomology. Univ. of Arizona, Maricopa Ag. Ctr., 37860 W. Smith-Enke Rd., Maricopa, AZ, USA 85239; ³Plant Protection Unit. CATIE, Turrialba, Costa Rica, E-mail: Ihilje@catie.ac.cr; ⁴Dept. Crop Prot. Ext. Serv., POBox 28, Bet Dagon 50250, Israel.

Whiteflies (Bemisia tabaci and B. argentifolii) are among the most important pests worldwide, either as direct pests or geninivirus vectors. They can cause severe damage to at least 23 crops, as well as to several ornamental and wild plants. The need to develop economically and environmentally sound management systems in a coordinated manner prompted the appointment of task forces (local, regional or national level) involving researchers, extension agents, pest control advisors, growers, policy-makers, and industry representatives. In addition, both national or international networks were created in order to set research and extension agendas aimed at the development and implementation of integrated pest management (IPM). This presentation summarizes achievements in the implementation and adoption of IPM programs in North America, Mexico, Central America and the Caribbean Basin, and Israel. Despite differences in agricultural systems, as well as in cultural, educational, and economic aspects, there are several common trends, which are highlighted here. Task forces drafted action plans and defined priorities on: whitefly bioecology, geminivirus epidemiology, and management tactics (cultural practices, host-plant resistance, biological control, chemical control and insecticide resistance management), biotype and geminivirus diagnosis, training of extension agents and growers, on-farm validation and transfer of IPM tactics, and regulatory and industrial development of strategic, novel and effective insecticides. Even though accomplishments between countries have been rather uneven, in general growers are now better aware of the implications of the problem in economic, agricultural and environmental terms, and thus are more prone to adopt and implement IPM. They understand the need to look for multitactic approaches instead of a single-tactic, and are willing to participate in area-wide preventative and curative approaches. These include: quarantine regulations and cultural practices (planting dates, short-season production, weed and crop destruction, host-free periods, and avoidance of susceptible crops); other farm level exclusion practices such as seedbed or greenhouse coverage with special netting, floating row covers, and mulching; coordinated sampling and use of thresholds over large areas; and strategic or restricted use of novel insecticides in a sustainable use pattern. Despite these remarkable advances, there is still the need to increase coverage of successful IPM programs, especially by involving growers through participatory research in order to strengthen adoption and implementation of such programs.

Index terms: Whiteflies, Bemisia tabaci, Bemisia argentifolii, geminivirus, integrated pest management (IPM)

[0106] THE POTENTIAL EFFECT OF UNITED STATES LEGISLATION, THE FOOD QUALITY PROTECTION ACT, ON INTERNATIONAL TRADE

J. J. Brown, Department of Entomology, Washington State University Pullman, WA 99164-6382.

The United States Congress passed and the Food Quality Protection Act [FQPA] was signed by the President on August 3, 1996. This legislation set in motion its implementation by the Environmental Protection Agency [EPA] over a 10-year period ending in 2006. This legislation targeted pesticide residues on crops most often consumed by children, therefore much attention has and will be given to pest management practices on fruits and vegetables. The EPA announced its first implementation action on August 3. 1999; when it banned the use of methyl parathion on tree fruits and reduced the amount of azinphos methyl that can be sprayed on tree fruits each growing season from 6.0 down to 4.5 pounds of active ingredient per acre. The EPA will continue to announce implementation actions between now and August 2000, the time of the Congress. The worst case' scenario could cause major shifts in fruit and vegetable production within the United States and perhaps provide other countries a significant opportunity to market their fruits and vegetables to the United States. Within the United States, apple growers with severe pest pressure, may find that management practices without broad spectrum pesticides will limit profits to where growers might shift to alternative crops. However, the real 'winners' may be exporters to the United States. Where growers will not be restricted in management practices, their concern will be to avoid detectable residues. A practice that is well developed in many countries already, because pesticide residues on imported fruits and vegetables routinely are lower than residues detected on domestic produce. EPA's action on azinphos-methyl will have no international effect on orchard pest management, but its 'ban' on methyl Parathion could pose cause any shipment with a detectable residue to be rejected.

Index terms: Orchard Pest Management, FQPA, codling moth

[0108] THE POTENTIAL EFFECT OF UNITED STATES LEGISLATION, THE FOOD QUALITY PROTECTION ACT, ON INTERNATIONAL TRADE. THE CASE OF CHILE

R. H. Gonzalez, University of Chile, e-mail: rgonzale@uchile.cl

Chile, as a major fresh fruit exporting country from the Southern Hemisphere must meet a wide array of pesticide tolerances set by world markets. With respect to the United States, current EPA tolerances could be easily met through a national supervised scheme to establish pre-harvest intervals for each crop/registered pesticide combination. When the U.S. Congress enacted the Food Quality Protection Act (FQPA) in 1996, notwithstanding there were no provisions specifically aimed at regulating foods imported into the United States, there was an immediate local reaction to cope with impending limitations, at the same time, anticipating domestic benefits emerging from these actions. Thus, in line with planned FQPA regulatory activities, the Chilean private sector set new priorities aimed at reducing broad-spectrum pesticides, a process currently under assessment, and searching for new alternatives such as insect growth regulators (IGR's), molting accelerating compounds (MAC's) and chemicals of biological origin.New IGR's field tested include flufenoxuron, nuvaluron and fenoxycarb for early control of Cydia pomonella, a key pest of pome orchards. Among the MAC's, tebufenozide is already in full usage whilst metoxyfenozide is awaiting for registration. The insecticides of biological origin, abamectin (avermectin) and spinosad seem promising for mites and thrips control, respectively, apart from other benefits which are under evaluation. Among IPM tactics, the male confusion approach has been tried out for over a decade, testing too many formulations that the method is still far from acceptance, particularly with respect to the Codling moth. For a fruit exporting country suffering from plant quarantine barriers which do nothing but increasing pesticide usage, the adoption of a full integrated management scheme seems a heavy proposition. Zero quarantine risk increases pesticide use. not necessarily of newer, target specific compounds.

[0107] FOUR -YEARS OF FQPA: IPM CHALLENGES FOR THE US APPLE INDUSTRY

<u>L. J. Gut</u>

ABSTRACT NOT RECEIVED

[0109] POTENTIAL EFFECTS OF THE UNITED STATES FOOD QUALITY PROTECTION ACT LEGISLATION ON TREE FRUIT PRODUCTION IN BRITISH COLUMBIA, CANADA

<u>M. J. Smirle</u>, Agriculture & Agri-Food Canada, Pacific Agri-Food Research Centre, Summerland, British Columbia, VOH 1Z0, CANADA, E-mail smirlem@em.agr.ca

The United States is the largest market for exported Canadian fruit. As such, access to this market is of primary importance to Canadian producers. New legislation in the United States, the Food Quality Protection Act (FQPA), may severely limit the types of insecticides allowable for fruit grown for export, and may therefore represent a serious challenge to Canadian production practices. Tree fruit production systems, including insect control strategies, are different from region to region in Canada, and my presentation will focus on the effects of FQPA on tree fruit production in British Columbia (BC). The key pest in BC pome fruit production is the codling moth, Cydia pomonella, and historically the most widely used control chemical has been azinphos methyl. This situation has changed somewhat since the introduction of the Sterile Insect Release Program, but azinphos methyl has remained an important material for codling moth population supression prior to sterile insect release and for control of leafrollers (Tortricidae). Application rates of azinphos methyl are lower in BC than the Environmental Protection Agency (EPA) tolerances, with currently recommended label rates of 1.4-2.2 kg/ha for codling moth and 1.4 kg/ha for summer leafroller control on apples. However, it remains to be seen how the reduced tolerances imposed by the EPA for use by US growers will translate to azinphos methyl tolerances on apples imported from Canada. It is also likely that moves to restrict the use of azinphos methyl and other organophosphates in the US will affect the availability and cost of these materials. An additional important factor in determining the potential effect of FQPA will be the availability of mite control products that are compatible with the current BC program of biological control. Currently, predaceous mites are resistant to organophosphates, which can be used to control other insect pests without disrupting biological mite control on apples. This program is vital to advances in integrated pest management, and the effect of having to move to other classes of insecticides, such as pyrethroids, would have serious consequences. The FQPA legislation in the US will have important effects on tree fruit production in western Canada, as it will on other fruit growing areas worldwide, but it is also true that advances in and particularly grower adoption of integrated pest management systems often come as the result of "having no choice". Those producers wishing to continue to export their fruit to US markets will be forced to change the way they have traditionally controlled their insect pests. The consequences of this will hopefully be the adoption of more advanced and sustainable integrated pest management systems. Index terms: Cydia pomonella, FQPA, tree fruit IPM, organophosphates.

[0110] THE NEW ZEALAND APPLE INDUSTRY: THE AGROCHEMICAL AND PHYTOSANITARY CHALLENGES FOR GLOBAL EXPORTS

J.T.S. Walker, HortResearch, Private Bag 1401, Havelock North, New Zealand.

New Zealand produces 1% of the global apple crop with 90% of this production shipped to over 60 countries, primarily through the exporter, ENZAFRUIT. Europe and North America are important markets with about 25% of our production reaching the US market. The paradoxical relationship between international quarantine requirements and regulatory and market demand for lower pesticide residues, required development of two different pest, and pesticide, risk management strategies for these markets. In 1996 the apple industry began to develop an Integrated Fruit Production (IFP) programme to meet EU supermarket requirements of food safety and environmental integrity. During this development we identified alternative pesticides to replace classes such organophosphates (OPs), which we considered to be 'at-risk' pesticides under developing US Food Quality Protection Act (1996) legislation. This IFP programme, covering many aspects of orchard management, led to development of an apple pest management programme based on selective insecticides, such as buprofezin, tebufenozide and lafenuron. Pest thresholds were developed and IFP programme information documented in industry manuals. Implementation followed in 1997 with consultant and grower training programmes. Growers were required to monitor pest populations and maximise use of biological control by using these insecticides only when justified. During implementation, industry-wide pest risk analyses were undertaken to refine recommendations for specific markets. This included a lower threshold for leafroller activity in crops destined for the US due to stringent quarantine requirements. Using this process, the confidence of growers, exporters and regulatory authorities developed in IFP pest management as evidenced by 85% industry-wide adoption by 2000. Since the introduction of IFP the frequency of insecticide use has decreased by 49%, OP use by 82% and azinphosmethyl use by 97% when compared to traditional programmes. US quarantine requirements have limited insecticide reductions in crops intended for that market but, a variant of the programme for US market crops (IFP-USA), has still seen OP and azinphosmethyl use decline by 58% and 78% respectively. Other pest risk reduction procedures, such as apple washers and modified storage regimes, have been introduced to further reduce reliance on OP insecticides to meet quarantine requirements. The low level of OP use remaining (primarily chlorpyrifos and diazinon for control of mealybugs and scale insects) is targeted for elimination within two years. New products and tactics for the control of pests are presented within the context of New Zealand's readiness for the further implementation of the Food Quality Protection Act (1996).

Index terms: organophosphates, residues, pest risk, IFP adoption

[0111] THE POTENTIAL EFFECT OF UNITED STATES LEGISLATION, THE FOOD QUALITY PROTECTION ACT, ON SOUTH AFRICAN FRUIT EXPORTS

M. F. Addison, Hortec, P.O. Box 1231, Stellenbosch, 7599, South Africa, e-mail matthew@hortec.co.za.

The potential impact of the Food Quality Protection Act (FQPA) on fruit exports from South Africa is vast. Deciduous fruit and citrus make up the bulk of exports and South African fruit is sold in approximately 70 countries world wide. Europe has been the principle market for South African fruit where an estimated 80% is sold annually. After 1993, with the lifting of trade sanction and the resumption of fruit exports to North America, approximately 10% of fruit exports are directed to this market. The FOPA has a direct impact on pest management practices within the South African fruit industry. The example pest management in apple and pear production illustates this. Due to the marketing strategy of selling fruit in a number of countries, including Europe and North America, pesticide application programs have to accommodate a number of residue standards. The restrictive nature of the FQPA dictates that a limited number of pesticides are available for use on export crops. While this limits the number and type of pesticides applied, it also excluded the use of more recently developed pesticide groups such as certain insect growth regulators. The developing problem of insecticide resistance in codling moth (Cydia pomonella) populations poses a unique threat to the industry Resistance to organophosphate insecticides is widespread and resistance management programmes require the use of alternative pesticides. Thus fruit produced in orchards under resistance management programmes is withdrawn from export to North America. The future export of apples and pears from South Africa to the North American market will depend on the FQPA. The loss of certain key pesticides would result in South African fruit exporters withdrawing from the North American market. Index terms: FQPA, South Africa, Cydia pomonella, insecticides

[0112] OVERVIEW OF FDA's PESTICIDE RESIDUE MONITORING PROGRAM

<u>Y. H. Lee</u>, P. M. Bolger & T.C. Troxell, Office of Plant and Dairy Foods and Beverages, Center for Food Safety and Applied Nutrition, U.S. Food and Drug Administration, 200 C Street (HFS-308), Washington, DC 20204, USA.

The US Food and Drug Administration (FDA) shares responsibility with two other federal government agencies for the regulation of pesticides. The US Environmental Protection Agency (EPA) registers the use of pesticides and also sets tolerances (the maximum amount of residue that is permitted in or on a food), if use of that pesticide may result in residues in or on food. FDA is responsible for enforcing these tolerances in imported and domestically produced food shipped in interstate commerce, except for meat and poultry for which the U.S. Department of Agriculture is responsible. FDA's pesticide residue monitoring program consists of three approaches; regulatory monitoring, incidence/level monitoring, and the Total Diet Study (TDS). FDA's regulatory monitoring program is conducted under the guidance of the Center for Food Safety and Applied Nutrition, FDA. Domestic foods are collected as close as possible to the point of production in the US; import samples are collected at the point of entry into the US. Emphasis is on raw agricultural products, which are analyzed unwashed and whole (unpeeled); however, some processed foods are also included. If illegal residues (above tolerance or no tolerance for particular food/pesticide combination) are found in domestic samples, FDA can invoke sanctions such as a seizure or injunction. For imports, shipments may be stopped at the point of entry when illegal residues are found. "Detention without physical examination" may be invoked based on the finding of one violative shipment, if there is reason to believe that the same situation will exist in future lots during the same shipping season for a specific shipper, grower, geographic area, or country. Factors considered by FDA in planning the types and numbers of samples to collect include review of recently generated state and FDA residue data, regional intelligence on pesticide use, dietary importance of the food, information on the amount of domestic food that enters interstate commerce and of imported food, chemical characteristics and toxicity of the pesticide and production, Incidence/level monitoring is a complementary approach to the regulatory monitoring, This approach is used to increase FDA's knowledge about particular pesticide/commodity combinations by analyzing certain foods to determine the presence and levels of selected pesticides. The TDS is an annual market basket program that provides data on pesticide levels that are present in table-ready foods; the data also enable us to estimate dietary exposure in specific age-sex groups in the US. Findings of FDA's residue monitoring will be discussed.

Index terms: pesticide residue monitoring, Total Diet Study, FDA.

[0113] PARTICLE PROCESSING

D. G. Sekutowski, Engelhard Corporation, 101 Wood Ave, Iselin, NJ USA 08830.

The mineral Kaolin is the active ingredient in the majority of the papers presented during this symposia session. Many of the chemical and physical properties of mineral particles can be engineered during processing. A review of kaolin processing is given demonstrating how various particle properties are controlled or modified to yield particles with enhanced performance. A brief overview of kaolin safety and industrial markets is also provided.

Index terms: kaolin, mineral

0114] PARTICLE FILM TECHNOLOGY FOR CONTROL OF ARTIIROPOD PESTS AND DISEASES IN PLANTS

G. J. Puterka & D. M. Glenn, USDA-ARS, Appalachian Fruit Res. Stn.,45 Wiltshire Rd.,Kearneysville, WV, 25430 USA, E-mail: gputerka@afrs.ars.usda.gov.

Particle film technology was recently developed at ARS, Kearneysville, as a method for controlling arthropod pests and diseases of agricultural and horticultural crops. The film is based on the inert mineral, kaolin, that is purified has had its size and shape specifically modified, to enable it to coat plants with a protective barrier that will not interfere with photosynthesis. The hydrophobic kaolin particle, M-96-018, was the first prototype of particle film technology applied to trees as dust to make the plant surfaces water repellent. This material suppressed arthropod pests and diseases by a number of different mechanisms. Fungal and bacterial diseases that require moisture to become infective were suppressed by coating the plant with a hydrophobic particle film barrier that prevented disease inoculum or water from directly contacting the leaf surface. Arthropod infestations were suppressed by particle films for several reasons. Plants coated with a hydrophobic particle film barrier become visually or tactilely unrecognizable as a host. In addition, insect movement, feeding, oviposition, and other activities can also be severely impaired by the attachment of particles to the arthropods bodies as they crawled upon the film. Dust applications of particle films were not practical because of drift and lack of particle adhesion to the plant surfaces. For this reason, our research on particle film formulations was directed toward the development of kaolin particles suspended in water so these formulations could be applied with conventional spray equipment. Tests comparing hydrophobic and hydrophilic particle films found that both insects and diseases were controlled equally by both types of films, indicating that only a physical barrier of hydrophilic kaolin was required. However, particle film mineral type and formulation was found to affect arthropod species differently with regard to survival, oviposition, and particle attachment to the arthropod cuticle. Particle films have been field tested for seveal years and many types of arthropod pests have been controlled in a variety of crops. Index terms: dust, kaolin, barrier, repellent

[0116] PARTICLE FILM TECHNOLOGY DEVELOPMENT IN CHILE

<u>E Prado</u>, Inst. de Investigaciones Agropecuarias, INIA. Casilla 439-3, Santiago, Chile. Email: eprado@platina.inia.cl.

Since 1996 field trials have been conducted in Chile to develop Particle Film Technology. Pest control was target at the beginning by means of hydrophobic kaolin. Codling moth and mite control on fruit trees was successfully achieved in organic and commercial conditions. Subsequent seasons included different formulations of hydrophilic particles. These formulations provided a substantial mite control (Panonychus ulmi and Brevipalpus chilensis), on fruit trees and grapevines respectively, but continuous monitoring is necessary. Despite of mite presence on almond trees, leaves kept longer on the tree, making them presumably more resistant to mite attack. Codling moth suppression was also achieved but last generation should be conventionally treated. Scales (Saissetia olene, Lepidosaphes ulmi and Quadraspidiotus perniciosus) and woolly apple aphid were not controlled and particle interfering with natural enemies may cause an increase of these pests. Further research is needed to assess the effect of kaolin on natural enemics. Vegetable pests have been more difficult to control due to the poor coverage of the lower part of the plant and the underneath of the leaf. Pest suppression has been achieved on South American Tomato Pinworm (Tuta absoluta) and leafminers (Liriomyza huidobrensis). Also potato tubers mixed with kaolin avoided potato tuber worm attack on storage conditions. However, twospotted mite (Tetranychus urticae) was not controlled on pepino fruit (Solanum muricatum) and aphids population increased on kaolin treated sweet pepper plants because aphids aggregated on uncovered leaves and apparently because of a detrimental effect of kaolin on aphid natural enemies. Leaves covered with kaolin have lower temperature than uncovered ones and light incidence is reduced. By consequence, pesticide degradation rate could be affected modifying residual activity and pre-harvest interval. Degradation rate was tested in applications of kaolin mixed with insecticides azinphos methyl and dimetoate. No change was found on residues and degradation rate. At the same time, horticultural benefits as better color and sunburn protection were observed on apples, plums and cherries. Main troubles with the new technology appeared to be an uneven coverage with the usual farm turbo sprayer, if this is not correctly regulated, and avoiding kaolin spots on some fruits producing a "green spot". In addition, the formulation to be used must permit an easy washing off of the fruit in the packing line. Further research is carried out to reduce the number of sprayings, doses and an improved coverage.

Index terms: kaolin, pest control, fruit quality, mites, moths

[0115] BENEFICIAL PHOTOSYNTHETIC AND HORTICULTURAL EFFECTS OF PARTICLE FILM APPLICATIONS ON PLANTS: DESTROYING THE DOGMA OF THE NEGATIVE EFFECTS OF DUSTS ON PLANTS

D.M. Glenn & G. Puterka, USDA-ARS Appalachian Fruit Research Station. Kearneysville, WV 25430, USA, Email: mglenn@afrs.ars.usda.gov.

Particle film technology utilizes inert mineral particles to envelope a plant in a protective and porous "particle film". Being porous, the particle film allows free exchange of water and carbon dioxide from the leaf during photosynthesis. The white mineral particles are reflective of infrared radiation and reduce the heat load on the plant. Laboratory, greenhouse, and field trials demonstrate that particle film technology is a viable pest control practice for a wide range of insect and disease problems with additional horticultural benefits due to reduced heat stress. In field studies, reducing heat stress improved red apple color development while reducing sunburn damage and increased photosynthetic rates, yield, carrying capacity, and return bloom. These horticultural benefits demonstrate that particle film technology is not just limited to pest control. Particle films have the added benefits of reducing plant heat stress and improving safety to farm workers, consumers and the environment.

[0117] EFFICACY OF PARTICLE FILMS TO CONTROL TRIBOLIUM SPP. IN MILLS AND FOOD STORAGE FACILITIES

F. II. Arthur & G. J. Puterka, USDA, ARS, Grain Marketing & Production Research Center, 1515 College Ave, Manhattan, KS 66502, USA, E-mail arthur@usgmrl.ksu.edu. USDA, ARS, Appalachian Fruit Research Laboratory, 45 Wiltshire Rd, Kearneysville, WV 25430, USA, E-mail GPuterka@afrs.ars.usda.gov.

Experimental particle films have been developed that will repel or control insect pests in several different agricultural systems. These materials are similar to insert dusts, and were tested for activity toward two stored-product beetles, *Tribolium castaneum* (Herbst), the red flour beetle and *Tribolium confusum* (DuVal), the confused flour beetle. Studies were conducted to determine application rates and exposure intervals required for control, relative susceptibility of the 2 species, effects of environmental conditions on product efficacy, and recovery after exposure. Results for one particle film were comparable to a labeled formulation of diatomaceous earth containing silica. *T. confusum* was less susceptible than *T. castaneum*, and mortality of both species decreased as relative humidity increased. Mortality of *T. castaneum* that were not given food after they were exposed decreased as the original exposure interval increased. However, when given food after exposure, survival of *T. castaneum* was virtually 100% regardless of how long they were exposed to the narticle film.

Index terms: stored products, particle film, dust, *Tribolium confusum*, confused flour beetle, *Tribolium castaneum*, red flour beetle, food, recovery

[0118] POTENTIAL OF KAOLIN BASED PARTICLE BARRIERS FOR TERMITE CONTROL

W.D. Woodson & B.A. Wiltz, USDA-ARS, Southern Regional Research Center, 1100 Robert E. Lee Blvd., NewOrleans, LA,USA, 70179-0687, E-mail: dwoodson@nola.srrc.usda.gov

Recently a particle film technology was developed at ARS, Kearneysville, as a method for controlling arthropod pests and diseases of agricultural and horticultural crops. The film is based on the inert mineral, kaolin, that is purified has had its size and shape specifically modified, to enable it to coat plants with a protective barrier that will not interfere with photosynthesis. Effects of three of these compounds, M-96-018, M-97-009, and Surround WP on tunneling and survival of Formosan subterranean termites, Coptotermes formosanus Shiraki, were determined by a choice test, forced exposure and indirect exposure laboratory bioassays. In the choice test C. formosanus was presented with two 2.5 x 2.5 x .05 cm pieces of southern yellow pine, one treated with one of the kaolin products the other untreated. Mean consumption was significantly different between the treated and untreated wood after 21 days of exposure. There were no significant differences between M-96-018, M-97-009 and Surround WP in the amount of wood consumed over the duration of the study. In the indirect exposure assays, termites were given the choice of tunneling through sand treated with each compound to reach a supplemental food source. Although C. formosanus was unable to tunnel in sand containing 1% M-96-018, this concentration did not prevent it from tubing over the treated sand to reach the supplemental food supply. At the 5% concentration of M-96-018 C. formosanus was unable to either penetrate or tube over the treated soil. Index terms: Coptotermes formosanus, dust, pest suppresson, termite.

[0120] SELECTIVE USE OF PARTICLE FILM TECHNOLOGY IN WASHINGTON POME FRUIT PEST MANAGEMENT

E. H. Beers¹, J. F. Brunner¹, J. E. Dunley¹ & M. Doerr¹, ¹Dept. of Entomology, Washington State Univ., Tree Fruit Research & Extension Ctr., 1100 N. Western Avc., Wenatchee, WA USA 98801 E-mail: cbcers@wsu.edu.

Much of the research to date on particle film technology (PFT) has focused on seasonal programs and their effect on the pest spectrum. The focus of this research was to partition out the effects on various pests to better integrate PFT with existing strategies and technologies and mitigate any undesirable effects. PFT applications targeting the oviposition period of Washington's key apple pest, codling moth, were equally effective as applications directed at the hatching neonates. The same strategy was tested with a noctuid pest, Lacanobia subjuncta. Both oviposition and hatch applications provided some suppression, but the hatch period appeared to be the more critical of the two. In a choice test, larvae of both species of leafroller tested (Choristoneura rosaceana and Pandemis pyrusana) in addition to those of L. subjuncta, avoided PFT residues on foliage in a choice test; however, leafroller larvae were able to successfully utilize any discontinuities in residue coverage. Field tests against C. rosaceana using PFT during the oviposition and hatch period (total of 6 applications) provided good control of this pest. PFT applications suppressed nymphs of white apple leafhopper (Typhlocyba pomaria), but provided no control of twospotted spider mite or first generation western tentiform leafminer (Phyllonorycter elmaella). PFT appeared to suppress phytoseiid mites and their alternate prey, eriophyid mites. This is a possible explanation of the increased levels of tetranychid mites seen in some plots. A prebloom program of PFT targeting pear psylla (with a standard program after bloom) was successful in preventing fruit damage by this pest; however, a postbloom-only or seasonal program of PFT had unacceptable amounts of fruit damage. PFT may have a uniquely useful effect on the expression of damage by mite-susceptible pear cultivars. It appeared to reduce transpiration burn, thus possibly raise the economic injury level and allow more latitude for biological mite control. Index terms: Cydia pomonella, Tetranychus urticae, Cacopsylla pyricola, Tetranychus urticae, Panonchyus ulmi

[0119] MULTIPLE USES OF PARTICLE FILMS IN PEAR PEST MANAGEMENT

R. J. Hilton, Southern Oregon Research & Extension Center, Oregon State Univ., 569 Hanley Rd., Medford, OR 97502, USA.

Particle film formulations were tested on pear in southern Oregon from 1997 through 1999. Field tests included replicated handgun applications to single trees conducted at the Research Center, and air-carrier sprayer applications conducted at the Research Center and in commercial orchards. Repeated applications of the particle films in the foliar period resulted in control of pear psylla-and pear rust mite. Particle film treatment resulted in a significant reduction of codling moth entries. No significant differences were observed between a hydrophobic and a hydrophilic formulation when they were compared in 1998. In some cases, an increased level of twospotted spider mite was observed while predator mites were almost totally absent from the particle film treated trees. Laboratory tests showed little effect of a particle film treatment with respect to twospotted spider mite mortality or oviposition behavior, while another laboratory study demonstrated that pear psylla oviposition was decreased on dormant pear wood which had been treated with a particle film. Particle film treatment improved fruit finish, reducing both sunburn and overall russet on pear fruit.

Index terms: Cacopsylla pyricola, Cydia pomonella, Epitrimerus pyri, Tetranychus urticae, oviposition behavior.

[0121] EVALUATION OF SEASONAL PARTICLE FILM SPRAY PROGRAMS IN A WESTERN APPLE ORCHARD

A.L. Knight¹, <u>G. Puterka²</u> & B. A. Christianson¹, ¹USDA-ARS, Fruit and Vegetable Research Laboratory, 5230 Kannowae Pass Rd., Wapato, WA 98951 aknight@yarl.ars.usda.gov; ²USDA-ARS, Appalachian Fruit Research Station, 45 Wiltshire Rd., Kearneysville, WV 25430 gputerka@afrs.ars.usda.gov.

Studies were conducted in a north central Washington apple orchard in 1998 and 1999 to evaluate the impact of seasonal spray programs of the kaolin-based particle film (PF) hydrophobic formulation, M96-018, on orchard pests, natural enemies, and fruit quality. We evaluated a half- and full-season PF spray program versus an untreated control in 1998, and during 1999, we compared plots treated with one or two years of PF, plots treated the year before with PF, and plots left untreated. PF treatments in both years significantly reduced populations of fruittree leafroller (FILR), Archips argyrospilus (Walker), white apple leafbopper, Typhlocyba pomaria (McAtee) and mullein bug, Campylomma verbasei (Meyer). Stink bug population densities (Euschistus conspersus Uhler and Acrosternum hilare (Say)) were unaffected by PF applications. PF treatments reduced the density of the most abundant generalist predator species, such as spiders and ants, while coccinellids and the earwig, Forficula auricularia L., were not affected. Parasitism of western teniform leafminer Phyllonorycter elmaella (Doganlar & Mutuura) was significantly reduced and the density of mines per leaf were also higher on PF treatments compared with the untreated control. Levels of fruit injury from San Jose scale (SJS) Quadraspidiotus pernicious (Comstock), were significantly higher in PF treatments in 1998, however the use of chlorpyrifos in the spring in 1999 subsequently controlled SJS in all plots. FTLR injury was significantly reduced in 1998 in PF treatments and was significantly lower in plots treated with PF for two years in 1999 at harvest. Nocturd fruit worm injury was significantly lower in the mid-season sample in the PF-treated plots. Fruit size was increased in PF-treated versus untreated plots in both years. Soluble solids were increased in 1998 in the full season PF program.

Index terms: kaolin, pest suppression, natural enemies, barrier, repellent

[0122] USE OF KAOLINIC PARTICLE FILM IN A CITRUS IPM PROGRAM

D. L. Kerns, Dept. of Entomology, Univ. of Arizona, Yuma Agricultural Center, 6425 W. 8th St., Yuma, AZ 85364, USA, E-mail dkerns@ag.arizona.edu.

Citrus thrips, Scirtothrips citri, is the most economically damaging insect pest affecting Arizona citrus. Although the feeding action of citrus thrips can leave citrus leaves highly distorted, it's the scarring of the fruit rind that is of the most economic concern, leaving the fruit unsuitable for fresh market. Traditionally, broad spectrum insecticides have been extensively utilized for managing citrus thrips in Arizona citrus. Chemical control of thrips is costly, sometimes ineffective or short lived, and often results in outbreaks of secondary insect pests and mites. Kaolin (Surround WP) is a mineral particle with insect management potential. It is a highly refined, white, non-abrasive, nonporous, aluminosilicate mineral manufactured by Engelhard. When sprayed on plant surfaces it is similar in appearance to whitewash materials used to protect foliage from sunburn. Kaolin appears to offer insect control through visual repellency, by acting as a physical barrier, and by disrupting insect behavior after attachment to the insect's cuticle. Kaolin has been shown to effectively suppress a number of insect pest in a variety of crops. In field trials on lemons in Arizona, kaolin maintained citrus thrips populations below 3% infested fruit, while a untreated control exceeded 33% infested fruit. At harvest, trees treated with kaolin produced 95% fancy grade lemons, while the untreated control produced 50% fancy fruit. For thrips management in citrus, kaolin should be applied preventively. Treatments should be applied before thrips are numerous, and near petal fall or before fruit set. Additional treatments are necessary to insure coverage of new growth and expanding fruit until the fruit reaches 2.5 cm in daimeter. In addition to citrus thrips control, kaolin may also aid in the tree's heat stress management resulting in higher yeilds. Index terms: Scirtothrips citri, citrus, kaolin, particle film

[0124] CONSERVATION TILLAGE: PHYSICAL CONTROL AT THE LANDSCAPE SCALE

B. R. Stinner

ABSTRACT NOT RECEIVED

[0123] LITTLE UNDERSTOOD AND DIFFICULT TO MANIPULATE, THE OLDEST CLASSICAL TACTIC HAS UNTAPPED POTENTIAL

M. E. Irwin, Dept. Nat. Resources & Environ. Sci., Univ. Illinois at Urbana-Champaign, 1101 W. Peabody Dr., Urbana, IL 61801, USA .Email: mirwin2@uiuc.edu

Integrated pest management (IPM) implies a set of principles for reducing pest populations in an economically sound and environmentally friendly manner. IPM can be thought to have three organizational levels: a basic knowledge bank; the weaponry to suppress pest populations; and the capacity to deploy these weapons to manage pest complexes. The knowledge bank consists of fundamental information; each category of weaponry is termed a tactic; and putting these tactics to use invokes a management strategy. Several categories of tactics exist; the major ones include host resistance, chemical control, biological control, legal control, and cultural control. Molecular or genetic mechanisms are potentially manifest in several of these tactics. Each category of tactic employs a set of mechanisms for suppressing populations. This symposium focuses on the tactic of cultural control at the landscape scale and explores approaches to ensure that this, the oldest classical tactic, can be both potent and flexible at the larger spatial scales when devising pest management strategies. Cultural control, often taking the form of selected cultural practices or specific manipulations of the habitat, often renders a habitat more favorable to natural enemies or less favorable to pests. At the larger spatial scales, it can also concentrate pests in areas where they do little damage to the target crop by attracting them (e.g., trap cropping) or repelling them (e.g., intercropping in some cases). Designed to disfavor pests and ultimately reduce their ability to cause damage, this ecological approach relies a great deal on behavior responses of target species and requires a solid understanding of how pests and natural enemies respond to changes in the habitat structure, including fragmentation. These larger scale practices can take advantage of temporal windows for planting, cultivating, and harvesting. Similarly, spatial patterns of crop mosaics might be utilized to "hurd" pests to areas where they will do less damage. Both spatial and temporal larger scale manipulations aree considered.

Index Words: IPM, cultural_control, landscape_scale, spatial, temporal.

[0125] LARGE TACHINID PARASITOIDS RESPOND TO HABITAT STRUCTURE AT LARGER SPATIAL SCALES

J. Roland, Department of Biological Sciences, University of Alberta, Edmonton, T6G 2E9. Alberta, and P.D. Taylor. Department of Biology, Acadia University, Wolfeville, Nova Scotia, Canada, B0P 1X0.

We estimate the effect of forest fragmentation on rates of parasitism caused by four species of fly parasitoid attacking the forest tent caterpillar. Parasitism by each species was estimated from collections of host larvae and pupae from 130 population sites across and area of 400 km². Parasitism rates for each species was related to the degree of forest fragmentation at each site. Because the level of fragmentation was estimated at multiple scales (form 53m to 1700m) around each site, we could determine at which scale forest structure affects each fly species most. Supporting data suggest that the scale at which each species is affected by forest structure is in part determined by the scale over which they normally move. For most parasitoid species, forest fragmentation reduces the rate of parasitism, and those thought to move the most are affected by fragmentation measured at larger spatial scales.

Index terms: dispersal, fragmentation, spatial scale, tachinid, parasitoid

[0126] CROPPING PATTERNS, A LANDSCAPE PERSPECTIVE OF CULTURAL CONTROL

G.P. Fitt & M.L. Dillon, Australian Cotton Co-operative Research Centre, CSIRO Entomology, P.O. Box 59, Narrabri NSW 2390, Australia. Email: gary.fitt@ento.csiro.au.

Integrated pest management seeks to optimise the use of a range of complimentary control tactics to achieve management of key pests. Cultural controls, which may involve physical disturbance, crop rotations, intercropping, trap cropping among others, is one IPM component receiving increasing attention from researchers and producers. The significance of this work from a landscape perspective will be illustrated by focussing on a key pest of multicropping agricultural systems. As significant pests of many agricultural systems around the world, Helicoverpal Heliothis species (Lepidoptera: Noctuidae) are the focus of considerable basic and applied research. The ecological attributes of high mobility and polyphagy which characterise the pest species of Heliothines demand that population management operates at the regional, rather than field scale. Adult mobility of pests like Helicoverpa introduce considerable complexity to their dynamics and genetic structure since populations defined at any scale (field, ecosystem, region) can be comprised of individuals with differing ecological attributes which have developed on different hosts or have moved from different populations With increasing understanding of their population ecology, a range of cultural tactics are now being developed and implemented for use in area-wide systems for population management and resistance management. Several of these involve manipulation of the cropping system at varying scales to modify the suitability of the crop environment for pests by introducing trap crops, refuge crops, predator nurseries. Some examples of these cultural controls in cotton systems will be discussed.

Index Words: Helicoverpa, IPM, cultural_control.

[0128] INTERACTIONS BETWEEN PREDATOR SPECIES, THEIR PREY AND THE HOST PLANT

S. D. Wratten & C. N. Merfield, Ecology & Entomology Group, Soil, Plant & Ecological Sciences Division, P.O. Box 84, Lincoln University, Canterbury, New Zealand.

Most studies on invertebrate predation concern single predator or parasitoid species and evaluate their behaviour and ecology with little consideration of other natural enemies in the same or different guild, or of tri-trophic-level effects between plant, prey/host and the natural enemy. In many agricultural habitats however, there may be hundreds of natural enemy species potentially interacting and the crop itself may respond to herbivore feeding via wound-induced changes in plant defences. The interaction between the plant, the herbivore and the predator can therefore involve "top down" (ie predator) and/or "bottom up" (ie plant) effects on the herbivore population. This paper will explore two systems in which these interactions have been recently studied. The first is tomato/caterpillar/predatory carabid interaction while the second concerns commensal relationships between predatory arachnid species. Work on the lepitopteran Spodoptera litura on tomato (Lycospersicon esculentum) and the non-climbing carabid predator Megadromus antarcticus showed that the carabid increased S. litura mortality with a subsequent decrease in leaf damage. Leaf wounding produced a possible decrease in herbivory and there was a trend for the presence of the carabid on the soil to interact with wound-induced changes in the plant; the latter caused a higher proportion of lavac to move to the soil surface, where they were available to the epigeal predator. Using time-lapse video techniques in the field and in the laboratory showed that when some predatory mite species (whirlygig mites: Anystis spp. and mites in the super-family Erythraeoidea) had pierced a dipteran egg, the latter was more likely to be predated by harvestmen (Arachnid: Opiliones). The latter type of commensal interaction, between predators in the same guild with similar feeding mechanisms, has been very rarely demonstrated in predator-prey systems and maybe more common among predators in cropping systems than previously assumed.

[0127] PLANT VIRUS EPIDEMICS. CAN CULTURAL PRACTICES HELP CURB THIS LOOMING THREAT TO MODERN AGRICULTURE?

A. Fereres, Dept. of Plant Protection, Centro de Ciencias Medioambientales, CSIC. Serrano 115 dpdo., 28006 Madrid, Spain, Email: afereres@ccma.csic.es

Most of the known plant viruses causing economic damage are transmitted by insect vectors. Plant viruses depend in one way or another on insects or seeds for their dispersion and spread. Therefore, insect movement and dispersal modulate the temporal and spatial scale of virus epidemics. Sometimes, virus outbreaks are associated to high vector population densities such as the case of viruses that are transmitted in a persistent fashion. However, in many cases viruses are transmitted by transient insects that may never be seen by the farmer because they remain for a very short period of time in the crop. This is the case of the widely spread nonpersistent viruses that are exclusively transmitted by aphids during very brief superficial probes lasting only few minutes. There are a number of cultural control options that theoretically can be used to prevent and reduce the spread of plant viruses. Sometimes, slight modifications of specific crop managment practices (e.g., irrigation, plant density, tillage, chemical applications of synthetic fertilizers and pesticides) may have a direct effect on vector ecology and its associated natural enemies, and hence will influence the rate or timing of virus epidemics. In this sense, the agroecosystem can be manipulated to favor natural enemies or/and disfavor insect pests. Some of the cultural control measures concentrate on removing sources of inoculum (crop volunteers, weed reservoirs, infected seeds or vegetative stocks, etc...), or by avoiding the periods of maximum risk of infection (changing the sowing or harvesting date, changing to a cultivar with a different growth cycle, etc...). Some other control tactics are designed to interfere with the main vectors of plant viruses by modifying their behavior and preventing alighting on the protected crop. Thus, physical barriers (natural or artificial) can significantly reduce the number of insect vectors alighting on the crop. Under greenhouse conditions, several kinds of physical barriers such as insect-proof screens or UV-absorbing plastics have given very promissing results. Also, agrotextile row covers can reduce the spread of several viruses infecting horticultural crops. However, before implementing specific cultural measures to control plant viruses they should be analyzed together with economic and environmental considerations. The viability and compatibility of integrating cultural options to control virus diseases under the scope of other crop management strategies will be discussed.

Index terms: vector, physical barrier, row cover

[0129] LANDSCAPE LEVEL CULTURAL CONTROL: FUTURE PROSPECTS AND LIMITATIONS

<u>M. P. Zalucki¹, M. Miles², D. A. II. Murray² & Wayne Rochester¹, I. Department of Zoology and Entomology, The University of Queensland, Australia, 4072, Email: M.Zalucki@mailbox.uq.edu.au; 2. Farming Systems Institute, Queensland Department of Primary Industries, Toowoomba, Australia, 4350.</u>

Cultural control is part of all pest management systems as it involves activities that are central to agricultural practices at a landscape level. Physical disturbance of the soil as part of ploughing, normal crop rotations, intercropping, refuge crops, and trap cropping (even if these are just alternative hosts) impinge on the distribution and potential abundance of pest species. Increasingly such practices are being advocated as a deliberate ploy to manipulate the agricultural habitat of pests and their natural enemies to make it less favourable to the former. This approach is thought to be particularly useful for polyphagous mobile species such as heliothis, for which standard IPM at the field level is likely to be ineffective. We present a case study of Area Wide Management of Helicoverpa spp. on the Darling Downs in Queensland, Australia. The future of landscape level cultural control will hinge on our ability to assess the impact of any implemented practices. Thus trap cropping may sound plausible but does it make any difference to pest pressure, and how can such impacts be assessed? Increasingly landscape level control will require more detailed information on potential pest pressure and current pressure mapped over the region. Such an approach will demand data sharing among farmers, consultants and researchers as well as ready access to rapid analysis of the changing pest landscape. The problem of suitable 'controls' on which to judge the success of Area Wide Management is discussed. Perhaps there will be a use for "predictive" models after all. The future prospects and constraints to cultural control at a landscape level are discussed in relation to trap cropping, which attempts to implement our detailed understanding of moth behaviour to manipulation of adults moths at a local level leading to regional impacts on abundance.

Index terms: *Helicoverpa* landscape management, IPM, scientific controls, models, data sharing, analysis tools.

Symposium and Poster Session

[0130] TOWARDS INSECTICIDE-FREE VITICULTURE IN AUSTRALIA AND NEW ZEALAND

<u>P.T.Bailev</u>¹ & D.M. Suckling², ¹South Australian Research & Development Institute, Entomology Section, Waite Campus, GPO box 397, Adelaide South Australia 5001. Austrália, E-mail: bailey.peterT@saugov.sa.gov.au; ²HortResearch, PO Box 51, Lincoln New Zealand. e-mail: msuckling@hort.cri.nz

There are few major arthropod pests of wine grapes in Australia and New Zealand, and synthetic insecticides are rarely used. Consequently there is no history of insecticide resistance, and pests can be managed with selective inputs in both countries. In Australia, the grapeleaf blister mite, Colomerus vitis, is a widespread pest, controlled by a combination of sulphur at budburst, and predators. The use of some newly-available fungicides appears to be related to increasing bud damage by this mite, perhaps because their natural enemies have been suppressed. Another key pest, the lightbrown apple moth, Epiphyas postvittana, is controlled by natural enemies and the hot summers of inland areas. In New Zealand vineyards, this insect is generally controlled by one or two Bacillus thuringiensis sprays. Native New Zealand leafrollers are seldom detected in this crop, although they do pose problems for many other horticultural crops. Few vineyards choose to control mealybugs (several Pseudococcus species), although this group can vector grapevine leafroll disease, mainly in the North Island. There has been only limited research on vineyard pests in New Zealand, with most research focussed on diseases. Most Australian vineyards can actively conserve beneficial arthropods by avoiding cover sprays of synthetic insecticides, and use of pheromones for mating disruption, Bacillus thuringiensis or Trichogramma spp. to control lightbrown apple moth, with toleration of some yield loss. However, conservation of natural enemies may be threatened by a number of factors. The high value of wine grapes means that managers are less prepared to accept some losses caused by lightbrown apple moth, and organophosphate use on plantings in some cool viticultural areas is increasing. Fungicide use needs to be integrated into a vineyard pest management program. Some observers note that insecticide use may increase in some vineyards from fears that (yet to be identified) insect vectors are spreading Australian grapevine yellows and grapevine leaffoll disease, and more work is needed on potential vectors of these diseases.

Index terms: Vineyard IPM, Australia, New Zealand, Conservation of Beneficials

[0131] THE ROLE COVER CROPPING IN VINEYARD IPM

<u>K.M. Daane</u>¹, M.J. Costello² & G.Y. Yokota¹, ¹Div. Insect Biol. (ESPM), Univ. of California, Berkeley, CA 94706, USA, daane@uckac.edu; ² Costello Agricultural Research & Consulting, PO Box 165, Tollhouse, CA 93667 USA

Many California grape growers are managing floor vegetation as one component of their IPM program. Here, we present data from 1993 to 1996 studies in California vineyards testing effects of cover cropping on pest and beneficial insects and vine health parameters. The target pests were leafhoppers (Erythroneura variabilis and Erythroneura elegantula), which cause direct damage to grape leaves through feeding and indirect damage from accumulated honeydew. Results show third generation nymph densities were commonly lower (about 15%) in cover crop treatments at juice, table and wine grapes, but not in the raisin grapes. Research sought to determine how cover crops affected leafhopper densities, focusing on both biotic and abiotic leafhopper mortality factors. There were no consistent differences in the number of mymarid egg parasitoids, Anagrus erythroneurae and Anagrus daanei (formerly grouped as Anagrus epos) between ground cover treatments. The predator community on the vines is dominated by various spider species, which composed >90% of the predators which fed on insects. We found that in 3 of 4 vineyards (8 of 10 annual trials) the addition of a cover crop did not significantly increase the total number of spiders on the vines. Overall spider abundance (vines and cover crop) was higher in cover crop plots because many spiders reside on the cover crop and results showed little movement. We conclude that the cover crop did not provide an important alternate habitat for vine-dwelling spiders. Another, less well studied effect of ground covers, is the change in host pant condition. At 3 of 4 sites (table, wine, and juice) the addition of a cover crop affected vine condition, as indicated by significantly lower pruning weights and petiole nitrate levels. At these same sites there was a reduction in leafhoppers in all but one year. At the raisin site, where cover crops were tilled under by mid-season, there was no measurable vine stress (or difference in leafhopper numbers). The data suggest that the reduction in vine vigor contributed to the reduction in leafhopper numbers. We conclude that cover crops maintained throughout the year (juice, table, and wine grape sites) resulted in lower third-brood leafhopper densities, however, the level of leafhopper reduction was often not economically significant (about 15%). The most commonly observed trait amongst plots with lower leafhopper densities was not a biotic change but an abiotic one. There were relatively few differences in natural enemy densities in cover crop and no cover treatments. However, year-round cover crops, especially resident grasses reduced vine vigor and this was directly related to leafhopper reduction.

Index terms: Erythroneura, spiders, Anagrus, cover cropping, vineyard IPM.

[0132] ROLE OF SPIDERS IN GRAPE IPM

M.]. Costello¹, K.M. Daane ²& D.J. Schmidt², ¹Dept. of Crop Science, California Polytechnic State Univ., San Luis Obispo, CA, 93407, USA, ²Dept. of ESPM, Insect Biology, Univ. of California, Berkeley, CA, 94720, USA

Spiders comprise over 95% of vineyard predators collected in California's central valley. They exist in grape vineyards as a complex of species, which respond differently to environmental conditions and have various methods of prey capture. We conducted a series of studies on spiders and cover cropping in vineyards, and found only one species, the hunting spider *Trachelas pacificus* (Corinnidae), whose population density increased with the presence of cover crop. The feeding habits of web spinning spiders can often be determined by enumerating prey captured in webs, but it is difficult to evaluate predation by hunting spiders, *T. pacificus* and *Cheiracanthium inclusum* (Miurgidae) on omnivorous leafroller (OLR) Platynota stultana (Lepidoptera: Tortricidae). We developed a monoclonal antibody to OLR and assayed for its presence in the guts of spiders using the enzyme linked immunosorbent assay (ELISA). We conducted laboratory studies to determine the OLR digestion rates of *T. pacificus* and *C. inclusum* at a constant temperature of 21°C. In *C. inclusum* reacting positively. More positive reactions were recorded when spiders were diluted with coating buffer at a rate of 1:1000 than at 1:100. Key words: Trachelas pacificus, Cheiracanthium inclusum, Platynota stultana, monoclonal antibodies

[0133] TOWARDS FEWER PESTICIDE APPLICATIONS IN QUEBEC VINEYARDS

N. J. Bostanian & C. Vincent, Hortic. Res. Dev. Centre. Agric. and Agri-Food Canada, St. Jean sur Richelieu, Quebec, CANADA J3B 3E6. E-mail: bostaniannj@em.agr.ca

Viticulture started in Quebec by the first French settlers several centuries ago. However, it has always remained a marginal agricultural activity because of the cool climate. Nevertheless, in recent years there has been a great surge in viticultural activity and several wineries have come to exist. This paper establishes the different arthropods such as the grape berry moth *Endopiza viteana*, potato leafhopper, *Empooasca fabae* and others in their order of importance as pests and discusses their abundance throughout the season-Based on a better understanding of the biology and abundance of these pests, insecticide treaments have now been reduced by 50%. Index terms: Grapes, pests, cool-climate

[0134] INTEGRATED MANAGEMENT OF SPIDER MITES IN CALIFORNIA VINEYARDS

R. Hanna¹, F. G. Zalom² & L. T. Wilson³, ¹Intern. Inst. of Trop. Agric., PHMD, IITA-Benin Station, 08 B.P. 0932, Cotonou, Benin, E-mail r.hanna@cgiar.org; ²Statewide IPM Project, Univ. of California, One Shields Ave., Davis, CA 95616 USA, E-mail fgzalom@ucdavis.edu; ³Beaumont Res. & Ext. Cent., Texas A&M Univ., 12509 Aggie Drive, Beaument, Texas 77713 USA, E-mail It-wilson@aesrg.tamu.edu.

The phytophagous spider mites, Tetranychus pacificus and Eotetranychus willamettei, are the most common spider mites in California vineyards. While both species can cause losses in grape yield and quality, T. pacificus is generally considered much more destructive than E. willamettei. Research over the last 30 years has identified several factors that affect population abundance and pest status of T. pacificus and E. willamettei in vineyards. As on many perennial crop plants, predation by phytoseiid predators, if not disrupted by pesticides used for insect and disease control, can generally provide effective biological control of both spider mite species. Extensive research has also abundantly shown that populations of the two spider mite species, particularly T. pacificus, can be negatively affected by interspecific interactions such as induced resistance and shared predation. In addition, numerous observations have associated increasing severity of mite infestations with increasing vine stress caused by water and nutrient deficiencies and probably exacerbated by nematode damage, but the effect of these factors on spider mites in vineyards has not been rigorously tested. Manipulation of the above factors has been used in developing tactics for integrated management of vineyard spider mites. We will review the successes and challenges in using these tactics with emphasis on predator conservation through selective use of pesticides, predator enhancement through augmentative releases, incorporation of predator-prey ratios in population monitoring, and grower perception and adoption of available IPM tactics.

Index terms: Tetranychus pacificus, Eotetranychus willamettei, Metaseiulus occidentalis, biological control.

[0135] PHYTOSEIID-POLLEN RELATIONSHIPS IN ITALIAN VINEYARDS

V. Girolami, <u>V. Malagnini</u>, A. Di Bernardo & C. Duso, Institute of Agricultural Entomology, University of Padua, Via Romea 16, 35020 Legnaro (Padova), Italy, E-mail ento@agripolis.unipd.it

In northern Italy, Kampimodromus aberrans, Typhlodromus pyri and Amblyseius andersoni are the most important phytoseiid mites in vineyards. They survive and reproduce on different kinds of food. The first two species are able to persist even when prey are scarce. Laboratory studies demonstrated pollen to be a very important alternative food for these generalists. Therefore, pollen availability on grapevine leaves could affect phytoseiid population dynamics. For three years, samples of grapevine leaves from three vineyards were treated by acetolysis, in order to identify pollen grains and assess their density over the time. The pollen diagrams, generally, showed a richness of non arboreal pollen (NAP) in which Poaceae pollen was dominant. Arboreal pollen (AP) was found mostly during spring and grapevine bloom. The pollen density declined in mid summer but increased slightly in September. A comparison between pollen abundance and phytoseiid population dynamics showed that reproduction and juvenile numbers increased after large pollen availability. This relationship was more evident during sprouting, after grapevine bloom, and sometimes in September. Moreover, the application of pollen (hornbeam or hop) was associated with an increase in oviposition and juvenile numbers of K. aberrans. In some areas, K. aberrans and T. pyri releases sometimes fail or phytoseiid densities decrease progressively to very low levels in August and September. On the other hand, the investigation on pollen abundance in vineyards showed a dramatic reduction of pollen densities during the same period. Therefore, phytoseiid decrease could be linked to low pollen availability. Weed management could improve phytoseiid persistence in vineyards. Experiments were carried out on small plots colonized by K. aberrans and characterized by low or frequent mowing. Results showed that K. aberrans populations increased and persisted by flowering grasses.

[0136] MIGRATION AND IPM IN DEVELOPING COUNTRIES

<u>R. J. Cooter</u>, Pest Management Dept., Natural Resources Institute, University of Greenwich, Chatham Maritime, Chatham, Kent, ME1 4TB, UK.

It is projected that world population will increase to 8-9 billion in the next 30 years Currently about 800 million people are food insecure and even with projected improvements in yield the challenge to reduce crop losses to pests remains enormous. Integrated Pest Management or its more holistic relative Integrated Crop Management has been driven in developed countries by pressure from the environment and health lobbics and supported by consumers willing to pay a premium for pesticide-free produce. In developing countries the farmer's priorities are different and food security, yield and stability are the forces driving farmers to reduce crop losses and ICM has a role to play here too. Of migrant or highly mobile insects only those which feed on plants important to man are seen as pests. Whilst it is the larval stage of many of them that cause direct damage to crops (e.g. armyworm) others cause damage both as adults and throughout their lives (e.g. locusts). Whilst armyworm and locusts can cause catastrophic and dramatic damage it is those insects which vector plant, human and animal diseases (aphids, whitefly, leaf and planthoppers, biting flies, etc.) probably cause the most economic damage and which constitute a persistent threat to food security, livelihoods and health in developing countries. In this overview, examples will be given drawn from work on armyworm, Helicoverpa armigera and important plant disease vectors will be given to show how a pests powers of dispersal influence ICM strategies in smallholder cropping systems.

Index terms: *Helicoverpa annigera*, whitefly, armyworm, grasshoppers, locusts, disease vector, migration, Integrated Pest Management, ICM, smallholders

[0137] A EUROPE-WIDE NETWORK FOR MONITORING FLYING APHIDS `EXAMINE': ACHIEVEMENTS AND PROSPECTS

R. Harrington¹, ¹Inst. of Arable Crops Research - Rothamsted, Harpenden, Hertfordshire, AL5 2JQ, UK, E-mail: richard.harrington@bbsrc.ac.uk.

As a family, aphids rank amongst the most important pest invertebrates in many parts of the world. In the 1960s, a monitoring system using 12.2m suction traps was initiated in the UK to provide data to help understand the spatial and temporal dynamics of aphids in order, ultimately, to aid decisions on control. Eighteen countries throughout Europe have now adopted traps of the same design and over 70 are in operation. These provide daily data throughout the aphid flight season on all important pest species, with some countries identifying all, or most, individuals. A 'Thematic Networks' project with the acronym 'EXAMINE' (EXploitation of Aphid Monitoring IN Europe) has recently begun under the European Union FP5 programme 'Energy, Environment and Sustainable Development'. The objective of the project is to provide a common database for 20 pest aphid species throughout Europe and to use the database to examine relationships between aphid dynamics and global change. The project will provide the most comprehensive standardised spatio-temporal database for any terrestrial invertebrate group anywhere in the world, and will also facilitate analyses leading to Europe-wide forecasting of aphid outbreaks. This paper will describe major uses of suction trapping to date and discuss the opportunities presented by the 'EXAMINE' project. Major uses of suction trapping to date include: i) studying the spatial and temporal dynamics of aphids; ii) understanding aphid cold hardiness; iii) analysing conditions leading to wing production, sexual morph production and flight; iv) demonstrating biological impacts of global environmental change; v) analysing gene flow; vi) understanding dynamics of insecticide resistance; vii) pre-season forecasting of pest potential and viii) providing within season advice on pest control. All of the above uses will continue but will be enhanced by the Europe-wide scale of analyses. In the near future, advances will be made in understanding the relationship between aphid dynamics and climate, land use and concentrations of gaseous pollutants. Also, the routine use of genetic markers will allow the build up of a database on subsamples of a few key species, which over time will reveal much about gene flow and migration rates.

Index terms: long term data, forecasting, global change

[0138] SEASONAL MONITORING OF THE INSECT FAUNA FLYING AT ALTITUDE OVER SOUTHERN ENGLAND: RESULTS FROM A VERTICAL-LOOKING RADAR

J. R. Riley, D. R. Reynolds & A. D. Smith, Natural Resources Institute Radar Unit, Univ. of Greenwich, North Site, Leigh Sinton Road, Malvern, Worcestershire WR14 1LL, UK. Email: jriley@nriradar.demon.co.uk.

The unique capacity of radar to observe high-flying insects has been amply demonstrated over the past 30 years, and the bulk of our current knowledge of insect migration at altitude stems directly from this very powerful technique. Although conventional entomological radars are not suitable for long-term observational tasks, the recent advent of nutating-beam, vertical-looking radar (VLR) equipped with novel signal processing capabilities has made season-long monitoring an economic and practicable proposition. This paper describes such a radar, and how it was used in a three-month study of insect flight activity over southern England during the exceptionally warm summer of 1995. Our measurements were made automatically, once every half hour, in the altitude range from 150 to 1050 m. The results showed how insect aerial density varied throughout the summer, revealed the presence of both day time and nocturnal layer concentrations at altitude, and gave estimates of the mass distribution, aerial density, displacement vectors and orientations of the overflying insects. The potential of the new VLR for various operational pest monitoring tasks will be discussed. Index terms: migration, radar, monitoring, layering

[0140] DISTANT NATIVE HOSTS IN SEMI-ARID REGIONS AS A SOURCE OF PEST INFESTATIONS IN CROPPING AREAS: THE AUSTRALIAN EXPERIENCE

P.C. Gregg, Agronomy & Soil Science, School of Rural Science & Natural Resources, Univ. of New England, Armidale, NSW 2351 Australia, E-mail pgregg@metz.une.edu.au.

The semi-arid areas of inland Australia are characterised by extremely variable and patchy rainfall. For extended periods of drought these regions may be absolutely unsuitable for breeding by the many migratory insect pests which originate there. However, rainfall at critical times can produce abundant growth of native host plants for these pests, which include Australian Plague Locust, Chortoicetes terminifera (Walker), common armyworm, Mythimna convecta Walker, cotton bollworm Helicoverpa armigera (Hübner) and native budworm, Helicoverpa punctigera (Wallengren), as well as several other minor noctuid moth pests. The native hosts include perennial grasses which support the growth of populations of C. terminifera and M. convecta. The root systems of these grasses allow them to survive extended drought but respond quickly to rainfall, especially when the rain falls in the warmer months. The host plants for *Helicoverpa* spp. and other noctuits include ephemeral broadleaf species, especially in the families Asteraceae and Fabaceae, which germinate quickly in response to autumn or winter rainfall. These plants can support large numbers of larvae over wide areas, covering several different habitat types. When the warm dry conditions of early spring arrive, there is a rapid and synchronous deterioration of the host plants. This is accompanied by large scale migration over distances of 500 to 1500km, in some cases reaching the cropping regions of southeastern Australia and resulting in serious economic losses. Examples of such migrations will be presented. Comparisons of the suitability of key host plants for the survival and development of *H. punctigera* (which is common in these migrations) and *H. armigera* (which is rare) indicate that both are equally well adapted to the inland native hosts. This suggests that it is the migratory strategy of the pests rather than the availability of hosts which is the key to success in these variable environments.

[0139] REGIONAL MOVEMENT OF THE PLANTHOPPER, DELPHACODES KUSCHELI, VECTOR OF MAIZE ROUGH DWARF VIRUS IN CENTRAL ARGENTINA

M.P. Grilli

ABSTRACT NOT RECEIVED

[0141] *HELICOVERPA* FORECASTING IN AUSTRALIA: STATISTICAL MODELS INCORPORATING LOCAL AND NON-LOCAL FACTORS

<u>M. P. Zalucki¹ & D. A. Maelzer², 1.</u> Department of Zoology and Entomology, The University of Queensland, Australia, 4072, Email: M.Zalucki@mailbox.uq.edu.au; 2. School of Land and Food, The University of Queensland, Gatton, Australia, 4345

The use of long-term forecasts of pest pressure is central to better pest management. Serious infestations of Helicoverpa punctigera Wallengren and II. armigera (Hübner) (Lepidoptera: Noctuidae) are experienced yearly in the eastern cropping regions of Australia. Regression analyses of a long series of light-trap catches were used to describe the seasonal dynamics of both species. The size of the first generation in spring of *II*. punctigera, which is comprised mostly of immigrants from inland Australia, was related to monthly rainfall in inland winter breeding areas. The size of the second generation of *H*. armigera was significantly related to the size of the first generation, to winter rainfall, which had a positive effect, and to spring rainfall which had a negative effect. Rainfall and crop hosts were also important for the size of the third generation. When winter rain was omitted from the analysis, the sizes of both the second and third generations could be expressed as a function of the size of the previous generation and of the areas planted to lucerne, sorghum and maize. For H. punctigera, which declines in abundance after the second generation, winter rain had a positive effect on the sizes of the second and third generations, and rain in spring or early summer had a negative effect. Only the area grown to lucerne had a positive effect on abundance. As rainfall figures prominently as a predictor variable and may itself be predicted using the Southern Oscillation Index (SOI) and the Sea Surface Temperature (SST) we also related trap catches to these variables. The size of the first spring generation of both species was significantly correlated with the SOI in certain months, sometimes up to 15 months before the date of trapping. Forecasts of pest levels from many months to a few weeks in advance are discussed, along with the improved understanding of the seasonal dynamics of both species.

Key words: Helicoverpa armigera, Helicoverpa punctigera, forecasting, light trap, climate, Southern Oscillation Index

[0142] LOCUST FORECASTING AND PREVENTIVE CONTROL IN AUSTRALIA

D. M. Hunter & E. D. Deveson, . Australian Plague Locust Commission, AFFA, GPO Box 858, Canberra, ACT 2601, Australia. E-mail david.hunter@affa.gov.au.

Locust plagues occur when there is a sequence of rains that allow relatively continuous breeding and high survival for at least 4-5 generations. In Australia, locusts are managed through programmes of preventive control where treatment begins with the small bands and swarms that form early in breeding sequences. Locating the small early infestations in the more than 3 million km² of inland eastern Australia has been made possible by integrating data into a Decision Support System (DSS) for locust operations. The critical event that begins a locust generation in a region is rainfall that allows adults to mature their eggs and oviposit. In the arid inland, rain is often localised and locusts normally must migrate in order to locate any rain areas present. Likely areas of invasion are identified by using GIS techniques to integrate data on habitat, rainfall and locust survey. The background layer of favoured locust habitats is overlaid with rainfall information which consists of daily rainfall reports interpolated on a one or several day basis by a Bureau of Meteorology computer programme. This combined favoured habitats/likely rainfall distribution delineate areas suitable for oviposition. However, locusts are likely to be in only a few of the suitable areas, particularly early in outbreaks when preventive control programmes begin. From the distribution of the parent generation and a trajectory model that calculates winds at the 300-900 m height at which locusts undertake long distance night migrations, flight paths taken by migrating locusts are estimated. Locusts are likely to invade areas where their flight paths intersect areas of recent rain. Such areas are surveyed immediately to locate maturing adults and if dense swarms are located a treatment programme begins. For regions where maturing adults are seen, a locust development model is run to forecast when offspring mymphs and adults are likely to be present. These forecasts are used to determine the best time for survey so that offspring bands and swarms can be found quickly and treated as part of a programme of preventive control.

Index terms: Locusts, preventive control, decision support system

[0143] RAINFALL AND RECENT OUTBREAKS OF THE AFRICAN MIGRATORY LOCUST IN THE LAKE CHAD BASIN

G. Balança, P.-E. Gay, T. Rachadi & <u>M. Lecoq.</u> CIRAD, Centre de coopération internationale en recherche agronomique pour le développement, D.P. 5035, 34032 Montpellier Cedex 1, France, E-mail : nuchel.lecoq@cirad.fr

Heavy outbreaks of migratory locusts, *Locusta migratoria migratorioides*, were observed in southwestern Chad and northern Cameroon from September to November 1997. For many years, similar outbreaks were a recurrent phenomenon in this region, with the last one occurring in 1989. An analysis of rainfall distribution from 1986 to 1997, was undertaken according to the ecological requirements of this locust. To assess the possibilities of good breeding and gregarisation, the monthly position of the areas receiving an optimal rainfall for this species (50 to 100 mm/month) was studied. The following parameters, assumed to be key factors, were considered: northern limit of the optimal area in May and June, northern limit of the area with excessive rainfall (>100 mm/month) in June, maximal northern limit of the optimal area during the rainy season, maximal northern limit of the area where the rainfall is excessive, duration of optimal pluviometric conditions around Lake Chad during the rainy season. This study showed that the outbreaks were strongly linked to the extent and distribution of rainfall during the 1988-1989 and the 1996-1997 periods. A simple index, calculated on the basis of rainfall data, was correlated with outbreak years. It appeared that two successive years of suitable conditions are necessary to induce an outbreak.

Index terms : Orthoptera, Acrididae, Locusta migratoria, Chad, Cameroun

[0144] HABITAT RELATIONSHIPS BETWEEN MOBILE INSECT PESTS AND THEIR NATURAL ENEMIES IN DIVERSIFIED AGROECOSYSTEMS: A BASIS FOR FORCASTING AND MANAGING THESE PESTS AND NATURAL ENEMIES

Y. Hirose, Inst. of Biological Control, Fac. of Agriculture, Kyushu University, Fukuoka 812-8581, JAPAN, E-mail hirose@grt.kyushu-u.ac.jp

Mobile pests are defined as polyphagous and multivoltine pests that move freely over large areas and between crops in diversified agroecosystems (Hirose, 1998). Most mobile pests are major pests, and this may be largely because natural enemies of these pests have difficulty in shifting their habitats to follow the seasonal movement of the pests. Thus, habitat relationships between mobile pests and their natural enemies in diversified agroecosystems could provide a basis for forecasting and managing these pests and natural enemies. To explain this, I determined habitat relationships between mobile phytophagous bugs and their major egg parasitoids in agroecosystems in Japan as these bugs are important mobile pests of different many crops and egg parasitoids are effective natural enemies of these mobile pests. The habitat relationships showed a habitat similarity between the major egg parasitoids and their ovipositing hosts, suggesting that these parasitoids often move to follow the scasonal host movement. However, some host species escaped high parasitism because of a habitat discrepancy between hosts and parasitoids. This was also found in parasitism by a mobile egg parasitoid characterized by polyphagy. multivoltinism, high dispersal ability, and high mobility. As shown in this case, it seems impossible that mobile insect pests are always attacked by their mobile natural enemies in diversified agroecosystems. In habitats where mobile insect pests escape attacks of their natural enemies, proper management is needed. Forecasting and managing mobile insecci pests and their natural enemies are also discussed in relation to mechanisms involved in the habitat discrepancy between these pests and natural enemies. Index terms: phytophagous bug, egg parasitoid, movement.

[0145] MOVEMENTS OF PLANTHOPPERS AND THEIR NATURAL ENEMIES BETWEEN HABITATS IN RICE ECOSYSTEM

J.A.Cheng, X.P.Yu & J.M.Chen (Inst. Appl. Entomol., Zhejiang Univ., Hangzhou, China 310027).

The arthropod community in rice paddy will be reestablished 2-3 times every year based on the cropping system. Large-scale investigations were carried out to study the interaction between rice and non-rice habitats during the development of arthropod community in rice paddy. The results showed that the planthoppers and their natural enemies moved from habitats to habitats, and the main source habitats of planthoppers and natural enemies changed from season to season, and from region to region. The main source habitats of natural enemies for the 1^{84} rice crop season were green manure fields (spiders) and wheat fields (*Anagrus*). The main source habitats for the single of/and 2^{164} rice crop season were the paddies planted 1st rice crop season in mono-cultivating area, but Zazania fields in mixed cultivate area. These non-rice habitats provided initial populations, recruits and refuges, as well as alternative and supplemental foods for arthropods in rice paddy. The seasonal movements of planthoppers, Anagrus and spiders between rice paddy and Zazania field were monitored in the Yangtze Delta area. The results showed that more Anagrus moved from Zazania field to rice paddy in May, June and July, but from rice paddy to Zazania field in October and November. More spiders moved from rice paddy to Zazania field after harvesting of previous crop and from Zazania field to rice paddy after transplanting. Experiments indicated that the planthoppers feeding on Zazania (or rice) did not cause any damage to rice (or Zazania), but the Anagrus sp. could parasite the eggs of all the planthopper species in the two kinds of habitats. These results implied that arrangement of Zazania field in fice ecosystem could be used to enhance natural biological control. Index terms: Anagrus; Zazania; Spiders

[0146] HELICOVERPA LOCAL MOVEMENT AND RESISTANCE MANAGEMENT STRATEGIES FOR TRANSGENIC COTTON: STUDIES WITH A SPATIALLY EXPLICIT METAPOPULATION MODEL

M.L. Dillon & G.P. Fitt, Australian Cotton Co-operative Research Centre, CSIRO Entomology, Locked Bag 59, Narrabri NSW 2390, Australia. E-mail: martin.dillon@ento.csiro.au.

Refuges are a key component of the Helicoverpa resistance management strategy for transgenic cotton in Australia. The premise is that refugia will generate sufficient moths with susceptible alleles to effectively dilute the frequency of rare resistant alleles that may arise within transgenic crops. This strategy relies heavily on the assumption that susceptible adult moths from refugia will disperse throughout a region containing transgenic crops. It follows that Helicoverpa local flight behaviour and the distribution of refugia and transgenic crops upon the landscape will be crucial determinants of the effectiveness of the resistance management strategy. Using the HElicoverpa Armigera and Punctigera Simulation (HEAPS) model we simulated Helicoverpa dispersal over landscapes containing varying layouts and proportions of refuges and transgenic crops. HEAPS is a stochastic, spatially explicit metapopulation model that can simulate moth dispersal and metapopulation dynamics within user defined landscapes. We present the results of multiple simulations exploring the interaction between moth behaviour, environmental cues affecting moth flight, the agronomy and phenology of host crops, the spatial and temporal distribution of Helicoverpa within the region, and the distribution of refuges and transgenic crops within the landscape. The results demonstrate that wind speed and direction have the potential to interact with the spatial distribution of host patches to substantially influence the dispersion of moths from refuges and transgenic crops. The timing of moth emergence from different crops, and the phenology and temporal attractiveness of crops hosts for Helicoverpa can also produce heterogeneous moth dispersion. Such heterogeneity may result in parts of the landscape supporting subpopulations that contain high proportions of moths originating from transgenic fields. We conclude that refuges should be placed as close as possible to transgenic crops to maximise the likelihood that resistant alleles will be diluted by susceptible alleles. We discuss refuge placement options in the light of our findings. Index terms: HEAPS, dispersal, refuges, Bt

[0148] POLLEN AS A MARKER FOR LONG-DISTANCE MIGRATION AND LOCAL MOVEMENT OF *HELICOVERPA* MOTHS IN AUSTRALIA

A. P. Del Socorro & P. C. Gregg, Australian Cotton Cooperative Research Centre, Agronomy & Soil Science, School of Rural Science & Natural Resources, Univ. of New England, Armidale, NSW 2351 Australia, E-mail: adelsoc2@metz.une.edu.au.

The cotton bollworm, Helicoverpa annigera and the native budworm, H. punctigera are serious pests of cotton and many other summer crops in Australia. In cotton alone, control of these pests is estimated to cost over AUD\$200m annually. Although both species are recognised migrants, there is little information on the timing, frequency, direction and distance of movement. Moth-borne pollen is a natural marker that has been used to show long-distance migration of moths. Helicoverpa spp. visit flowers of many plants, collecting pollen on their probosces, antennae, head and legs. Pollen carried by these moths on their probosces was identified by scanning electron microscopy. investigated long-distance migration by comparing moth-borne pollen of Helicoverpa spp. collected in western Queensland in early spring with that of moths collected in three cropping areas of eastern Australia. Pollen of Ptilotus (Amaranthaceae), Velleia (Goodeniaceae) and *Eremophila* (Myoporaceae), and the Asteraceae (Tubuliflorae) were found on moths trapped in the east. These plants either did not occur in the areas where the moths were caught, or did not flower there at the time the moths were caught. However, they were abundant in possible source areas such as western Queensland. Pollen from one or more of these plants were found on 30% of H. punctigera and 18% of H. armigera caught in the eastern regions, suggesting that these moths were likely to be migrants. We also conducted field mark-capture experiments to study local movement of II. armigera using sunflower pollen as the marker, in southeastern Queensland. A network of 20 pheromone traps was set up within a 6-km radius from a flowering sunflower crop. The numbers and proportions of moths that had pollen as well as mean pollen loads of moths significantly declined with distance from the sunflower crop. Cage studies suggested that sunflower pollen is a transient marker in the field and may be a reliable marker only of recent (ie, previous 1 or 2 nights) local movement of H. armigera moths.

Index terms: Helicoverpa armigera, Helicoverpa punctigera, movement.

[0147] STUDIES OF APHID MIGRATION USING MICROSATELLITE MARKERS

K. S. Llewellyn¹, <u>H. D. Loxdale²</u>, R. Harrington³ & C. P. Brookes^{4, 1, 2, 3, & 4}. Entomology and Nematology Dept., IACR-Rothamsted, Harpenden, Herts, AL5 2JQ, U.K. E-mail: hugh.loxdale@bbsrc.ac.uk

There are many gaps in our knowledge about the migration of aphids, in spite of the large body of research devoted to this area. We present an alternative approach: the combined use of molecular markers and suction traps to study the population genetics of these insects. If migration is limited, then insects in different geographical regions may become isolated from one another and hence genetically differentiated. We have examined length polymorphism at four microsatellite loci amplified using PCR to assess the degree of genetic differentiation between populations of the grain aphid, *Sitobion avenae* from around the UK. The insects used were collected in 1997 and 1998 from different parts of the country using 12.2 m Rothamsted Insect Survey suction traps. A substantial amount of polymorphism was detected in these populations, with large differences in the numbers of genetic structure (i.e. frequencies of alleles and genotypes present) was found to be remarkably similar throughout the country. We suggest that extensive migration must be occurring in order to maintain this homogeneity, in spite of the forces which would tend to cause genetic differentiation between regions.

Index terms: Aphididae, Sitobion avenae, PCR, molecular markers, suction trap

[0149] THE USE OF POLLEN SPORES AS NATURAL MARKERS FOR DETERMINING MIGRATION

G.D. Jones & <u>W.C. Hoffmann.</u> USDA-ARS, APMRU, 2771 F&B Rd, College Station, TX, USA. E-mail: g-jones@tanu.edu.

Numerous insect species feed on nectar, pollen, and plant exudates that are associated with flowers. As a result of this feeding activity, these adults become contaminated with pollen. Pollen is distinctive, easily recognizable, and identifiable to the family, genus, and often species rank. In addition, pollen is durable and does not easily decay. Thus, pollen remains as a natural marker on or in an insect. From the identification of the pollen found on or in an insect, the geographical origin of the plant, from which the pollen came, often can be determined. Because some plants are endemic to certain habitats or geographical regions, pollen from these plants found on/in an insect can indicate and validate migration routes, support insect migration pathways, and help determine foraging source zones. This is especially useful when there is temporal and geographical variation in the distribution of the identified plant. Besides long range migration, local movement can be determined from pollen or spores. Insects can be marked with non-native pollen or spores, released. and recaptured. This type of marking is non-toxic, relatively easy to use, and does not interfere with the insect. Presence of the pollen or spores on the recaptured insects indicates movement to and from the initial capture area. Likewise, when a plant species only occurs in a particular area near a field, presence of pollen from that plant indicates that the insects moved from the plant's location to the capture point. From understanding insect movement and migration, management techniques can become more effective and less costly.

[0150] MIGRATION AND DIAPAUSE OF HELICOVERPA ARMIGERA IN CHINA

K. Wu, G. Xu & Y. Guo, Institute of Plant Protection, Chinese Academy of Agricultural Sciences, Beijing, 100094, China, E-mail wukm@mail.east.net.cn.

Cotton bollworm, *Helicoverpa amigera* (Hübner) is an important insect pest in agriculture in China. Inducement and termination, inheritance and variation of facultative diapause, coldhardiness and overwintering, and biology and routes of facultative migration in China were investigated from 1993 to 1999. The results indicated that the populations of *H. armigera* in the whole country can be divided into four regional groups, namely, the tropical, subtropical, temperate zone and Xinjiang geotypes, their adaptive zones are respectively in southern China, middle and lower Changjiang River valley including Sichun Province, Hubei Province, and Zhejiang Province etc., Huanghe River valley including Henan Province, Hebei Province, and Shandong Province etc., and the southern part and Turfan Basin of Xinjiang Uygur autonomous region. The damage of the temperate zone geotype can be extended into northeastern China such as Liaoning and Jilin Provinces etc., by a long distance facultative migration with east Asia monsoon in Summer.

Index terms: Helicoverpa armigera, diapause, migration, geotype

[0152] INDIVIDUAL-BASED MODELS: VIRTUAL INSECTS ?

D. Morgan & P. J. Proctor, Central Science Laboratory, Sand Hutton, York, UK, YO41 1LZ

Individual-based models, also known as agents, are the basis of an innovative approach to study the temporal and spatial-dynamics of organisms. By representing each individual organism virtually with dynamic and stochastic processes that are biologically realistic it is possible to investigate detailed aspects of their population and spatial dynamics irrespective of scale (e.g. host plant, field, population, meta-population, community). Although the inherent stochasticity of such an approach increases the complexity of model development, implementation and experimentation the ability to manipulate the system methodically and thus, the insight gained greatly outweighs any developmental costs and over-heads. This paper will present a modelling framework that utilises individual-based models to study the temporal and spatial dynamics of insects. The framework employs a modular structure so that generic 'virtual' insect are represented within the system with common population and behaviour processes. Specific information are integrated with the framework to develop models for particular insect species. At present only a single species of insect can be modelled, although further development of the framework is underway that will allow several species of insects to be modelled simultaneously, including predator-prey/parasitoid-host interactions.

[0151] SUMMING UP AND GENERAL DISCUSSION

M. E. Irwin, Dept. Nat. Resources & Environ. Sci., Univ. Illinois at Urbana-Champaign, 1101 W. Peabody Dr., Urbana, IL 61801, USA. Email: m-irwin2@uiuc.edu

This symposium focuses on migratory pests, mostly in agricultural settings. It covers a diverse array of technologies, both tried and new. Included are techniques to follow populations as they move such as genetic, including microsatilite, markers; pollen foreign to the local area but attached to the migrant; and field mark-recapture. Techniques to capture invading species over a large geographic ranges (e.g., the European suction trap network) or observe migrants as they fly by using a nutating-beam, vertical-looking radar are also imbedded in this symposium. Analysis using statistical, trajectory, and qualitative (rule-based) simulation models for forecasting movement are featured. Furthermore, Geographic Information Systems and Decision Support Systems are used to help predict source and impact locations of migrants. The findings from this symposium are many and varied. They include a better understanding of gene flows and migration rates; a knowledge that distant native hosts can be a major source of pest infestations, that local rain events correlate with the buildup of important migrant species; that biotopes, meteorological conditions and the existence of continuous gallery forests help localize and isolate migratory locusts in tropical South America; that natural enemies of mobile pests have difficulty in shifting habitats to follow seasonal movements of their hosts; that populations of mobile insect pests can better avoid attack by their mobile natural enemies in diversified agroecosystems; that in rice fields, planthoppers and their natural enemies move between habitats, and their main source habitats change from season to season and from region to region; that refugia may provide an answer for managing insecticide resistance in highly mobile pest species; and that recent environment changes (i.e., deforestation) in Madagascar have modified some of the locust invasion routes, with swarms progressing quickly along the east coast (a naturally forested region). Demonstrated also are the utilitarian needs to employ technologies to reduce the threat of migrant pests. It was shown, for instance, that dispersal can greatly influence how integrated pest management (IPM) is designed and deployed in developing countries; how the appropriate juxtaposition of alternate crops within a rice ecosystem might be used to enhance natural biological control of planthoppers; and how season-long monitoring by the vertical looking radar is both an economical and practical way of keeping track of mobile pests.

Index Words: Migration, technology, habitat manipulation, economics.

[0153] MODELLING THE SPATIAL DYNAMICS OF INSECT-TRANSMITTED PLANT VIRUSES

K.F.A. Walters & D. Morgan, Central Science Laboratory, Sand Hutton, York, UK, YO41 1LZ

Insect-transmitted plant viruses (IPV) are important diseases of crops throughout the world. Traditionally management of IPV have depended upon the application of pesticides to control vector populations and dispersal. However pesticides tend to be applied routinely and irrespective of the risk of virus infection. Reliable forecasting systems are needed to ensure rational management of IPV but for many IPV thorough understanding of the biological processes involved is often limited, especially the spatial dynamics of vectors and disease^[1]. The paper will present a modelling framework that describes the temporal and spatial dynamics of an insect vector and subsequent spread of virus quantitatively. Initially the framework has been developed to study the epidemiology of barley yellow dwarf virus (BYDV), an aphid-transmitted virus of cereals and grasses. The system combines a cellular automata of plant hosts with individual-based aphid model^[2] and the framework utilises routines to simulate aphid development, reproduction and mortality, and the dispersion of vectors and virus between plants. The predicted spatial dynamics and temporal incidence of both aphids and virus are similar to those observed in fields in the UK and the system has provided useful insights into understanding the complex interactions between biological processes involved in BYDV epidemiology. Furthermore, the modular structure of the framework ensures it applicability to other crop, vector and virus ecosystems.

1. Mann, J. A., Harrington, R., Morgan, D., Walters, K. F. A., Barker, I., Tones, S. J. & Foster, G. N. 1996. Towards decision support for control of barley yellow dwarf vectors. Proceedings 1996 British Crop Protection Council Conference - Pests and Diseases, 1, 179-184.

2. Morgan, D. & Morse, D.R. 1996. Modelling the spatial dynamics of plant viruses. Aspects of Applied Biology. 46. 257-262.

[0154] PESTICIDES, ECOLOGY AND IPM: OPTIMIZING PESTICIDE USE WITHIN PEST MANAGEMENT SYSTEMS

P.C. Jepson, Dept. of Entomology, Oregon State University, Cordley Hall, Corvallis, OR 97331, USA.

Can pesticides be exploited more effectively, with reduced risks of pest resistance, pest resurgence, impacts on beneficial organisms and environmental contamination? The next phase in the short but complex history of synthetic pesticide use in agricultural crops should make use of accumulated knowledge of pesticide science to tune the selection of active ingredient, and the pattern and level of use, to the agroecosystem in question. Pesticide application and delivery to the target is an inefficient process and there is evidence that efficiency could be improved through more detailed investigation of dose delivery. This includes not only the application and distribution process and the behavior of the pesticide, but also a knowledge of pesticide exposure and uptake by target and nontarget organisms. The small number of current examples of the successes that can be achieved through this process will be outlined, including research on locusts, cotton Lepidoptera, non-target organisms in small grain cereals and pests of potato. The analysis will consider conventional and transgenic means of pesticide delivery. Following application, ecological impacts evolve within and beyond the treated area. There is again, evidence that these impacts can be mitigated by taking physical and ecological attributes of exposed habitats more fully into account in pesticide decision making. This requires integration of our knowledge of environmental fate, susceptibility and exposure of a wide range of taxa, and the ecology and life history of organisms at risk. An analysis of the most recent advances in this area will be presented, including candidate decision aids for pesticide users. Without more widespread us of these approaches, it will not be possible to properly exploit the opportunities that are being presented by new active ingredients. Index terms: bioavailability, ecotoxicology, environmental fate, resistance management, transgenic crops

[0155] MANAGING THE SPATIAL DYNAMICS OF PREDATORS IN AGRO-ECOSYSTEMS

<u>S. D. Wratten¹</u> & G. M. Gurr², ¹Ecology & Entomology Group, Soil, Plant & Ecological Sciences Division, P.O. Box 84, Lincoln University, Canterbury, New Zealand. ²Pest Management Group, Orange Agricultural College, The University of Sydney, P.O. Box 883, Orange, NSW, Australia 2800.

Predators and parasitoids in agro-ecosystems move at a range of spatial scales, often driven by seasonal factors and their need for microclimatically-suitable refuges, prey/hosts and pollen or nectar. Many species of parasitoids, and predators such as hoverflies (Diptera: Syrphidae) need the protein, sugars and amino acids from these floral resources for egg maturation and to enhance "fitness". "Conservation biological control" manipulates these required resources also at a range of spatial scales, up to landscape level. When this is done, it is relatively easy to change positively some aspects of predator biology, while others in the hierarchy of "desired" successes maybe more difficult to achieve. The aspect of natural enemies' spatial dynamics which is most readily changed is the enhancement of populations in the vicinity of floral resources. The next stage in the desired hierarchy is enhancement predation or parasitism rates. The third more, more difficult, step is achieving a reduction in the targeted pest population, ideally to below the economic threshold. In most of these conservation biological control studies, the key aspect missing is a knowledge of the spatial dynamics of the agent and hence the ideal spacing of the plant resources. This latter critical factor will be discussed.

[0156] CASE STUDY: GLASSHOUSE PESTS AND COCCINELLIDS

W. van der Werf

ABSRTACT NOT RECEIVED

[0157] SOUTHERN CORN ROOTWORMS <u>Barbercheek, M</u> ABSTRACT NOT RECEIVED

[0158] INTRODUCTION TO DIABROTICINE PESTS IN THE UNITED STATES

<u>J. J. Tollefson¹</u>, ¹Dept. of Entomology, Iowa State Univ., 17 Insectary Bldg., Ames, IA 50011-3140, USA, E-mail tolly@iastate.edu.

Diabrotica is a New World genus of galerucine chrysomelids. Krysan reported that the catalog of Wilcox lists 338 species in three groups and that the virgifera and fucata groups include pests. Further, the greatest diversity of Diabrotica species occurs in the tropics, with only seven species occurring in the U.S., but four of these species are pests. The two North American pest species of the fucata group cannot overwinter in the temperate north, but the two pest species in the virgifera group can. The fucata group is multivoltine, overwinters as adults, and the adults disperse north during the warm season. The virgifera pest species are univoltine and overwinter as eggs. These two virgifera species, Diabrotica barberi and Diabrotica virgifera, are the most serious pests of maize in North America. Because the virgifera species are univoltine and overwinter as eggs, they have been pests primarily when maize is planted where it was grown the previous year (continuous maize). The practice of planting continuous maize became increasingly common in North America following World War II when inexpensive synthetic pesticides and fertilizers became available. As soon as this practice was adopted, D. barberi became a pest in the temperate maize-growing areas because it is a Nearctic species. D. virgifera was first described in the United States in 1868 just east of the Rocky Mountains. It remained confined to the western maize growing area until the practice of planting continuous maize became common and then it rapidly spread east, reaching the Atlantic coast by 1990. In the 1950s the practice of applying insecticides to the soil to prevent larval injury to maize roots became common practice whenever maize was planted after maize. Initially broadcast applications of the chlorinated hydrocarbons were used. Within 10 years D. virgifera had developed resistance to these insecticides and the organophosphates and carbamates replaced them. Soybeans began to be planted extensively in the U.S. in the 1950s and are now commonly rotated annually with maize. This annual rotation with a non-host crop effectively controlled the pests. Recently varieties of the virgifera species adapted to the annual rotation have been selected for. A variety of D. barberi with a two-year lifecycle that remains dormant during the year soybeans are grown became common in the 1980s and a variety of D. virgifera that oviposits in soybeans has appeared recently. With the adaptability of *virgifera*, what will happen when genetically modified varieties of maize are planted next year? Index terms: Diabrotica virgifera, Diabrotica barberi, corn rootworm, maize

[0159] CROP ROTATION COLLAPSES AS A VIABLE PEST MANAGEMENT STRATEGY FOR WESTERN CORN ROOTWORMS, *DIABROTICA VIRGIFERA VIRGIFERA*, IN THE EASTERN CORN BELT OF THE USA

<u>M. E. Grav</u>¹, S.T. Ratcliffe¹, J.L. Spencer², E. Levine² & K.L. Steffey¹, ¹Dept. of Crop Sciences, Univ. of Illinois, S-320 Turner Hall, 1102 S. Goodwin Ave., Urbana, IL 61801, USA, E-mail m-gray4@uiuc.edu; Center for Economic Entomology, Illinois Natural History Survey, 607 E. Peabody Drive, Champaign, IL 61820, USA.

Western and northern corn rootworms, Diabrotica virgifera virgifera LeConte and Diabrotica barberi Smith & Lawrence, respectively, inflict severe economic damage to maize, Zea mays (L.), throughout much of the USA Corn Belt as well as some regions of Canada. Both species have a univoltine life cycle and a narrow host range that includes primarily maize and a few other grass species (Setaria spp.). For decades, the annual rotation of maize with soybeans, Glycine max, has proven an excellent pest management strategy because corn rootworm larvae are unable to survive on the roots of soybean plants. In the mid-1980s, it was widely reported that some rotated cornfields in Illinois, Iowa, Minnesota, and South Dakota had root injury caused by northern corn rootworms that prolonged their embryonic diapause through two consecutive winters. In 1987, agronomists reported corn rootworm larval injury in several rotated maize seed-production fields in east-central Illinois. Entomologists collected larvae and returned them to the laboratory where they completed their development as western corn rootworms. Explanations for the western corn rootworm larval injury to rotated maize were not lucid. Since 1987, crop rotation has continued to fail as a pest management strategy for western corn rootworms across an expanding geographical region of the eastern Corn Belt of the USA. Rather than prolonging their embryonic diapause, western corn rootworms have seemingly adapted to crop rotation by laying at least a portion of their eggs directly into soybean fields. Oviposition into other crops such as alfalfa, Medicago sativa L., also has been confirmed. Our current hypothesis suggests that the intensive selection pressure of an annual rotation of maize with soybeans has selected for a new western corn rootworm strain that does not restrict its oviposition to maize. The consequence of this novel adaptation to a cultural pest management strategy has been an impressive escalation of soil insecticide use in rotated maize fields in Illinois, Indiana, southern Michigan, and western Ohio. Designing effective resistance management plans for transgenic cultivars for corn rootworms will be a challenge because producers are likely to plant these varieties on both rotated and non-rotated maize acres.

Index terms: Diabrotica virgifera virgifera, Diabrotica barberi, crop rotation.

[0160] INSECTICIDE RESISTANCE IN THE WESTERN CORN ROOTWORM: IMPLICATIONS TO CURRENT AND FUTURE MANAGEMENT STRATEGIES

B.D. Siegfried¹, L.J. Meinke¹, M.E. Scharf¹, R.J. Wright² & L.D. Chandler³, ¹Dept.of Entomology, University of Nebraska, Lincoln, NE 68583-0816, E-mail bsiegfried1@unl.edu; ²South Central Research and Extension Center, university of Nebraska, Box 66, Clay Center, NE 68933; ³USDA-ARS, Red River Valley Agricultural research Center, P.O. Box 5674, Fargo, ND 58501

Insecticide resistance in the western corn rootworm Diabrotica virgifera virgifera (Coleoptera: Chrysomelidae) has been identified in two separate instances. Both times the resistance was first detected in Nebraska. Cyclodiene resistance was detected in the late 1950's and was accompanied a rapid eastward range expansion for this species. Cyclodiene resistance has been maintained in western corn rootworms despite the absence of selective pressures since this class of insecticides was banned from use in the United States since 1972. Resistance to organophosphate insecticides was first detected in 1995 and was associated with areas where adult rootworm control was utilized as the primary management strategy in excess of 10 years. The distribution of resistant populations suggests that the resistance evolved independently in two separate locations. However, populations previously documented as being susceptible have shown increased tolerance to diagnostic concentrations of insecticide in relatively short periods of time (<2 years). The mechanism of resistance seems to be relatively specific because the performance of other organophosphates and insecticide classes are unaffected by the resistance. However, larval rootworms exhibit similar levels of resistance as adults. Similarities and differences between the development of cyclodiene resistance in the 1950's and organophosphate resistance in the 1990's will be discussed and will provide a basis for assessing the risk of resistance evolution to new rootworm management strategies such as areawide pest management and transgenic plants.

Index terms: Diabrotica, resistance, cyclodienes, organophosphates

[9161] AREAWIDE MANAGEMENT OF *DIABROTICA* SPP. (COLEOPTERA: CHRYSOMELIDAE): USE OF NOVEL CONTROL TECHNOLOGIES ACROSS THE LANDSCAPE

L. D. Chandler, USDA-ARS, Red River Valley Agricultural Research Center, P.O. Box 5677, Fargo, North Dakota, 58105-5677, USA. E-mail: chandlel@fargo.ars.usda.gov

Areawide pest management can be an effective tool to control insect pests of economic importance using organized and coordinated attacks on pest populations over large geographic areas. This approach can enhance the effectiveness of biologically-based technologies (e.g., mating disruption, attract and kill systems, augmentative biological control, & sterile male release). Within the United States maize (Zea mays L.) production areas insects in the genus Diabrotica (corn rootworms) inflict serious damage to millions of hectares of maize roots in any given year. In recent years corn rootworms have become more difficult to manage due to behavioral adaptations. The ability to overcome maize/soybean rotations throughout major portions of the production area, plus insecticide resistance development in Nebraska have caused concern among crop managers, and has resulted in the need to develop alternative management strategies. Over the last four years application of a semiochemical insecticide-bait in a coordinated fashion (areawide approach) to maize has occurred at several sites across the United States. These baits are specific to corn rootworm adults and have lowered populations and reduced maize plant damage during preceding growing seasons. Rootworm populations and accompanying damage within these sites in 1999 were lower than in 1997 (the first year of program Recently, studies have been initiated to evaluate the role of genetically evaluation). modified maize for rootworm resistance within an areawide management program. As new maize hybrids with rootworm resistance traits are introduced into the market, strategies will be needed to adequately manage resistance development and hybrid use. Areawide management offers growers the opportunity to use genetically modified plants alongside semiochemical insecticide-baits and other biologically-based technologies to more effectively control corn rootworm and to adequately protect new technologies for future long-term use.

Index terms: Diabrotica virgifera virgifera, Diabrotica virgifera zeae, Diabrotica barberi, integrated pest management, semiochemical insecticide-baits.

[0162] MANAGEMENT OF MEXICAN CORN ROOTWORM (COLEOPTERA:CHRYSOMELIDAE)

W. C. Hoffmann¹ & J. R. Coppedge², ¹USDA-ARS-Areawide Pest Management Research Unit, 2771 F&B Rd., College Station, TX 77845, USA, email: choffmann@tamu.edu; ²USDA-Southern Plains Area, 7607 Eastmark Drive, Suite 230, College Station, TX 77840, USA.

An adult management program for the Mexican corn rootworm (Diabrotica virgifera Krysan and Smith) has been conducted in Texas, USA since 1995. The program has focused on establishing scouting and treatment protocols that can be used by producers, extension agents, and crop consultants to manage corn rootworm populations. Rootworm populations are monitored through traps and plant counts. By working with a private company, traps were developed that made it easier to monitor rootworm abundance. Treatment thresholds were set at 100 cumulative beetles per trap. If treatment thresholds are exceeded, a semiochemical-based insecticide is used to control the adults. This insecticide contains a feeding stimulant that is specific to Diabrotica spp.; therefore, no non-target or beneficial organisms are impacted by the treatment. The management program has been very successful in Texas. At one site in central Texas, the corn that was treated due to corn rootworm infestations was reduced from 810 ha (2000 acres) in 1995 to only 39 ha (95 acres) in 1998. The use of soil insecticides in the area was also reduced to 1/4 to 1/2 of the conventional rate, which greatly reduces to amount of chemicals used in corn production. Due to the success of the adult program at this site, additional sites around Texas were added in 1998 and 1999. The purpose of these additional sites was to introduce the control program to others around the state and to refine the program protocols to each site. By 1999, adult control programs in Texas were being conducted at 5 sites involving 24 producers and approximately 4000 ha (9900 acres). Index terms: rootworm, Diabrotica, areawide management, corn.

[0163] MANAGEMENT OF WESTERN CORN ROOTWORM IN EUROPE

J. Kiss¹, J. Igrc-Barcic² & C.R. Edwards³, ¹Dept. of Plant Protection, Szent István Univ. Gödőll 6. H-2100 Gödöll 6, Hungary, E-Mail jkiss@gikk.gau.hu; ²Faculty of Agriculture, Univ. of Zagreb, Svetosimunska cesta 25, 10000 Zagreb, Croatia, E-mail ibarcic@agr.hr; ³Dept. of Entomology, Purdue Univ, W. Lafayette, Indiana 47907-1158, USA, E-mail rich_edwards@entm.purdue.edu

The western corn rootworm (WCR) was first detected (larval damage) in a cornfield near Belgrade, Yugoslavia, in 1992 (Baca 1993). It is likely to have arrived in Yugoslavia in the early to mid 1980's (Edwards et al. 1998). By 1999 it had spread over about 150,000 km² in Europe (Bulgaria, Bosnia-Herzegovina, Croatia, Hungary, Romania and Yugoslavia). WCR beetles were trapped in 1998 and 1999 in Italy, near Venice airport. WCR spread in Europe has continued in all directions from the original infestation point. The greatest movement was observed on the plains, in valleys with some movement in hilly regions. The population build up in infested areas depends on corn growing practices (continuous or rotation, insecticide application) and on soil properties (moisture, type of soil). By late 1999, an economic population of WCR was well established in Yugoslavia, while larval damage below the economic threshold was observed in Bosnia-Herzegovina, Croatia, Hungary and Romania. Countries around the infested area operated traps as part of the WCR NET networking activity (supported by FAO), but they have not detected any WCR beetles. It is expected that other countries in the region (Austria, Slovakia, Ukraine) will be infested and an economic WCR population will build up in Bosnia-Herzegovina, Croatia, Hungary and Romania in coming years. Its biology in the infested regions is almost the same as that of middle Indiana, USA. The spread and population buildup of the western corn rootworm (WCR) requires that multiple management strategies be developed for the control of this corn pest (crop rotation, soil pesticide application, control of adult

WCRs). The concept of SLAM[®]-based areawide pest management of WCR is being developed in the USA (Chandler, 1998) and has been adapted in Hungary as part of UN FAO TCP 6712 Project, that included the following in Hungary: - selection of suitable area and fields; - adaptation of application techniques; - field scouting of WCR for decision making; - post treatment scouting and evaluation to determine outcomes. SLAMbased areawide management of WCR resulted in efficacy rates of over 90% (5 days after treatment) with a slow decrease after 10 and 15 days in 1998 and 1999. The concept of areawide management has proven to be an effective way to manage WCR and should be considered a viable control strategy in Europe. Details on population level, treatments will be discussed in the lecture. Spiders (Theridiidae and Agelenidae) as predators of WCR adults were proved in confields in Hungary (Toth et al. 2000).

Index terms: Diabrotica virgifera virgifera, spread, biology, control, Europe.

[0164] MANAGEMENT OF DIABROTICA SPECIOSA IN BRAZIL

<u>P. A. Viana¹, ¹</u>Embrapa Milho e Sorgo, Caixa Postal 151, Sete Lagoas, MG 35701-970, Brazil, E-mail pviana@cnpms.embrapa.br.

Diabrotica spp. is a serious pest in the Americas. Two species, Diabrotica speciosa and Diabrotica viridula, occur in Brazil, where D. speciosa is predominant. This pest is distributed in both South and Central America. The adults feed on the leaves of vegetable crops, beans, soybean, sunflower, banana, cotton and corn. The larva damage the corn root and potato tubers. The damage caused by the larva in corn roots interferes in the absorption of nutrients and water and it reduces the stability of the plants, causing lodging under severe wind and rainfall conditions. The eggs of this insect are yellowish-white and they are deposited on the soil around the base of plants. The larvae reach 10 mm in length, are white in color with brown heads a dark plate in the last abdominal segment. The adults beetles measure about 6 mm in length, are green color with six yellow stains with a black tibia and a brown head. The life cycle ranges from 24 to 40 days. There is little information available about the management of this pest. The sampling method most commonly used for larva of D. speciosa is sifting the soil on a black plastic, where the larva can be identified. Other methods, such as the Berlese's funnel and flotation can also be used. Preliminary results indicate that an average density of 3,5 to 5 larvae per plant causes damage to corn root, corresponding to the value of 4,2 on the scale of Hills & Peters (1971), while a density of about 30 larvae corresponds to a 5,7 on the same scale. In Brazil, the control of the larva of D. speciosa in corn is almost exclusively with the use of chemical insecticides, but it is rarely employed. In no-tillage systems, the best results in the control of the larvae with insecticides have been obtained with granular forms tebupirimfos, phorate, chlorpyrifos or spraying with chlorpyrifos, both applied in furrow, In situations where control was not used at planting, the application of terbufos and tebupirimfos granules in the row and chlorpyrifos sprayed on the base of the plants and incorporated into the soil with a cultivator have been the most efficient for larvae control. Although in other countries there is reference to resistant cultivars of corn to other species of Diabrotica, in Brazil, research seeking genetic resistance to this pest is incipient. The occurrence of the biological control has been reported through the use of natural enemies. Celatoria bosqi, Centistes gasseni, and the fungus Beauveria bassiana and Metarhizium anisopliae. Preliminary results indicate that soil moisture is one factor to be considered in the management of D. speciosa. A greater occurrence of larva has been observed in experimental areas in soils with higher moisture content. Soil preparation methods have also been shown to influence the population dynamics of this insect. A larger occurrence of larva has been found in areas prepared with the moleboard plow than in no-tillage. Index terms: corn rootworm, soil insect, insecta, control, Zea mays

[0165] TRANSGENIC MAIZE FOR MANAGEMENT OF DIABROTICINE PESTS

J.E.Foster, Dept. of Entomology, Univ. of Nebraska, 312F P.I. Bldg., Lincoln, Nebraska, USA 68583-0816, Email jfoster1@unl.edu.

Several crops have been developed for resistance to major insect pests. Maize has been transformed for resistance to *Diabrotica virgifera virgifera*, the westorn corn rootworm. This Diabroticine pest is the major maize insect pest in North America. The use of transgenic deployed resistance genes offers a safe and environmentally strategy for management of this insect. The performance of transgenic maize will be discussed and compared and contrasted to use of conventional management tools.

Index terms: Diabrotica virgifera virgifera, corn rootworms, transgenes.

[0166] GLOBAL PERSPECTIVE OF DIABROTICA MANAGEMENT

C. R. Edwards, Dept of Entomology, Purdue Univ., 1158 Smith Hall, W. Lafayette, IN 47907-1158, USA, E-mail rich_edwards@entm.purdue.edu.

The Diabroticites are pests of corn in areas of South, Central, and North America, as well as Central Europe. Although the damage caused by these chrysomelids to corn is similar in all infested areas, the means of control can vary. In South America, Diabrotica speciosa and D. viridula are of importance, although D. s. is the most important. The larvae of D. s. cause damage in southern, southeastern, and west-central Brazil, as well as some areas of southwest-central and northwestern South America. In Brazil, granular and liquid insecticides are applied mostly in-furrow. Also, low numbers of larvae have been observed where soil moisture is low and where no-till is used. In Central America, D. balteata is the most important species, although problems with this species on corn are few. D. virgifera virgifera, D. v. zeae, D. barberi, D. undecimpunctata howardi, and D. balteata are the major Diabroticite pests of corn in North America, although pest status varies from north to south. The species of greatest importance are the D, v, v, D, v, z, and D, barberi. In the Midwestern USA, D. v. v. and D. barberi are the primary pest species with the D. v. v. being a problem primarily in the more central and southern areas of this region, including southern Ontario, Canada, and D. burberi in the northern areas of the Midwest and into parts of southern Canada. D. v. z. is primarily a pest of corn in Texas, Oklahoma, and Mexico. In North America, there are some differences in how rootworms are control, but soil insecticides are often used. These are applied as band or in-furrow treatments in either granular or liquid form. Also, crop rotation is used throughout the infested area for managing these species except where continuous corn is grown or where the variant of D. v. v. is found (parts of Illinois, Indiana, Michigan, and Ohio). In parts of North America, areawide management of adults to reduce egg laying is being evaluated. In Central Europe, the D. v. v. is the only Diabrotica species that has been observed. The primary area of economic infestation is in Serbia, although this species is also found in Bosnia-Herzegovina, Bulgaria, Croatia, Hungary, Italy, Montenegro, and Romania. Where economic infestations occur, farmers use crop rotation and soil insecticides for larval management, or do nothing. Because of the present economic situation in this area, many farmers do not have enough money to purchase insecticides or may not be able to use crop rotation due to their need for corn to feed livestock. Also in this region, areawide management of adults is being tried as noted above for the Midwestern USA.

Index terms: Diabrotica spp., insecticide control, soil insecticides, crop rotation, areawide management.

[0167] FORAGING ACTIVITY OF BUMBLEBEES IN GREENHOUSE MUSKMELON CROP

S. Albano¹, E. Salvado¹, M. C. Godinho² & A. Mexia³, ¹Instituto Superior de Agronomia, DPPF, Secção de Protecção Integrada, Tapada da Ajuda, 13449-017, Lisboa, Portugal; ²Escola Superior Agrária de Viseu, Campus Politécnico, 2500 Viseu ceugodinho@isa.utl.pt; ³Instituto Nacional de Investigação Agrária, Estação Agronómica Nacional, Quinta do Marquês, 2780 Oeiras amexia@isa.utl.pt

The use of bumblebees (*Bombus terrestris*) to attend the pollination of greenhouse muskmelon crop is a recent practice in Portugal. Foraging activity of the bumblebees' coloay in muskmelon greenhouse conditions was analysed either at the activity level of the bive (tunnel-traffic) or at individual activity on the flowers. The high number of individuals that entered in the hive without pollen baskets evidenced that the nectar was the main resource explored by this colony. Small amounts of pollen collected to the colony may have contributed to reduce its longevity (1.5 to 2 months) and for the non-emergence of male or female sexual forms. Bumblebees had been observed to collect pollen from the weed plants *Solanum nigrum* that were abundance inside the greenhouse, what meaning that they should work as magnetic plants, since they did allow a greater number of visits to muskmelon flowers. Staminate flowers have received visits after 9:00h and the hermaphroditic only after 12:00h. Bumblebee pollination activity apparently was adjusted to the periods of the day that allow a higher concentration of sugar in the nectar and when the foraging was energetically more advantageous.

Index terms: Bombus terrestris, pollinator activity, Cucumis melo

[0168] GENERAL PATTERN OF BUMBLEBEE VISITS TO TOMATO FLOWERS IN GREENHOUSE CONDITIONS

<u>S. Albano¹</u>, E. Salvado¹ & J. Cadima², ¹Instituto Superior de Agronomia, DPPF, Secção de Protecção Integrada, Tapada da Ajuda, 13449-017, Lisboa, Portugal; ²Instituto Superior de Agronomia, Departamento de Matemática, Tapada da Ajuda, 13449-017, Lisboa, Portugal.

The behavioural study of bumblebees (Bombus terrestris) during the flower visits and throughout a sequence of visits is important for a more correct evaluation of the pollinator effectiveness in greenhouse tomato crops. The average time visit of a bumblebec to a tomato flower was 5.03 s \pm 0.16 and the buzz time (flower vibration time for pollen extraction) was 2.72 s \pm 0.06. The majority of the visits had been to flowers already visited (revisits). From all observed foragers visiting flowers, 26.99% presented grooming behaviour during the visit and in 73.01% only buzz was detected. The occurred variations in buzz time had not been explained by the oscillations of temperature and relative humidity in the greenhouse. Some factors may explain the variations in visits time: occurrence of grooming behaviour, learning the best way for foraging flowers, size of pollen baskets carried by forager and amount of available pollen in the flowers. Individuals that were followed at his foraging activity in the flowers allowed us to characterise the foraging strategy of bumblebees in greenhouse conditions. The high number of visits per minute and short interflower time have revealed the capacity of one forager to visit many flowers in a short space of time. Throughout a sequence of visits, bumblebees visited more flowers of the upper cluster and only one flower per plant. This behavioural pattern showed an optimal foraging strategy that allow to decrease interflower time, minimising the energy costs of flight, and to maintain a particular direction while moving through a flower patch.

Index terms: Bombus terrestris, pollinator behaviour, foraging strategies

[0169] INFLUENCE OF CROPPING SEASON IN FORAGING ACTIVITY OF BUMBLEBEE IN GREENHOUSE TOMATO CROP

<u>S. Albano¹, E. Salvado¹, E. Figueiredo¹ & A. Mexia², Instituto Superior de Agronomia, DPPF, Secção de Protecção Integrada, Tapada da Ajuda, 13449-017, Lisboa, Portugal; ²Instituto Nacional de Investigação Agrária, Estação Agronómica Nacional, Quinta do Marquês, 2780 Oeiras amexia@isa.utl.pt</u>

The effectiveness of bumblebee's (Bombus terrestris) use in greenhouse tomato pollination is variable. Different cropping seasons provide different conditions to the crop, being expectable that foraging behaviour of bumblebees adjusted to those variations and their efficiency, as pollinators, could be affected. Pollination activity at different cropping season (spring and autumn) was analysed, as well as pollinators behaviour in foraging activity on flowers. The main difference was a smaller visit duration at autumn. This result is related with higher temperatures and smaller humidities registered during the autumn, which facilitates pollen extraction from the flowers. In autumn, a bigger portion of pollen is collected in each visit. In order to obtain a certain amount of pollen, bumblebees need to visit a small number of flowers, which result in less time spent by each individual in foraging through this season. The hives tunnel traffic and pollination intensity on the crop was significantly bigger (α =0.05) in the spring. The significant differences were also verified for the individual behaviour of foragers: a higher number of visits per minute and smaller interflower times were observed in the autumn. As a result of these differences in pollinators activity, it was detected a smaller number of marks from bumblebee flower visits in the autumn, and they are less noticeable in this season. In spite of bumblebees efficiency as foragers, which was bigger in the autumn, their contribution to the tomato crop pollination was more important in the spring season. Index terms: Bombus terrestris, pollinator efficiency, cropping season

[0170] AGRONOMIC EFFICIENCY OF INSECTICIDES AT DIFFERENT RATES TO THE CONTROL OF APHIS GOSSYPII IN COTTON CROP

<u>F. A. Albuquerque¹</u>, A. B. Ros¹, S. C. Mendes¹ & L. F. Weber², ¹Univ. Estadual de Maringá, Dept. de Agronomia, Av. Colombo, 5790, CEP 87020-900, Maringá, PR, Brasil, E-mail: faalbuquerque@uem.br; ²Bayer S/A, Proteção de Plantas, Londrina, PR, Brasil.

The cotton aphid has a nearly cosmopolitan world distribution and infest innumerable species of Dicotyledonous plants. The transmission of virus diseases is a further pernicious aspect attaching to their infestations. The purpose of this work was to evaluate the efficiency of different rates of insecticides in the control of Aphis gossypii, in cotton crop. The research was conducted at Iguatemi Experimental Farm, State University of Maringá, Paraná State, Brazil, using a randomized blocks design with 8 treatments and 4 replications. The experimental units had 5 rows (0.8 m apart) by 6 m long. Treatments evaluated were the insecticides: carbosulfan (Marshal) at 120 g a.i./ha, oxydemeton-methyl (Metasystox R) at 200 g a.i./ha, prothiofos (Tokution) at 500 and 750 g a.i./ha, imidacloprid (Provado) at 50 g a.i./ha, thiacloprid (Calypso) at 34 and 48 g a.i./ha and check without insecticides. The products were applied in an unique dose on January, 16th 99, using a CO2-pressurized knapsack sprayer calibrated for an output of 165 liters of water per hectare. The application was done at the beginning of infestation. Three evaluations were realized, being the first one just before spraying and the others at 3 and 8 days after application. For each evaluation, the number of insects was counted in 10 plants in each parcel. The final data were submitted to statistics analyses (F and Tukey tests) and the calculated efficiency percentages by Abbott formula. The results showed that imidacloprid (Provado) at 50 g a.i./ha and thiacloprid (Calypso) at 34 and 48 g a.i./ha were distinguished as the best treatments, showing levels of control of at least 96%, at 3 days after applications, and 80% at 8 days after applications. Carbosulfan (Marshal) at 120 g a.i./ha provided adequate control until 3 days after application. The others treatments did not present the necessary efficiency.

Index terms: carbosulfan, oxydemeton-methyl, prothiofos, imidacloprid, thiacloprid

[0171] AGRONOMIC EFFICIENCY OF INSECTICIDES AT DIFFERENT RATES TO THE CONTROL OF *STERNECHUS SUBSIGNATUS* IN SOYBEAN

<u>F. A. Albuquerque</u>¹, F. C. Pattaro¹, A. V. Zabini¹, J. U. T. Brandão Filho¹ & O. Callegari¹, ¹Univ. Estadual de Maringá, Dept. de Agronomia, Av. Colombo, 5790, CEP 87020-900, Maringá, PR, Brasil, E-mail: faalbuquerque@uem.br

The purpose of this work was to evaluate the efficiency of different rates of insecticides in the control of Sternechus subsignatus, in soybean. The research was conducted in Faxinal city, Paraná State, Brazil, using a randomized blocks experimental design, with 6 treatments and 4 replicates. Each experimental unity was composed by 10 rows, 10 m long, 0.4 m apart from each other. Treatments evaluated were the insecticides: betacyfluthrin (Turbo) at 8 g a.i./ha, methamidophos (Tamaron BR) at 480 g a.i./ha, thiacloprid (Calypso) at 36, 48 and 72 g a.i./ha and check without insecticides. The products were applied in an unique dose on December, 16th, 99, using a CO2-pressurized knapsack sprayer calibrated for an output of 250 liters of water per hectare. The application was done when infestation level reached 2 adults insects/n. Three evaluations were realized, being the first one just before spraying and the others at 3 and 7 days after application. For each evaluation, the number of adults insects was counted in 10 m of soybean rows in each parcel. The final data were submitted to statistics analyses (F and Tukey tests) and the calculated efficiency percentages by Abbott formula. The results showed that thiacloprid (Calypso) at 36, 48 and 72 g a.i./ha provided a excellent control at 3 days after application, showed a efficiency of 91.67%, 100% and 100%, respectively. Betacyfluthrin (Turbo) and methamidophos (Tamaron BR) showed a efficiency of 75% and 83,33%, respectively. At 7 days after application, thiacloprid (Calypso) at 48 and 72 g a.i./ha were the best treatments, with 81% and 86% of efficiency, respectively. Betacyfluthrin (Turbo), methamidophos (Tamaron BR) and thiacloprid (Calypso) at 36 g a.i, Ana, showed a efficiency of 70.59%, 76.47 and 76.47%, respectively.

Index terms: chemical control, betacyfluthrin, methamidophos, thiacloprid.

[0172] EFFICIENCY OF DIFFERENT INSECTICIDES IN THE CONTROL OF THRIPS, FRANKLINIELLA SCHULTZEI, IN LETTUCE

F. A. Albuquerque¹, F. C. Pattaro, J. U. T. Brandão Filho¹, O. Callegari¹ & K. Silva¹, ¹Univ. Estadual de Maringá, Dept. de Agronomia, Av. Colombo, 5790, CEP 87020-900, Maringá, PR, Brasil, E-mail: faalbuquerque@uem.br

This work was carried out in Maringá city, Paraná State, Brazil, from September to October, 1999, to evaluate the efficiency of some insecticides in the control of thrips, Frankliniella schultzei, in lettuce, cv. Veronica. A randomized blocks design with 6 treatments and 4 replications was adopted. Each parcel was composed by 4 lines, 7 m long, 0.3 m apart from each other. Treatments evaluated were the insecticides: thiacloprid (Calypso) at 48 g a.i./ha, imidacloprid (Provado) at 70 g a.i./ha, methiocarb (Mesurol) at 375 g a.i./ha, clorpirifos (Astro) at 338 g a.i./ha, betacyfluthrin (Turbo) at 3.75 g a.i./ha and check without insecticides. The products were applied in an unique dose on September, 28th, 99, using a CO2-pressurized knapsack sprayer calibrated for an output of 500 liters of water per hectare. The application was done at the beginning of infestation. Three evaluations were realized, being the first one just before spraying and the others at 2 and 7 days after application. For each evaluation, the number of insects was counted in 10 plants in each parcel. The final data were submitted to statistics analyses (F and Tukey tests) and the calculated efficiency percentages by Abbott formula. The results showed that imidacloprid (Provado), methiocarb (Mesurol), cloppirifós (Astro) and betacyfluthrin (Turbo) provided a excellent control at 2 days after application, showed a efficiency of 91.25%, 98.99%, 95.62% and 97.31%, respectively. Thiacloprid (Calypso) at 48 g a.i./ha, showed a efficiency of 70.37%. At 7 days after application, the insecticides imidacloprid, methiocarb, clorpirifós and betacyfluthrin showed a efficiency of 95.88%. 92,65%. 83.09% and 82.35%, respectively. Thiacloprid showed a efficiency of 75.74%. Index terms: thiacloprid, imidacloprid, methiocarb, clorpirifós, betacyfluthrin.

[0173] EFFICIENCY OF INSECTICIDES IN THE CONTROL OF PECTINOPHORA GOSSYPIELLA IN COTTON CROP

F. A. Albuquerque¹, F. C. Pattaro¹, J. U. T. Brandão Filho¹, O. Callegari¹ & L. M. Borges¹, ¹Univ. Estadual de Maringá, Dept. de Agronomia, Av. Colombo, 5790, CEP 87020-900, Maringá, PR, Brasil, E-mail: faalbuquerque@uem.br

This work was carried out in Maringá city, Paraná State, Brazil, from February to April 1997, to evaluate the efficiency of some insecticides on Pectinophora gossypiella control in cotton crop. A randomized blocks design with 6 treatments and 4 replications was adopted. The experimental units had 5 rows (0.8 m apart) by 10 m long. Treatments evaluated were the insecticides: lambdacyhalothrin (Karate 50 CS) at 12.5 g a.i./ha; lambdacyhalothrin (Karate 250 CS) at 12.5 g a.i./ha; lambdacyhalothrin (Karate 50 CE) at 12.5 g a.i./ha; deltamethrin (Decis 25 CE) at 7.5 g a.i./ha; betacyfluthrin (Bulldock 125 SC) at 10 g a.i./ha and check without insecticides. Two applications were done; the first one at the beginning of infestation and the second 15 days later. The products were applied using a CO2-pressurized knapsack sprayer calibrated for an output of 250 liters of water per hectare. Evaluations were realized in 3 central lines, the first one prior to insecticide spraying and the other at 4 days after application of insecticides, counting the number of small bolls attacked. The final data were submitted to statistics analyses (F and Tukey tests) and the calculated efficiency percentages by Abbott formula. The results showed that lambdacyhalothrin (Karate 50 CS) at 12.5 g a.i./ha and lambdacyhalothrin (Karate 250 CS) at 12.5 g a.i./ha were the best treatments, both with 71.43% of efficiency. Lambdacyhalothrin (Karate 50 CE) at 12.5 g a.i./ha, deltamethrin (Decis 25 CE) at 7.5 g a.i./ha and betacyfluthrin (Bulldock 125 SC) at 10 g a.i./ha showed a efficiency of 53,57%, 50% and 57,14%, respectively.

Index terms: pink bollworm, lambdacyhalothrin, deltamethrin, betacyfluthrin.

[0174] EFFICIENCY OF INSECTICIDES IN THE CONTROL OF THRIPS, FRANKLINIELLA SCHULZEI, IN COTTON CROP

A. Albuquerque¹, M. A. Kaiser¹, M. Stülp¹ & L. F. Weber², ¹Univ. Estadual de Maringá, Dept. de Agronomia, Av. Colombo, 5790, CEP 87020-900, Maringá, PR, Brasil, E-mail: faalbuquerque@uem.br; ²Bayer S/A, Proteção de Plantas, Londrina, PR, Brasil.

The purpose of this work was to evaluate the efficiency of different rates of insecticides in the control of Frankliniella schulzei, in cotton crop. The research was conducted at Iguatemi Experimental Farm, State University of Maringá, Paraná State, Brazil, using a randomized blocks design with 8 treatments and 4 replications. The experimental units had 5 rows (0,8 m apart) by 6 m long. Treatments evaluated were the insecticides: carbosulfan (Marshal) at 120 g a.i./ha, oxydemeton-methyl (Metasystox R) at 200 g a.i./ha, prothiofos (Tokution) at 500 and 750 g a.i./ha, imidacloprid (Provado) at 50 g a.i./ha, hiacloprid (Calypso) at 34 and 48 g a.i./ha and check without insecticides. The products were applied in an unique dose on November, 12th, 98, using a CO2-pressurized knapsack sprayer calibrated for an output of 187 liters of water per hectare. The application was done at the beginning of infestation. Four evaluations were realized, being the first one just before spraying and the others at 2, 5 and 7 days after application. For each evaluation, the number of insects was counted in 10 plants in each parcel. The final data were submitted to statistics analyses (F and Tukey tests) and the calculated efficiency percentages by Abbott formula. The results showed that imidacloprid (Provado) at 50 g a.i./ha and thiacloprid (Calypso) at 34 and 48 g a.i./ha provided levels of control of at least 90%, in all evaluations. Carbosulfan (Marshal) at 120 g a.i./ha and prothiofos (Tokution) at 500 and 750 g a.i./ha provided adequate control until 2 days after application.

Index terms: carbosulfan, oxydemeton-methyl, prothiofos, imidacloprid, thiacloprid

[0176] EFFICIENCY OF THE FORMULATION 50 SC OF THE PYRETHROID LAMBDA-CYALOTHRIN IN THE CONTROL OF ANTICARSIA GEMMATALIS IN THE SOYBEAN CROP

B. Alleoni ¹ & A. M. De Souza Neto ², ¹Dept. of Agronomy, Ponta Grossa State Univ., Praça Santos Andrade, s/nº, Ponta Grossa, PR, 84010-790, BR; ² Technical Department, Zeneca Brasil Ltda, R. Aldo Vergani, 952, Ponta Grossa, PR, 84035-160, BR.

The effects of rates and formulations of the pyrethroid lambda-cyalothrin in the control of the Anticarsia gemmatalis in soyean crop (Glycine max) were evaluated in this trial in Ponta Grossa, 1998. The treatments conducted as randomized blocs and with four replicates were as folow: Karate Zeon 50 CS (3,75 g i.a./ha), Karate Zeon 50 CS (5,0 g i.a./ha), Karate 50 CE (3,75 g i.a./ha), Karate 50 CE (5,0 g i.a./ha), Thiodan CE (175 g i.a./ha) and control. Each experimental unit was 2,5 m wide and 6,0 m long. The spraying was done once in 04/03/98 with a CO₂ equipment and outflow of 300 l/ha and the evaluations were done 1, 3, 7, 10 and 14 days after the spraying. The evaluations of the mortality of the caterpillars were done with the "cloth method". The results showed that all dosages of the two formulations of Karate were efficient in the control of A. gemmatalis until 7 days after the spraying and until 10 days when the highest dosages were used. The insecticide Thiodan CE was efficient until 7 days after the spraying. The formulations CS (microencapsuled) and CE (emulsionable concentrated) and the dosages of 3,75 and 5,0 g i.a./ha of the insecticide lambda-cyalothrin did not differ statistically in the control of the pest on the seventh day after the spraying, but differed between both dosages of both formulations on the tenth day. The caterpillar A. generatalis that usually reaches high populational levels during the crop development, was efficiently controled by the pyrethroid lambda-cyalothrin.

Index terms: Anticarsia gemmatalis, soybean, Glycine max, pyrethroid, lambda-cyalothrin.

[0175] SURVEY OF THE ARTHROPODS ASSOCIATED TO MALPIGHIA GLABRA IN ANGULO, PARANA, BRAZIL

F. A. Albuquerque¹, F. C. Pattaro¹, L. M. Borges¹ & R. S. Lima¹, ¹Univ. Estadual de Maringá, Dept. de Agronomia, Av. Colombo, 5790, CEP 87020-900, Maringá, PR, Brasil, E-mail: faalbuquerque@uem.br

Surveys to determine the occurrence and abundance of arthropod populations associated to Malpighia glabra were conduced from September 1997 to March 1999, in Angulo city, Paraná State, Brazil. Insects and mites were collected once every two weeks in an acerola orchard. Seventeen families of insects were observed: Acrididae, Chrysopidae, Pentatomidae, Pyrrhocoridae, Coreidae, Reduviidae, Membracidae, Aphididae, Coccidae, Diaspididae, Cicadellidae, Ichneumonidae, Vespidae, Formicidae, Chrysomelidae, Tephritidae e Otitidae. The most common species were: Schistocerca spp., Chrysopa sp, Nezara viridula, Piezodorus guildinii, Euschistos heros, Thyanta spp., Dysdercus ruficolis, D. peruvianus, Leptoglossus zonatus, L. gonagra, Enchenopa gracilis, Toxoptera citricidus, Aphis citricidus, Saissetia coffeae, S. oleae, Coccus viridis, Selenaspidus articulatus, Dilobopterus costalimai, Oncometopia facialis., Diabrotica speciosa, Cerotoma spp., Colaspis spp., Lagria vilosa, Ceratitis capitata, Anastrepha fraterculus and Euxesta sp. C. capitata and D. speciosa were the predominant species. The first specie showed a higher frequency in September, October and November, and the second showed a higher frequency in September, March and April. Five families of mites were observed: Tydeidae, Tenuipalpidae, Tarsonemidae, Tetrannychidae e Phytoseiidae. The most common species were: Lorrya formosa, Brevipalpus phoenicis, Polyphagotarsonemus latus, Tetranychus urticae and T. mexicanus. Index terms: Barbados cherry, West Indian cherry, acerola.

(0177) EFFICIENCY OF THE FORMULATION 50 SC OF THE PYRETHROID LAMBDA-CYALOTTIRIN IN THE CONTROL OF PSEUDALETIA SEQUAX (MYTHIMNA SEQUAX) IN THE WHEAT CROP

<u>B. Alleoni</u>¹ & A. M. De Souza Neto², ¹Dept. of Agronomy, Ponta Grossa State Univ., Praça Santos Andrade, s/n^o, Ponta Grossa, PR, 84010-790, BR; ²Technical Department, Zeneca Brasil Ltda, R. Aldo Vergani, 952, Ponta Grossa, PR, 84035-160, BR.

The effects of rates and formulations of the pyrethroid lambda-cyalothrin in the control of Pseudaletia seguax in wheat crop (Triticum aestivum) were evaluated in this trial in Ponta Grossa, 1997. The treatments conducted as randomized blocs and with four replicates were as folow: Karate Zeon 50 CS (5,0 g i.a./ha), Karate Zeon 50 CS (7,5 g i.a./ha), Karate 50 CE (5,0 g i.a./ha), Karate 50 CE (7,5 g i.a./ha), Lorsban 480 BR (480 g i.a./ha) and control. Each experimental unit was 2.5 m wide and 6.0 m long. The spraying was done once in 03/11/97 when the population of caterpillars averaged 12.5 individuals per square meter, with a CO2 equipment and outflow of 300 l/ha. The evaluations were done 1, 3, 7, 10 and 14 days after the spraying. The evaluations of the mortality of the pest were done with a square wire frame of 0,5 m. The results showed that all dosages of the two formulations of Karate were efficient in the control of P.sequax until 10 days after the spraying, having its efficiency decreased on the fourteenth day. The insecticide Lorsban 480 BR was efficient until 7 days after the spraying. The formulations CS (microencapsuled) and CE (emulsionable concentrated) did not differ statistically in the control of the pest on the seventh day after the spraying, but did the dosages at this time. P.sequax can be efficiently controled by the pyrethroid lambda-cyalothrin.in wheat fields, when its population reaches the threshold of damage during the crop development Index terms: Pseudaletia sequax, wheat, Triticum aestivum, pyrethroid, lambda-cyalothrin[0178] EFFICIENCY OF THE FORMULATIONS 50 CS AND 250 CS OF THE PYRETHROID LAMBDA-CYALOTHRIN IN THE CONTROL OF *DIABROTICA SPECIOSA* IN BEAN CROP

B. Allconi ¹, A. M. De Souza Neto ² & II. Wiecheteck ³, ¹Dept. of Agronomy, Ponta Grossa State Univ., Praça Santos Andrade, s/n°, Ponta Grossa, PR, 84010-790, BR; ² Technical Department, Zeneca Brasil Ltda, R. Aldo Vergani, 952, Ponta Grossa, PR, 84035-160, BR; ³ R. Benjamin Constant, 871, Ponta Grossa, PR, 84010-380, BR.

The effects of rates and formulations of the pyrethroid lambda-cyalothrin in the control of *Diabrotica speciosa* in bean crop (*Phaseolus vulgaris*) were evaluated in this trial in Ponta Grossa, 1997. The treatments conducted as randomized blocs and with four replicates were as follow: Karate Zeon 50 CS (7,5 and 10,0 g.i.a./ha), Karate Zeon 250 CS (7,5 and 10,0 g.i.a./ha), Karate 50 CE (10,0 g.i.a./ha), Ortho-hamidop 600 (600,0 g.i.a./ha) and control. The spraying was done once with a CO₂ equipment and outflow of 200 l/ha and the evaluations were done 1, 3, 6 and 9 days after the spraying. The evaluatins were done with a cage of 0,4 x 0,8 m, covered with a tissue of thin mesh. The results showed that the rates and the formulations of the pyrethroid were efficient in the pest control until 6 days after spraying, decreasing its efficiencies until 9 days. Ortho-hamidop was efficient in the pest control until 9 days. The formulations SC (microencapsuled) and EC (emulsionable concentrate) and also the rates of 7,5 and 10,0 g.i.a./ha of lambda-cyalothrin gave the same control of *D. speciosa*, accourding to the statistical analysis.

Index teerms: bean, Phaseolus vulgaris, Diabrotica speciosa, pyrethroid, lambdacyalotrin.

[0180] SUBLETHAL EFFECTS OF ABAMECTIN SUPPRESSING COLONIES OF THE LEAF-CUTTING ANT ACROMYRMEX SUBTERRANEUS SUBTERRANEUS

E. C. Antunes¹, <u>R. N. C. Guedes</u>¹, T. M. C. Della Lucia¹ & J. E. Serrão², ¹Dept, of Animal Biology, Federal Univ. of Viçosa, Viçosa, MG 36571-000, Brazil, Email:guedes@mail.ufv.br; ²Dept. of General Biology, Federal Univ. of Viçosa, Viçosa, MG 36571-000, Brazil.

The assessment of the sublethal effects of abamectin on queens of the leaf-cutting ant Acromyrmex subterraneus subterraneus (Hymenoptera: Formicidae) was carried out. A concentration-response bioassay was conducted by exposing media workers to impregnated filter paper containing dried insecticide residue. This bioassay allowed the selection of the abamectin concentrations (0, 10, 50 and 100 mg a.i. ml⁻¹) to be used in the next phase in which eight queens were exposed to the insecticide. The highest concentration killed the queens, but the others survived and were placed back in their nests. Reductions in leaf consumption, fungus garden volume, and foraging activity were observed in colonies whose queens were exposed to higher abamectin concentrations. Colonies with queen serves at the other strong decrease in ovarioles per ovary and oocytes per ovariole with increased insecticide concentrations. It seems that abamectin-exposed queens became reproductively impaired producing little or no progeny and not properly replacing the colony members thus leading to the colony suppression.

Index terms: avermectin B1; macrocyclic lactones; reproductive impairment; oocyte development; Hymenoptera; Formicidae; ant control;

[0179] PERFORMANCE OF THE INSECTICIDES BUPROFEZIN 250; PYRIPROXIFEN 100 AND BUPROFEZIN 250 + ACEPHATE, IN CONTROL OF "WHITE FLY", *BEMISIA ARGENTIFOLII*, IN CABBAGE CROP

M. A. R. Alvarenga¹; <u>A.C. Silva²</u> & L. O. Salgado², 1 – Universidade Federal de Lavras/UFLA C.P 37 Lavras/MG 37.200-000 Brazil, 2 - Agroteste - Pesquisa e Consultoria Praça Leonardo Venerando, 284 C.P 201 Lavras/MG 37.200-000 Brazil Email agrotest@ufla.br

A serious problem occur throughout the Brazil for various years with "White fly" in many crops. The efficacy of Buprofezin 250, Pyriproxifen 100 and Acephate against "White fly", was tested at Agroteste Experimental Station - Lavras/Minas Gerais State - Brazil, from 05/02/99 until 25/06/99. The trial was set up in c.v. "Kenzan" planted in 1,0 x 0,5 m spacing. The experimental design used was randomized blocks, with 7 treatments replicated 4 times, each plot with $4,0 \text{ m}^2$. Were realized 4 applications weekly starting in 14/05/99 until 04/06/99. The treatments in commercial product/100L were: 1. Buprofezin 250-100g; 2. Buprofezin 250-150g; 3. Pyriproxifen 100-50 ml; 4. Pyriprofexin 100-75 ml; 5. Buprofezin 250 + Acephate - 150g + 50g; 6. Acephate 750 + Fenpropathrin 300 - 75g + 25ml and 7. Untreated. The products were applied in spray method with volume of 625L/ha. Were realized 3 evaluations in 7DAA (Days after the last application); 14 DAA and 21 DAA. Evaluated 2 leaves/plot established the number of nymphs and pupas living. The means were separate with Tukey (p<0.05) and the efficiency established with Abbott formula. The insecticide Buprofezin 250 showed and efficiency between 80,00 and 95,67% until 21 days after the last application. The insecticide Pyriproxifen 100 showed an efficiency between 78,00 and 92,06% until 21 days after the last application. The associate of insecticides Buprofezin 250 + Acephate showed an efficiency between 87,33 and 97,11 until 21 days after the last application.

Index terms: Bemisia argentifolii, white fly, cabbage crop., chemical control.

[0181] FRUIT FLIES OF THE GENUS ANASTREPHA IN THE FRUIT PRODUCING REGION OF MOSSORO/ASSU, RIO GRANDE DO NORTE, BRAZIL

<u>E. L. Araujo</u>¹, V. E. Silva², M. A. Filgueira³ & R. A. Zucchi¹, ¹Dept. de Entomologia, Fitopatologia e Zoologia Aplicada, ESAL/USP, Piracicaba-SP, 13418-900, Brasil, E-mail: elaraujo@carpa.ciagri.usp.br, ²COEX, Brasil; ³ESAM, Mossoró-RN, Brasil.

The counties of Mossoro and Assu are located in one of the few areas in the world recognized by the USDA as being a South American cucurbit fruit fly Anastrepha grandis free area. Therefore, this region has been one of the most important melon exporters, mainly for the USA and Europe. Besides melon, this region produces other fruits that can potentially be exported, however studies on fruit flies are scarce. An extensive survey of fruit fly species, host plants and parasitoids, population fluctuation, infestation index and biology began in 1999 aiming to obtain basic knowledge on fruit flies of the genus Anastrepha in the Mossoro/Assu region. So far, 5,373 fruit flies were collected, 2,771 (970 males and 1,801 females) of which were captured in McPhail traps and 2,602 (1,287 males and 1.315 females) reared from fruits. The species collected were A. zenildae. A. obliaua. A. sororcula, A. dissimilis, A. distincta and Anastrepha sp. (near A. pickeli). A zenildae is the most common. It is important to emphasize no specimens of A. grandis were collected. More than thirty plant species, native and exotic, belonging to different families, were analyzed. However, only 6, seriguela Spondias purpurea, caja Spondias sp., umbu-caja Spondias sp. (Anarcadiaceae), acerola Malpighia emarginata (Malpighiaceae), guava Psidium guajava (Myrtaceae) and jua Ziziphus joazeiro (Rhamnaceae) were confirmed as Anastrepha hosts. The most heavily infested hosts were guava and jua with infestation induce of 68 puparia/kg of fruit and 112 puparia/kg of fruit, respectively. Were obtained 64 parasitoids from the fruit fly puparia, all of which belong to the species Doryctobracon areolatus (Braconidae). The parasitism index in this region is relatively low, and the highest parasitism index obtained from the fruit samples collected was 5%. Fruit flies populations are low throughout the year in this region, peaking on May, June and July (research supported by FAPESP).

Index terms: Diptera, Tephritidae, host plants, parasitoids, biodiversity

[0182] ATTEMPTS TO MANAGE ANTICARSIA GEMMATALIS (LEPIDOPTERA, NOCTUIDAE) ON SOYBEAN IN COLONIA OKINAWA, SANTA CRUZ DISTRICT, BOLIVIA WITH BACULOVIRUS ANTICARSIA COMMERCIALIZED IN BRASIL

L. Arroyo¹ & <u>O. Mochida</u>¹ ¹CETABOL, Casilla #555, Santa Cruz, Bolivia: cetabol@daitec.scz.com

In our area, A. gemmatalis is a latent defoliator pest on soybean. Baculovirus anticarsia is said to be efficiently used for managing this pest in Brazil & Paraguay. Since Apr 1996, we have been working at the followings how efficiently to use the Baculovirus against A. gemmatalis at farmers' level. Light trap (with a 40-Watt ultraviolet fluorescent tube as light source) record of Anticarsia moths & its larval populations were surveyed in soybean field (see the figure). Egg, larval (via 6 instars), pupal, & adult stage were for 2, 19, 7, & 14 days, respectively, at room temperatures of 25-37°C. We are trying to 1) produce Anticarsia larvae massively, 2) infect them with Baculovirus, 3) propagate virus or virus-infected Anticarsia larvae, & 4) develop the practical application technology in the field. Adult males & females were kept together in 45x45x 100cm (in WxLxH) screen cage boxes with potted soybean plants for oviposition. Eggs were usually deposited on the under surface of leaves. Potted plants with eggs were transferred to smaller screen cage boxes in 35x35x80cm. Eggs hatched out & larvae were also reared with a commercialised artificial diet for insects (Nihon-Noosan-Kakou Co., Yokohama, Japan) & grew very well as those with soybean leaves

[0184] FUNCTIONAL RESPONSE OF CHRYSOPERLA EXTERNA (NEUROPTERA: CHRYSOPIDAE) FED NYMPHS OF UROLEUCON AMBROSIAE (HEMIPTERA: APHIDIDAE) APHID FROM LETTUCE

<u>A.M. Auad¹</u>, S. Freitas¹ & L.R. Barbosa¹. ¹Universidade Estadual Paulista (UNESP), Faculdade de Ciências Agrárias e Veterinárias (FCAV), Departamento de Fitossanidade, Via de Acesso Paulo Donato Castellani, s/n⁰, 14870-000, Jaboticabal, SP, E-mail: amauad@fcav.unesp.br.

The functional response of Chrysoperla externa (Hagen) larvae of 2nd e 3rd instar related to different nymphs densities of 3rd e 4th instar of aphid, Uroleucon ambrosiae (Thomas), from lettuce, was evaluated. The experimental design was randomly chosen, consisting of a 2 x 3 factorial scheme for evaluated of predator larvae response at 1, 2, 4, 8, 16 and 24hs after the beginning of the experiment, and at each 24h until the larvae stage changing (2nd instar) or until the pupation (3rd instar), on the three densities of the prey (30, 40 and 50), with 10 repetitions for each density. The insects were kept at temperature 25 ± 2 °C, UR 70 ±10% and 14 hours photophase. It was observed that for the 2nd instar larvae, during 1 to 24 hours, there was a decreasing on prey consumption for density 30 for 40, followed by an increasing on density 50. After this, period the larvae C. externa presented progressive increasing on nymphs consumption according to prey density, showing no stabilization tendency, which corresponded to a linear positive functional response. The same fact occurred to 3rd instar larvae, from predator in all evaluations. The predator:prey relation, under laboratory condition, was 1:23, 1:27 and 1:33 (2nd instar larvae), 1:27, 1:33 and 1:41 (3rd instar larvae) as studying daily mean consumption, on densities 30, 40 and 50, respectively.

Index terms: Green lacewing, biological control, predation.

[0183] USE OF GAMMA RADIATION TO CONTROL SITOPHILUS LINEARIS (COLEOPTERA: CURCULIONIDAE) ATTACKING TAMARINDUS INDICUS (LEGUMINOSAE: FABOIDEAE)

V. Arthur¹ & <u>E. Berti-Filho²</u>, ¹ Laboratório de Irradiação de Alimentos e Radioentomologia, CENA/USP, caixa postal 96, 13.400-970. Piracicaba, SP. E.mail:vaathur@pira.cena.usp.br; ²Depto de Entomologia, Fitopatologia e Zoologia Agrícola - ESALQ/USP. Caixa postal 9, 13418.900, Piracicaba, SP. eberti@carpa.ciagri.usp.br. Financial support: IAEA - CONTRACT Research N⁰ 10851/RO

This research was carried out to determine the disinfestant doses of Cobalt-60 gamma radiation to *Sitophilus linearis* in tamarind legumes. Previous sampling indicated that the mean number of insects per tamarind legume was 1.4. Each treatment consisted of 26 tamarind legumes and 4 replications totalizing 144 legumes and approximately 201 insects per treatment. The radiation doses used were: 0 (check), 0.1, 0.5, 1.0 and 2.0 Kgy, under a doses rate of 1.756 Kgy hour. The experiment was set in a room with controlled conditions (temperature $25 \pm 3^{\circ}$ C and $79 \pm 5^{\circ}$ relative humidity). The evaluation of the insect mortality was done 24 hours after irradiation. The results showed that the dose of 2.0 Kgy was sufficient to induce total mortality of this insect. Index terms: irradiation, weevil, tamarind, quarantine.

[0185] BIOLOGICAL ASPECTS AND VITAL STATISTICS OF *EDESSA MEDITABUNDA* (IIEMIPTERA, PENTATOMIDAE) UNDER CONTROLLED CONDITIONS

D.S. Avalos & N.C. La Porta, Dept. of Vegetal Protections, Agricultural Zoology. Faculty of Agricultural Science. Univ. of Cordoba. C.C 509. 5000. Cordoba, Argentina, E-mail: d-avalos@agro.uncor.edu.

Edessa meditabunda is a polyphagous insect found on Southern America. In Argentina it has been detected as a species which attacks different horticultural crops such as potato, salt-wort, chicory, capsicum, calabash, tomato, and field crops such as alfalfa, soybean, sunflower, grapevine and tobaeco. Biological aspects of *Edessa meditabunda* were studied under controlled conditions (temperature = 24,81 ± 0,51 °C; relative humidity = 53,76 ± 6,97 %; photoperiod = 16 h light). Stinkbugs were fed with fresh fruits of *Phaseolus vulgaris*. The following results were obtained: mean time from oviposition to adult was: 52,23 ± 6,28 days; nymphal mortality: 36,71% the greatest mortality occurring in the second instar; the sex ratio of adults reared in laboratory: 1,8 females: 1 males. The mean of eggs for female was: $81,75 \pm 69,83$; mean fecundity was $6,05 \pm 5,12$ egg masses per female. The following vital statistics were computed: net reproduction rate (R_0), generational time (T) and intrinsic rate of natural increase (r). Compared to the other Pentatomidae such as *Nezara viridula* and *Piczodorus guildinii* under laboratory conditions, *E. meditabunda* showed a biological cycle, nymphal mortality and generational time more large than those species.

Key words: Edessa meditabunda, Pentatomidae, biological aspects, vital statistics.

[0186] MORPHOLOGICAL, BIOLOGICAL ASPECTS AND DAMAGE OF TENTHECORIS BICOLOR DISTINTUS (HETEROPTERA: MIRIDAE): AN AMARILLIDACEAE AND ORQUIDACEAE PEST

<u>S. G. Bado</u> C. Sills & M.J. Pannunzio, Cátedra de Zoología Agrícola- Facultad de Agronomía. Ave. San Martín 4453 (1417) Universidad de Buenos Aires. Argentina. sbado@mail.agro.uba.ar

Amarillidaceae and Orquidaceae families comprise numerous species of ornamental interest. Damaging some of them it was found *Tenthecoris bicolor distintus*. The aim of this job was to describe their morphological and most important biological aspects, which are fundamental to manage the pest. Damage and hosts are mentioned. In order to achieve the objetives, an individual rearing was made feeding nymphs with *Crinum asiaticum* and *C. zeylanicum*. The duration of nymphal stages for four generations was registered meanwhile the description of their morphological aspects was done. The medium temperature was 24°C and R. H. of 60%. Nymphs are translucid with read spots in head, pronotum and the first abdominals segments. A dark spot due to intestinal content is also noticed in the middle of their abdomen. Female is tead and male reddish orange. Both of them present mesoescutelum black and hemielitres with corium and cunca read. Clavus dark. Membrane with dark spot. The medium period of development was 20 days. The damage consists of diminute clorotic spots covered with dejections and necrotic leaves borders. Plant loses its vigour and ornamental value. *T. bicolor* was found damaging *Crinum asiaticum L. , Crinum zeylanicum* L. *Amaryllis belladonna L*, y *Sprekelia formosissina L.*

Key words: Tenthecoris bicolor distintus, ornamental pest, Crinum asiaticum L., Crinum zevlanicum L

[0188] CONTROL OF ORTHEZIA PRAELONGA IN WEST INDIAN CHERRY, MALPIGHIA GLABRA USING FORMULATIONS AND THREE APPLICATION METHODS OF THIAMETHOXAM

<u>R. Burros¹</u></u>, M. D. R. O. Silva¹ & S. Araújo¹, ¹Fitossanidade, Univ. Fed. Rural de Pernambuco, Av. Dom Manoel de Medeiros S/N, Dois Irmãos 52171-900 Recife, PE. E-mail: rbarros@nelore.npde.ufrpe.br.

The scale Orthezia praelonga (Homoptera: Orthezidae) had been recorded recently as a serious pest in West Indian Cherry (WIC) Malpighia glabra growing area in Brazil. In Pernambuco, Brazil WIC population has been verified seasonally from July to November. The lack of insecticides registered by Agricultural Minister for WIC has impeded the use of this method for *O. praelonga* and others insects pests attacking WIC. Thus, this work aimed to evaluate the efficacy of Thiamethoxam for *O. praelonga* control in WIC. The experiments were set up in a WIC orchard five years old, spaced 3.5 x 3.5 m between and within line. The experiment was carried out in a randomized complete block with 8 treatments and 4 replications composed by two plants each. The treatments consisted by: I - Control; II - Foliar spray (Actara 250 WG) 1g/1.2 L water/plant; III - Foliar spray (Actara 250 WG) 2 g/1.2 L water/plant; IV - Stem spray (Actara 250 WG) 1 g/0.5 L water/planta; V - Stem spray (Actara 250 WG) 2 g/0.5 L water/plant; VI - Soil placement (Cruiser 700 WS) 2 g/plant; VII - Soil placement (Cruiser 700 WS) 4 g/plant and, VIII -Soil placement (Cruiser 700 WS) 6 g/plant. For foliar and stem treatments were used a costal sprayer 40 lbs/pol² and a trigger-pump 1.0 L volume, respectively. Thiamethoxam soil placement was applied by distributing granules in a semi-circle furrow 5.0-cm depth distant = 50% plant canopy projection from plant base. The evaluations were carried out at 9, 18, 27, and 36 days after application for all treatments. Each evaluation consisted of 16 leaves per replication-plant. The samples were took up to laboratory and the number of scale alive/leaf was counted using a stereo microscope and recorded. Application of Actara 250 WG 2 g/1.2 L water/plant through foliar spraying promoted efficiency of 60.7% in the first evaluation and maintained inferior to 45% in following evaluations. The treatment through stem application and soil placement showed efficacy inferior to 52% and only 27 days after application. Based on our results Thiamethoxam applied by foliar spraying, stem application and soil placement did not show an efficient control of O. praelonga in WIC orchard. However, investigation with higher Thiamethoxam doses than those used in this study should be carried to determine an efficient control method for this important pest in WIC

Index terms: Insecta, chemical control, systemic insecticide, scale, orchard pest.

[0187] BIOLOGY OF THE GUAJAVA WEEVIL, *CONOTRACHELUS PSIDII* (COLEOPTERA: CURCULIONIDAE), REARED UNDER LABORATORY CONDITIONS

O. Bailez, A. M. Viana-Bailez, D. Moreira & J. O. G. de Lima, Laboratório de Proteção de Plantas/CCTA, Univ. Estadual do Noroeste Fluminense, Av. Alberto Lamego, 2000, Campos dos Goytacazes, RJ, 28015-620, Brazil. E-mail: obailez@uenf.br

Constrachelus psidii is an important pest of the guaiava fruit in Brazil. The mater female eats cavities into the new fruits and lays a single egg in each hole and usually more than one egg/fruit. As soon as the egg hatches, the larva feeds inside the fruit destroying the pulp. When completing growth, the larva deserts the fruit and pupates in the soil. We studied the biology of the guajava weevil under laboratory conditions (25 ° C and 65-75 % HR). The egg hatches in an average of 3.9 ± 0.58 days (n=677). The larva undergoes four molts over an average period of 9.6 ± 2.58 days (n=247). After leaving the fruit, the mature larva remains in the soil for an average of 165 \pm 26 days (n=80), before transforming in a pupa. Pupation is then completed in an average of 15 ± 1.6 days (n=65), but the adult beetle still stays in the soil for an average of 25 ± 7.2 days. Feeding and sexual activity are initiated fifteen to thirty days after the adult emergence from the soil. Observations realized with a reduced number of females (n=5), showed that they starts ovipositing three days after mating, and may oviposit more than 750 eggs (observation under way) during its entire reproductive life. The highest number of eggs/day oviposited by the female was fourteen. After emergence from the soil, the male and female longevity may be more than 180 days (observations under way). We have developed a rearing method for the guajava weevil that will be reported elsewhere.

Index terms: Psidium guajava, laboratory rearing, guajava, beetle

[0189] BIOTYPIC VARIATION OF THE RUSSIAN WHEAT APHID BETWEEN SOUTH AFRICA AND HUNGARY

<u>Z. Basky</u>¹ & J. Jordaan², ¹Plant Protection Institute, Hungarian Academy of Sciences, P. O. Box 102, Budapest 1525, Hungary, E-mail h10433bas@ell.hu, ²Sensaco Cooperative. Ltd., P. O. Box 566 Bethlehem 9700, South Africa

The Russian wheat aphid Diuraphis noxia (Kurjumov) is indigenous in the Mediterranean in the Iranian-Turkestanian mountain range. However, in these regions D. noxia seldom becomes as serious pest as it has been in South Africa since 1978 and in the United States since 1986. To reduce D. noxia damage, intensive resistance breeding programs were undertaken in South Africa and the United States. Biotypic variation can affect the success of such breeding programs. D. noxia was first detected in Hungary in 1989, but has not become a pest. To test the difference between South African and Hungarian D. noxia, experiments were done in each country with the South African winter wheat cultivars Betta, which is susceptible to D. noxia and the resistant SST 333 and PI 262660 and the Hungarian spring barley cultivar Isis, which is susceptible to D. noxia. The effect of aphid infestation on fresh plant weight, leaf area over time differed between Hungarian and South African D. noxia for the susceptible barley cultivar Isis, and the resistant wheat cultivar SST 333. The aphid infestation significantly affected leaf area between South Africa and Hungary for susceptible wheat cultivar Betta and resistant wheat cultivar SST 333. In Hungary D. noxia feeding resulted in leaf rolling and chlorotic spots and stripes on resistant wheat cultivars SST 333 and PI 262660. Furthermore, the dynamics of the number of aphids per plant differed between South Africa and Hungary for Betta and SST 333. Infestation by Hungarian D. noxia reduced plant fresh weight and leaf area of the resistant wheats SST 333 and PI 262660 as much as the susceptible wheat Betta regardless the growing conditions (growth chamber or greenhouse). In addition water imbalance occurred in resistant wheats SST 333 and PI 262660 in greenhouse. These differences between Hungarian and South African D. noxin suggest genetic differences between these populations. Our results support the idea that resistant plant germplasm has geographical limits because of geographical variation in pest species. Index terms: Diuraphis noxia, resistance breeding, biotype

[0190] DIFFERENT INSECTICIDES AND DOSES FOR EUSCHISTUS HEROS CONTROL ON SOYBEAN CROP

S. Bellettini¹, N.M.T. Bellettini¹, L.H. Kajihara², J. Conte² & L.L. Biaggi², ¹FFALM, P.O. Box 261, ZIP 86360-000. Bandeirantes-PR - Brazil, E-mail: bellettini@ffalm.br; ²Hokko do Brasil. Mato Grosso Street, 1493; 91350-000 Londrina-PR-Brazil, E-mail bokko@tdnet.com.br

Among different bugs on soybean crop, brown stinkbug is one of the most important, due by damage that causes on leaves, pods and seeds. It were evaluated in Londrina-Pr, different insecticides and doses on brown stinkbug control in soybean crop, cultivar OCEPAR-13, with spacing 0,45 m among lines and 20 plants per meter. Experimental design was randomized block using 06 treatments, 04 replications and plots with 135 m² each. It was done a single spraying with following treatments in a.i./ha acephate (Orthene 750 Br) 187,5; 225 and 300 g; endosulfan (Thiodan CE) 210 and 437,5 g and control (with no spraying). For insecticides application it were used a sprayer with constant pression of 65 lb/pol² and volume of 200 l/ha. Evaluations were done by pre-counting and at 4, 9, 12 and 16 days after application. On each evaluation it were done 4 randomized samples per plot, using "cloth method", by counting adults of alive brown stinkbug, fallen down the cloth. It were conclude that a) acephate (Orthene 750 Br) 225 e 300 g and endosulfan (Thiodan CE) 437,5 g a.i./ha, at 4 and 9 days after application showed efficiency above 80% on brown stinkbug control; b) different insecticides and doses had no plants toxicity.

Index terms: Euschistus heros; soybean, chemical control

[0192] EFFECT OF DIFFERENT SEED TREATMENTS ON APHID APHIS GOSSYPH CONTROL VEGETATIVE DEVELOPMENT AND YIELD OF COTTON CROP

S. Bellettini¹, P. H. Aramaki², L.S. de Biaggi¹, A. Minucci & W.G. da Silva¹, ¹FFALM, P.O. Box 261, ZIP 86360-000. Bandeirantes-PR - Brazil, E-mail: bellettini@ffalm.br; ²Novartis Biociências S/A. Research and Development. 04706-900 -São Paulo City-S.P.-Brazil

Higher aphids attack occur since 40 till 70 days of cotton plants age. Seeds treated by insecticides allow plant protection against aphids till 30 days. It were evaluated in Bandeirantes-Pr, with the cultivar COODETEC-401, the effect of different seeds treatments on a.i/100 kg of seeds: thiamethoxan (Cruiser 700 WS) 150; 210 e 300 g imidaeloprid (Gaucho) 140 g; carbofuran (Furadan 350 TS) 700 g; acephate (Orthene 750 BR) 750 g and control (with no insecticide). Experimental design was randomized blocks, with 7 treatments and 4 replications, using plots with 27 m² size. Evaluations were done by counting the number of alive aphids at 15; 20; 25; 30 and 35 days after emergence on 10 summit randomized leaves, per plot; plant height at 10, 20, 30, 40 and 120 days after plants emergence using 10 marked plants per plot and cotton seed yield. If were concluded that: a) different seed treatments showed efficiency above 82% on aphids control; b) insecticides thiamethoxan (Cruiser 700 WS) 210 and 300 g, and imidaeloprid (Gaucho) 140 g showed efficiency among 90 to 97,3% on aphids control respectively; c) 9,3; 17,3 and 11,8% higher plants height and 26,1; 30,7 and 25,9% higher on cotton seeds yield, respectively, relating to control.

Index terms: Aphis gossypii; cotton; chemical control

[0191] DIFFERENT INSECTICIDES AND DOSES TO CONTROL GREEN STINKBUG NEZARA VIRIDULA ON SOYBEAN CROP

<u>S. Bellettini¹</u>, N.M.T. Bellettini¹, L.H. Kajihara², J. Conte² & L.L. Biaggi², ¹FFALM, P.O. Box 261, ZIP 86360-000. Bandeirantes-PR - Brazil, E-mail: bellettini@ffalm.br;
²Hokko do Brasil. Mato Grosso Street, 1493; 91350-000 Londrina-PR-Brazil, E-mail hokko@ldnet.com.br

Among different pests attacking soybean crop, green bedbug is considered most important, due by injury that causes. It were evaluated in Londrina-Pr, different insecticides and doses to control green stinkbug on soybean crop, cultivar OCEPAR-13, at spacing 0,45 m among lines and 20 plants per meter. Experimental design was randomized block using 06 treatments, 04 replications and plots with 135 m² each. It was done a single spraying with following treatments and doses, in a.i./ha acephate (Orthene 750 Br) 187,5; 225 and 300 g; endosulfan (Thiodan CE) 210 and 437,5 g and control (with no spraying). For insecticides application it was used a sprayer with constant pression (CO₂); X_3 nozzle, pression of 65 lb/pol² and volume of 200 l/ha. Evaluations were done by pre-counting and at 4, 9, 12 and 16 days after application. On each evaluation it were done 04 randomized samples per plot, using "cloth method", by counting adults of alive green stinkbug, fallen down the cloth. It were conclude that: a) insecticides endosulfan (Thiodan CE) 210 and 437,5 g at 4 and 9 days after application, acephate (Orthene 750 Br) 187,5 and 225 g at 4,9 and 12 days after application and acephate (Orthene 750 Br) 300 g at 4, 9, 12 and 16 days after applications showed efficiency above 81% on green stinkbug control; b) insecticides and doses had no plants toxicity.

Index terms: Nezara viridula, soybean, chemical control

[0193] EFFECT OF DIFFERENT SEED TREATMENTS ON THRIPS FRANKLINIELLA SCHULTZEI CONTROL VEGETATIVE DEVELOPMENT AND YIELD OF COTTON CROP

S. Bellettini¹, P. H. Aramaki², L.S. de Binggi¹, A. Minucci & W.G. da Silva¹, ¹FFALM, P.O. Box 261, ZIP 86360-000. Bandeirantes-PR - Brazil, E-mail: bellettini@ffalm.br; ²Novartis Biociências S/A. Research and Development. 04706-900 -São Paulo-SP-Brazil.

Thrips are sucker insects of wich higher population densities occur at 10 and 20 days of plants age. Adults and nymphs, during feeding, induce necrosis and leaves deformity, besides temporary stoppage on plants development. it were eveluated in Bandeirantes-Pr, using COODETEC-401 cotton cultivar, following seed treatments in a.i./100 kg of seeds: thiamethoxan (Cruiser 700 WS) 150; 210 e 300 g imidacloprid (Gaucho) 140 g; carbofuran (Furadan 350 TS) 700 g; acephate (Orthene 750 BR) 750 g and control (with no insecticide). Experimental design was randomized blocks, with 7 treatments and 4 replications, each plot with 27 m² size. Evaluations were done by counting the number of alive thrips at 10; 15; 20; 25 and 30 days after emergence per plot; plant height at 10, 20, 30, 40 and 120 days after plants emergence, using 10 marked plants per plot and cotton seed yield. If were concluded that: a) different seed treatments showed efficiency above 81% on thrips control; b) insecticides thiamethoxan (Cruiser 700 WS) 210 and 300 g, and imidacloprid (Gaucho) 140 g showed efficiency among 90 to 97,3% respectively; c) 9,3; 17,3 and 11,8% higher plants height and 26,1; 30,7 and 25,9% higher on cotton seed yield, respectively, relating to control.

Index terms: Frankliniella schultzei; cotton; chemical control

<u>J. van den Berg1.</u> Z.R. Khan₂& J. Pickett₃, ₁ARC - Grain Crops Inst., Private Bag X1251, Potchefstroom, 2520, South Africa. ₂ICIPE, PO Box 30722, Nairobi, Kenya, ₃IACR-Rothamsted, Harpenden, Herts AL5 2JQ, United Kingdom. E-mail: Johnnie@igg2.agric.za.

Maize and sorghum are the most important cereal crops in Africa. The stem borers Busseola fusca (Lepidoptera: Noctuidae) and Chilo partellus (Lepidoptera: Pyralidae) are serious pests of these crops and can cause yield losses ranging from 20 to 80 %. New crop protection strategies need to be developed since chemical control is not a viable option and resistant varieties are not available to resource-poor farmers. One such approach is a stimulo-deterent-diversionary strategy or a "push-pull" system, by which wild host and non-host plants are used to manage pests. Such a system was developed in Kenya where intercropping with the non-host molasses grass (Melinus minutiflora) significantly reduced stem borer infestation and increased larval parasitisation by Cotesia sesamiae. Planting of Napier grass (Pennisetum purpureum) as a trap crop around maize fields and intercropping with the legume Desmodium uncinatum, which repels stem borer moths, further reduced stem borer infestation on the main crop. Desmodium uncinatum was also observed to control Striga hermonthica in maize. Kenyan farmers perceived the following as benefits of this habitat management system: reduced borer infestation, increased milk yield and household income. The habitat management system developed in Kenya, where two rainy seasons occur and rainfall is high, is being adapted to the semi-arid conditions in southern Africa where only one rainy season occurs and crops are planted in areas of low rainfall (400 to 600 mm). While a zero-grazing system is used in Kenya and traps crops are fed to cattle, free grazing is largely practiced in southern Africa. The non-host inter-crops and trap crops used in East Africa are therefore not suited to southern African conditions and farming systems. A survey was conducted to search for wild host plants of stem borers for use in a habitat management system in South Africa. Results indicated that wild host plants are rare or absent in areas where annual rainfall is less than 600 mm. Field studies on the colonisation process of C. partellus and B. fusca on cultivated host plants (maize, sorphum, sweet sorphum and pearl millet) and wild host plants (Panicum maximum and Hyparrhenia tamba) indicated that C. partellus preferred sorghum and maize to the other plant species while B. fusca had no distinct preferences. In two-choice tests with maize and Vetivier grass (Vetiveria zizanoides), the latter was preferred for oviposition by C. partellus moths. Vetivier grass and wild sorghum are therefore likely candidates as trap crops for C. partellus in southern Africa.

Key words: Busseola fusca, Chilo partellus, maize, Sorghum spp., Vetiveria sp

[0195] APHID COLONISATION OF LUPIN CROPS; YIELD LOSSES AND CONTROL STRATEGIES

<u>F. A. Berlandier</u>, Entomology Section, Biological Services, Crop Improvement Institute, Agriculture Western Australia, Locked Bag No. 4, Bentley Delivery Centre WA 6983, Australia.

Lupins are the principal grain legume cropped in the State of Western Australia, and since 1993 over 1,000,000 tonnes has been harvested annually. The crop is harvested for its grain, which is primarily used for animal feed, both locally and as an important export commodity. Lupins are winter grown crops and are well adapted to the infertile deep sandy soils of Western Australia. There are currently eight cultivars of narrow-leafed lupin (Lupinus angustifolius) and one of yellow lupin (Lupinus luteus) recommended for cultivation in Western Australia. Aphids are common pests of lupin during the bud and flowering stages, and are most abundant from late winter (August) to early spring (September) in Western Australia. The three most common species found attacking lupin crops are Acyrthosiphon kondoi, Aphis craccivora, and Myzus persicae. Field trials were undertaken to quantify the effects of aphid colonisation and feeding on crop yields. Three cultivars of L. angustifolius (Tallerack, Merrit and Kayla) and one of L. luteus (Wodjil) were sown in replicated field plots and were either treated every 21 days with aphicide until maturity, sprayed once with aphicide, or left untreated. From bud formation onwards, aphid numbers developed very rapidly on untreated plants of cvs. Tallerack and Wodjil, but very slowly on cv. Kayla. Up to 130 and 200 aphids per 10-cm portion of stem tip were recorded for respectively cvs. Tallerack and Wodjil, and only 36 aphids for the cv. Kayla. Acyrthosiphon kondoi was the dominant species, making up over 70% of the species complex. Aphid attack on untreated cv. Tallerack caused grain yield losses of 84% when compared to plots sprayed regularly with an aphicide, and on cv. Merrit losses of between 28 - 34% were recorded, whereas untreated plots of cv. Kayla suffered negligible losses. Yield losses were almost 100% in untreated plots of cv. Wodjil. A single spray of insecticide minimised yield losses in cv. Tallerack to 23% at one site, but greater losses of 42% were recorded at a different site with a longer growing season. Similarly, a single spray could minimised losses in cv. Wodjil to 19% at one site but losses were still almost 60% at the second site with the longer growing season. Aphid colonisation rates are strongly correlated with subsequent feeding damage if plants are left untreated, and the extent of colonisation is influenced by cultivar. Local farmers are advised to frequently monitor their crops from early bud formation, particularly if susceptible cultivars are sown, and to spray if the economic threshold is reached.

[0196] DILOBODERUS ABDERUS (COL. SCARABAEIDAE) CONTROL THROUGH SEED WITH GAUCHO 600 FS IN WILEAT AND BARLEY ON RS

N. G. Bertoldo¹ & W. Caetano¹, ¹Dept. of Entomology, FEPAGRO, Gonçalves Dias Ave. 570 - Porto Alegre/RS 90130-060 e-mail: producao@fepagro.rs.gov.br , BRAZIL.

Diloboderus abderus, knows like "coró-das-pastagens" is between principal soil pests that happens frequently in winter cereals, given rise to great injuries last years. Due to manly difficulties in it control and low efficacy of insecticides applied at conventional way, was install this work with objective to evaluate the effect of Gaucho 600 FS through seed treatment in this pest control. This test was done by FEPAGRO São Borja's Experimental Station, in 1998 season, was doing in wheat and barley. The experimental plan was casual blocks with 4 repetitions and following treatments express in ml (commercial product) / 100 kg seeds: Gaucho 600 FS – 40; 60; 80; 100; Furadan 350 SC – 2000 and check. The experimental unity was represented in an area with 30 m². The evaluations were made at 7; 15; 25 and 35 days after plant stand, through 3 samples / parcel, counting the number of warms / m², in a 20 cm - soil profundity. It was found out by observations that Gaucho 600 FS (80 and 100 ml/100 kg wheat seeds and 60; 80 and 100 ml/100 kg barley seeds) showed high efficacy in *Diloboderus abderus* control.

Index terms: *Diloboderus abderus* control, wheat, barley, seed treatment; insecticide Gaucho 600 FS.

[0197] EFFICIENCY OF INSECTICIDE CRUISER IN THE CONTROL OF DILOBODERUS ABDERUS (COL. SCARABAEIDAE) BY SEED TREATMENT IN THE WHEAT, OAT, AND BARLEY

N.G. Bertoldo & W. Caetano, Eng^o Agronomist researchers from FEPAGRO; Rua Gonçalves Dias, 570 – ZIP CODE 90130-060 – POA/RS – 3:E-MAIL: producao@fepagro.rs.gov.br

In the decade of 70 when pest control managing began, it was recommended the use of adequate insecticides and the use of the direct plantation as new alternative for soil protection. The use of these techniques came to bring great benefits to the agroecosistem, but some time the soil insects colonized plantations again and reaching at insect pest Among the species the Diloboderus abderus, in general called "coró of the level. pasture", comes causing damages quite accentuated in winter cereals in the last years. Due to control difficulty through conventional method and the small number of available products in the market, three experiments was carried out for D. abderus control through seed treatment for wheat, oat and barley cultivation in a experimental field in Rio Pardo -Rio Grande do Sul State, during 1999. The experimental design was a split-plot arranged in randomized blocks with four replications and following treatments with the respective doses in g or 1 of commercial product for 100kg of seeds: Cruiser 700 WS - 35, 50, 75, 100; Gaticho 600 FS -75, Furadan 350 - 2 and control. After 26, 49 and 63 and 91 days from sowing were made three samplings by m² in each portion for evaluation. From the results was verified that insecticide Cruizer 700 WS at the used doses, 50, 75 and 100g/100kg of seeds together with Gaúcho 600 FS and Furadan 350, evidenced high percentage of control for D. abderus in winter cereals, providing larger and better options control.

Index terms: Diloboderus abderus control; seed treatment; insecticide Cruizer

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[0198] CONTROL OF THE *DICHELOPS* SPP. BY TREATING THE CORN SEEDS OF DIFFERENT SIZES WITH A MIXTURE OF THIAMETHOXAM AND THIODICARB

<u>R. Bianco¹</u> & M. Nishimura², ¹Instituto Agronômico do Paraná / IAPAR, C. Postal 481, 86001-970, Londrina-PR, E-mail rbianco@pr.gov.br. ²Novartis Biociências S/A, Av. Rio de Janeiro, 1452, 86010-150, Londrina-PR.

Dichelops spp. became an important pest of corn seedlings in the last years. Seed treatment with new generation insecticides such as the neonicotinoids has resulted in a satisfactory control of this pest. In some cases, however, seed treatment has failed in controlling the insects and this could be associated with the reduction in the dosages of the products induced by variation in size of the seeds. The objective of this work was to determine the efficiency of Thiamethoxam, in mixture with Thiodicarb, using various seed sizes and either correcting or not the dosages of the pesticide. The study was conducted in screened cages (1,20 by 1,00 by 1,00 m) under field conditions. Corn cultivar TORK (NK seeds) was sowed in January 7, 2000 leaving 10 plants per cage. Two and nine days after seedlings emergence each cage was infested with four *Dichelops* adults. Evaluations of the number of dead insects were performed seven days after insect releases. Twenty days after the corn emerged the percentage of plants with strong symptoms of damage was determined. The experiment design was set up in randomized blocks, with subdivided plots, with three corn seed sizes: 1) seed sift 16 (10 kg/ha); 2) seed sift 18 (12 kg/ha); and 3) seed sift 20 (16 kg/ha), and three insecticides dosages: 1) 140 g a.i. (Thiamethoxam WS 70%) + 525 g a.i. (Thiodicarb 350 FROG)/100 kg of seeds; 2) corrected dosage: 100% (sift 16); 60% (sift 18); and 25% (sift 20); and 3) control (without seed treatment). The results showed the following: 1) there were not differences among the treatments (100% of insect mortality) when the insects were released two days after corn emergence; 2) after the second release there was a significantly lower number of insects dying in the treatments where smaller seeds were used, that corresponded to lowest insecticide dosage. When the dosages were corrected, the mortality did not differ (75%); 3) as the size of the seeds increased the number of plants injured decreased even for the corrected dosages. These results emphasize the importance of the greater initial vigor of the seedlings in reducing pest damage.

Index terms: Dichelops spp, Maize, control, seed treatment

[0199] EFFICIENCY OF PYRETHROID INSECTICIDES IN THE CONTROL OF ALABAMA ARGILLACEA IN COTTON CROP

<u>A.L. Boica Júnior</u>¹ & G. L. Barbosa¹, ¹ Dept de Fitossanidade, Univ. Estadual Paulista. Via de Acesso Prof. Paulo Donato Castellane, s/n. 148700-000. Jaboticabal – SP. Brasil. E-mail: aboicajr@fcav.unesp.br.

The efficiency of betacypermethrin 100 SC, betacypermethrin 100 CE, and cypermethrin 200 CE insecticides, in several doses, in the control of Alabama argillacea in a cotton crop was evaluated. The experiment was carried out in a area at Jaboticabal City, State of São Paulo, Brazil. The cotton cultivar was used Coodetec-401, sowed on October 29, 1998. The field experimental plots were set up in a randomized block design, with 7 treatments and 4 replications. The treatments were applied with an application rate of 7.50; 8.75 and 10.00g i.a/ha of betacypermethrin 200 CE; and no application at the control plot. The evaluations were made in the 54m² of the useful area in each plot, accomplished before the application (January 26, 1999) and at the 3rd, 5th and 8th days after the application of the insecticides. The number of alive caterpillars in 20 plants in the useful area of the plot was sampled. It has been concluded that: (1) all the products and evaluated rates presented efficiencies above 80% at the 8th day after application; (2) the average number of A. argillacea per 20 plants was lower when betacypermethrin 100 SC was applied (10.0 g i.a. ha) and betacypermethrin 100 CE (12.5 g i.a. /ha) with efficiency above 80% at the 3rd days after the application, such as lower show betacypermethrin 100 SC was applied (10.0 g i.a. ha) Sth days after the application, reaching efficiency above 90% at the 8th day; and 5th days after the application, reaching efficiency above 90% at the 8th day; and, (3) betacypermethrin 100 SC, in the rate of 8.75 g i.a. /ha, has also presented superior efficiency at 80% in the three evaluations.

Index terms: Insecta, cotton leafworm, chemical control.

[0200] AMMONIUM ACETATE: AN EFFICIENT ADULT ATTRACTANT OF ANASTREPHA SPP & CERATITIS CAPITATA IN MANGOES PLANTATIONS IN MARACAY, VENEZUELA

N. Boscán de M.¹ & F. J. Godoy¹, ¹Plant Protection Dep., Agronomic Research Institute, National Agricultural Research Center, P.O Box 4653.University area, El Limón, Maracay, Venezuela.

Five attractants were tested for the capture of fruit fly adults (Anastrepha spp and Ceratitis capitata) in mango plantations in El Limón, Maracay, Venezuela. The attractants used were hydrolyzed protein Nulure 9% + borax 3%, ammonium acetate 16%, Urea 16%, Torula yeast extract and sugar cane juice 80%. Homemade traps built with plastic bottles with two litter capacity, with a circular hole 3 cm wide, for the entrance of the flies. A totally random design with five treatments and four repetitions. From February 19th to august 08th every 15 days all traps were collected and trapped flies counted. Results show the the best attractant for both species was ananyzed through analysis of variance and Tuckeymeans test at 5% of probability. Ammonium acetate was 2.3, 4.4, 10.7, and 25.6 times higher than urea, nulure, sugarcane juice and torula. Anastrepha showed higher numbers of captured adults, compared to Ceratitis.

Key words: Ammoniun acetate, fruit flies, Mangifera indica, Nulure, Urea, Sugarcane.

[0201] CHEMICAL CONTROL OF MAHANARVA FIMBRIOLATA (HEMIPTERA-HOMOPTERA: CERCOPIDAE) IN SUGARCANE

<u>P.S.M. Botelho¹</u>, N. Macedo¹ & M.S. Campos², ¹CCA/UFSCar, P. O. Box 153, Araras, SP, Brasil,E-mail photelho@cca.ufscar.br; ²Sugarmill Bonfim, Guariba, SP. Brasil.

The insecticides: Thiamethoxan, Imidacloprid, Carbofuran, Clorpirifos etil, Metarhizium anisopliae (fungi) and Carbaril on the control of root froghopper ninfae, Mahanarva fimbriolata, in sugarcane area were studied. Sugarcane was harvested by machine without burning. The experimental design was randomized blocks, three replicates, with five row parcels, 30 m long, being 15 m with and 15 m without (the thrash was amassed inter rows) thrash on the rows. The chemicals were applied straight on the base of the sugarcane plants. After chemical applications the number of alive nymphs/linear meter, at 15, 30, 60 and 90 days were counted. The pest was controlled until 30 days by Carbofuran - 350 SC (6.5 l do p.c./ha) and until 90 days by Thiamethoxan - 10 G (30 kg do p.c./ha). Similar to the two fungi strains of *M. anisopliae*, evaluated until 90 days after application, the pattern insecticide, Carbaril (2 l c.p./ha) was not efficient in froghopper control. When the thrash was put aside from the row the occurrence of nymphs was minor. Index terms: root froghopper, nymphs control, insecticides.

[0202] CERCONOTA ANONELLA (LEP., OECOPHORIDAE) IN SOURSOP (ANNONA MURICATA) IN ALAGOAS STATE, BRAZIL: OCCURRENCE AND CONTROL

S. M. F. Broglio-Micheletti¹ & <u>E. Berti-Filho</u>², ¹FTT/CECA/UFAL, BR 104, Km 85, 57.100-000, Rio Largo, Alagoas, Brasil, ; ²Dept^o de Entomologia, Fitopatologia e Zoologia Agrícola, ESALQ/USP. Caixa postal 9, 13418,900, Piracicaba, SP, E-mail: eberti@carpa.ciagri.usp.br.

The spatial and probabilistic distribution of *Cerconota anonella*, in soursop orchards were studied in Maceió, State of Alagoas, Brazil from March 1997 to April 1998. The spatial distribution of *C. anonella* is binomial negative, characterizes the distribution of the type aggregate or in focus. The dispersion index of the insect was 2.15 and the sample size was 52 fruits/ha. To detect and monitorate the pest in the field the population was surveyed by collecting fruits for observation or dissection and also by using traps with virgin females. *C. anonella* occurred during the whole period of study, with a population acme between April and May and the infestation decreasing with the time. The sex ratio was 0.47 and the mean longevity for females and males was respectively 7.07 and 6.68 days. The mean damage observed on fruits was 17.64%, which represents a control level of 2 holes/fruit, if microperforated plastic bags (0.39 m long x 0.34 m wide) were used. When comparing chemical and mechanical controls used individually or together, the most effective and economic one was the microperforated plastic bags.

Index terms: soursop borer, sampling, damage evaluation, chemical control, mechanical control.

[0204] INFLUENCE OF CULTURAL PRACTICES ON PRE-HARVEST INFESTATIONS OF CORN BY MAIZE WEEVILS (SITOPHILUS ZEAMAIS)

<u>S.L. Brown</u>¹ & D. Lee², ¹Depts. of Entomol., ²Crop and Soil Sciences, University of Georgia, P.O. Box 1209, Tifton, GA 31793, USA, E-mail: bugbrown@arches.uga.edu

The maize weevil (Sitophilus zeamais) is the primary pest of stored corn in Georgia. Infield infestations occur prior to harvest, and kernels containing maize weevil eggs and larvae are often placed into the storage bin. Subsequent, emergence of adults in the storage bin initiates in-storage infestations that can result in severe losses if timely, expensive and sometimes dangerous control measures are not used. A three-year study was conducted to 1) quantify the influence of cultivar and planting date on in-field infestations, and 2) determine when maize weevil oviposition was occuring in the field relative to crop phenology. Each year, four replications of 6-8 cultilvars of corn were planted on 3-4 different planting dates. Beginning at the three-quarter milk line stage, paper bags were placed over 10 ears in each plot and secured with rubber bands to prevent maize weevil oviposition. Bags remained in place for two weeks. Ten more ears per plot were similarly bagged for a second and third two-week period. Individual ears were identified with a tag so that ears that had been bagged for the same time period could be hand harvested and kept separate from others. Kernels from individual ears were removed from the cob, placed into paper bags and bags were placed in a grain bin. After 30 days, the contents of each bag were sieved and maize weevil adults were counted. The first planting date had significantly more infested ears than any other, but the number of maize weevils per 500g of corn did not significantly differ among planting dates. This may indicate that overwintering weevils readily oviposit in the first available corn in the spring but fecundity and/or survivability may not be as great as in subsequent generations. It could also indicate a behavioral difference whereby overwintering weevils oviposit in many different ears attempting to find suitable hosts whereas subsequent generations tend to oviposit in the ear from which they emerged. In terms of percentage of infested ears and number of weevils per 500g, the cultivar Pioneer 3146 had a significantly lower level of infestation than Mycogen 7559, indicating maize weevils may 1) have ovipositional preferences for certain host characteristics and/or 2) have greater larval survival on certain cultivars. More weevils were found in unbagged ears than in ears that had been bagged for any of the three exclusion periods. Prevention of oviposition during the third exclusion period had the greatest impact on final weevil numbers, indicating that period was when the greatest oviposition was occuring in the field.

Index terms: stored products, integrated pest management, post-harvest

[0203] AREA-WIDE CONTROL OF MEDFLY (CERATITIS CAPITATA) IN CITRUS IN SOUTH WEST AUSTRALIA

S. Broughton & C.P.F. de Lima, Entomology Division, Agriculture Western Australia, 3 Baron-Hay Crt, South Perth, Western Australia. E-mail smbroughton@agric.wa.gov.au.

The Mediterranean fruit fly (Medfly), *Ceratitis capitata*, has become an extremely important pest of commercial orchards in Western Australia in recent years. Research has shown that while recommended treatments are effective, control failures resulted from insufficient knowledge of the ecology of the pest. It was suspected that the increase in the Medfly problem was taking place in response to climatic change (global warming) and to change in the host environment with the increase in the trend towards rural sub-division and neglected orchards. In 1999, an area-wide approach to Medfly control was initiated in citrus. Male and female traps were installed on grower's properties in 5 citrus-growing areas in Western Australia. Adult fly populations peak in January, when few ripe citrus crops are present on commercial properties. A second peak occurs in autumn when Medfly disperse into citrus for over-wintering. Adults are active in winter when temperatures exceed 12°C, and Medfly over-winter as adults, ggod control of Medfly is achieved. Index terms: *Ceratitis capitata*, area-wide control.

[0205] SELECTIVE TARGETING OF LOCUSTS WITH ULTRA-LOW DOSES OF FIPRONIL INSECTICIDE IN RANGELAND AND SORGHUM

R. M. Bull, Aventis CropScience Australia P/L, 261 Tingira Street, Pinkenba, Brisbane Q4008, Australia

Ultra-low doses of fipronil were applied to outbreaks of Australian plague locust (Chortoicetes terminifera), spur-throated locust (Austracris guttulosa) and migratory locust (Locusta migratoria) in a number of large field trials in sorghum crops and rangeland to determine optimum commercial dose and assess environmental impact. Fipronil treatments were sprayed from aircraft over banding hoppers and concentrations of adults as oil based ULV at 150-300ml/ha on 100m track spacing, or by conventional high water volume (15-201/ha) methods at 25m spacing, Juveniles and adults of all 3 species were shown to be highly susceptible to fipronil at ultra-low (1.25-5g ai/ha) dose rates, 1.25g a.i./ha being optimum and resulting in >98% mortality. Intoxication and loss of coordination of locusts occurred within 2 hours of application at 26-38°C but maximum mortality took 2-7 days depending on species and diurnal temperatures. A. guttulosa and L. migratoria adults ceased to feed on sorghum crops as soon as first symptoms of intoxication developed. High volume water treatments produced slightly more rapid speed of kill than the ULV, but both achieved =100% locust mortality at all dose rates. Low Fipronil doses were shown to have high environmental safety for almost all non-target arthropods within the treated areas as cicadas, spiders, adults and larvae of Coccinellidae and Neuroptera and other beneficial species were unaffected in both pasture and sorghum crops. Studies of organisms in small temporary ponds within sprayed areas found aquatic insects, tadpoles, freshwater crabs and pulmonate snails also unaffected. Hundreds of insectivorous birds attracted to 3 trial sites soon after spraying were unaffected despite gorging for several days on debilitated or dead locusts. Non-target insects killed by fipronil were mostly solitary grasshoppers, crickets or phytophagous pest species in sorghum crops. Australian registration for Adonis 8.5UL and Regent 200SC at 1.25g a.i./ha for control of C. terminifera, A. guttulosa and L. migratoria in rangeland/pasture and grain sorghum was approved in December 1999.

[0206] EFFECT DIFFERENT DOSES OF THE INSECTICIDE CRUIZER FOR CONTROL OF THE "LARVA-PIN" DIABROTICA SPECIOSA (COL.; CURYSOMELIDAE) IN MAIZE CULTIVATION

W. Caetano & N. G. Bertoldo, Engº Agronomists researchers from FEPAGRO: Rua Gonçalves Dias, 570 - ZIP CODE 90130-060 - POA/RS - 3: E-MAIL: producao@fepagro.rs.gov.br

Rio Grande do Sul State, southeastern of Brazil, is constituted of 467 regions occupying a territorial area of 282. 062 Km2. The corn crops, Zea mays L. has significant socioeconomic importance. The cultivating of corn grain reaches 26% approximately of the total areas for grain cultivation. The larva -pin " is the most serious among the insect pests that damage the corn cultivation. A diagnosis was conducted to investigate the occurrence of soil-pests in 28 crops group of economical interest at conventional planting system. This study identified more than two dozens of soil-pests being classified in order of larger frequency, nematóides (73%); "corós" (64%); ants cutters (50%) and other (41%). The objective this study was to evaluate the effects of insecticide Cruizer 700 WS in the seed treatment in the "larva-pin" corn cultivation control. The trial was carried out at experimental field in São Borja - Rio Grande do Sul State, during 1999. The experimental design was a split-plot arranged in randomized blocks with four replications with six treatments. The following treatments were used with the respective doses in g. i. a./hactare for 100 Kg/seeds: Cruizer 700 WS, 50, 100, 150 and 200; Gaucho 600 FS, 80 and control. After 25, 45 and 60 days from field emergency five randomized plants were removed from two central arrays for evaluation. From the results was verified that insecticide Cruizer 700 FS at the used doses, together with the Gaucho 600 WS, evidenced high control index for the insets pest when accomplished the seeds treatment. Index terms: Control of " larva-pin", insect pest control

[0208] IMPACT OF CHRYSOPERLA (NEUROPTERA: EXTERNA CHRYSOPIDAE) ON CINARA SPP. (HOMOPTERA: APHIDIDAE) IN LABORATORY

J. T. Cardoso & S. M. N. Lazzari, Depto. de Zoologia, Universidade Federal do Paraná, Curitiba, PR, BR. E-mail lazzari@bio.ufpr.br.

Recent outbreaks of the aphid Cinara Curtis on Pinus spp. have been registered in southern Brazil, where it is causing significant losses to the forestry, lumbering, and paper mill industry. The genus Cinara is holarctic in origin, and includes 220 species, predominantly on Coniferae. The main symptoms are needle shedding, malformation of the branches, and tree stunting. Large colonies can be observed feeding on the branches, producing abundant honeydew, which allows extensive sooty mold development. A few predators have been collected, including Coccinellidae (Coleoptera), Syrphidae (Diptera), and Chrysopidae (Neuroptera). Green lacewing larvae are especially abundant and voracious. Laboratory tests were conducted in order to evaluate the impact of the larvae of the chrysopid Chrysoperla externa (Hagen) on Cinara spp. Batches of twenty larvae of each instar of C. externa were reared individually in plastic vials and fed with first to fourth instar Cinara pinivora (Wilson) and Cinara atlantica (Wilson) nymphs. Aphid consumption was studied under three temperatures: 15 °C, 20 °C .and 25°C, with 12L:12D photoperiod and 60% relative humidity. Feeding was evaluated every 24 hours. At 15 °C, the first instar larvae ate an average of 16.6 aphids; while the second consumed 44.9, and the third, 264.4 aphids. At 20 °C, the average consumption was 12.0; 28.8; and 183.2 aphids for the first, second, and third instar larvae, respectively. At 25 °C the consumption was 11.0; 21.6 and 108.3 aphids, respectively, for the first, second and third instar of C. externa larvae. The consumption of the third instar larvae represented about 80% of the total number of aphids predated at the three temperatures. At 15 °C the total consumption was greater because the time for the development was also significantly longer than at the other temperatures. The developmental period from egg hatching to the pupation was 63.0; 22.2; and 10.0 days at 15 °C, 20 °C, and 25 °C, respectively. The larval mortality was less than 10% at 20 and 25 °C, however it reached 40% at 15 °C, suggesting that this temperature, despite the high consumption, is not adequate for mass rearing. The best temperature for mass rearing in the laboratory is 25 °C, at which the development period is shorter and a smaller number of aphids is needed to feed the larvae. The results showed that C. externa can be a very efficient biological control agent for Cinara spp. on Pinus, especially due to its voracity and rearing easiness.

Index terms: Biological control; chrysopids; pine aphids; food consumption.

[0207] CHARACTERIZATION OF GREENBUG POPULATIONS COLLECTED IN ARGENTINA AND CHILE

<u>A.M.Castro¹</u>, A.A. Clúa¹, S. Ramos¹, D.O. Giménez¹ & H.O. Chidichimo^{2,3}, ¹Dept. of Biology and Ecology and ²Dept. of Production, Fac. of Agronomy, Univ. Nac. La Plata, CC 31, 1900-La Plata, Argentina ³ CICBA amcastro@isis.unlp.edu.ar

Greenbug, (Schizaphis graminum, Rond.) is one of the aphid pests that most seriously damages the cereal hosts and it is also one of the most important virus vector of sugarcane, potato, tomato, strawberry and pepper. Greenbug natural populations have been collected throughout Argentina and Chile during six years in order to establish the population dynamics for improving its control. Different traits economically important have been studied with these insects reared on susceptible barley and wheat plants. Ten maternal linages were isolated from every population. The host preference, the biotypic composition and their aggressiveness, the isozymes variability and the reproductive behaviour, were determine in 37 populations and in the derived clones. The aphids collected at low latitudes preferred S. halepensis as host, those ones collected on cereals significantly preferred barley and wheat, and insects collected on grasses preferred sorghums and oats. Three over 37 populations showed known biotypes being the most frequent biotypes B, C and F. Highly significant differences were determined between populations in greenbug aggressiveness in terms of coleoptile straight growth test of susceptible cultivars. Twenty different isozymes systems were analysed and it was found highly significant variability for estearases, phosphatases, and GOT. It was found no correlation between the population origin and the lapse required for sexuals differentiation. In two populations, (one from Argentina and the other from Chile), and in their derived clones there was not sexual induction. In another two Argentinean populations and derived clones only one sex was induced. The variability in host preference, aggressiveness, and isozymes systems could be explained by the reproductive behaviour. It is worth noticing that greenbug populations in Argentina and Chile have a different structure from those ones in the USA, since sexual reproduction is a common strategy of that aphid throughout very contrasting climates in our region.

Index terms: Greenbug, host-preference, biotypes, aggressiveness, reproductive behaviour

[0209] EVALUATION OF THE EFFICACY ON AN AGGREGATION PHEROMONE AS A MEANS OF CAPTURE AND PROTECTION AGAINST COSMOPOLITES SORDIDUS GERMAR (COLEOPTERA: CURCULIONIDAE) IN THE CANARY ISLANDS

A. Carnero¹, M. Montesdeoca² & J. Barquín³, ¹Inst. Canario de Investigaciones Agrarias, P.B. 60 - E38200 La Laguna, Tenerife, Canary Islands, Spain, ²Dept. Ciencias Agrarias, Univ. La Laguna, Tenerife, Canary Islands, 3Dept. Zoología, Univ. La Laguna, Tenerife, Canary Islands

The banana picudo, Cosmopolites sordidus was first cited for the island of Tenerife in 1986, after a century of banana cultivation free of this pest. It has spread rapidly constituting presently the most important pest for this crop due toits significant effect on yield. The assays have taken place on the north of the island of Tenerife, at a banana plantation located at sea level. The banana cultivar was Dwarf Cavendish, grown under drip irrigation. The pheromones were commercial origin. Pit-fall type traps were set up using a 3% detergent solution, located 20-m. apart and moved every week according to a pre-established statistical design. Treatments used were pheromone, pheromone + activator, activator and water control. The mixture pheromone+activator is the most effective treatment. The useful life of the pheromone was a 9 weeks. Using spatial analysis it was determined that the insect has focal distribution. Index term: Cosmopolites sordidus, pheromone,

[0210] EFFECT OF BLUE-YELLOW STRIPING ON STICKY TRAPS FOR THRIPS AND WHITEFLIES

<u>P. I. Carrizo</u>, Fac. Cs. Agr. y Ftales., Univ. Nac. La Plata. Calle 60 y 119, CC 31 (1900) La Plata. Argentina. e-mail: **Erro! Indicador não definido.**

It is possible to obtain an increase in total thrips caught on sticky traps, by putting them in front of a contrasting background colour, which result also attractive to the target species. If combined colour traps would produce a higher caught on trips by unit surface, and it does not affect other insect's behaviour, it may be an optimal choice. A possible advantage would be its potential use in mass trapping. The purpose of this study was to prove a combination of two different attractive colours - arranged as vertical striping - in order to improve thrips and whiteflies captures on greenhouse vegetable crops. Four trials were carried out in greenhouses, in tomato, pepper, cucumber and strawberry - the last one with onion as intercropping -. Thirty commercial sticky traps were placed on blossom, for one week. Colours were blue, yellow, and blue/yellow striping; adhesive surface was 10cm x 15cm, with striping 2 cm wide. Average captures/cm² were compared by mean of ANOVA and Tukey for thrips trials, and Kruskal-Wallis non parametric test for whiteflies trials (α =0.05). In pepper, trips caught were not different; Frankliniella occidentalis was the only species present. In strawberry there was not difference for thrips caught, because of a lower captures on yellow portions in striping traps; there were remarkable differences on F. occidentalis and Thrips tabaci presence, depending on that kind of trap involved. In tomato crop, there was highest caught for thrips on blue and lowest on yellow, while stripping trap was in the middle; F. occidentalis represented 75% and Thrips tabaci 25% of species caught. For cucumber trial, thrips caught on blue was the greatest, and clearly separated from yellow and striping ones; F. occidentalis being 90%, and T. tabaci 10% of species caught. Different thrips species composition might explain, at least in part, some apparent contradictions in colour tests - 'crop effect', as Mateus and Mexia named - and it is probably owing to mixture factors. Then, combined colours were not strong enough to overcame this crop effect, and enhance captures. For Trialeurodes vaporariorum, results were mostly negative, and were the same for every crop: yellow striping had very low captures by unit surface. Whiteflies seemed to reject yellow striping; the ratio (yellow striping / yellow pure) captures by unit surface were notably small: from 0.08 to 0.39. This is a negative non-expected consequence on whiteflies's behavior. No improving was attained because of two-coloured traps, because there was not evidence concerning an improvement in the thrips attraction, and there was some negative effect on white flies. Key words: Frankliniella occidentalis, Thrips tabaci, Trialeurodes vaporariorum, tomato, pepper, strawberry, cucumber

[0211] LEAST COUNTING SURFACE IN STICKY TRAPS FOR THYSANOPTERA AND ALERODOIDEA. L PRELIMINARY TESTS

<u>P. I. Carrizo</u>, Fac. Cs. Agr. y Ftales., Univ. Nac. La Plata. Calle 60 y 119, CC 31 (1900) La Plata. Argentina. e-mail: Erro! Indicador não definido..

Counting time for sticky traps might be reduced, by carrying out only on a portion of them; however, it should be examined how those insects arrange along trap surface. It was intended to prove the choice of carrying out countings in a smaller area of the traps - for a standard size -, taking two taxa, which currently are pests in greenhouse. Trials were carried out in cucumber; traps had an adhesive surface of 10cm x 13cm. Blue traps were used for thrips (9 trials, n=5), and yellow traps for thrips and whiteflies (5 trials, n=5). They were counted in the whole trap, and in 7 different arrangements, from 12 early created (see figure below). The expected capture was compared with actual ones on each arrangement, by means of G test, and paired t test was performed to settled down if caughts - by unit surface, of each arrangement - was higher or lower than average of the whole-trap counts (α =0.05). Frankliniella occidentalis represented more than 95% of trips species, and whitefly species was Trialeurodes vaporariorium. For trips, only 32% and 13% G tests adjusted to those expected values for yellow and blue traps, which shows a kind of cluster, especially on blue ones. According to t paired test, thrips caught on blue traps was meaningful higher than expected on: ii, iii, x, xii; meaningful lower than expected on: viii, ix. For yellow traps, it was meaningful higher than expected on: ii, iii, x, xii, meaningful lower than expected on: viii. Thrips behavior did not seem different because of color tested. For whiteflies, 96%~G tests adjusted to those expected, so these insects tended to be more uniformly distributed than the trips along the trap surface. Paired t test for whitefly shows that only caughts on viii and xii were meaningful different, higher than average. By counting two horizontal strips on top and bottom edges, 2 cm wide arrangement named i - it was obtained counts that were not significantly different from whole-trap counts, for both whiteflies and trips, in blue and yellow traps. That technique may reduce counting time by 70% compared with whole-trap counts, because only 30% of the total area are recorded.

Key words: Frankliniella occidentalis, Trialeurodes vaporariorium, counting time, cucumber

[0212] MULCH COLOR ATTRACTIVENESS FOR TRIPS AND WHITEFLIES BY MEANS OF STICKY TRAPS TRIALS

P. L Carrizo, Fac. Cs. Agr. y Ftales., Univ. Nac. La Plata. Calle 60 y 119, CC 31 (1900) La Plata. Argentina. e-mail: **Erro! Indicador não definido.**

The ideal trap should attract highest numbers of the pest populations; the ideal mulch should not. Blue or yellow - fairly most attractive - are not currently used on mulch color. About those currently used on La Plata horticultural belt - from more to less frequent: black, white, and orange - there is not information. Evaluations by means of true mulch may be costly, and a first approach might be obtained by means of sticky traps, in order to predict its behavior. In commercial greenhouses, there were carried out trials in tomato, cucumber and eggplant. Five colours were tested: yellow, blue, orange, white, and black; traps surface was 10cm x 13cm (n=10), and each trial was repeated twice. The traps were suspended on a wire; each one spaced 150 mm apart, and randomly distributed. Indeed, blue and yellow were used as witness for thrips and whiteflies populations. Total caught were compared, by means of ANOVA and Tukey tests; Kruskal-Wallis non-parametric test was used to compare eggplant results (α =0.05). Orange traps had meaningful lower caught for thrips, and meaningful higher for whiteflies; white ones were the opposite. Black ones had always the lowest caughts. A summary may be: blue ≥ white > orange = black for thrips, and yellow ≥ orange > white = black for whiteflies. Thrips species were different, depending on crop. Whitefly species was Trialeurodes vaporariorum. Both taxa had a divergent behavior, but their results should be not taken in an isolated manner. Even being not attractive to thrips, orange mulch might be a risk for whiteflies; a similar advice may be given for thrips and white mulch, so they should be not used. Thrips and whiteflies do attack together greenhouses crops, and every single cultural measure should be take account this. Table: thrips species on sticky traps, by color and crop.

Keywords: Frankliniella occidentalis, Thrips tabaci, Trialeurode's vaporariorum, tomato, eggplant, cucumber

[0213] AFRICANIZED HONEYBEE AND STINGLESS BEE AS POTENCIAL POLLINATORS OF SOME TROPICAL AND EXOTIC FRUITS IN BAILIA STATE, BRAZIL

M. S. de Castro¹ & F. F. de Oliveira², ¹Exp. Unit of Bahia Enterprise of Agric. Develop. EBDA, Salvador, Bahia and Dept. of Biology Sciense, State Univ. of Feira de Santana, Bahia. Dorival Caymi Av., 15.649 Itapuã Salvador, Bahia, Brazil 41.635-150. E-mail: marina@e-net.com.br; ²Dept. of Entomology, Federal Univ. of Paraná. Curitiba, Paraná, Brazil 81.531-970. E-mail: favizia@garoupa.bio.ufpr.br.

The bee community of a mixed orchard was studied at an experimental Station in the State of Bahia, Brazil. In this station, 20 species of native tropical and exotic fruits were observed. These ecological studies are important for the conservation of plants and bee fauna diversity. The pollinators play an important role on the reproductive success and gene flow of many agricultural and native plants and the plants are important food sources for the pollinators. A total of 14 highly eusocial bee species (Apidae) were recorded. The Africanized honeybee (*Apis mellifera scutelatta* L.) was the most abundant species at fruit flowers, representing 41.1% of all individuals or 51.7% of all Apidae. Of the stingless bees, 5 species can be considered as abundant fruit flower visitors, representing 1% or more of the sample and 8 species can be considered as rare. The analysis of the sampling shows the importance of the stingless bees (Apidae; Meliponinae) for some native tropical fruit trees as mainly potencial pollinators. Some patterns of bee species composition and relative abundance was studied.

Index Terms: Crop pollinators, bee community, highly eusocial bee, Bee Fauna

[0214] IMPACT OF CULTIVATION SYSTEMS ON *DICHELOPS MELACANTHUS* (HEMIPTERA: PENTATOMIDAE) ABUNDANCE AND ITS DAMAGE TO WHEAT IN SOUTHERN BRAZIL

V. R. Chocorosqui¹ & A. R. Panizzi², ¹Department of Zoology, Federal University of Paraná, P.O. Box 19020, Curitiba, Paraná 81531-990, Brazil. Email: viviane@cnpso.embrapa.br; ²Centro Nacional de Pesquisa de Soja (CNPSo), Empresa Brasileira de Pesquisa Agropecuária (Embrapa), Caixa Postal 231, Londrina, Paraná, 86001-970, Brazil. E-mail: panizzi@cnpso.embrapa.br.

The pentatomid *Dichelops melacanthus* (Dallas) was found as a new pest of wheat, *Triticum aestivum* L. in southern Brazil. Results of field evaluations indicated that this bug is associated with the no-tillage cultivation system, which favors its biology resulting in increase of the population. Adults and nymphs were found mostly on the soil, near the plant stems and underneath crop residues of the preceding summer crop, usually soybean, *Glycine max* (L.) Merrill or corn, *Zea mays* L. Wheat under conventional cultivation system was free of the bug attack. *D. melacanthus* caused substantial damage to wheat plants, particularly to seedlings. As a result of the bug attack, a reduction in the number of seed heads of up 34% was observed. Seed yield was reduced in 31% due to bugs attack, compared to plants free of damage. Weight of 1000 seeds was also reduced in approximately 5%. Management strategies to eliminate debris on the soil that offer shelter to stink bugs through plowing may mitigate the impact of D. melacanthus to wheat in southern Brazil.

Index terms: Hemiptera, Heteroptera, pentatomid, stinkbug, wheat, cultivation systems, pest management)

[0216] RESISTANCE TO GRAIN APHID IN WINTER TRITICALE CULTIVARS IN RELATION TO THE CONTENT OF MONO- AND OLIGOSACCHARIDES

<u>A. P. Ciepiela</u> & G. Chrzanowski, Dept. of Molecular Biology and Biophysics, Univ. of Podlasie, Prusa 12, 08-110 Siedlce, POLAND, e-mail: GrzegorzC@ap.siedlce.pl

Sugars are important nutrients for aphids, being their main energy source. Quantitative and qualitative sugar composition considerably affects choice of host plants by the aphids. Proportions of various sugars in the food determine aphid feeding activity, thus – amount of consumed and assimilated food. In present study soluble and reducing sugar content, and concentrations of saccharose, fructose and pentoses were evaluated in the cars of winter triticale cultivars of different resistance to grain aphid (*Sitobion avenae IF.J*). The results of entomological tests showed that Dagro cultivar was susceptible to grain aphid, and Malno – fairly resistant. Chemical analyzes revealed that aphid-free Dagro ears collected at the milk-maturity stage contained more soluble saccharides and saccharose, fructose and saccharose than Dagro plants. The differences of mono- and oligosaccharide content between the cultivars were statistically significant. The results indicate that high constitutive resistance of Malno winter triticale to the grain aphid is related to high content of reducing sugars, fructose, and pentoses in the areas.

Index terms: Sitobion avenae, winter triticale resistance, constitutive.

[0215] EFFECT OF THE GRAIN APHID FEEDING ON POLYSACCHARIDE CONTENT IN EARS OF WINTER TRITICALE CULTIVARS

A.P. Ciepiela, G. Chrzanowski & E. Radomyska, Dept. of Molecular Biology and Biophysics, Univ. of Podlasie, Prusa 12, 08-110 Siedlee, POLAND, e-mail: GrzegorzC@ap.siedlce.pl.

Grain resistance to aphids is closely related to structural polysaccharides of cell wall (cellulose, hemicelluloses, pectins). These compounds determine chemical structure of cell wall, and possibility of cell penetration by the aphids, acting as a mechanical barrier. Aphid saliva introduced into the host plant tissues during feeding affects the rate and direction of metabolic processes, e.g. synthesis of structural polysaccharides. In the present study the effect of feeding by grain aphid (Sitobion avenae /F./) on cellulose, hemicellulose, and pectin in ears of two triticale cultivars was evaluated. The cultivars differed in natural resistance to aphids – Dagro being more susceptible, and Malno – fairly resistant. Chemical analyzes revealed that non-infested by the aphids Dagro ears contained more hemicellulose, and less pectin and cellulose comparing to Malno plants. The differences of polysaccharide content in the non-infested plants of both cultivars were statistically significant. Aphid feeding on Dagro ears resulted in a significant decrease of content of all polysaccharides, comparing to the control. In Malno plants infested by grain aphid wingless females concentration of pectin and cellulose significantly increased, and content of hemicellulose dropped, comparing to the aphid-free plants. The results show that high resistance of Malno cultivar to the pest, constitutive and induced by S. avenae feeding, is related to the high pectin content, and low concentration of hemicellulose. The authors suggest that resistance of winter triticale to grain aphid is closely related to the structure and chemical composition of cell walls.

Index terms: Sitobion avenae, winter triticale resistance, constitutive, inducible.

[0217] EFFECT OF PYRIPROXYFEN ON WHITEFLY (BEMISIA ARGENTIFOLII) EGGS, IN THE EGGPLANT (SOLANUM MELOGENA), IN FIELD CONDITIONS

S.A.M.P. Coelho¹, M.H. Calafiori¹ & C.L. da Silva², Agronomic Engineering Course. CREUPI. Postal Box 05. 13990-000 - Espírito Santo do Pinhal – SP – Brazil. E-mail: cpagrpin@rantac.com.br. ²Hokko do Brasil. E-mail: issamu@hokko.com.br

B. argentifolii has caused great damage due to its aggressiveness and difficulty to control it. Trial was carried out, in field conditions, to applied pyriproxyfen on the eggplant culture, variety Napoli, in Estiva Gerbi county - SP, in April, 1999 and after in laboratory. Treatments were arranged in a completely randomized design with 10 replications. The treatments were: A- control; B- pyriproxifen (Cordial 100 - 75 ml/100 \Box). The plots were shaped by 4 plants being evaluated 1 cm²/eaf and 1 leaf/plant. Nymphs and adults were taken from leaves and only the eggs were left to observe the hatching. The leaves were maintained in BOD at 25°C. Evaluations were realized at the 3rd and 6th day after the first and second application of pyriproxyfen. Nymphs are counted after the emergence under binocular microscope and the percentage of hatching was established. The results allowed to conclude that pyriproxyfen applied in field conditions inhibit the nymph emergence after the second application with efficiency of 70,78% and 88,85% at the 3rd and 6th day, respectively. There wasn't phytotoxicity.

Index terms: ovicide, control, egg hatching.

[0218] DETERMINATION OF INJURY AND DAMAGE OF THE MEALYBUG DYSMICOCCUS BREVIPES (HEMIPTERA: PSEUDOCOCCIDAE) IN PINEAPPLE

K. G. F. Colen¹; J. C. Moraes¹; L. V. C. Santa-Cecília²; R. Zanetti¹ & A. B. Carnevale¹, ¹Dept² de Entomologia, Universidade Federal de Lavras 37200-000 Lavras Carnevale', 'Dept^a de Entomología, Universidade Federal de Lavras, 37200-000, Lavras, MG - Brazil. E-mail: jemoraes@ufla.br; ²Empresa de Pesquisa Agropecuária de Minas Gerais - EPAMIG, Campus da UFLA, 37200-000, Lavras, MG - Brazil.

Among the insects which are present on pineapple crop stands out the mealybug D. brevipes (Cockerell), which is spread in all the producing countries. Infestations under field conditions with the mealybug (0, 1, 5, 15, 30 mealybug per plant) on pineapple cuttings of the c.v. Smooth Cayenne potted in plastic pots were done. The objective was determining the injury and damage of that insect in terms of its density. The experimental design was completely randomized with four replicates and five treatments. The agronomic characteristics of the plants, population density of mealybug and wilt symptoms on pineapple plant through visual note scale were evaluated. The results showed that plant height, green matter weight of the root and aerial part were affected by the mealybug. A low population density of the mealybug was enough to transmit pineapple wilt. Index terms: IPM. Ananas comosus

[0220] FILTH IN FRUIT PRODUCTS MARKETED IN SÃO PAULO, BRAZIL

M. Correia & ²M.J. Roncada, Food Microscopy Division, Adolfo Lutz Institute, Avenida Dr. Arnaldo, 355, 01246-902, E-mail: mcorreia@ial.sp.gov.br; 2 Department of Nutrition, Public Health College from the University of São Paulo, Brazil. Financial support: FAPESP.

This survey was developed aiming the standardisation of the analytical methodology to the filth found in fruit jams, fruit pastes in sweets and in canned syrup fruits, and to determine the levels of filth contamination of such products. To isolate the filth found in the fruit jams, the method 16.10.06/950.89a of the Official Methods of Analysis of Association of Official Analytical Chemists International/1995 (AOAC International) was used; the same method was adapted to the fruit pastes in sweets, adding a new stage of sample boiling for dissolving. With the canned syrup fruits the methods 9L4a and 9L7a of the Macroanalytical Procedures Manual/1984 were adapted, which, with some modifications, allowed to carry out in one same sample the analysis of isolation of filth, of Howard mold count and Geotrichum mold count. To determine the levels of filth contamination, samples from the three products (fruit jams, fruit pastes in sweets and canned syrup fruits) were collected in supermarkets from São Paulo city. The analysis were carried out through the methods mentioned above. The results proved that the methods were appropriate, allowing a good visualisation of the light filth present in the filter paper. In relation to the levels of the contamination, it was found that 56.4% of the fruit jams, 54.4% of the fruit pastes in sweets and 31.6% of the canned syrup fruits were in disagreement with the Brazilian legislation for food which requires absence of extraneous materials, parasites or larvae in fruit products. The most contaminated products were: among the jams, the blackberry and raspberry ones; among the fruit pastes in sweets, the guava; and among the canned syrup fruits, the plums, mainly dead mites and insects and fragments of insects. Such results lead to the need of the alteration of the Bromatology legislation in force, establishing limits of toleration to strange materials such as fragments of insects.

[0219] COMPARISON OF DAMAGES CAUSED TO SOYBEAN BY DIFFERENT SPECIES OF STINK BUGS

B. S. Corrêa-Ferreira, Embrapa Soja, Caixa Postal 231, 86001-970 Londrina, PR, Brazil, E-mail beatriz@cnpso.embrapa.br

Damage caused by the three main species of stink bugs occuring on soybean were compared in field cages (1m x 1m) containing cultivar BR 37 soybean plants. Cages were infested with adults of Nezara viridula, Piezodorus guildinii and Euschistus heros, at a level of four stink bugs/m (8/cage), for 15 days, at pod filing stage (R5-R6). Evaluations were performed every two days when dead insects were replaced. After the infestation period the insects were eliminated by endossulfan aplication. Cages containing control plants remained free of stink bugs during all crop cycle. At harvesting, the number of healthy and damaged pods/plant and yield were evaluated. Seed quality from the control and infested plants were visually classified, as good, intermediate or bad seeds and also by tetrazoliun test (damaged seeds and non viable seeds). There was no difference in yield between infested and insect free plants, but damage on seed quality varied with stink bug species. For all cases, the seed quality was lower than for control plants. Results obtained by both visual and tetrazoliun evaluations showed that plants damaged by *P. guildinii* had the lowest quality seeds. From 50g seed samples, the average of the seeds classificated as good was 37.3g in plants infested with P. guildinii, compared to 41.8g, 44.2g and 46.6g in plants infested with *E. heros*, *N. viridula* and control, respectively. *P. guildinii* plants infested had about 18% of seed injuried and this value was higher than the 3.6% and 3.4% of plants infested with the two other species and 0.1% of the control plants. Similar results were obtained for the percentage of non viable seed due to stink bugs damage which was 5.7% for P. guildinii.

Index terms: Pentatomidae, Nezara viridula, Piezodorus guildinii, Euschistus heros. Glycine max

221] AGRONOMIC EFFICIENCY THE INSECTICIDES AND DOSES OF CONTROL TO TIBRACA LIMBATIVENTRIS IN IRRIGATED RICE

E. C. Costa¹, J.A.S. França¹ & R.C.Borin¹, ¹ Depto. de Defesa Fitossanitária, Centro de Ciências Rurais - Universidade Federal de Santa Maria, Campus Universitário, prédio 42, 1º andar, 3225 - CEP 97105-900 - Santa Maria - RS - Brasil e-mail: eccosta@ccr.ufsm.br.

A trial was carried out during 1998/99 season, in Santa Maria, RS-Brazil, in order to evaluated different inseticides and doses to control (Tibraca limbativentris) on El Passo L-144 irigated rice cultivar. The sampling of T. limbativentris was done with a sweeping trap into an experimental plot with 100m2. The area covered byy each sumpling was 3,8m2. The experimental field design was the complete random blocos with six treataments and four replications. The insecticides were Actara WG 25 (12,5g, 25g e 37,5g); Stron EC 60 (600g), Folidol 600 (270g) and a check. The insecticida was by a three, five and eight days after spraying. The insecticides were spraying by calibrated to 150 l/há. The evaluation were done three, five and eight days after the pre-spray, insecticides spraying. The treataments efficiency was calculate using Abbott (1925) formula and the two way analysis considerate the Duncan Test at probability of 5%. The result showed that Actara WG 25 (25 and 37,5 a.i.g/ha) controlled efficiently T. limbativentris despite the development stage.

Key-words: rice: insecticides

[0222] THE USE OF ABOVE GROUND HEXAFLUMURON BAITS IN THE ELIMINATION OF A *COPTOTERMES HAVILANDI* COLONY LOCATED IN RIO CLARO, SP, BRAZIL (ISOPTERA, RHINOTERMITIDAE)

A. M. Costa-Leonardo¹, C. R. R. de Camargo-Dietrich¹ & S. L. Almeida², ¹Department of Biology, Universidade Estadual Paulista, Av. 24-A, 1515, 13506-900, Rio Claro, SP, Brazil, E-mail: amcl@rc.unesp.br; ² Dow AgroSciences Industrial Ltda. Rua Alexandre Dumas, 1671-4°C, 04717-903, São Paulo, SP, Brazil. E-mail: salmeida@dow.com

Coptotermes havilandi is an important termite pest in Brazil and its infestations are extremely difficult to control because of its large populations and satellite nests. In this study, the foraging population and foraging territory of a C. havilandi colony was determined and the action of hexaflumuron baits over the colony was investigated. Foraging population of a colony of C. havilandi was estimated at ca. 730,000 using two cycles of mark-release metodology with a weighted mean method. This colony was located in the campus of the University (UNESP, Rio Claro, SP) with termite activity spread into two buildings and a foraging territory that covered ca. 972 m². It was the single mature C. havilandi colony present in an area almost entirely occupied by the native subterranean termite Heterotermes tenuis. After characterizing the colony (estimating foraging population, foraging biomass and territory) through the use of both in-ground and above-ground stations, the hexaflumuron bait was introduced in only the above-ground stations. C. havilandi colony was eliminated in a period of 56 days through baits that had a matrix containing hexaflumuron, an insect growth regulator. The baiting procedure was initiated on February, 12, 1999 with the use of above ground stations only. Eleven bait stations were installed but only eight had consumption with termite activity (72.7% of hits). C. havilandi foraging ceased completely on April, 8, 1999 in the treated baits and on March, 3, 1999 in the untreated monitoring traps containing cardboard. Continuous monitoring through April, 22, 1999 showed an opportunistic invasion of H. tenuis termite in one bait station located within the original territory of C. havilandi. This H. tenuis infestation was controlled by June 1999. No termite activity was found in the foraging territory 10 months after control procedures were completed.

Index terms: subterranean termite, termite monitoring, mark-recapture technique.

[0223] OCCURRENCE AND DAMAGES OF ONCIDERES SAGA (COLEOPTERA, CERAMBYCIDAE) IN MIMOSA CAESALPINAEFOLIA (LEGUMINOSAE, CAESALPINOIDAE)

A. B. Coutinho¹, M. Scalise¹, C. R. S. Júnior¹ & A. G. Carvalho¹, ¹Depto. Produtos Florestais, Univ. Fed. Rural do Rio de Janeiro, Seropédica, RJ 23851-970, Brasil. E-mail: acacio@ufrrj.br.

Mimosa caesalpinaefolia (Leguminosae, Caesalpinoidae), the popular "sabiá", happens in the northeast of Brasil. Its leaves are good as forage for the cattle and its wood for the production of stakes. Oncideres saga (Coleoptera, Cerambycidae), known by the name common of "sawyer", a menace has been considered for some botanical species. The work verified the occurrence and it evaluated the damages of O. saga in M. caesalpinaefolia in the period of February to June of 1998. It was made a research accomplished in the area of Fazenda do Viegas, in the city district of Bangu, RJ, to verify the occurrence of O. saga sawing branches of M. caesalpinaefolia, in plantation for recovery of degraded area. The inspection and it collects they were accomplished in an unit sample to verify the occurrence of sawed branches and with emergency holes, being measured the diameter, in centimeters, close to the base until the apex of the branch, and the length in meters. It was verified the occurrence and damages of the O. saga in just five copies of a unit of eighteen trees. The diameter measures and found medium length were of 1,33 cm (index of variation from 1,0 to 1,9) and 1,87m (1,22 to 2,98). The adults' of O. saga presence was observed, two females, accomplishing posture in a same branch. For the obtained results, it was verified that M. caesalpinaefolia is susceptible to O. saga when planted in degraded area causing alteration in the architecture of the crown, facilitating the organisms attack; it is necessary, therefore, a study of the flotation of O. saga, because through the same, they can be defined times for a cash it controls. Index terms: Degraded areas, "Sawyer".

[0224] SIMULATION OF THE TRI-TROPHIC SYSTEM COFFEE-BROCA-PARASITOIDS: POSSIBLE OUTCOMES FROM TWO DIFFERENT CLIMATIC REGIMES

J. R. Cure, Facultad de Ciencias. Departamento de Biologia Aplicada. Universidad Militar Nueva Granada.

As biologists we understand that life history traits affect the growth rates of populations. Numbers and size of the offspring, age distribution of reproduction and life span are all life history traits in which species differ (Futuyma, 1998). The problem has always been to have a consistent method that enables the practical use of this information, in terms of the useful application of laboratory data with field data and observations. When we talk about tri-trophic simulations we are referring to a very well structured system analysis for the simulation of ecological interactions and its outcomes. The system has been developed during the last 20 years, and although it has been extensively illustrated with biological control examples, it can also apply to basic ecology and applied biology in general (for a complete reference, see Gutierrez, 1996). Strengths of the system are: its ability to describe complex patterns using simple biological criteria as drivers of the models; the possibility of using available data to make initial assumptions; the capacity to incorporate new data as they are available; and its' modular approach, which permits the modification of functional relationships among variables as simulations suggest a new way for interpreting the data. In many countries of South America, coffee production is threatened by the introduced coffee berry borer, Hypothenemus hampei (Ferrari). There is a serious need to have a good method of control, which at the same time should be safe for the consumer. Several agencies in Latin America are currently looking for such a control and are introducing parasitoids and pathogens to deal with the problem (Hoyos and Aristizabal, 1996); however, there has not been a previous evaluation of the possible results of the introduced agents for the control of the borer. A tritrophic model was developed in order to have in advance, an estimate of the possible outcome of each parasitoid and their combination under different management strategies and climatic regimes (Gutierrez et al., 1998). Elements of behavior and life history of the borer and the parasitoids are incorporated into the model. The model is driven by climatic and management data (fertilization, pruning, etc.). What we are going to present is an example of the use of the approach to practical biological control. References:

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[0225] EFFECT OF THE INSECT GROWTH REGULATOR DIFLUBENZURON ON REPRODUCTION OF EUSCHISTUS HEROS (HETEROPTERA: PENTATOMIDAE)

C. Czepak'; E. A. R. de Oliveira'; B. da S. Vieira'; H. G. Santana'; K. R. Kobus'; K. C. Albernaz'; A. L. da Silva'; P. M. Fernandes'; V.R.S. Veloso¹ & E. Moura², 'Universidade Federal de Goiás, Escola de Agronomia, c.p. 131, Cep: 74001-970, Goiânia-Go. ²Basf S. A

The effect of diflubenzuron (Dimilin), an insect growth regulator, on the fecundity and egg hatchability of *Euschistus heros* (Fabr.) (Hemiptera: Pentatomidae) was evaluated under controlled conditions. Newly-emerged adults from a stock culture were sexed and transferred to acrylic cages (1 couple/cage). Treatments were arranged in a completely randomized design with twenty replications, each couple/cage considered as a experimental unit. Treatments were: diflubenzuron 60 and 140 ml of the commercial product/100 L H₂O and control. The couples were fed with diflubenzuron-treated soybean legumes during 3 d. after emergence. Thereafter, they were fed on untreated soybean legumes during all period of observation. Adult fecundity and egg hatchability were evaluated daily. The averagee number of eggs laid/female (49,4 and 46,6) and egg hatchability (16,3 and 16,1) were lower when insects were fed on diflubenzuron seems to affect the embryonic development of *E. heros* by means of a transovarian action, thus avoiding larval eclosion. Results show the possibility of diflubenzuron application to reduce *E. heros* flipping production.

Index terms: diflubenzuron, Euschistus heros, soybean, transovarian action
[0226] BIO-CONTROL FOR NEW PESTS INVASIONS IN CALIFORNIA VINEYARDS: OBSCURE MEALYBUG AS A CASE EXAMPLE

K. M. Daane¹, A. Jani¹, M. Bianchi² & K. M. Weir¹, ¹Div. Insect Biology, Univ. of California, Berkeley, CA 94706, USA, daane@uckac.edu; ² Univ. of California Cooperative Extension, 2156 Sierra Way, San Luis Obispo, CA 93401, USA.

During the past two decades, a number of new insect pests have disrupted well-established IPM programs California vineyards. These include the variegated leafhopper (Erythroneura variabilis), obscure mealybug (Pseudococcus viburni), vine mealybug (Planococcus ficus), and glassy-winged sharpshooter (Homalodisca coagulata), Chemical controls for any one of these pests can disrupt the well-established biological control of other pests. Here, we present research on the bio-control of the obscure mealybug, and discuss regional IPM practices needed to curtail future pest problems. During the 1990s, obscure mealybug pest status increased dramatically in the Central Coast wine grape regions, requiring 2-4 applications of synthetic insecticides. Fruit infestation rates of 70-90% were recorded. Initial research indicated (1) there were no effective natural enemies and (2) ant populations were significantly correlated to mealybug populations. In 1996, two encyrtid parasitoids were imported from Chile: Leptomastix epona and Pseudaphycus flavidulus. These parasitoid were released at five vineyard sites and, in 1996 and 1997, recoveries of both species were made after winter no-release periods. However, mealybug densities remained high at all study sites and percentage parasitism was low. Field observations indicated that bio-control would not be effective until ant populations were reduced. In 1998 and 1999, laboratory and field studies investigated the role of anttending on obscure mealybug and its parasitoids. Laboratory studies showed ants interfere with parasitoid oviposition and remove parasitized mummies. Ants are most disruptive against L. epona, which has a slower oviposition time, compared with P. flavidulus, and lays eggs singly. In commercial vineyards, plots were established to test releases of imported parasitoids into ant-tended and ant-excluded plots. Results show that mealybug densities dropped significantly in ant-excluded plots. Parasitism levels were low in all but one vineyard where there was good ant control, where percentage parasitism climbed to over 75% and remained there throughout the season. When ants were present, percentage parasitism was <25% and mealybug abundance remained high. Predatory beetles were found both in ant-tended and ant-excluded plots. Results suggest that to improve biological control of obscure mealybug, insecticide treatments must first be made for ant control. A comparison is made of the obscure mealybug pest status with other new pest associations in vineyards and, through this comparison, a call is made for more regionwide IPM programs to reduce the spread of current pests to new vine-growing regions in California and the introduction of new pests.

Index terms: Pseudaphycus, Leptomastix, Pseudococcus, ant-tending.

[0227] AVERMECTINS VS DORAMECTIN: WHATS IN IT FOR DUNG BEETLES

I. R. Dadour¹ & D. F. Cook², ¹Zoology Dept. Univ. of Western Australia, Nedlands, 6009; ²Entomology Section, Agriculture Western Australia, South Perth, 6151, Western Australia.

Two groups of 50 cattle were given a subcutaneous injection of either abamectin (Avomec) or doramectin (Dectomax) at a dose rate of 200 µg/kg liveweight. A third group of 50 cattle remained untreated. Dung samples were collected on 1, 3, 6, 9, 18, 24, 34 and 42 days post-injection and excreted residues were bioassayed using the dung beetle Onthophagus binodis Thunberg. Abamectin residues excreted at 3 and 6 days postinjection and doramectin residues excreted at 9 days post-injection caused significant mortality in newly-emerged adults of O. binodis. Both compounds induced a range of sub-lethal effects on O.binodis, however, abamectin residues excreted in dung up to 42 days post-injection had a deleterious impact on ovarian condition, brood mass (egg) production, and larval survival. Doramectin residues only had a deleterious effect on these parameters at 3 and 6 days post-injection relative to dung from control cattle. Analysis of the dung collected at each date post-injection indicated that moisture content, pH, and %nitrogen were not different from other physico-chemical profiles conducted on cattle dung. The bioassay data indicated that doramectin concentrations of < 60 (g/kg have minimal impact on the mortality and reproductive potential of O. binodis and that deleterious effects to this species will be evident for only 1-2 weeks following administration of the drug to cattle. The potential ecotoxic effects of these compounds are discussed in terms of dung beetle activity and strategies for parasite control of cattle in the Australian.

[0228] EFFECT OF PREVENTIVE INSECTICIDES ON SITOPHILUS SPP (COLEOPTERA: CURCULIONIDAE)

L.R. Descamps¹, M.E. Reviriego¹ & <u>A.A. Suarez</u>², ¹Univ. Nac. Del Sur. San Andres S/N. (8000), Bahía Blanca, Argentina. e-mail Errol Indicador não definido. ²E.E.A.INTA Anguil, Ruta Nac. N°5 Km 580, C.C. 11, (6326) Anguil, La Pampa, Argentina; e-mail asuarez@anguil.inta.gov.ar.

Application of preventive insecticides is the most common practice to control insect pests in grain storage facilities. Treatment efficacy and residuality depend on the pesticide used. The objective of this study was to determine the effectiveness of different insecticides to control Sitophilus spp. Insects were collected from wheat storage places in the Bahia Blanca aerea and reared in laboratory at 25° C temperature and 70% relative humidity. The experiment design was a randomized complete block with four replications. Wheat grain was treated with the following insecticides: DDVP (100% EC) 10 cc/tn, Fenitrotion (100% EC) 6 cc/tn, Clorpirofos metil (48% EC) 10 cc/tn and Deltametrin + Piperonil Butoxide (2.5%+20% EC) 20 cc/tn. Fifty grams of treated grain were infested at 1, 30, 60, 90, 120, 150 and 180 days with 30 adult insects without sex determination. Dead insects were counted 5-7 d after infestation. Mortality was ajusted using Abbott's formula. The data obteined were analized using PROC ANOVA and means were separated using MEANS / LSD test (P=0.05) (SAS Institute, 1988). Signifficant differences were observed among treatments. Clorpirifos and Fenitrotion showed 100% mortality when grain infestation was done at 1, 30, 60, 90, 120 and 150 d. At 180 d mortality was 98% for Fenitrotion and 86% for Clorpirifos. DDVP mortality was 100% at 1,30,60,90 d, 98.7% at 120 d, 79.7% at 150 d and 69% at 180 d. Deltametrin + Piperonyl Butoxide mortality was 98% at 1 d, 79% at 30 d, 42.5% at 60 d, 82.7% at 90 d, 98.7% at 120 d, 99% at 150 d and 91.5% at 180 d. We conclude that all treatments, except DDVP, were effective to control *Sitophilus spp.* in stored wheat for up to 180 d.

Index words: Sitophilus spp., insecticides, stored wheat.

[0229] DAMAGE LEVEL EFFECT TO A NUMBER OF GRAINS PER SPIKE AND WEIGHT PER HEAD CAUSED BY CEREAL LEAF BEETLE (CLB) OF WHEAT AND BARLEY

B. Dimitrijevic, Agricultural research institute "Serbia", Center for small grains, Yugoslavia, 34000 Kragujevac, Save Kovacevica 31, tel +381 34 33 36 63, mail: bvd@uis0.uis.kg.ac.yu, or ddimitrijevic@ptt.yu.

Lema melanopus L. (Coleoptera, Chrysomelidae) is the most important pest on small grains of Yugoslavia. The damages CLB causes are frequent and in some years very significant. Research concludes of eight genotypes of winter wheat (Dicna, NS Rana 5, Proteinka, Jugoslavija, Studenica, KG 56-S, Levcanka, Ravanica) and winter barley (Partizan) on Center for small grains experimental fields in Kragujevac during 1996/97, and 1997/98, years. The experiment was concluded in controlled conditions (the plants were in cages) and in field conditions (control plants) also. After the cages were set adults of CLB were inserted (45 females and 45 males) manualy. Those adults were collected during copulation period. After the larvae feeding the damages were registered using the numbered scale (0-5). Analysis of quantitative traits of wheat and barley included number of grains per spike and weight per head. Plants under cages (treatment) were exposed to severe attack of CLB and had a less number of grains per spike then those outside cages (control), except from barley (Partizan). This genotype had 2.35 higher average number of grains per spike compared to control. The highest influence to a number of grains per spike was concluded on genotype Dicna where the difference between the average number of grains per spike of treatment and control was 13.68. The Studenica, Ravanica and Jugoslavija had 9.32, 9.12 and 8.65 respectively. Lowest damage effect for this trait was registered on NS Rana 5 genotype (3.40). Except from that, the small differences were obtained for Proteinka (3.65) and KG 56-S (4.05). This leads to conclusion that the damage effects of those genotypes were less than the damage effects obtained for Studenica, Ravanica and Jugoslavija. Weight per head in all investigated genotypes, observed in average numbers for both experimental years, was less for damaged plants The highest difference in average weight per head compared to control was obtained for genotype Diena (0.86 g). The Jugoslavija and Studenica, Ravanica, NS Rana 5 and KG 56-S had 0.59g, 0.49g and 0.46g respectively. The least influence of treatment compared to control plants was obtained for genotypes Levennka (0.33g) and Proteinka (0.39g). Statistical significance exists in all differences. The correlation factor between the damage effect of treatment and the weight per head was -0.505 which represents strong negative dependence.

Index terms: Cereal Leaf Beetle, small grains, quantitative traits.

[0230] ANNIHILATION OF FOUR FRUIT FLY PEST SPECIES ON THE PACIFIC ISLAND OF NAURU USING FIPRONIL IN PASSIVE BAITING SYSTEMS

R. A. I. Drew¹, A. J. Allwood² & <u>R. M. Bull³</u>, ¹Australian School of Environmental Studies, Griffith Uni., Nathan Campus, Q4111, Australia; ²South Pacific Commission, Private Mail Bag, Suva, Fiji; ³Aventis CropScience Australia P/L, 261 Tingira St., Pinkenba, Brisbane Q4008, Australia

An experimental programme using male annihilation and feeding attractant techniques to eradicate exotic fruit flies from Nauru Island was commenced in October 1998 targeting Bactrocera dorsalis, B. xanthodes, B. frauenfeldi and B. cucurbitae. Male annihilation methods used 40x40mm caneite blocks impregnated with methyl eugenol (ME)/0.1% fipronil (B. dorsalis and B. xanthodes) and Cue-lure (CL) /0.1% fipronil (B. frauenfeldi and cucurbitae) attached to trees at 300-700/km² and replaced at approximately 6 weekly intervals for 3 successive treatments. Protein autolysate feeding attractant containing 0.005% fipronil was also sprayed on host tree foliage to provide additional mortality of adult breeding populations. Fruit fly populations were monitored by rearing adults from fallen fruit and collecting flies in modified Steiner traps at 22 sites on the island. major reductions of B. dorasalis and B xanthodes were recorded within 9 days of commencement of ME/fipronil block distribution and trapping and fruit rearing data indicated both species were close to extinction by May 1999. CL /fipronil block treatment commenced in February 1999 but produced less dramatic reductions of B. frauenfeldi than ME attracted species. Mortality responses increased when a modified formulation of protein autolysate/fipronil gel spray was adopted in August in conjunction with CL blocks. In December 1999, the island was declared free of *B. dorsalis* and *B. cucurbitae*, but traps continued to record occasional incidence of B. frauenfeldi and B. xanthodes.

[0332] SUSCEPTIBILITY OF DIFFERENT ONION HYBRIDS AND VARIETIES TO THE ATTACK OF ONION MAGGOT DELIA ANTIQUA (DIPTERA: ANTHOMYIDAE)

A. C. Dughetti & C. D. García, National Institute Technology Agriculture (INTA), Agric. Hilario Ascasubi Exp. Station, Hilario Ascasubi, Bs. As.- 8142, Argentina, E-mail adughetti@inta.gov.ar

The onion maggot Delia antiqua is the principal pest of onion crop and the others liliaceous related to her in world's regions of temperate climate. At 1997, this insect was registered to make important damage at the irrigation area of bonaerense valley Colorado River, Province of Buenos Aires, Argentina. Damage was made at onion's seedling and crops, in direct sowing, in early date (last days of april to beginning may) and used varieties of long days (Valcatorce INTA and Australian Brown). The use of resistance varieties to the attack of these maggots is an interesting crop management by reducing or eliminating the use of insecticides because of contamination the soils and environment and increased the cost. The objective of this research was to evaluate susceptibility of different hybrid's onion and varieties to the attack of Delia antiqua, measured in the percentage of damaged plants. The experiment was done at field plots to the Experimental Station INTA Hilario Ascasubi, Argentina, in 1999. Plots were 2.40 m² and treatments were randomized in complete block design replicated four times. Onion was direct seeded in double rows (0.8 m row spacing). Hybrid onions and varieties were 24 and all the cases of short days. The onion plants damaged by Delia antiqua were evaluated by visually inspected of the plot's rows. The data's percentage damage plants from each plot were transformed to arc sin $\sqrt{\{x (\%) / 100\}} + 0.5$ and they were subjected to analysis of variance. Treatment means were separated using Tukey's Multiple Range Test (α = 0.05). "Caballero" had the smallest onion plants damaged by Delia antiqua. Hybrids "XPH67772" and "Valle F1 RS" were different to number damaged plant's by onion maggot from "Caballero" (α = 0.05).

Index terms: onion maggot, Delia antiqua, damage, onion, hybrid & varieties.

[0231] EVALUATION OF THE DAMAGE PRODUCED BY CLOVER SEED CHALCID BRUCHOPHAGUS GIBBUS (HYMENOPTERA: EURYTOMIDAE) IN RED CLOVER, IN THE COLORADO RIVER BONAERENSE VALLEY

<u>A. C. Dughetti</u>, National Institute Technology Agriculture (INTA), Agric. Hilario Ascasubi Exp. Station, Hilario Ascasubi, Bs. As.- 8142, Argentina, E-mail adughetti@inta.gov.ar

The clover seed chalcid is a microhymenopterous that cause damage of variable intensity in other lands of the world where produce seeds of this leguminous. The seed red clover is damaged by the larvas of this chalcid. They feed inside the seed and therefore it remains empty. It consumes all of the contents and pupates inside the hollow seed coat. The farmer doesn't known the loss that produced this chalcid because the infested seed is lighter than healthy seed. During the harvest most of the chalcid-bearing seed are removed during the mill cleaning operation since they are lighter weight than the good seed. Therefore, the seed with the wasp is a source of chalcid infestation in the field. The objective of this research was evaluated the damage produced by this chalcid in different red clover fields of seed production, in the Colorado River bonaerense valley. The experiment was done in red clover fields of seed production in the area during the years 1988, 1990, 1991 y 1992. Damage was evaluated by infestation percentage. It was tacked of the total seeds of the every head. From every field, 500 heads were harvested at random and they were kept paper bag. In 1988, were harvested 200 heads; and in 1992, were harvested 400.At the laboratory, the heads were thrashed by hand, helped with forceps (medium point) separating seeds of vegetal cover (sepals and receptacle). The healthy seeds were separated of infested and holed seeds by the chalcid. The doubtful seeds were pressed by a forceps. If they exuded a white creme liquid, they were considered the larvas inside the seeds. The percentage of infestation was get using the total number of seed and the damage seed by head. The sample of every field was a great number of heads, for this reason the dates was resumed in a frequency table. Using this table was calculated the means, the mode, the modal class, the standard deviation and the variation coefficient. The infestation percentage of this chalcid in the years 1988, 1990, 1991 and 1992 changes of the 6.3 % to the 44.7 % of damage, with a mean of the 24.9 %.

Index terms: Bruchophagus gibbus, chalcid, red clover, seeds, damage

[0233] OVO-LARVICIDAL EFFECTS OF LUFENURON TO POTATO TUBER MOTH, PHTHORIMAEA OPERCULELLA (ZELLER) (LEPIDOPTERA: GELECHIIDAE)

E O. Edomwande,¹ A. S. Schoeman,¹* J. A. Brits,² & M. van der Merwe¹, ¹Dept. of Zoology & Entomology, Univ. of Pretoria, Pretoria 0002, South Africa. ²Crop Protection Sector, Novartis SA, P.O.Box 92, Isando 1600, South Africa.

The effects of the chitin synthesis inhibitor, lufenuron against potato tuber moth *Phthorimaea operculella* (Lepidoptera: Gelechiidae) eggs, were assayde by topically exposing different egg age groups (1-, 2-, 3- and 4-d- old) to treated potato tubers under laboratory conditions. Two concentrations (4 and 12 g a.i. litre⁴ respectively) of lufenuron were used and the controls were treated in distilled water. Each concentration glus its control was replicated four times and kept at a constant temperature of $28 \pm 1^{\circ}$ C and 12L: 12D photoperiod. Hatched first instar harvae were further reared to the adult stage on the treated tubers, while the controls were fed untreated tubers. Egg hatch from both treated and untreated tubers was very high (>95%), but mortality (>90%) of the first instar larvae were unable to penetrate or cause any noticeable damage to the potato tubers. At the higher concentration (12 g a.i. litre⁴) tested, adult emergence was less than 2% and this is a good indication that lufenuron may significantly reduce the amount of damage caused by the potato tuber moth when used in IPM programs.

Index terms: Chitin-synthesis inhibitor, lufenuron

[0234] FIRST REPORT ON THE PRESENCE OF MULBERRY THRIPS PSEUDODENDROTHRIPS MORI (THYS., THRIPIDAE) AS A NEW SPECIES FOR INSECT FAUNA OF MULBERRY FIELD OF NORTH OF IRAN

K. Etebari¹, J. Jalali¹ & M. Tak sokhan², 1.Dept. of Plant Protection, College of Agriculture, Univ. of Guilan. IRAN, 41335-3179; ²Research unit of silkworm rearing Co. IRAN, Rasht, P.O.Box 41635-1538.

The mulberry thrips *Psuedodendrothrips mori* NIWA is introduced as a dominant species in the insect fauna of mulberry field of Guilan province. The insect sucks the sap of the plant thus reducing the protein content of the leaves by 17.8% and the moisture by 3.57%, therefore have a negative impact on the quality of the leaves consumed by silkworm. The insect has 6-8 generations in a year and enjoys 3 highest peaks in summer season. The highest peak being the second week of august recorded 206.8 numbers in 100 cm² of leaf surface. The duration of each generation in summer ranges from 15-25 days. This insect hibernates as an adult. Two other thrips species (*Thrips tabaci* and *Heliothrips haemorrhodalis*) have also been collected from mulberry field of the area. However, their population stands next to *P. mori*. The collected species were confirmed by Prof. R. Zur Strassen of Frankfurt museum. The predator (*Orius minutus*) seens to control the thrips population in the area.

Index terms: Mulberry thrips; Psuedodendrothrips mori; Thripidae

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[0235] THE BIOLOGICAL STUDY OF WHEAT LEAF MINER SYRINGOPAIS TEMPERATELLA (*LEPIDOPTERA ELACHISTIDAE*) IN KHUZESTAN PROVINCE

<u>P. A. Fard¹</u>, Entomology Dept. College of Agriculture Univ. of Tehran, Karaj Iran 31584 E-mail:pafard@chamran.ut.ac.ir.

A study was carried out during 1993-1995 to investigate the biology of wheat leaf miner at two different areas: Shushtar (irrigated wheat field) and Izeh both at field and lab conditions. The results obtained during two years of studies reaveled that: 1) Duration of larval stage in the soil is about 233-250 days (aestivation); 2) Feeding period of larvae on the plant is about 75-100 days; 3) The prepupation and pupation duration is about 12-15 days; 4) The adult life time is 9-13 days; and 5) Incubation time of egg is between 10-12 days. The adults appear late February and feed of nectars from flowers of various plants for two days and mating periods take about 2-3 days. A female lays 29-56 eggs in the soil cracks around plant's base. Hatched larvae (neonate) enter the soil such as a soil chamber in which they pass hot and dry spring and summer as aestivation. The appearance of larvae in next growing season is dependent on environmental conditions. If the autumnal rain occurs early, the activity of hibernated larvae will start early too. Index terms: Leaf miner-Pupation-Hibernated

[0236] POPULATIONAL COMPOSITION AND SOIL MOBILITY OF SCAPTOCORIS CASTANEA (HETEROPTERA:CYDNIDAE) IN GOIÁS, BRAZIL

P. M. Fornandes¹; I. R. O. Cruvinel¹; K. Kobus¹; C. Czepak¹A.C. Oliveira¹; E. Almeida¹ & G. Ottoni¹¹, ¹Universidade Federal de Goiás, Escola de Agronomia, c.p. 131, Cep. 74001-970, Goiânia – Go. Pmarta@terra.com.br.

High S. castanea populations are becoming frequent in savanna crops. During the year crops 97/98 and 98/99, the average population reached more than 1000 adults and nymphs/m3 soil in soybean, cotton, rice and mayze crops. The knowledge of insect stational behavior in the soil is a requirement for the adoption of efficacious control methods. From august/99 to february/00 monthly sampling were conduced on infested fields in Acreúna_GO. Five spots were sampled every time using a 20cm diameter trade to obtain soil at 0 and 100cm. The first evaluations in 08/27 and 09/23 showed that although the soil was extremely dry up to more than 3.0m deep, about 90% of insects were found between 0 and 60cm. More than 50% were 1st and 2nd instar nymphs with normal appearence sheltered inside small round chambers in the soil. Living plants were taken during the raining season, with increased soil humidity and soybean plantation. The insects migrated to the surface, mainly between 0 to 40cm. First and second-instar nymph populations decreased after 11/25. Adults were only found after 10/29 and their frequency increased afterwards. It was evident that they probably present annual cycle.

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[0237] PEST-INSECTS ASSOCIATED WITH CITRUS IN BOM JESUS DO ITABAPOANA, RJ, BRAZIL

E. A. A. Ferrara¹, P. R. R. Silva² & P. C. R. Cassino², ¹CTAIBB, Univ. Fed. Fluminense, Bom Jesus do Itabapoana, RJ 28360-000, Brazil, E-mail fernando@lutarc.com.br; ²Depto. de Entomologia e Fitopatologia, CIMP "CRG" '/ UFRRJ, BR 465 - km 7, Seropédica, RJ 23890-000, Brazil, E-mail: pramalho@fst.com.br; E-mail pr.cassino@uol.com.br.

Bom Jesus do Itabapoana is located in the northwest of the state of Rio de Janeiro with the coordinates of 21° 08'09"S of latitude and 41° 40' 08"W of longitude, at an elevation of 114 m above sea level. Presently, this region focuses the irrigated fruit crops. The citrus crop, mainly "Tahiti" true lime (*Citrus latifolia*) takes part of the potential exploration of the agriculture in this region due to its geomorphology and suitable conditions of soil and climate. Aiming to identify pests and regulator biotic organisms associated with the cultivar "Tahiti", a technical visit was made in some commercial orchards throughout the city and surroundings in January 2000. Seven true limes were selected and inspected. Infestation rates were registered by the presence and absence of insects on each quadrant of the canopy, and expressed in percentage of presence. Seven species were recovered: *Selenaspidus articulatus* (55%), *Pinnaspis aspidistrae* (70%) (Homoptera, Diaspididae), *Aleurothricus floccosus* (75%), *Dialeurodes citrifolii* (90%), *Paraleyrodes bondari* (50%), *Lleurotachelus cruzi* (30%) (Homoptera, Aleyrodidae), *Phylloenistis citrella* (75%) (Lepidoptera, Gracillaridae). We recorded 3 species of predators: *Pentilia egena* (5%), *Cycloneda sanguinea* (5%) (Coleoptera, Coccinellidae) and *Chrysoperla* sp. (5%)

Index terms: Diaspididae, Aleyrodidae, Gracillariidae, Coccinellidae, Chrysopidae, citrus

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[0238] PRELIMINARY SURVEY OF TEPHRITID FRUIT FLIES IN THE NORTHWEST OF THE RIO DE JANEIRO STATE, BRAZIL

F. A. A. Ferrera¹, E. L. Aguiar-Menezes² & P. C. R. Cassino³, ¹CTAIBB, Univ. Fed. Fluminense, Bom Jesus do Itabapoana, RJ 28360-000, Brazil, E-mail fernando@lutarc.com.br; ²Embrapa Agrobiologia, Caixa Postal 74505, Seropédica, RJ 23890-000, Brazil, E-mail menezes@cnpab.embrapa.br; ³Depto. de Entomologia e Fitopatologia, CIMP "CRG"/ UFRRJ, BR 465 – km 7, Seropédica, RJ 23890-000, Brazil, E-mail pr.cassino@uol.com.br.

Irrigated fruit crops have been stimulated in the northwest of Rio de Janeiro state, such as mango, citrus, guava and passion fruit. Tephritid fruit flies are considered one of the most important pests of commercially grown fruits in Brazil. Aiming to survey the species of tephritid flies that may occur in the northwest of Rio de Janeiro, we installed McPhail traps in orchards in six cities of this region (Bom Jesus do Itabapoana, Natividade, Italva, Porciúncula, Itaperuna, Varre-Sai). Traps were baited with hydrolyzed protein plus borax as preservative. They were serviced every 7 days and all insect captured were taken to the laboratory where the flies were separated from the other insects and placed in vials containing 70% alcohol for conserving until the identification. In our first collection, we identified a total of 4 Anastrepha species (A. amita, A. fraterculus, A. grandis and A. obliqua) and Ceratitis capitata. New record for the state of Rio de Janeiro from the present study includes A. amita.

Index terms: Tephritidae, Anastrepha spp., Ceratitis capitata, survey

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[0239] EFFECT OF RATES, VOLUMES AND APPLICATIONS METHODS ON THE CONTROL OF SPODOPTERA FRUGIPERDA IN MAIZE BY METHOMYL

M.C. Ferreira¹ & J. Belasque Júnior², ¹Dept. Fitossanidade, Univ. Estadual Paulista-Campus de Jaboticabal, Via de Acesso Paulo Donato Castellane s/n, 14870-000, São Paulo/Brazil, E-mail: mdacosta@fcav.unesp.br; ²Dept. Produção Vegetal, Univ. Estadual Paulista-Campus de Jaboticabal, E-mail: belasque@hotmail.com.

The control of fall armyworm - FAW - (Spodoptera frugiperda) in Brazil usually accomplished by spraying insecticides when plant damages is visible. Transgenic plants is the most developed technique for FAW control, but it is not used to Brazilian conditions yct. Thus, the chemical control is still used nearly as the unique alternative. Therefore, studies for optimisation of rates, volumes, and application methods, are very important to reduce economic and environmental impacts. Taking in account the aforementioned this work was developed aiming to evaluate the effect of methomyl applied by two application methods (band and broadcast), in two rates (0.6 and 0.3 Uha), and in two volumes (300 and 150 Uha), on the FAW control, in maize (hybrid Agromen 2010). The field trial was carried out as a randomised block with three replications, and analysed as a factorial $2^3 + 1$ control, on the university farm of Faculdade de Ciências Agrárias e Veterinárias/UNESP – at Jaboticabal, SP - Brazil, starting on 20-april-99. Evaluations were performed 1, 3, 5, and 9 days after applications (daa), by collecting 5 plants per plot, to numeric quantification of alive FAW. There were no difference between rates or applications volumes on the FAW control. Band showed better effect than broadcast application on 3 and 5 daa, but no difference was verified on 1 and 9 daa. The control plots presented higher numbers of living FAW per plant on all evaluation times studied, compared to other treatments.

Index terms: fall armyworm, chemical control, application technology

[0240] ABUNDANCE OF MESO AND MACROFAUNA IN PAMPEAN HAPLUDOLLS AND ARGIUDOLLS: THE INFLUENCE OF TOPSOIL MACROPOROSITY

A.M. Folcia¹; M.T. Taboada² & D.J. Consentino², ¹Catedra Zoologia Agricola, ²Catedra de Fertilidad y Fertilizantes. Facultad de Agronomia-UBA. Ave. San Martin 4453 (1417) Bs. As. Argentina. Email: afolcia@mail.agro.uba.ar

Soil pores have different size and functionality. Those > 30 Im in diameter are the habitat for meso- (100 [m - 2 mm) and macro-fauna (> 2 mm). This was studied in sandy loams (Hapludolls) and silty loams (Argiudolls). These soils are presumed to have high and low macroporosity in their top horizons respectively. We hypothesized that this different macroporosity determines different abundance of meso- and macro-fauna in each site. Topsoil undisturbed samples (0-20 cm) were taken in July 1999 in four sites in Bs. As. province: a) Alberti, sandy loam Typic Hapludoll (pastures grazed by cattle); b) Bragado, sandy loam T. Hapludoll (park); c) Perez Millan, silty clay loam Vertic Argiodoll (pasture grazed by cattle); and d) Rafael Obligado, silty loam Typic Argiudoll (forest, Eucalytus sp.). In each site we determined (direct observation) the abundance of macrofauna (Oligochaeta, Arthropoda[Insecta, Myriapoda, Crustacea, Arachnida] and saprophytic Nematoda), and the abundance of mesofauna (Enchytreidae, Colembolla and Acarina) by the Berlese method. The volumen of soil macropores (> 30 m) was determined from the difference between water volumes retained at 0 - 10 kPa matric potential (pressure apparatus) times soil bulk density. Soil macroporosity was correlated (Pearson) to the abundance of the whole meso and macrofauna and of each taxon. Soil macroporosity varied greatly among sites (5-35% total porosity), but this variation did not explain differences observed in taxon abundance (r= -0.14 to 0.42; FD = 9). This rejects our hypothesis. The abundance of meso- and macrofauna was not related to the amount of habitable space. Unlike, the abundance of macrofauna was rather related to land use, regardless topsoil texture. Both pastures (Alberdi and P. Millan) showed great abundance while the park (Bragado) and forest (R. Obligado), sites showed low abundance of macrofauna. The latter showed no presence of Oligochaeta. Soil mesofauna showed erratic differences between sites. About the factors causing different abundance of macrofauna can be thought that cattle grazing determines a greater recycling of residues from excreta and thus a greater availability of food. This would affect trophic chains, and so, the density of the different groups. Index terms: Arthropoda, Oligochaeta, Nematoda.

[0241] ROOTWORM EMERGENCE FROM Cry3Bb HYBRIDS COMPARED TO THAT OBSERVED WITH INSECTICIDE-TREATED MAISE

B.W. Fuller¹, M.A. Boetel², L.D. Chandler³ & P.M. Davis⁴, ¹Plant Science Dept., South Dakota State Univ., 248-C NPB, Brookings, SD 57007, USA, E-mail Billy Fuller@sdstate.edu; ²Dept of Entomology, P.O. Box 5346, Hultz Hall, North Dakota State Univ., Fargo, ND, 58105, USA. ³USDA, ARS, Red River Valley Ag. Res. Ctr., Fargo, ND 58105, USA; ⁴Monsanto Co., 3302 SE Convenience Blvd., Ankeny, IA 50021. USA.

Rootworms in the genus *Diabrotica* are typically the most economically important maize pest in North America. Consequently, to combat this serious pest, maize producers often use insecticide in a prophylactic manner. Currently under the Food Quality Protection Act, many of these insecticides are under intense review. Efforts by Monsanto Co. and other major seed producers has sought to investigate a more environmentally-sound alternative to insecticides by use of hybrids expressing a Cry3Bb protein derived form Bacillus thuringiensis. This inserted protein is believed to offer maize producers superior options by allowing reduced contact from handling synthetic insecticide, prevents misapplication or calibrations problems, and increased safety toward non-target organisms. Resistance management is possibly the most pressing issue to safeguard this valuable technology for its long-term sustainability. Therefore, our experiment was initiated to established baseline data on general efficacy and rootworm survivability as it relates to resistance management. Adult rootworms were collected from pyramid-shaped emergence cages using methods according to Boetel & Fuller (1997). Seven treatments including four transgenic events (code named: Event-A, -B, -C, and -D), three insecticides (Counter, Force, Lorsban) and untreated maize were use in this evaluation. These treatments were arranged in a randomized block design with four replications near Cavour, South Dakota, USA. Emergence and root rating data were analyzed using the SAS GLM procedure and an LSD test was used to compare treatment means. A 4.2 root rating mean was derived from the untreated check plots using the root damage scale by Hill and Peters (1971). All transgenic events provided sufficient root protection to prevent damage from reaching a 3.0 economic injury level (EIL). Counter, Force, and Lorsban all performed equally well from this perspective. Event D was outstanding in preventing damage and averaged a perfect 1.0 with no observable rootworm feeding scars present. All emergence data by species and sex will be review in the actual presentation. However, one key finding was that Event D showed very little survival in addition to its excellent role in damage reduction. These data represent an early assessment and many factors (inbred & hybrid yield, stacking compatibility, insertion related factors, and potential to develop resistance) may ultimately decide which event(s) are chosen by industry for release.

Index terms: Diabrotica virgifera, Diabrotica barberi, resistance.

[0242] ENTROPY OF ADULT WASPS OF POLISTES LANIO MISCHOCYTTARUS CERBERUS (HYMENOPTERA, VESPIDAE) F AND (HYMENOPTERA, VESPIDAE) FROM COLONIES STUDIED IN FIELD CONDITIONS

E. Giannotti^{1, 2} & C.J. Von Zuben^{1, 3}, ¹Dept. of Zoology, Universidade. Estadual Paulista, P.O. Box 199, Rio Claro, SP, 13506-900, Brazil. ²E-mail edilgian@rc.unesp.br; ³E-mail vonzuben@rc.unesp.br.

The entropy is a measure of heterogeneity in the distribution of deaths by age in a insect population. The formula for this measure using life table notation is $H = \left\{ \sum_{x=0}^{\omega} e_x d_x \right\} e_0 \text{ The numerator (i.e., the sum of the products } e_x d_x \text{ can be}$

interpreted as the average days of future life that are lost by the observed deaths and ω represents the last day of possible life from the initial age (x = 0). The denominator is the expectation of life at birth (e0). The entropy serves as a quantitative characterization of survival pattern and can be interpreted as the number of days lost owing to death per number of days lived. If H = 0, then all deaths occur at the same age, and if H = 1, then the I_x schedule is exponentially declining. The intermediate value, H = 0.5, indicates a linear I_x schedule (Carey, 1993). The adult wasps of 12 nests of Polistes lanio (n = 1,803) and 14 nests of Mischocyttarus cerberus (N = 345) were marked on the thorax for determining their life-span. It was assumed that an adult was dead when it disappeared from the nest. The life tables of these wasp populations were made according to Carey's (1993) method described as follow: the proportion of wasps surviving from birth to exact age x is lx; the proportion of wasps alive at age x that survive through the interval x to x + 1, is calculated

as: $p_x = l_{x+1}/l_x$; the proportion of wasps alive at age x that die through the

interval x to x + 1, is calculated as: $q_x = 1 - p_x$; the difference in number of

survivors from successive ages x and x+1, is calculated as: $d_x = l_x - l_{x+1}$; the per capita fraction of interval lived in the age interval x to x + 1, is evaluated as: $L_x = l_x (d_x/2)$; the total number of days lived beyond age x, is obtained from:

 $T_x = \sum\nolimits_v^\omega L_x$; and the expectation of life at age x, is calculated as: $e_x = T_x \left/ l_x \right.$.

The values for P. lanio were: $e_0 = 28.8$ days, $\omega = 230$ days and H = 0.869; and M. cerberus $e_0 = 14.4$ days, $\omega = 95$ days and H = 0.767. These high values of entropy in both species (that are primitively eusocial wasps, with small colonies) were due to the deaths that occurred during the first days of life, probably because of the beginning of foraging activities. Thus, foraging has a critical importance on the survival of Polistes and Mischocyttarus populations.

[0243] DAMAGE LEVELS AND EVALUATION OF COTTON YIELD LOSSES CAUSED BY ANTHONOMUS GRANDIS (COLEOPTERA: CURCULIONIDAE)

F. S. Gielfi¹ & A. C. Busoli², ¹Faculdade de Ciências Agrarias, Univ. Camilo Castelo Branco, Estrada Projetada F-1, Fazenda Santa Rita. ZIP: 15600-000, Fernandópolis, São Paulo State, Brazil. E-mail gielfi@fcav.unesp.br, ²Faculdade de Ciências Agrárias e Veterinárias, Univ. Estadual Paulista, Campus de Jaboticabal. Via de Acesso Prof. Paulo Donato Castelanne, km 05, ZIP:14870-000, Jaboticabal, São Paulo State, Brazil.

The Boll Weevil, Anthonomus grandis, is considered the major of the cotton pest in America. The determination of the damage level and evaluation of losses caused by insects are fundamentals to sucess of IPM programs. The objeticve of this research was to study different infestation levels and cotton losses caused by Boll Weevil. The experiments was carried out during 1995/96 growing season. The experimental design used was the randomized blocks (RCB), with five treatments ("check", 5, 10, 15, 20% damaged squares) and four replications. A hundred squares were sampled randomly (1 square/plant) from each plot at intervals from of 3 to 7 days. A square was damaged when it presented oviposition or feeding puncture. When the average damaged squares was equaled to the specified infestation level, the plots were sprayed. There was differences in the cotton yield (fiber plus seeds) for the several infestation levels. The results indicate that infestation levels between 5% and 10% are suitable for Boll Weevil control control and each 1% damaged squares the cotton yield decreases 33,1 kg/ha. Index terms: IPM, sampling, infestation level.

[0244] INCIDENCE OF THE DAMAGE OF PLATYPUS SULCATUS CHAPUIS (COLEOPTERA, PLATYPODIDAE) IN THE QUALITY OF POPULUS DELTOIDES WOODS

R. A. Giménez¹, A. E. Etiennot², R. Frank³ & G. Alvarez⁴, Proyecto UBACyT, TG16.¹ ^{2,4} Cátedra de Terapéutica Vegetal, Facultad de Agronomía, Univ. de Buenos Aires. Av. San Martín 4453, (1417), Buenos Aires, Argentina. E-mail: rgimenez@agro.uba.ar; ³ Cátedra de Administración Rural, ditto.

Platypus sulcatus Chapuis, ambrosia beetle, cause loses in Populus deltoides Marshall production, Caroline poplar, showed as the reduction of growth, breaking down of weakened trees and the loose of quality in the wood. This pest attack healthy trees. After the cut down of the orchard, the wood goes drying and the mycelium of the fungi ambrosia, which recovers the walls of the tunnels produced by P. sulcatus, turns in a brownish colour. The wood pieces or boards appeared with perforations with dark borders that restring the destiny of the production and difficult the commercialisation. The production of sawed wood of poplar clones Catfish 5 and I-72/51 from the Delta of Paraná nd section was evaluated. From 370 logs analysed we obtained 2049 boards 8 feet long, with different thickness from which only 28.039% had not damage. The board's attack by P. sulcatus did not present a clear special pattern of distribution because the dispersed attacks (30%), the concentrated ones (25.5%) and the combinated ones (16.7%) did not differed statistically. Neither difference between the location of damage was observed along the boards: 29.07% were attacked at the extremes, 43% at the proximal areas and 25% at the central area (ANOVA $\alpha = 0.05$). Between the tables with concentrated damage a great frequency of boards with less than 10 holes (43.15%) was observed, 17.81% with 11 - 20 holes, 4.9% with 21 - 30 and 5.8% with more that 30 ones were found. Between the tables with disperse attack a major frequency of the first class with less account of holes, was found. The damages presented an aleatory distribution along the boards with a predominance of few holes, being concentrated or dispersed, and the incidence of damage was of 72% of the boards.

Index terms: ambrosia beetle, wood borer, forestry products, damage

[0245] STUDIES ON INFECTION MECHANISMS OF THE FUNGI BEAUVERIA BASSIANA AND METARHIZIUM ANISOPLIAE ON HYPOTHENEMUS HAMPEI USING FLUORESCENCE MICROSCOPY AND SCANNING ELECTRON MICROSCOPY

F. Delgado¹, P.E. Vélez¹, E. M. Giraldo¹ & Y. López¹, ¹Disciplina de Entomología. Centro Nacional de Investigaciones de Café (Cenicafé). Chinchina, Caldas, Colombia. Email fefdelb@cafedecolombia.com Fax: 0968-506630. A.A 2427.Manizales. Caldas. Colombia.

Among the several pests that attack coffee crop (Coffea arabica), the most serious for colombian coffee growers is the coffee berry borer (Hypothenemus hampei). So far the use of entomopathogenic fungi B. bassiana and M. anisopliae are considered to control this insect pest of economic importance. We have studied infection mechanisms of both B. bassiana and M. anisopliae on adults of H. hampei and cuticle fragments by light fluorescence microscopy and scanning electron microscopy (SEM). The infection seems to involve the following events: (1) adherence of the spores to the cuticle (2) germination of spores and growth of the mycelium on cuticle surface (3) penetration of germinative tubes into the cuticle (4) extensive lateral development of hyphae followed by strong degradation of the cuticle layers. Labelling with Calcofluor White suggests that cuticle penetration and colonization mechanisms by both B. bassiana and M. anisopliae are closely related to enzymatic hydrolisis and mechanical pressure. Germinative tubes of B. bassiana and M. anisopliae can penetrate at any place of the H. hampei cuticle, although the most frequently penetration site is the insect abdomen close to the adherence site of the spores. A fissure is produced on the cuticle surface after penetration of the germinative tube into the insect. These observations bring further insights into the infection mechanisms of both fungi on H. hampei and on the localization of fungal spores and their penetration site on the insect cuticle. Spores localization, germination, mycelium growth and development of these fungi were observed from 48 h to 12 days after inoculation on growing media containing fragments of *H. hampei* cuticle using fluorescence microscopy and SEM.

Index terms: Entomopathogenic fungi, Coffee herry borer, conidial attachment, microscopy

[0246] *DIGLYPHUS* SP. COMPLEX IN OESTE REGION OF PORTUGAL AND ITS ROLE AS NATURAL CONTROL AGENTS IN GREENHOUSE VEGETABLES

<u>M. C. Godinho¹</u> & A. Mexia², ¹Escola Superior Agrária de Viseu,, Campus Politécnico, 2500 Viseu ceugodinho@isa.utl.pt ; ²Instituto Nacional de Investigação Agrária, Estação Agronómica Nacional, Quinta do Marquês, 2780 Oeiras, amexia@isa.utl.pt

Leafminers (Liriomyzn sp.) have been referred as key-pests of greenhouse vegetables mostly on greenbeans, tomato, lettuce and cucumber. Liriomyza trifolii, Liriomyza bryoniae, and Liriomyza huidobrensis, this last species after 1991, were the species responsible for damages. Growers in Portugal spray mostly abamectine, imidaclopride and ciromazine against leafminers and other active ingredients against whiteflies and thrips can disrupt equilibrium between leafminers and their parasitoids, resulting in leafminers outbreaks. Studies were carried out during three years in order to assess population densities of Liriomyza adults and larvae at six greenhouses located 50 km Northwest from Lisbon. Insect and plant samples were collected fortnightly and observed at the laboratory. Data about active, dead and parasitised larvae with ectoparasitoids were recorded endoparasitoids presents were recorded after emergence. Ectoparasitoids adults obtained in laboratory were identified. Levels of parasitised leafminers larvae and levels of dead larvae, presented important differences related with crop protection practices followed in each greenhouses. In fact, growers have different attitudes towards control of leafminer's populations and, consequently, they chose different active ingredients with very distinct secondary effects on beneficials naturally occurring. In the present study is referred: (i) L. huidobrensis as the unique species found at present in the Oeste region; (ii) Diglyphus crassinervis, Diglyphus isaen and Diglyphus popoea as the most important ectoparasitoid species and their different external morphological aspects and (iii) the reasons that can explain the differences found on species diversity and abundance.

Index terms: leafminers, protected crops, Diglyphus crassinervis, Diglyphus isaea, Diglyphus popoea

[0247] IS WOLBACHIA INFECTION RESPONSIBLE FOR REPRODUCTIVE INCOMPATIBILITY IN THE SPIDER MITE, TETRANYCHUS KANZAWAI (ACARI: TETRANYCHIDAE)?

T. Gotoh, Lab. of Appl. Entomol. & Zool., Faculty of Agriculture, Ibaraki University, Ami, Ibaraki 300-0393, JAPAN, E-mail: gotoh@msv.ipc.ibaraki.ac.jp.

The Kanzawa spider mite, Tetranychus kanzawai Kishida, is a serious pest threatening many agricultural crops in Japan and China. It is known to occur in two strains, T and K (Gomi & Gotoh, 1996; Gotoh et al., 1999). There is a reproductive incompatibility between the two strains: no females appeared from a cross between females of the K strain and males of the T strain, whereas the reciprocal cross produced female offspring but the proportion of females was lower in comparison with the intra-strain crosses. *Wolbachia* are maternally inherited bacteria that mediate cytoplasmic incompatibility (CI), thelytokous parthenogenesis and feminization in animal hosts such as insects and terrestrial isopods (O'Neill et al., 1997). CI manipulated by Wolbachia has been observed in crosses between uninfected females and infected males, and resulted in no production of offspring in diplodiploids or in only male progeny in haplodiploids. The presence of Wolbachia has also been detected in T. kanzawai (Gomi et al., 1997). The current study was undertaken in order to discriminate *T. kanzawai* populations collected from different localities into either the K strain or the T strain and to survey local populations for the presence or absence of Wolbachia endosymbionts by PCR of ftsZ gene. Of 74 local populations tested, eleven belonged to the K strain and the others the T strain. Wolbachia infection occurred in local populations belonging to both the T and K strains. As all of the infected populations harbored a Wolbachia strain which does not influence compatibility of the host (i.e., modification negative), Wolhachia is not responsible for the incompatibility between the T and K strains.

Index terms: Tetranychus kanzawai, Wolbachia, reproductive incompatibility, ftsZ

[0248] EFFICIENCY OF THE INSECTICIDE ACTARA (THIAMETOXAN) ON CONTROL OF SHARPSHOOTER VECTORS OF XYLELLA FASTIDIOSA ON CITRUS

<u>S. Gravena</u>⁴, S.R. Benvenga¹, P.E.B. Paiva¹, J.L. Silva¹& L.C.S. Amorin¹, ¹Gravena ManEcol Ltda, Rua Monteiro Lobato 856, 14870-000, Jaboticabal/SP, Brazil. E-mail gravena@asbyte.com.br

The Citrus Variegated Chlorosis (CVC) is a serious citrus disease caused by the xylem limited bacterium Xylella fastidiosa that has been transmitted by the sharpshooters Acrogonia sp., Dilobapterus costalimai and Oncometopia facialis which have been controlled on young citrus orchards. The efficiency of Actara in two formulations 250 WG and 10 GR in different dosagens was compared to a standard insecticide Winner (imidacloprid). A four years old citrus orchard (*Citrus sinensis*) variety Pera was used for the study. The insecticide Actara 250 WG was applied on trunk and soil at 0.5 g of thiametoxan per plant, Actara 10 GR was applied on soil at 0.5 and 1.0 g of thiametoxan per plant and Winner applied on trunk at 1.5 g of imidacloprid per plant. The treatments were replicated 3 times where sharpshooter adults were released in voil cages weekly and evaluated up to 7 days. The insecticide Actara 250 WG (0.5g) and Winner (1.5g) applied on trunk, Actara 10 GR (1g) applied on soil controlled the sharpshooter vectors for 76 days, with mortality up to 80%.

Index Terms: Acrogonia sp., Dilobopterus costalimai, Oncometopia facialis, Chemical Control

[0249] EFFICIENCY OF THE INSECTICIDE TEMIK 150 (ALDICARB) ON CONTROL OF SHARPSHOOTER VECTORS OF XYLELLA FASTIDIOSA ON CITRUS

S. Gravena¹, S.R. Benvenga¹, J.L. Silva¹, N. Araújo¹ & R.D. Martíns¹, ¹Gravena ManEcol Ltda, Rua Monteiro Lobato , 856, 14870-000, Jaboticabal/SP, Brazil. E-mail gravena@asbyte.com.br

The Citrus Variegated Chlorosis (CVC) has affected all sweet orange varieties in Brazil. The CVC is caused by the bacterium *Xylella fastidiosa* which has been transmitted by the sharpshooters *Acrogonia* sp., *Dilobopterus costalimai* and *Oncometopia facialis*. The efficiency of the granulated insecticide Temik 150 with systemic action on control these insects was evaluated on a 2 years old citrus orchard variety Natal, during March to June of 1999. This insecticide was applied on soil at 10, 15, 20 and 25 g per plant. The treatments were replicated 3 times, where insect adults were released weekly in voil cagos and evaluated up to 7 days after that. The insecticide Temik 150 at 20 and 25g per plant was effective for 76 days against these insects, with mortality higher than 80%, at 7 days after the insects were released. The dosages 10 and 15g resulted 30 and 48 days of effective control, respectively.

Index Terms: Acrogonia sp., Dilobopterus costalimai, Oncometopia facialis, Chemical Control

[0250] EFFICIENCY OF THE INSECTICIDE WINNER (IMIDACLOPRID) ON CONTROL OF SOME CITRUS PESTS AND SELECTIVITY TO NATURAL ENEMIES

S. Gravena¹, S.R. Benvenga¹, P.E.B. Paiva¹& J.L. Silva¹, ¹Gravena ManEcol Ltda, Rua Monteiro Lobato 856, 14870-000, Jaboticabal/SP, Brazil. E-mail gravena@asbyte.com.br

The continuous leaf flushes on young citrus trees have predisposed these plants to particular pests such as the sharpshooters *Acrogonia* sp. *Dilobopterus costalimai* and *Oncometopia facialis*, the citrus leafminer *Phyllocnistis citrella* and the brown citrus aphid *Toxoptera citricidus*. The efficiency of the sistemic insecticide Winner on control of these pests and the effect on predators was compared to a conventional strategy where insecticides were sprayed. An one year old citrus orchard with two plots of 2.5 hectares was used for the trial. The insecticide Winner was applied on trunk four times a year at 0.5 g of imidaeloprid per plant in January, 0.5 g. in April, 0.6 g in June and 1.0 g. in September, according to the pest infestations and the conventional area was sprayed monthly with Decis 25 CE(deltamethrine) at 25 ml per hectolitre or Dimetoato 400CE (dimetoathe) at 100 ml, both mixed with Vertimee 18 CE (abameetin) at 5 ml and Natural oil (soybean oil) at 0.25%. At fortnightly frequency, 20 plants were evaluated randomly and the sharpshooters were collected in 8 yellow traps(15X5cm) per plot during one year vectors of *Xyllela fastidiosa, Acrogonia* sp., *D. costalimai* and *O. facialis* in winter and spring season when compared to the conventional strategy. The mean infested branches by *P. citrella* was 12.9 and 29.2% on Winner and conventional strategy. respectively. *T. citricidus* was reduced more significantly on Winner strategy. The higger abundances of the insect predators *Pentilia egena* and *Coccidophilus citricidus* and predatory mites *Euseius citrifolius* and *Iphiseiodes zuluagai* were observed on Winner strategy.

Index terms: Acrogonia sp., Dilobopterus costalimai, Oncometopia facialis, Phyllocnistis citrella, Toxoptera citricidus

[0252] DEVELOPING PRACTICAL RECOMMENDATIONS FOR MANAGING INSECT RESISTANCE TO BT TRANSGENIC MAIZE

R. L. Hellmich¹, **R. A. Higgins²**, **& E. C. Ortman³**, ¹USDA-ARS, Corn Insects and Crop Genetics Research Unit and Dept. of Entomology, 109 Genetics Laboratory, c/o Insectary, Iowa State University, Ames, IA 50011, USA, E-mail rlhellmi@iastate.edu; ²Dept. of Entomology, Waters Hall, Kansas State University, Manhattan, KS 66506, USA; ³Agricultural Research Programs, 1140 Agriculture Administration Building, Purdue University, West Lafayette, IN 47907, USA.

Managing resistance of insects to Bacillus thuringiensis (Bt) transgenic maize is necessary because Bt maize is valuable and all stakeholders want to preserve its efficacy. Currently, the high-dose/refuge strategy is the resistance management strategy of choice. There are potential problems with this strategy, yet research is underway to try to better define these problems and to offer solutions. A Regional Research Committee has fostered dialouge between industry, producers, academics and regulators. The NC205 committee formally addresses research on the AEcology and Management of European Corn Borer and Other Stalk-Boring Lepidoptera.@ For the past six years this committee has sponsored several meetings and symposia with industry and the Environmental Protection Agency to discuss insect resistance management issues. The NC205 Resistance Management meeting provides a forum for all parties to discuss general and specific issues concerning managing the resistance of European corn borer, Ostrinia nubilalis. The meetings have provided opportunities for sharing information, fine-tuning programs, establishing research priorities, reducing redundancies, and building understanding among participants. dialogue has allowed the committee to identify science-based practical resistance management strategies. The importance of resistance management strategies that are practical cannot be overemphasized because NC205 recognizes that the ultimate stewards of the Bt technology are the growers. So the committee has tried, whenever possible and without compromising the scientific integrity of resistance management, to consider grower realities. Topics discussed include monitoring for insect resistance, education, extension, grower surveys, managing resistance of other insects (especially rootworm), ongoing research, and future needs for research.

Index terms: Ostrinia nubilalis, resistance management, NC205 committee.

ALEYRODIDAE) OF THE CANARY ISLANDS (SPAIN)

[0251] CROP ROTATION COLLAPSES AS A VIABLE PEST MANAGEMENT STRATEGY FOR WESTERN CORN ROOTWORMS, *DIABROTICA VIRGIFERA VIRGIFERA*, IN THE EASTERN CORN BELT OF THE USA

M. E. Gray¹, S.T. Ratcliffe¹, J.L. Spencer², E. Levine² & K.L. Steffey¹, ¹Dept. of Crop Sciences, Univ. of Illinois, S-320 Turner Hall, 1102 S. Goodwin Ave., Urbana, IL 61801, USA, E-mail m-gray4@uiuc.edu; Center for Economic Entomology, Illinois Natural History Survey, 607 E. Peabody Drive, Champaign, IL 61820, USA.

Western and northern corn rootworms, Diabrotica virgifera virgifera LeConte and Diabotica barberi Smith & Lawrence, respectively, inflict severe economic damage to maize, Zea mays (L.), throughout much of the USA Corn Belt as well as some regions of Canada. Both species have a univoltine life cycle and a narrow host range that includes primarily maize and a few other grass species (Setaria spp.). For decades, the annual rotation of maize with soybeans, Glycine max, has proven an excellent pest management strategy because corn rootworm larvae are unable to survive on the roots of soybean plants. In the mid-1980s, it was widely reported that some rotated cornfields in Illinois, Iowa, Minnesota, and South Dakota had root injury caused by northern corn rootworms that prolonged their embryonic diapause through two consecutive winters. In 1987, agronomists reported corn rootworm larval injury in several rotated maize seed-production fields in east-central Illinois. Entomologists collected larvae and returned them to the laboratory where they completed their development as western corn rootworms. Explanations for the western corn rootworm larval injury to rotated maize were not lucid. Since 1987, crop rotation has continued to fail as a pest management strategy for western corn rootworms across an expanding geographical region of the eastern Corn Belt of the USA. Rather than prolonging their embryonic diapause, western corn rootworms have seemingly adapted to crop rotation by laying at least a portion of their eggs directly into soybean fields. Oviposition into other crops such as alfalfa, Medicago sativa L., also has been confirmed. Our current hypothesis suggests that the intensive selection pressure of an annual rotation of maize with soybeans has selected for a new western corn rootworm strain that does not restrict its oviposition to maize. The consequence of this novel adaptation to a cultural pest management strategy has been an impressive escalation of soil insecticide use in rotated maize fields in Illinois, Indiana, southern Michigan, and western Ohio. Designing effective resistance management plans for transgenic cultivars for corn rootworms will be a challenge because producers are likely to plant these varieties on both rotated and non-rotated maize acres.

Index terms: Diabrotica virgifera virgifera, Diabrotica barberi, crop rotation.

E. Hernández-Suárez¹, J.H. Martin² & <u>A. Carnero¹,</u> ¹Inst. Canario de Investigaciones Agrarias, P.B. 60 – E38200 La Laguna, Tenerife, Canary Islands, Spain. ²Dept. Entomology, The Natural History Museum, London, UK

[0253] CURRENT STUDIES ON THE WHITEFLY FAUNA (HOMOPTERA:

Whiteflies (Hemiptera: Aleyrodidae) are a group of sap-sucking insects of undisputed economic importance, which can cause significant direct damage to plants. Until very recently, whiteflies were an insect group that had been almost completely unstudied in the Canary Islands. Nevertheless, in a relatively few years several species have become major pests, and nowadays whiteflies are among the most serious agricultural pests in the archipelago. For this reason, whiteflies are the subject of a current research programme being carried out in the Canaries. Emphasis has been given to systematics, and thus a recent survey has resulted in six new additions to the Canarian whitefly species list, and three probable new species are under investigation. However, various taxonomic problems still exist and await solutions. These mainly include members of Bemisia afer and Bemisia tabaci species-groups, the larval stages of which show great morphological differences when developing on different host plants. The whitefly fauna of the Canaries presents a complex and scientifically interesting mixture of endemic and introduced species. While endemic species are mainly associated to the so-called "Macaronesian Laurel Forest" and the "Macaronesian Succulent Shrub" floras, several introduced species have caused serious economic problems in the archipelago. In particular, Aleurodicus dispersus and Lecanoideus floccissimus (both of them Neotropical members of the subfamily Aleurodicinae) can be considered the most important pests of ornamentals and shade trees in the Canaries, and have caused serious losses in tropical fruit tree plantations. Aleurothrixus floccosus and Parabemisia myricae are important pest in Citrus orchards, but Aleyrodes proletella and Siphoninus phillyreae are only considered of minor economic significance in these islands. Several cosmopolitan whitefly pests are also present through the Canaries, particularly Trialeurodes vaporariorum and Bemisia tabaci (biotypes "B" and "Q"). Besides causing direct damage, phytotoxic disorders and whitefly-transmitted virus outbreaks have been occurring recently, and are correlated with these species. Solutions are being sought to this new, and continuing, whitefly problems and, thus, research efforts have been also focused on whitefly biology, IPM management strategies and classical biological control. The authors aim to present an update overview of the whitefly problems occurring in the Canary Islands, combined with data on host plants, distribution, biological, and taxonomic aspects.

Index terms: Aleyrodidae, whiteflies, Canary Islands.

[0254] SOYBEAN STEM BORER IN KANSAS: LIFE HISTORY, SAMPLING, AND SEVERITY OF RECENT INFESTATIONS

R. A. Higgins¹, P. E. Sloderbeck¹, L. L. Buschman¹, S. B. Ramaswamy¹, C. Daves¹, H. Li¹ & W. Schapaugh², ¹Dept. of Entomology, Kansas State Univ., Waters Hall, Manhattan, KS 66506, USA, E-mail thiggins@oznet.ksu.edu; ²Dept. of Agronomy, Kansas State Univ., Throckmorton Hall, Manhattan, KS 66506.

Annually, for at least 15 years, specialists with Kansas State University have received scattered inquiries about the soybean stem borer (Dectes texanus) from growers and consultants. Only rarely did these reports evoke more than limited interest because most infestations were of insignificant occurrence. Late in 1998, multiple telephone calls indicated that areas thought to be relatively free of this pest were experiencing heavy infestations in some fields. Growers, consultants, and university employees reported that several North-Central Kansas soybean fields exceeded 50% infestation, with dramatic lodging developing as untimely rains delayed the completion of harvest. Some 1998 plantings of rotated fields unexpectedly approached 100% infestation. The 1999 growing season was the first year we devoted serious research effort to this pest in Kansas. Infestations again proved to be unexpectedly severe in several locations, damaging 90 to 100% of plants in several rotated fields. Our year 2000 sampling program will include holding infested soften studied in outdoor cages to establish when overwintering larvae change stages, first to pupae, then to adults. This research will establish when adults emerge and, thus when sampling may yield results and when the insect first becomes vulnerable to insecticides. Adult soybean stem borer populations will continue to be monitored through weekly sweep net sampling during our growing season of June, July and August to better define the seasonal occurrence of the egg laying stage. Sampling of adults will be expanded beyond known heavily infested areas to understand the magnitude of the problem across the state. Data on field history and year 2000 infestation levels at selected sites will be compared to determine if obvious correlations among cropping practices (crop rotations, neighboring vegetation, planting dates, maturity groups, etc.) and soybean stem borer infestations exist. Work also is being initiated to identify a usable synthetic sex pheromone as part of a project to provide soybean growers, consultants, and researchers with less labor-intensive approaches for assessing adult activity and possibly abundance. Replicated variety and limited insecticide screening trials also are being planned. Information on the progression of larval tunneling within the plant petioles and stems, plus timing of first signs of girdling and percentage of lodged plants also will be acquired as resources permit. Collecting this type of multidisciplinary information should help us determine whether soybean growers have practical, management options beyond avoiding serious lodging through timely harvesting of heavily infested fields.

[0255] FIRST RECORD OF OCCURRENCE OF APHIS SPIRAECOLA (HEMIPTERA: APHIDIDAE) ON IXORA COCCINEA AND I. COCCINEA VAR, COMPACTA (RUBIACEAE)

S. D. L. Imenes¹, E. C. Bergmann¹, A. L. B. G. Peronti² & <u>S. Ide¹</u>, ¹Centro de Sanidade Vegetal, Instituto Biológico, Av. Cons. Rodrigues Alves, 1252, São Paulo SP 04014-900, Brasil, E-mail imenes@biologico.br; ²Depto. de Ecologia e Biologia Evolutiva, Centro de Ciências Biológicas e da Saúde, Universidade Federal de São Carlos, Rod. Washington Luiz km 235, São Carlos SP 13565-905, Brasil.

Aphis spiraecola is a polyphagous species that colonizes young twigs and inflorescences of host plants belonging to several families such as Compositae, Rosaceae, Solanaceae, Curcubitaceae, Apocinaceae, among others. Native from Far East now it is widely distributed in all zoogeographical regions. The apterae are light green, except for the siphunculi, antennae and cauda that are black, contrasting with the rest of the body. The alatae are black, with green abdomen and pale tibiae. In October/1999, the incidence of alatae and apterae forms of A. spiraecola was verified in home gardens in São José do Rio Preto, North São Paulo, Brazil. It was colonizing plants of Ixora coccinea var. compacta (Rubiaceae) growing on beds exposed to sunlight. The insects were found feeding on young shoots of the hosts. The plants were highly infested and their leaves were completely curled. Some aphid specimens were parasited by the microhymenopteran Aplelinus gossypii (Hymenoptera: Aphelinidae). In November of the same year the presence of this same aphid species was detected in Porto Seguro, South Bahia, Brazil, feeding mainly on inflorescences of *l. coccinea*. The aphid was identified by Dr. Carlos R. Sousa-Silva (UFSCar) and the aphelinid by Dr. Marcelo T. Tavares (UNIARA). Ixora has high ornamental and economic values, being largely used in parks and gardens, for growing in edgings, rows, along walls and pots. I. coccinea is a woody, erect, few branched shrub, with leathery, light-green leaves; the inflorescences are large, terminal, long, with flowers orange, pink or yellow. The var. compacta is a small-branched shrub with small, thick, dark-green leaves; the inflorescences are dense and globose, with pink, yellow or red-orange colored flowers.

Index terms: Aphelinus gossypii, Aphelinidae, ornamental plants, Brazil.

[0256] PERFORMANCE OF CERATITIS CAPITATA (DIPTERA, TEPHRITIDAE) ON FRUITS: COMPARISON OF TWO LABORATORY POPULATIONS

I.S. Joachim-Bravo¹, A. N. Guimarñes¹, T. C. Magalhñes¹ & A. S. Nascimento², ¹Inst. of Biology, Univ. Federal of Bahia, Ave. Barão de Geremoabo s/n, Campus Universitário de Ondina, Salvador, Bahia, 40.170-290, Brazil, E-mail ibravo@ufba.br; ²CNPMF/EMBRAPA, Cruz-das-Almas, Bahia, 44.380-000, Brazil.

The mediterranean fruit fly, Ceratitis capitata, in the imature phase, feed on countless fruit species, causing serious losses to world fruit culture. Rearing these flies in the laboratory permits attempts at biological control; furthermore, laboratory-reared populations can be used for basic research in different areas. Literature data show that artificial fruit fly rearing for many generations in the laboratory causes deleterious changes in behavior compared to wild populations. In general, laboratory-reared populations mature more rapidly, with an increased reproductive rate and a reduced ability to fly. Regarding the feeding behavior and the oviposition behavior studies show that flies do not show preference for artificial diets or natural hosts. Among others cares, a constant wild flies introduction in the laboratory flies colonies has been being a practice used to the variability genetics maintenance and for the decreesing of deleterious effects caused by the artificial rearing. Experiments were carried out to test the performance of two C. capitata laboratory-reared populations (a population reared with artificial diet for 18 years without the wild flies introduction - pop. A - and other reared with artificial diet for 10 years with individuals' wild periodic introduction - pop. B), when imatures fed on three natural hosts: papaya (Carica papaya), mango (Mangifera indica) and orange (Citrus sinensis). The performance parameters tested were percent emergence, time to emergence, adult female size, egg production during the pre-oviposition phase (first five days of adult life), longevity of adults, fecundity along the female adult life and pre-oviposition period. The data were analyzed statistically by the Mann- Whitney and Kruskal-Wallis tests at the 5% of significance. Considering the parameters, time to emergence, percent emergence, adult female size, egg production during pre-oviposition phase and fecundity along the life, the performance of both the populations were superior when the flies fed on papava and mango compared to orange. Comparing both populations to each other, the data show that the time to emergency was longer and the females longevity was shorter for population A compared to the population B, independent of the fruit host. However, the population A females had a larger fecundity along life regarding population B, with all the fruits tested. Comparing the others parameters the performance of the two populations was similar. The implications of these results for the practices used to the variability genetics maintenance of fruit flies laboratory-reared populations will be discussed.

Index terms: Ceratitis capitata, feeding behavior, laboratory rearing

[0257] FACTORS AFFECTING COTTON BOLL WEEVIL SURVIVAL IN VARIOUS OVERWINTERING HABITAT IN THE MIDDLE SOUTH REGION OF THE UNITED STATES

<u>D. R. Johnson</u>¹ & G. M. Lorenz¹, ¹Univ. of Arkansas Cooperative Extension Serv., P. O. Box 391, Little Rock, AR 73303, USA, E-mail djohnson@uaex.edu, and glorenz@uaex.edu.

Boll weevil (Anthonomus grandis) survives the winter in the mid-south cotton production region of the United States by movement during the fall into various types of vegetation surrounding cotton fields. The most favorable overwintering habitat in Arkansas is forested areas with deciduous trees. Forested areas with deep deposits of leaves and other organic materials were the most favorable for the survival of boll weevil. Areas that involve grass as a major portion of the habitat composition were the least favorable for survival. The effect of temperature and moisture in these deciduous habitats directly affects survival of boll weevil. Colder weather and high humidity conditions were the least favorable for the survival of boll weevil. Survival of boll weevil declines when the micro-habitat temperature drops below a minus 2.5 degrees centigrade coupled with high moisture conditions.

Index terms: Anthonomus grandis, vegetation, environment

[0258] GIANT BLACK BARK PEACH APHID PTEROCHLOROIDES PERSICAE (HOMOPTERA: LACNIDAE)

S. Kacic¹, K. Zanic¹, J. Igre-Barcic² & M. Katalinic¹, ¹ Inst. for Adriatic Crops and Karst Reclamation, Put Duilova 11, Split 21000, Croatia; E-mail: sonja@stijena.krs.hr, ² Faculty of Agriculture, Svetosimumska 25, Zagreb 10000, Croatia

Giant black bark aphid Pterochloroides persicae was observed at the end of seventies in Croatia and since then it has been a constant member of our entomofauna. Aphid colonies are easily visible on peach shady branches and trunk parts. The great infestation causes branch decline because of aphid colonies sucking. A few years infestation induces tree decline. Aphids excrete honeydew in abundant quantity that covers plant parts and soil under attacked tree. The presence of honeydew stimulates sooty mould growth and finally flacks like petroleum appear, separately under the tree. In the most cases, this pest habits and attacks a peach (Prunus persica), although it has been determined on other prunoideae. Pterochloroides persicae characteristics had not been investigated in our region before, so we did researches including: morphology, host plants, damages, location spots, biology, ecology and posibilities of its control. Field investigations were conducted from Zadar to Dubrovnik, coast and island region, to record the pest distribution and host plants in period 1996-1998. Bioecology of *Pterochloroides persicae* was investigated in selected peach orchard in Split region. Infested trees were observed twice a week during spring - autumn period and twice a month during the winter. Aphid colonies life duration was observed on peach woody cuttings in the laboratory. Other than peach, colonies of Pterochloroides persicae were found on these plant species: Prunus armeniaca, P. amygdali, P. mahaleb, Mespilus germanica and on sedlings G. F. root stock. Only on the peach aphid was presented all the year. Number and size of colonies varied through the year. The type of aphid reproduction was only parthenogenesis. It overwintered at all development stages except the egg. Otherwise, the egg stage of this aphid was not noted in our conditions during our study. Aphid colonies survived up to three months on woody cuttings in the laboratory, depending on air temperature and humidity.

[0260] FACTORS INFLUENCING DEVELOPMENTAL VELOCITY IN CHRYSOPERLA CARNEA

T. Kubota¹, ¹Kitakarasuyama 6-31-2, Setagaya, Tokyo 157-0061, Japan, E-mail: tkubota@mtd.biglobe.ne.jp

Environmental and genetic factors underlying developmental velocities in *Chrysoperla* carnea were explored. In this study, a strain of *Chrysoperla curnea* was propagated from a field-collected female (generation (gen) 0) and acclimatized to the insectary environment (chamber-a: temperature, ca. 26 °C; RH, 60%; photoperiod, 16L8D) and subdivided into 3 strains at gen 11. Each of these strains was then assigned to one of the 3 environments: chamber-a as described above, chamber-b (temperature, ca. 23°C; with same RH and photoperiod as chamber-a) and chamber-c (ca. 21°C; with same RH and photoperiod as chamber-a). The animals were reared successively through gen 27 and larvae of these strains were examined at each generation to see whether their developmental velocities (LDV) were different due to chambers they were reared and/or due to sibs they belong to ('sib' refers to offspring sharing the same parent and nests within each 'chamber'). First, the author found significant (at 5% level) seasonal fluctuation in generational LDV: highest in summer and lowest in winter for all 3 strains at each of 3 immediate temperature levels. Also, the generational mean LDV's were, in the order of chamber-a > chamber-b > chamber-c for most of generations except at gen 18 in which the order was chamber-a > chamber-to is most of generations except a gen to in which the order was chamber-a / chamber-b. Second, throughout the majority of generation, the LDV was higher in chamber-b and chamber-b. The differentiation in LDV due to chamber environment was significant at gen 17, 18, 24, 25 and 27 at 26 °C immediate temperature level, at gen 15, 17, (18), (23), 24 and 27 at 23°C immediate temperature level and at gen 17, 20, 26 and 27 at 21°C immediate temperature. Significant differentiation due only to sib was also observed, often in generations preceding these generations. The author employed thorough statistical analyses on various experimental data such as theritability, accidental selection, inbreeding, survival rates, reproductive performance in these strain and meteorological record to further deduce the factors influencing LDV. The author concludes that the environmental factor is the major determinant of LDV suggesting that the developmental velocity of chrysopid stock in insectaries is different from those in natural environment.

Index terms: environmental factor, heritability, founder effect, inbreeding, acclimatization.

[0259] STICKY NET CYLINDER TRAP FOR THE RICE LEAF BUG, TRIGONOTYLUS CAELESTIALIUM (HETEROPTERA: MIRIDAE)

M. Kakizaki¹ & H. Sugie², ¹ Hokkaido Ornamental Plants and Vegetables Research Center, Higashi-Takikawa 735, Takikawa, Hokkaido 073-0026, Japan, E-mail kakizams@agri.pref.hokkaido.jp² National Institute of Agro-Environmental Sciences

The rice leaf bug, *Trigonotylus caelestialium* (Kirkaldy) (Miridae), is distributed in China, Europe, Russian, North America and Japan. It is one of the major pests causing a pecky rice, and injures wheats, maize and forage grasses. It was reported that *T. caelestialium* females attract conspecific males (Kakizaki and Sugie, 1997), and that the female has a sex attractant pheromone. Although they are able to be captured by water pan trap, not by the horizontal sticky board trap with a roof and two entrances. Then, we made 'the sticky net cylinder trap' (1-mm mesh, 5 - 6 cm diam., 30 - 40 cm length, coated with the sticky material 'KINRYU Spray', vertically set on the ground and baited with pheromone lure at 25 - 30 cm in height), which captured more males than any of the other sticky type trap. The numbers of males captured at 0 - 10 cm and 11 - 20 cm in height by this trap, which was 40 cm long and set with the lure at height of 30 cm, were greater than at 21 - 30 cm und 31 - 40 cm, respectively; this trap captured more males than a trap 80 cm long set with he lure at a height of 70 cm. A 10-cm diameter trap captured smaller males than a 5-cm fiameter trap. The 5-mm mesh trap captured more males than the 1-mm mesh trap without a drop in the sticky efficiency. This trap is useful for investigation of trap design. index terms: sticky net cylinder trap, trap design, Miridae, rice leaf bug, *Trigonotylus* scalestialium [0261] USE OF THIAMETHOXAN IN BEAN PEST CONTROL

<u>A.M. Labinas</u>¹ & W. B. Crocomo², ¹Dept. of Ciências Agrárias - Univ. of Taubaté - 432 Quatro de março St. Taubaté - SP - Brazil, 12020-270, E-mail <adianal@tecsat.com.br>; ² Dept. of Vegetable Production - FCA - UNESP - P. O. Box 237, Botucatu - SP - Brazil, 18603-970, E-mail <wcrocomo@fca.unesp.br >

With the aim to evaluate the losses caused by different pests that occur in bean crops and analyze the economic gains of the control with Thiamethoxan insecticide. Two experiments, using 'carioca' bean, were conducted in two different seedling season. These experiments were conducted on the Pilot Farm of Taubaté University - SP - Brazil. The water season crop was realized from October to December of 1998 and the dry season crop from February to May of 1999. Both experiments followed the experimental design of 14 treatments with 4 repetitions, with 50 m² plot (10 rows distant 0,5 m with 10 m length and 5 plants per meter). Three treatments (1,2 and 3) with ACTARA 250 WG, in the dosage of 150,0g a.i. Ana applied in intervals of 7, 14 and 21 days; one treatment (4) with CRUISER 700 WS, in the dosage of 1,5g a.i. /kg applied in seeds treatment; three treatments (5, 6 and 7) with CRUISER 700 WS, in the dosage of 1,5g a.i../kg applied in seeds treatment plus ACTARA 250 WG, in the doage of 150,0 g i. a. /ha applied in intervals of 7, 14 and 21 days; three treatments (8, 9 and 10) with TAMARON BR, in the dosage of 600,0 g a.i./ha applied in intervals of 7, 14 and 21 days; three treatments (11, 12 and 13) with CRUISER 700 WS in the dosage of 1,5g a.i./kg applied in seeds treatment and a b) with extended the state of the stat indicative such as height, leaves number, leaf area, flowers number, pods number and the pests population of each insect species present in the plants and quantified their damage; in the end of the culture, the productivity parameters indicatives were evaluated such as grains number per pods, weight of 100 grains and production in Kg/ha. In the dry season crop occurred more insect species than in water season, however, the data got showed the populational level reached by different insect pest species, in both tests, did not cause significant losses that justified the use of chemical control. The treatments that applied both insecticides Cruiser and Actara caused a better vegetative development. No difference was detected in the production either because of insecticide treatments or because of cultive season.

Index terms: Thiamethoxan, Phaseolus vulgaris, chemical control, chemical treatment schedule

Symposium and Poster Session

[0262] CONTROL OF *DIABROTICA SPECIOSA* (COLEOPTERA, CHRYSOMELIDAE) NA CULTURA DA BATATA

C. A Lacerda¹, A M. C. de Lyra Netto², V. F. dos Santos², M. C. L. da Silva², Caixa postal 157, 37200-000 Lavras - MG, Brasil, E-mail cynthia@ufla.br; ² Empresa Pernambucana de Pesquisa Agropecuária - IPA, Ay. Gal. San Martin 1371, Bongi, 50761-000 Recife - Pe, Brasil.

It wish to control *Diabrotica speciosa* populations on potato crop and to reduce the crop damages, makes this research. It was studied the Deltamethrin 25 CE dosage effect: 0; 1; 8 and 16 ml/20 | of water only and with the presence (pg) and absence (ag) of trap crop small pigeon pea (*Cajanus cajan*) precursor of the cultivate IAPAR-43-Aratā on *Diabrotica speciosa* larva damage in Baraka potato roots. Planted in two times: begining june of 1995, 1996 and 1997 (e₁) and middle/final of june of 1995 and 1996 (e₂) in waste are in Caruaru, Pernambuco state, Brazil. The experimental delineation was chance blocks with four treatments and five repetitions. In (e₁) and in (e₂) planted one area with potato (b) and another area with potato and pigeon pea (bg). Counted the damage *D. speciosa* larva on roots and used Abbott to calculate the treatments efficience. Got untill 36,4 % efficience on number of commercial damaged roots from plants of (e₁), weekly powdered with Deltamethrin 25 CE on subdosage of 1 ml of the control of the damage of *D. speciosa* larva to Baraka potato roots in waste area of Caruaru, Pernambucos state, in Brazil. The crops of june middle and of june end were completely unfavorable to the control of the damage of *D. speciosa* larvae to Baraka potato roots in waste area of Caruaru, Pernambucos state, in Brazil. The crops of june middle and of june end were completely unfavorable to the control of the damage of *D. speciosa* larvae to Baraka potato roots in waste area of Caruaru, Pernambuco state, in Brazil.

Index terms: Diabrotica speciosa, damage, trap crop, pigeon pea, deltamethrin

[0263] A KAOLIN-BASED PARTICLE FILM DETERS FEEDING AND OVIPOSITION BY THE WEEVIL DIAPREPES ABBREVIATUS

S. L. Lapointe, USDA-ARS, U.S. Horticultural Research Laboratory, 2001 South Rock Road, Ft. Pierce, FL 34945, USA, E-mail slapointe@ushrl.ars.usda.gov

Broad-nosed weevils are pests of citrus and ornamentals throughout the Caribbean and peninsular Florida in the USA. Most notable of these is Diaprepes abbreviatus (L.), first discovered on the mainland U.S. at Apopka, FL in 1964. This species most probably originated on Puerto Rico where is causes considerable damage to citrus and other crops Females of this group place their eggs with an adhesive in a single layer in a niche most often fabricated by juxtaposing leaves. The options currently available to citrus growers in Florida for control of root weevils include entomopathogenic nematodes, oil sprays, and adulticides, none of which provide reliable, economically viable control. Recent interest in particle films for control of plant pathogens and insect pests has led to the development of experimental formulations of kaolin, an inert silicate, for foliar applications. A hydrophilic formulation of kaolin was tested in a screenhouse for its effect on the behavior of D. abbreviatus. Feeding by adults on treated foliage was reduced by 75 - 84% compared with adults fed untreated foliage. No direct insecticidal activity was detected. Oviposition was completely suppressed on treated foliage. While females oviposited >19,000 eggs during 2 trials on untreated foliage, no egg masses were found on foliage treated with the kaolin formulation. Studies under greenhouse conditions have determined a dose-response function that quantifies the amount of kaolin residue on leaves required to elicit the behavioral avoidance by D. abbreviatus. These data indicate potential for kaolin as a barrier to oviposition in citrus groves and may prove to be an economically viable and environmentally sound component of an integrated approach to control of D. abbreviatus and related root weevils.

Index terms: Diaprepes abbreviatus, kaolin, particle film, ovipostion, citrus.

[0264] APPLICATION OF BIODEGRADABLE, SUGAR-STARCH SPHERES TREATED WITH REDUCED-RISK INSECTICIDES FOR MANAGEMENT OF KEY *RHAGOLETIS* SPECIES

O.E. Liburd, L.S. Stelinski, & M. R. McGuire¹, Department of Entomology, Center for Integrated Plant Systems B-9, Michigan State University, East Lansing, MI 48824, USA-¹National Center for Agriculture Utilization Research, Bioactive Agents Research Unit, Agricultural Research Service, USDA, Peoria, IL 61604, USA.

The apple maggot, *Rhagoletis pomonella* (Walsh), and the blueberry maggot, *Rhagoletis mendax* Curran, are the key late-season pests of apples, *Malus domestica* Borkhausen, and blueberries *Vaccinium* spp. in northeastern and mid-western United States and southeastern Canada. Current methods of control involve 3-5 applications of insecticides, primarily organophosphates. In an attempt to develop nonorganophosphate alternatives for control of apple maggot and blueberry maggot, the effectiveness of baited, biodegradable, sugar-starch spheres treated with 7.4 (Al) indecloprid (Provado® 1.6 F) [Bayer, Kansas, City, MO] and (2) an untreated (control) sphere, were evaluated in several unsprayed apple orchards and blueberry plantings. In 1999, in addition to evaluating sphere effectiveness, three potential sphere deployment strategies were evaluated for efficacy in suppressing apple maggot and blueberry maggot files. These included (1) perimeter deployment of single spheres, (2) perimeter deployment of sphere clusters and (3) uniformed, grid, deployment strategy. Our standard inidacloprid treatment (evaluated in 1998) was also compared with a "new" neo-nicotinoid insecticide, thiomethoxam (Actara®) [Novartiis Crop Protection Iuc., Greensboro, NC] 2 % (Al) in 1999. *Rhagoletis* files were sampled twice per week on stickly plexi-glas panes placed horizontally 30 cm beneath biodegradable spheres. Our 1998 results indicated that significantly (P < 0.05) more *R. pomonella* and *R. mendax* flies were tecorded on plexi-glas panes placed unterated spheres. Also, the mean time *Rhagoletis* flies spent alighting on inidacloprid treated spheres was significantly longer than the time spent on untreated spheres sequent with panes placed under treated with our sphere deployment trails and there were no significant differences among the treatments evaluated. In our study of reduced risk insecticides, significantily more *R. pomonella* flies were caught on plexi-glas panes placed beneath inidacloprid-treated spheres compare

[0265] A GASOLINE-DRIVEN SUCTION APPARATUS FOR SAMPLING BLISSUS ANTILLUS (HEMIPTERA: LYGAEIDAE) AND OTHER ARTHROPODS IN PASTURES

J. O. G. de Lima¹ & N. L. Mendes², ¹Laboratório de Proteção de Plantas e ²Laboratório de Materiais Avançados, Univ. Estadual do Norte Fluminense, Av. Alberto Lamego 2000, 28.015-620 - Campos dos Goytacazes, RJ, Brazil. E-mail joscar@uenf.br.

In 1999, chinch bugs collected in pastures in several areas of Brazil were identified and confirmed as *Blissus antillus*. Previously, they had been identified as *Blissus leucopterus*. Since 1980 these chinch bugs have been damaging the pastures of *Brachiaria arrecta* and *B. purpuracens* growing in soils with high moisture content in the state of Rio de Janeiro. In a study regarding the preference of this insect for pastures, we employed a plastic tray and the "D-VAC" for sampling the bugs, and both methods presented several difficulties. Bending and shaking the plants over the tray cannot be done in low grasses (<20 cm), and is not so efficient and as fast as the sampling done with the "D-VAC". On the other hand, the "D-VAC" machine has considerable weight, is difficult to carry, is expensive, and presents frequent mechanical problems. In search of a more efficient cupument, we converted a grass-cutting machine (carried over the shoulder, when in operation), manufactured by Still, in a suction equipment for sampling *B. antillus* and other arthropods. In a field test, in a pasture of *B. arrecta* (height <25 cm) we compared its capture efficiency with that of the "D-VAC" (a motorized knapsack sprayer, manufactured by Hatsuta and converted into a suction sampler, with the general design of the American "D-VAC"). With the new equipment, we captured significantly larger numbers of arthropods, belonging to seven groups separated according to their size, number and capture frequency: I. *B. antillus*, 2. Hymenoptera (mainly Fornicide), 3. Acari, 4. Coleoptera, 5. Hemiptera (mainly Auchenorrhyncha), 6. Collembola, and 7. Araneae. It became evident that the new equipment has excellent potential for sampling arthropods in pastures, and may be an appropriate alternative for the traditional "D-VAC", because of its efficiency, low cost and lightness.

Index terms: Suction sampler, D-VAC, grassland

[0266] CHEMICAL CONTROL OF THE TOBACCO FLEA BEETLE

D. Link, Centro de Ciencias Rurais -UFSM. Predio 42. Santa Maria, RS. 97105-900 Brazil. E-mail: <dlink@ccr.ufsm.br>

The tobacco flea beetle, *Epitrix fasciata* (Coleoptera: Chrysomelidae) damage the tobacco leaves, decreasing the commercial value. The efficiency of chemical control of this pest on tobacco plants was studied in Vera Cruz county, State of Rio Grande do Sul, Brazil, during 1998/99 growing crop season. Lambdacyalothrin at 5.0g and 7.5g a.i./ha, CS and EC formulations; Acephate PS at 750g a.i./ha, and Imidacloprid WG at 70g a.i./ha, were sprayed on tobacco plants. Lambdacyalothrin, at two dosages and formulations, was efficient to control the tobacco flea beetle, reducing more than 82% the population until three weeks. Acephate and Imidacloprid reduced more than 64% until two weeks. Index therms: cultivated plant, pest control, *Epitrix fasciata*, efficave.

V. S. Lins & H. R. Santos, N.C.A, CEUD, Univ. Federal de Mato Grosso de Sul, C. Postal 533. Dourados - MS - BR, CEP 79825-070, E-mail: vilins@hotmail.com

IN GRAINS OF FIVE CULTIVATE OF CORN

[0267] NATURAL AND ARTIFICIAL INFESTATION OF THE SITOPHILUS SPP

The present work has as objective evaluates the damages provoked by the *Sitophilus* spp, in 5 corn varieties (AG612, AG5011, AG8012, AG1051 and Br473) in laboratory conditions, with the temperature accompaniment and humidity relative atmosphere. The research was constituted of 2 tests: Natural Infestation, represented by the 5 varieties supra mentioned, slightly infested in field; constituted of 5 treatments of 4 repetitions, totaling 20 portions. In the Artificial Infestation was used AG612 and AG5011, being established 4 treatments of 4 repetitions, being 2 of these treatments infested with 2 weevils and the other ones 2, with 8 weevils, totaling 16 portions. For each portion 200g of corn were placed in glass flasks (500ml) with mouth it releases, drained cover and prohibited with screen of steel with mesh 5mm to avoid the escape of the insects. All the treatments were them cultivate more infested; and AG5011 and AG8012 the fewer infested, therefore the most resistant. Test-2, it was verified that there was not significant difference among the two varieties. Humidity and temperature didn't influence in the population growth of the weevils.

Key - Words: Curculionidae, Maize Weevil, Plague, Zea Mays, Stored Products.

[0268] CONTROL OF ORTHEZIA PRAELONGA IN WEST INDIAN CHERRY, MALPIGHIA GLABRA USING FORMULATIONS AND THREE APPLICATION METHODS OF THIAMETHOXAM

R. Barros¹, **M. D. R. O. Silva¹ & S. Araújo¹**, ¹Fitossanidade, Univ. Fed. Rural de Pernambuco, Av. Dom Manoel de Medeiros S/N, Dois Irmãos 52171-900 Recife, PE. E-mail: rbarros@nelore.npde.ufrpe.br.

The scale Orthezia praelonga (Homoptera: Orthezidae) had been recorded recently as a serious pest in West Indian Cherry (WIC) Malpighia glabra growing area in Brazil. In Pernambuco, Brazil WIC population has been verified seasonally from July to November. The lack of insecticides registered by Agricultural Minister for WIC has impeded the use of this method for *O. praelonga* and others insects pests attacking WIC. Thus, this work aimed to evaluate the efficacy of Thiamethoxam for O. praelonga control in WIC. The experiments were set up in a WIC orchard five years old, spaced 3.5 x 3.5 m between and within line. The experiment was carried out in a randomized complete block with 8 treatments and 4 replications composed by two plants each. The treatments consisted by: I - Control; II - Foliar spray (Actara 250 WG) 1g/1.2 L water/plant; III - Foliar spray (Actara 250 WG) 2 g/1.2 L water/planta; IV - Stem spray (Actara 250 WG) 1 g/0.5 L water/planta; V - Stem spray (Actara 250 WG) 2 g/0.5 L water/plant; VI - Soil placement (Cruiser 700 WS) 2 g/plant; VII - Soil placement (Cruiser 700 WS) 4 g/plant and, VIII -Soil placement (Cruiser 700 WS) 6 g/plant. For foliar and stem treatments were used a costal sprayer 40 lbs/pol² and a trigger-pump 1.0 L volume, respectively. Thiamethoxam soil placement was applied by distributing granules in a semi-circle furrow 5.0-cm depth distant = 50% plant canopy projection from plant base. The evaluations were carried out at 9, 18, 27, and 36 days after application for all treatments. Each evaluation consisted of 16 leaves per replication-plant. The samples were took up to laboratory and the number of scale alive/leaf was counted using a stereo microscope and recorded. Application of Actara 250 WG 2 g/1.2 L water/plant through foliar spraying promoted efficiency of 60.7% in the first evaluation and maintained inferior to 45% in following evaluations. The treatment through stem application and soil placement showed efficacy inferior to 52% and only 27 days after application. Based on our results Thiamethoxam applied by foliar spraying, stem application and soil placement did not show an efficient control of O. praelonga in WIC orchard. However, investigation with higher Thiamethoxam doses than those used in this study should be carried to determine an efficient control method for this important pest in WIC

Index terms: Insecta, chemical control, systemic insecticide, scale, orchard pest-

[0269] EGYPTIAN ALFALFA WEEVIL (IIYPERA BRUNNEIPENNIS) CONTROL AND WATER QUALITY

<u>R. F. Long</u>, Univ. of CA Cooperative Extension, 70 Cottonwood St., Woodland, CA 95695 Email: rflong@ucdavis.edu

The organophosphate insecticides Chlorpyrifos (Lorsban® and Lock-On®) and Imidan® (Phosmet) moved offsite from alfalfa fields via irrigation runoff at levels high enough to kill the aquatic test invertebrate *Ceriodaphnia*. The Pyrethroids (Warrior® and Baythroid® were not detected in the alfalfa irrigation tailwater samples (as measured by toxicity to *Ceriodaphnia*). Efficacy trials for pest control showed that the pyrethroids controlled the Egyptian alfalfa weevil *Hypera brunneipennis* as well as the standard organophosphate treatments; however, they may cause aphid outbreaks. Costs for the pyrethroids are the same or lower than the organophosphates.

Index terms: Pest control, organophosphates, pyrethroids, aquatic toxicity

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[0270] OCCURENCE OF THRIPS ON NIAGARA TABLE GRAPE AND ITS CONTROL WITH THE INSECTICIDES THIACLOPRID AND METHIOCARB ASSOCIATED WITH *METARIHIZIUM ANISOPLIAE*

<u>R.B. Lopes¹</u>, M.A. Tamai¹, S.B. Alves¹, S. Silveira Neto¹, & S. Salvo², ¹Dept. Entomologia, Fitopatologia e Zoologia Agrícola, ESALQ/USP, Pádua Dias Ave., 11, P.O. Box 9, Piracicaba, SP, 13418-900, Brazil, E-mail rblopes@carpa.ciagri.usp.br; ²Bayer S.A., Domingos Jorge St., 1100, São Paulo, SP, 04779-900, Brazil.

Thrips are reported as important pests on table grapes in United States and several countries of Europe. Damage caused by thrips was observed in table grape (Niagara) crop in Limeira-SP, and a sample was send for identification to D.S. R.C.Monteiro in USA. This specie probably belows in genus Frankliniella. During the blooming period, high populations were observed feeding on pollen and small berries. The symptoms of the attack are more visible after the development of the berries and are characterized by dark scars and suberized surface on berries, sometimes causing the berry to crack of seed to prolapse. The effect on thrips population of one application of the insecticides Calypso 480SC (thiacloprid) or Mesurol (methiocarb) associated or not with the entomopathogenic fungus Metarhizium anisopliae was evaluated during the blooming period. For evaluation of thrips damage on fruits, the treatments were applied three additional times, 7, 14 and 21 days after the first application. The treatments were: a) M. anisopliae (strain 1037) 1x107 conidia/ml; b) Calypso 20ml/1001; c-d) Mesurol 100 and 150ml/100 l; e) Mesurol 100 ml/100 l + M. anisopliae 1×10^7 conidia/ml. Only Mesurol, associated or not with the fungus was effective in reducing thrips infestation, and no phytotoxic damage was observed. The efficiency of Mesurol 150ml/100l and the insecticide associated with the fungus for the control of the thrips population was 84.2 and 95.5%, respectively. In both cases, there was a reduction of approximately 70% in the number of berries with scars symptoms. For control of thrips on table grapes, chemical insecticides associated or not with M. anisopliae should be applied during at the blooming period of the crop. Index terms: chemical control, fungi, microbial control, thrips.

Symposium and Poster Session

[0272] COMPARATIVE PARASITOID GUILD ANALYSIS OF *RACHIPLUSIA NU* (LEPIDOPTERA: NOCTUIDAE) LARVAE IN DIFFERENT PLANT HABITATS

M.G. Luna¹ & <u>N.E. Sánchez²</u>, ¹Dept. Ecol. & Evol. Biol., UCI, 321 Steinhaus Hall, Irvine CA 92697-2525, USA; ²Centro de Estudios Parasitológicos y de Vectores, Univ. Nacional de La Plata-CONICET, 2 Nº 584 (1900) La Plata, Argentina, E-mail cepave@museo.fcnym.unlp.edu.ar

Rachiplusia nu is a pest of crops and it is also found on non-crop vegetation in Argentina. The objective of this study was to examine the structure of parasitoid guilds of R. nu larvae in 4 pesticide-free crops (soybean, sunflower, and mixed clover and alfalfa pastures) and in 2 non-agricultural legume patches (Melilotus alba and Galega officinalis) in the Pampean region. Through larvae sampling, from 1992 to 1998, and laboratory data plus the known biology of the species recorded during the study, host abundance. parasitoid species composition and richness, number of parasitoid guilds per plant species, and levels of parasitism, were determined. Highest R. nu population abundances were found in crops. All parasitoid species were primary endoparasitoids, except for 2 secondary endoparasitoid species registered in sunflower crops, and they belonged to Hymenoptera and Diptera orders. R. nu larvae hosted the highest number of parasitoid species in soybean (11) and the smallest in non-crops (3). Also, differences were found in the representation of parasitoid guilds among the six plant habitats. The number of parasitoid guilds ranged from 4 in sunflower and soybean crops (egg-prepupal endoparasitoid, early larval endoparasitoid, late larval endoparasitoid, and larval-pupal endoparasitoid) to 2 for G. officinalis patches (early larval endoparasitoid and late larval endoparasitoid). Levels of parasitism of R. nu were higher in crop than in non-crop habitats. Finally, it was observed that, in general, parasitoid species belonging to guilds that attack earlier host stages had higher percent of parasitism than those attacking later developmental stages. Results of this study are consistent with the host abundance hypothesis, which is among the key ecological variables determining parasitoid community structure.

Index terms: hymenopteran parasitoids, dipteran parasitoids, parasitoid community structure, agricultural habitats, natural habitats.

[0271] DEVELOPMENT OF AN EXTENSION-BASED SAMPLING SERVICE FOR COTTON APHID FUNGUS, *NEOZYGITES FRESENII*

<u>G. M. Lorenz¹</u>, D. C. Steinkraus², G. O. Boys² & D. R. Johnson¹, ¹Cooperative Extension Serv., Univ. of Arkansas, P.O. Box 391, Little Rock, AR 72203, USA, E-mail glorenz@uaex.edu, ²Dept. of Entomology, Univ. of Arkansas, Fayetteville, AR 72701, USA.

The cotton aphid, Aphis gosypii, has become a major pest of cotton in recent years due to insecticide resistance and behavioral changes. The cotton aphid fungus, *Neozygites fresenii*, is the most important natural enemy of the cotton aphid. Frequently in late-June through mid-August, the aphid fungus is very effective in reducing aphid populations. Since 1993 the cotton aphid fungus has been utilized in an IPM program in Arkansas and has since expanded to Louisiana and Mississippi since 1997. The objective of the program has been to sample aphid populations throughout the season, determine the percentage of the natural control provided by the fungus. The information is provided to consultants, growers, and Extension personnel to help make decisions on whether or not additional control tactics are necessary. Research in Arkansas has shown that declines in cotton aphid populations due to the cotton aphid fungus are widespread and somewhat predictable, and often result in rapid aphid population reductions. Generally, once 15% of the aphid population is infected a decline will occur in about seven days. When this level of infection is reached it is more economical and advantageous for growers to let the fungus reduce the aphid population than to apply an insecticide. With this in mind a service to diagnose field-collected aphids was developed where sample results can be communicated via internet, fax, or telephone within 24 hours of sampling. The objective of this project has been to provide cotton growers, consultants, and Extension personnel with timely information on the status of this valuable natural enemy that can be used to improve cotton IPM programs.

Index terms: Aphis gosypii, IPM, natural enemy

[0273] LIFE-TIME ACTIVITY BUDGET OF MANGO (MARULA) FRUIT FLY, CERATITIS COSYRA, AND ITS RESPONSE TO ATTRACTANTS

<u>S. A. Lux¹, N. Zenz¹ & P. Nemeye¹, ¹ International Centre of Insect Physiology and Ecology, Nairobi, Kenya, P.O. Box 30 772, s.a.lux@icipe.org, Nzenz@icipe.org, Pnemeye@icipe.org</u>

Based on our surveys conducted in many African countries, C. cosyra has been found to be one of the major mango pests throughout Sub-Saharan Africa. This very little known fruit fly, indigenous to Africa, does not respond to most standard commercially available attractants, hence is difficult to manage. Over 100 males and females were observed in laboratory conditions from 5:00 AM till 11:00 every day, starting from their emergence till death. Their longevity and dynamics of life-time behaviours were described. In addition, response of males and females to the standard, commercially available attractants, as well as several other non-commercial attractants was evaluated. Differences in the response, according to the sex, age, maturity and mating status were described.

[0274] THIAMETHOXAM ON THE CONTROL OF SUGARCANE BORER DIATRAEA SACCHARALIS (LEP., CRAMBIDAE)

N. Macedo & M.B.S. Campos, Centro de Ciências Agrárias/UFSCar, Araras, SP.cx.p.153, CEP 13600-970. E-mail: newmac@cca.ufscar.br.

This experiment aim to evaluate in field conditions the effects of different dosages of Thiamethoxam (commercial product ACTARA 10 G) on larvae of sugarcane borer, *Diatraea saccharalis*, in the plant infestation phase. The experiment was installed at Araras, (SP), in 20.01.99, on plant cane 9 months aged, RB 855453 variety. The parcels were infested by hand with 2^{nd} and 3^{rd} larval instars reared in laboratory. The treatments were: $T^1 = 150$ g a i./ha; $T^2 = 200$ g a i./ha; $T^3 = 250$ g a i./ha and T^4 = check, installed in bands, split plot design, each sub-parcel (a and b) constituted of one stool with 5 stalls, 6 replicates. Chemical was applied by hand, on the soil surface, by side of sugarcane row. Six weeks after infested stalls were collected, longitudinally opened and the damage of the pest was evaluated by means of a note scale as follows: small (S) = 1; medium (M) = 2 and great (G) = 3. The smallest damage occurred on infested stalls with 2^{nd} larval instar, treated with 200 and 250 g ai./ha (T^2a e T^3a) and 3^{rd} larval instar treated with 250 g, ai./ha (T^3b). It was concluded that Thiamethoxam applied on the soil, in the dosage of 250 g ai. or ormore/ha can control infesting first larval instars of *D. saccharalis* on sugarcane. Index terms: *Diatraea saccharalis*, sugarcane borer, control, Thiamethoxam

[0275] OCCURRENCE OF DEFOLIATOR CATTERPILARS (LEPIDOPTERA) ON EUCALYPTUS IN THE REGION OF LAVRAS-MG, BRAZIL

W. J. M. S. Maia¹ & V. H. P. Bueno¹, 1. Depto. de Entomologia, Univ. Fed. de Lavras, Caixa Postal 37, Lavras, MG, 37.200-000, Brasil, E-mail wimsmaia@ufla

The forest system of *Eucalyptus* spp. stands out as one of the main factors of increase of the planted area, about 60%, of reforestation in Brazil. In Minas Gerais (southest region of Brazil), this ratio reach 88%. But in parallel with that, there was also an increase in the number of insects associated with the eucalyptus trees in the country. In this context, the defoliator catterpillars, which along the last three decades have been taking over increased importance due their persistence and increase of the damage. This work was designed to determine the occurrence of lepidopterous associated with *Eucalyptus* spp. in the region of Lavras, Minas Gerais State. A number of 187 weekly collections were accomplished over the area (about 10 ha) from August 1995 to March 1999, with the use of a "Luiz de Queiroz" model light trap, placed at 2.0 meters height over the soil level, and working from 17 to 07 h. The occurrence of the species *Eupseudosoma aberrans* Schaus, 1905 (Arctiidae); *Apatelodes sericea* Schaus, 1896 (Eupterotidae); *Sabulodes caberata caberata* Guenée, 1857 (Geometridae); *Sarsina violascens* Herrich-Schaeffer, 1856 (Lymantriidae); *Adeloneivaia subangulata* (Herrich-Schaeffer, 1855) Travassos, 1940; Automeris illustris Walker, 1855; *Dirphia albolinea; Dirphia triangulatum* e *Eacles imperialis magnifica* Walker, 1855; November/95, March/97, June/97, October/96, March/98, March/96 and October/96, respectively for these species collected.

[0276] RESULTS FROM 3 YEARS OF BWACT USE IN THE NATIONAL BOLL WEEVIL SUPRESSION PROGRAM OF PARAGUAY

O. G. Manessi, Plato Industries, Inc., Ttc. Alfredo Nuñez 250, Asunción, Paraguay Email: platopy@highway.com.py.

Cotton in Paraguay is the main "cash" crop for more than 100,000 small family farms. The Paraguayan system of cotton production is unique and currently provides employment for approximately 1,000,000 people (20% of the country's population); it generates an annual "cash flow" of US\$ 400,000,000. Even with the social and economic importance of this crop, from 1990/91 to 1996/97 the planting decreased 80%. One of the main reasons for this reduction was the arrival of the boll weevil (Anthonomus grandis); it entered from Brazil and quickly established in 90% of the production zones, causing an average increase in the production cost of 35% and an average decrease in the cotton production of 40%. In the 1997/1998 cotton crop, the Ministry of Agriculture designed and started a "NATIONAL PLAN TO REACTIVATE COTTON" (NPRC); as an integral part of the NPRC, the boll weevil program was established and was based on the installation of Boll Weevil Attract and Control Tubes (BWACT or TMP or TMB) and stalk destruction. The objectives were, with a low cost per hectare to reduce the boll weevil population and avoid economic damage during the cotton crop cycle and to increase cotton production with lower production costs. The Program of BWACTs is "preventive" in approach and is based on the behavior and biology of the boll weevil in Paraguay. The use of the BWACT at planting protects the crop for about 50 days without spraying and this provides for a build-up of parasites and predators that normally continue to provide for boll weevil control during the remainder of the critical fruiting cycle. The "end of crop" BWACT installation drives the population to a low level and subsequent natural mortality forces the weevils to a lower level for the benefit of a next crop. The methodology of use at the end of the cotton crop is the destruction of stalks and the installation of 1 BWACT per hectare and at cotton planting, the installation of 1 BWACT per hectare. The use of BWACTs is very adaptable to the production system of small producers and it is not harmful for the environment or the small grower. The Program has a low cost of about US\$22/ hectare/ year. After 3 years of the BWACT Program, the boll weevil population has been decreased by more than 85% and there has been a decrease in the quantity of insecticide for boll weevils from 6-8 applications per crop to less than 1 in the cotton crops of 1998/99 and 1999/2000. Equally important, there was a decrease in production losses from boll weevil damage of about 40% in the 1996/1997 crop to damage levels of no economic importance in the 1998/99 and 1999/2000 crops. Results from the 3 year program will be presented in detail.

Index terms: Anthonomus grandis, boll weevil control, cotton

[0277] EVALUATION OF SYSTEMIC INSECTICIDE THIAMETHOXAN ON THE VEGETATIVE GROWTH OF DRY BEAN PLANTS

D. S. Martins¹ & M. J. Fornazier¹, ¹EMCAPER- Empresa Capixaba de Pesquisa, Assistência Técnica e Extensão Rural-Rua Afonso Sarlo, 160, Bento Ferreira, Vitória/ES, CEP 29052-010, Brazil, E-mail davidmartins@emcaper.com.br.

Different insect pests are associated to bean crop with the main importance for the happening in early stages, that cause directly losses on the plants development and growth or indirects losses as virus vectors with reduction the crop yield. The period from bean seed germination until flowering is the most susceptible to the crops needing keep plants free of the pests or maintain pests populations in acceptable level. The plant metabolism can be altered by some systemic insecticides that cause benefic or detrimetal effects on plants when used on the control of the pests. The effect of systemic insecticide thiamethoxan on the growth of dry bean plants of cv. Xamego (black bean) was studied under field conditions. A randomized complet block design experiment with 7 treatments and 4 replications was carried out during the rain season on the highland Region of Espírito Santo State. Each plot was formed by 6 rows of 3.0m apart and 0.5m into row, with 12 seeds/m. Thiamethoxan treatments were: Actara 250 WG at 100, 125 and 150g a.i./ha, spouted in the soil on botton the plants 3 days after seeds germination, and irrigated immediately; Cruiser 700 WS at 70, 140 and 210g a.i./100kg seeds as seed treatment; and untreated control. At 10, 17, 24 and 38 days after germination were evaluated: number of leaves; plant height; dry weight of leaves, stems and roots; number of Rhizobium nodules; and number of pods, of 5 plants harvested by plot. The experiment was irrigated and sprayed with methamidophos insecticide and tebuconozole fungicide to uniformize and avoid pests and diseases interference at the experimental area. There were no significant differences to the numbers of leaves, Rhizobium nodules and pods. Plants treated with the two thiamethoxan formulations had greater in dry weight and plant height, comparatively to the untreated plants, showing a benefic effect caused by the thiamethoxan, that was more evident with Cruiser 700 WG formulation on the early stages of plant development. With the growth of plants, the difference of this effect, among the two formulations, was decreasing until to same value. At flowering stage, excluding the plant height, was not observed significantly difference on treated and untreated plants. All doses of the both formulations, in growth early stages, were superior to the untreated plants, but the best plant growing and development was observed on the intermediate and highest doses recomended (Cruiser 700 WS at 140 and 210 g a.i./100kg of seeds and for Actara 250 WG at 125 and 150 g a.i./ha.)

Index terms: Phaseolus vulgaris, development, tonic effect

[0278] EVALUATION OF TWO COFFEE SPECIES AS HOST OF FRUIT FLIES (DIPTERA: TEPHRITIDAE) IN THE ESPÍRITO SANTO STATE, BRAZIL

D. S. Martins¹, M. M. Teixeira¹ & A. Malavasi², ¹EMCAPER-Empresa Capixaba de Pesquisa, Assistência Técnica e Extensão Rural - Rua Afonso Sarlo, 160, Bento Ferreira, Vitória/ES, CEP 29052-010, Brazil, E-mail davidmartins@emcaper.com.br; ²Departamento de Biologia, Instituto de Biociências-USP, Cx. Postal 11.461, São Paulo/SP, CEP 05422-970, Brazil.

The coffee cultive in the Espírito Santo State is realized with two coffee species: Coffea arabica, developped in the region with cold weather temperature, ranging from 19 to 21°C, and altitude more than 400 m over level sea, where there is culture of temperate and subtropical fruit plants too; and Coffea canephora (robusta) cultivated in warm weather conditions, ranging from 22 to 26°C, and altitude lowest that 400m, where are planted the tropical fruit plants. The coffee is host to different insect species; of this, there is the flies Ceratitis capitata and Anastrepha fraterculus, the most important and damage brazilian fruits. Despite this flies didn't cause direct damages to the coffee berry, because they eat fruit mesocarp only, the coffee plant is important to host sucession, that is the great process for the maitainance and development of fly populations. The objective of this research was to evaluate C. arabica and C. canephora as host and as natural repository of populations of th fruit flies. The data were obtained from may to june/1998, in 120 farms (60 of C. arabica and 60 of C. canephora), from 22 counties, seven of them cultivate only the C. arabica, nine only the C. canephora and six cultivate both species. The fruit samples of 0,51 "berry" in post harvest stage were immediately transported for laboratory; the flies emerged were identificated at Biology Departament of Bioscience Institute/University of São Paulo-USP. 19,5 kg (13.669 fruits) of arabica coffee and 18,3 kg (26.067 fruits) of robusta were observed. All C. arabica counties were infested with fruit flies and 98,3% of the farms had fruits infested, that originated 2.612 pupae. The C. *canephora* had 11,7% of the farms infested, originating only 9 pupae. The infestation index in *C. arabica* was 0,19 pupae/fruit and 131,23 pupae/kg of berry. In *C. canephora* was 0,0004 pupac/fruit and 0,49 pupae/kg of berry, respectively 475 and 268 less than C. arabica. From the 1.273 fruit flies obtained, 99,3% were originated of the 'arabica', being 76,6% C. capitata and 26,3% A. fraterculus. It was obtained also, an example of A. serpentina in C. canephora. So, it is concluded that: C. arabica had a major predominance as host of fruit flies, being of this C. capitata more frequent than A. fraterculus; C. canephora, on the contrary of C. arabica, for host succession, was showed very unfavorable to the fruit flies, so, less important as natural repose place of tephritid populations, at regions where this coffee specie is cultivated.

Index terms: Coffea arabica, Coffea canephora, hosts, Ceratitis capitata, Anastrepha fraterculus, Anastrepha serpentina

[0279] HOST PLANTS OF FRUIT FLIES (DIPTERA: TEPHRITIDAE) IN THE STATE OF ESPÍRITO SANTO, BRAZIL

D. S. Martins¹, K. Uramoto² & A. Malavasi², ¹EMCAPER-Empresa Capixaba de Pesquisa, Assistência Técnica e Extensão Rural - Rua Afonso Sarlo, 160, Bento Ferreira, Vitória/ES, CEP 29052-010, Brazil, E-mail davidmartins@emcaper.com.br; ²Departamento de Biologia, Instituto de Biociências-USP, CX. Postal 11.461, São Paulo/SP, CEP 05422-970, Brazil.

Trapping surveys of tephritid fruit flies have been systematically conducted since 1993 in the state of Espfrito Santo, resulting in 25 species of Anastrepha reported as well as Ceratiis capitata. Nevertheless, there is a lack of knowledge regarding the host plants of most species as well as the species that attack cultivated fruits. To fill this gap, native and introduced plant species were collected in several locations. Samples of freshly fallen fruits and fruits randomly picked from the trees were taken. A total of 29 plant species, belonging to 18 genera and 12 families were infested by fruit flies. Nine species of the family Myrtaceae were infested by seven species of Tephritidae. Anastrepha fraterculus, C. capitata, and A. obliqua had the broadest host range, infesting fruits of 19, 16, and 12 species. A total of six tephritid species were found associated to guava (*Psidium guajava*, Myrtaceae), and four to *Pouteria caimito* (Sapotaceae). The data obtained in this survey supplement the host plant list published by Zucchi (2000): the family Caricaceae is reported as a host for Anastrepha fraterculus in Brazil and 19 new records of host fruit tephritid associations are provided:

Index terms: Anastrepha spp., Ceratitis capitata, hosts, survey

[0280] SPATIAL DISTRIBUTION OF ACROGONIA SP., DILOBOPTERUS COSTALIMAI AND ONCOMETOPIA FACIALIS IN BRAZILIAN CITRUS

W. I. Maruyama¹ & J. C. Barbosa², ¹Depto: Fitossanidade - ²Depto Ciências Exatas, Univ. Estadual Paulista (UNESP), Via de Acesso Prof. Dr. Paulo Donato Castellane, s/n. Jaboticabal, São Paulo State, Brazil, 14870-000. E-mail: maruyama@fcav.unesp.br, jbarbosa@fcav.unesp.br. ¹Studentship and financial support from Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP).

Around 22% of orange tree in São Paulo State are infected by Xyllela fastidiosa bacterium, responsable for disease CitrusVariegated Chlorosis (CVC), transmited by Cicadellidae. The objetive of this work was to determine the spatial distribution the vectors Acrogonia sp., Dilobopterus costalimai and Oncometopia facialis. The capture of this insects was performed in orange area with yellow sticky traps, that were located at each plant and ordered in a grade sampling of 100 points in aproximaly 1 ha, at heigth 1,5 m under soil. It was realized sampling on 06/11, 20/11 and 04/12/1999. The statistical analysis was done by using 3 insect vectors and processing the total number of them in one tree (sum 4 traps/plant), total among line (sum 2 traps turn to line), and total among trees (sum 2 traps turn among trees). Vectors average collected at traps were in first, second and third sampling 1.85, 1.76 and 3.03 to total on plant, 0.77, 0.89 and 1.39 total among line, 1.08, 0.87 and 1.64 total among plants. Only the total on plants in the first sampling and total in line second sampling showed random distribution, with Morisita index 1.105 and 1.096 respectively, and showed agreement on Poisson's distribution. The other results are in agreement with negative binomial distribution, with Morisita's index among 1.160 to 1.504, with second sampling in the line (k=4.0) and the total on third sampling (k=1.30)showed behavior aggregation, and the others aggregation was moderate (k>5) with tendency to aleatory. Also we have observed that as the average population improved occourred a tendency to improve aggregation.

Index terms: Cicadellidae, Morisita-index, Citrus-Variegated-Chlorosis.

[0281] PHYTOPHAGOUS PENTATOMIDS ASSOCIATED WITH DIFFERENT LEGUMINOSAE IN PROVINCE OF BUENOS AIRES, ARGENTINA

G. E. Marzorati & G. Liljesthröm, CEPAVE Calle 2 Nº 584 (1900) La Plata. Argentina. E-mail cepave@museo. fcnym. unlp. edu. Ar.

Certain pentatomids are serious pests on different leguminosae cultures. In agroecosystems in the localities of Magdalena and La Plata, cultivated (Medicago sativa, Glycine max and Trifolium repens) and pure patches of spontaneous (Melilotus sp. and Galega officinalis) leguminosae are present. In this study, the densities and spatial distribution of phytophagous pentatomids on different leguminosae patches were analysed between October 1997 and January 2000. Every fifteen days 3 transects (100 m each) were distributed randomly in the 5 leguminosae, and the number of insects recorded. The Shannon index of diversity H, and the Levins niche amplitude index B, were calculated seasonally. M. sativa and T. repens were cut 3 times during the year and fundamentally remained in vegetative stage; G. max was in vegetative stage in summer and reproductive stage in autumn and Melilotus sp. and G. officinalis were in vegetative stage in early spring and in vegetative and reproductive in summer and autumn. All pentatomids were found on the different leguminosae in all seasons and the total number and percentage were: Nezara viridula (n=624; 57.3%), Piezodorus guildinii (n=301; 27.6%), Dichelops furcatus (n=104; 9.5%) and Edessa meditabunda (n=60; 5.5%). In stping H was higher on M. sativa (H=1.24) and Melilotus sp. (H=1.09); in summer on M. sativa (H=1.25) and T. repens (H=1.21), and in autumn in G. officinalis (H=0.88) and T. repens (H=0.79). N. viridula was concentrated on G. officinalis in the spring, and during the summer and autumn, it had a similar relative density on all leguminosae. P. guildinii and E. meditabanda were concentrated on M. sativa during the spring and on T. repens in summer and autumn. D. furcatus was concentrated on G. officinalis and M. sativa in spring, on T. repens in summer and on T. repens and G. officinalis in autumn. B was maximal for D. furcatus in summer (B=3.03) and spring (B=2.25) and for N. viridula in autumn (B=2.63). Results from these experiments show that pentatomid spatial concentration changes seasonally with M. sativa, T. repens and G. officinalis being the 3 most densely populated by the insects, the first one in spring, the second one in spring and summer and the third one in summer and autumn.

Index terms: Phithophagous pentatomids, pest, leguminosae

[0282] THE COMMON PISTACHIO PSYLLA, THE MAJOR PISTACHIO PEST IN IRAN

M.R. Mehrneiad, Pistachio Research Institute, P. O. Box 77175.435, Rafsanjan, Iran.

The common pistachio psylla, Agonoscena pistaciae is the most serious insect pest of cultivated pistachio trees and is distributed throughout all the pistachio-producing regions in Iran Usually the population rapidly increases from early spring. However, the presence of high population densities of psyllid nymphs and adults causes severe problems in kernel development and subsequently bud drop and defoliation occurs, therefore it causes significant economic losses. The common pistachio psylla has two seasonal forms. The winter-form psyllids appear in early October and emigrate towards the overwintering shelters. They are larger with generally darker forewings with brown shading in the cells and pigmented veins. The female ovaries are undeveloped at the time of emergence. The winter-forms appear in the late winter and attack pistachio trees in the early spring, feed on swollen buds, young leaves and shoots and establish the summer-form generation. The insect lays her eggs mainly on the upper surface of the pistachio leaves, but egg laying on the petiole of soft leaves and young succulent plant shoots was observed as well. Eggs are embedded in plant tissue by a very delicate pedicel. Feeding and ovipositing of the psyllids, either winter- or summer-forms, on the stem's tissues or on the base of buds of pistachio trees has not yet been observed. Both stages (nymphs and adults) produce huge amounts of a paste-consistency honeydew that turns to white solid granules immediately after secretion. This species develops and reproduces in the wide range of temperature, and produces several generations during the growth seasons. Natural control is exhibited by several species of parasitoids and predators including; Encyrtidae, Coccinellidae, Chrysopidae, Anthocoridae, Phytoseiidae, Anistidae and Erythreidae in the pistachio orchards

[0284] CHEMICAL CONTROL OF *THIPS TABACI* (THYSANOPTERA: THRIPIDAE) WITH INSECTICIDE CONFIDOR (IMIDACLOPRID), IN POTATO CROP, *SOLANUM TUBEROSUM*

R.S. de Mendonca¹, A.C. Silva², L.O. Salgado², E.C. Teixeira³ & A.P. Botelho⁴, ¹Inst. de Ciências Agrárias, Universidade de Alfenas/UNIFENAS, P.O. Box 23, Alfenas, MG, Brazil, Zip Code 37.130-000, E-mail: fileni@artefinal.com.br; ² Agroteste-Pesquisa e Consultoria, P.O.Box 201, Lavras, MG, Brazil, Zip Code 37.200-000, E-mail: agrotest@ufla.br; ³Trainee of the Univ. de Alfenas/UNIFENAS, Trainee in Machado City.

The focus of this paper was evaluate the efficiency of the insecticide Confidor (Imidacloprid) in the control of Thrips tabaci in potato crop. The trial was set up in Minas Gerais State, Brazil, Machado City, with geographical position defined by the coordinates 21° 40° 40" South latitude, 45° 55' 45" West longitude and altitude of 1096 meters, in South area of Minas Gerais. The potatoes seeds were planted on March 20, 1999, being used the variety Achat. It was used the spacing of 0.80 m X 0.30 m and sowed 15 cm depth. The experiment design used was randomized blocks, with 6 treatments and 4 replications. The treatments in commercial products/ha were 1. Confidor 700 GRDA (20) g); 2. Confidor 700 GRDA (350 g); 3. Confidor 200Sc (700 ml); 4. Confidor 480 SC (300 ml); 5. Temik (15 kg), check; and 6. Control. The Confidor insecticides were applied in spray method with volume of 270 L/ha, and was utilized tlat nozzle number 110-02 driven to the basis of the stem, very close of the soil. The Temik insecticide was applied in the day of the plantation. The evaluations were accomplished with 1, 5, 10, 15, and 30 days after the treatment (DAT). It was collected 10 leaflets by parcels and counted the total numbers of thrips alive with a glass magnifying (20 X). The means were analyzed by the Tukey test (p<0.05) and the efficiency established with Abbott formula. The results showed an efficiency of 100% from the third to the last evaluation for all doses and formulations of the insecticide Confidor, indicating that the treatments 1 to 4 can be recommende for the thrips control in the potatoes crops Index terms: Thysanoptera, Thripidae, insecticide, thrips

[0283] A DOSE RECOMENDATION AND AN EVALUATION OF THE EFFICIENCY OF THE FARM CHEMICAL CONFIDOR (IMIDACLOPRID) TO CONTROL MYZUS PERSICAE (HOMOPTERA: APHIDIDAE) IN THE POTATO CROP SOLANUM TUBEROSUM

R.S. de Mendonca¹, A.C. Silva², L.O. Salgado², D.H. Fileni¹ & E.C. Teixeira³, ¹ Inst. de Ciências Agrárias, Univ. de Alfenas/UNIFENAS, P.O. Box 23, Alfenas, MG, Brazil, Zip Code 37.130-000, E-mail: fileni@artefinal.com.br; ² Agroteste-Pesquisa e Consultoria, P.O.Box 201, Lavras, MG, Brazil, Zip Code 37.200-000, E-mail: agrotest@ufla.br; ³Estagiária da Univ. de Alfenas/UNIFENAS

The aphids have great importance as a viruses vector in the potato crop, being the *Myzus* persicae a vector of large number of virus species, specially the Pumpkin Mosaic Virus (PMV). These phitoviroses are responsible for an important looses in quality and quantity in potato crop. The focus of this study was to evaluate the efficiency and the recommended dose for differents formulations of the farm chemical Confidor (Imidacloprid) to control *Myzus persicae* in the potato crop. The test was set up in Carmo do Rio Claro City, Minas Gerais State, Brazil, during March up to June, 1999. The experimental design was the randomized block experiment with six treatments and four replications. The efficiency of the treatments was evaluated according to the numbers of alive aphids in sample of 10 foliols. It was used the Abbott formula as measure of efficiency and means were separated by Duncan test (p<0.05). It was made six evaluation during the observed period, the results from first, fourth and sixth.

Index terms: Homoptera, Aphididae, insecticides, aphids

[0285] THE SIBERT TECHNOLOGY DIGITAL MICROPROBE (DMP) AND ITS USES IN DETECTING TERMITE GALLERIES, CAVITIES, AND DECAYED WOOD IN TREES, STRUCTURAL LUMBER, AND TRANSMISSION POLES

M. T. Messenger & E. D. Freytag, City of New Orleans Mosquito and Termite Control Board, 6601 S. Shore Harbor Blvd., New Orleans, LA 70126-8012, USA.

The Formosan subterranean termite, Coptotermes formosanus Shiraki (Isoptera: Rhinotermitidae), is one of the most destructive pests of structural lumber in New Orleans and other sub-tropical areas of the southern U.S., including Hawaii. They are also found in trees but their damage potential against living trees is unknown. Locating termite galleries inside trees, structural lumber, and transmission poles can be difficult because of the cryptic nature of termites. Using the Sibert Technology Digital microProbe (DmP), investigators can assess the structural integrity of trees and lumber by locating termite galleries, cavities, and areas of wood decay. The DmP penetrates wood using a 350 mm long, 1.5 mm diameter probe at a constant rate of 7000 revolutions per minute, and with attachments, can penetrate up to one meter. The DmP measures the resistance in the wood, in addition to the pressure required to penetrate the wood. The results from each drilling are recorded using Sibert Technology software and can be graphically displayed in a spreadsheet program using a connected computer. The graph generated by the spreadsheet program shows the state of the wood, including growth rings, which are indicated by peaks of harder wood and troughs of softer wood. Termite galleries and cavities in the wood are indicated by horizontal lines of zero resistance along with a drastic drop in the amount of pressure required. The exact location and width of the termite gallery or cavity can also be determined. The DmP is effective in locating termite galleries inside trees and lumber and is less destructive than other methods. Results from each drilling can be of assistance in legal proceedings over liability of fallen trees, structural lumber, and transmission poles. Treating termite-infested trees, structural lumber, and transmission poles with termiticides becomes an easier task once the location and extent of termite activity is known. Data from using the DmP in New Orleans to locate termite galleries in trees and structural lumber will be discussed. Index terms: decay detecting device, termite detection, termite inspection

[0286] COMPARATIVE STUDY OF BUMBLEBEES AND HONEYBEES EFFICIENCY IN GREENHOUSE MUSKMELON CROPS

A. Mexia¹, S. Albano² & <u>E. Salvado²</u>, ¹Instituto Nacional de Investigação Agrária, Estação Agronómica Nacional, Quinta do Marquês, 2780 Oeiras amexia@isa.utl.pt; ²Instituto Superior de Agronomia, DPPF, Secção de Protecção Integrada, Tapada da Ajuda, 13449-017, Lisboa, Portugal.

In Portugal, honeybees are the pollinators commonly used in muskmelon crop. The application of bumblebee (Bombus terrestris) hives is a practice recently adopted in the pollination of this crop. The daily activity pattern of each pollinator, in this crop, was studied, as well as quantitative aspects of the visits (time per flower, interflower time and number of visits per minute) and qualitative aspects (frequency of foreleg scraping movement of the mouthparts). The honeybee activity pattern, in the studied conditions, demonstrates some advantages in relation to bumblebees: greater number of visits to the staminate and hermaphroditic flowers and in the last ones during the period of higher stigma receptivity. It was also verified that the honeybees presented significantly longer visits. However, the biggest frequency of scraping movement of the mouthparts and the greater number of visits per minute shown by bumblebees demonstrated that those also could be efficient for muskmelon pollination. If muskmelon plants seem to have benefits from the bumblebee visits in qualitative aspects, on the other hand, honeybees did compensate their performance through the high intensity of pollination that provide to the flowers. However this study suggest that the patterns of activity and foraging behaviour, exibited by each pollinator, are flexible to greenhouses conditions and can influence their effectiveness as pollinators.

Index terms: Apis mellifera, Bombus terrestris, foraging behaviour, Cucumis melo

[0288] DAMAGE EVALUATION OF HELICOVERPA ZEA ON THREE CORN HYBRIDS IN DIFFERENT PLANTING TIMES

J. M. Milanez¹ & L. A. Chiaradia¹, ¹Centro de Pesquisas para Pequenas Propriedades -Epagri, 89801-970, Chapecó-SC, Brasil, E-mail milanez@epagri.rct-sc.br

The corn earworm Helicoverpa zea (Lepidoptera: Noctuidae), is reported as one of the main pest on corn crop. The occurence is restricted to the last period of corn crop's development with technological difficulties in controlling the pest, even using chemical products. This study evaluated the number of damaged plants in three commercial hybrid corn, in nine different planting times in 1997/98. The experiment was conducted in the Research Center of Experimental Station for Small Properties - Epagri, located in Chapecó-SC, Brazil. Plants were arranged in a randomised block desing with nine treatments (planting times) and four replicates. The block areas were 27 m² with 0,90 cm between lines and a population of 55.000 plants/ha. The corn hybrids evaluated were: Agroceres 1051 (normal cycle), Cargill 901 (super precocious) and Pionner 3099 (precocious). The evaluation was conducted on the harvest, by counting the number of damaged spike. The results showed that there were significant statistical differences between the percentage of damaged plants and the different planting times for hybrid Agroceres 1051 and Cargill 90. Rates of the damaged spike for Cargill 90, Agroceres 1051 and Pionner 3099 was 17%, 11% and 10%, respectively. The lowest number of damaged spike, for the three hybrid studied, was observed in the first planting time, in August. In the result analysis, the hybrids did not differ significantly with respect to earworm damage, although it was verified that Pionner 3099 was less damaged, while Cargill 90 was the most damaged.

Index terms: corn earworm, hybrid corn

[0287] POLLINATION OF GREENHOUSE TOMATO CROP BY BUMBLEBEES

A. Mexia¹, E. Salvado² & <u>S. Albano²</u>, ¹Instituto Nacional de Investigação Agrária, Estação Agronómica Nacional, Quinta do Marquês, 2780 Oeiras amexia@isa.utl.pt ; ²Instituto Superior de Agronomia, DPPF, Secção de Protecção Integrada, Tapada da Ajuda, 13449-017, Lisboa, Portugal.

In Portugal, the use of bumblebees' hives (Bombus terrestris) for pollination in greenhouse tomato crops is already routine, but little it is known concerning the pollinator activity under these conditions. General aspects of the colony activity at the hive (tunneltraffic) and foraging activity on the crop have been analysed. The guard bee activity was also observed_at the hive entrance. The activity daily pattern at the hive showed a higher activity of the foragers at the beginning and end of the day, which did correspond respectively to the periods of crop flowers aperture and closing in the day. The main registered variations in hive activity, during the study period, were related to different colony developmental phases, reflected by the variation of forager's total population and pollen demands of the colony. The presence of the guard bee in the hive's entrance diminished during the study period, demonstrating a gradual loss of investment in the colony defence, probably because of resources abundance in the crop (pollen) and the little aggressive environment in the greenhouse. The reduction of visit number in the afternoon was related with the intense decrease of pollen amount in the flowers as a result of the high intensity of visits in the morning period. Despite pollination intensity not been equal in the different phases of the study period, the percentage of flowers with visit marks of bumblebees was very high, mainly from 2^{nd} week after the hive installation. At 3^{tu} generation emergency a systematic exit of bumblebees from the greenhouse was registered. These individuals did not carry pollen baskets to the hive. This occurrence revealed that limitations of another resource existed that could not be satisfied inside greenhouse. They exit period of these individuals did not affect pollination activity of bumblebees on the crop since it was in the highest phase. Index terms: Bombus terrestris, pollinator activity

[0289] DO INVERSIONS INCREASE SPRAY DRIFT

D.R. Miller¹, T.E. Stoughton¹, W.E. Steinke², <u>E.W. Huddleston³</u> & J.B. Ross³, ¹Univ. Ct., ²UCD, CA., ³NMSU, NM.

Single spray runs were conducted in a mature pecan orchard with orchard airblast sprayer. Sprays were made 54 m from the downwind edge. Drift was measured 33, 66, 132 and 198 m downwind, using ground plates, high volume air samplers and string. Atmospheric stability was the primary determinant drift on (ground) and above (1.2m) the adjacent field. Drift was approximately double in stable compared with unstable conditions. Drift decreased with higher intensity instability. There was little relationship between the intensity of stability and drift. Wind speed appeared less important than stability. Most of the drift was deposited within 66 m of the orchard edge. Measurable amounts drifted farther. Compared with the amount collected at 33 m and averaged over nine replications, 2.6% of the material on ground plates, 4.2% by high volume samplers and 17.1% by string samplers drifted farther than 198 m.

0290] HF-ENERGY INFLUENCE ON GRANARY PESTS

A.A. Mishchenko*, O.A. Malinin*, I.A. Mashkey*, <u>V.M. Rashkovan</u>**, Y.P. Mazalov***, *Institute of Experimental and Clinical Velerinary Medicine under Ukrainian Academy of Agricultural Sciences, **Kharkov Aviation Institute, ***National Scientific Center" Kharkov Institute of Technical physics".

Ecological and entomological investigations carried out at feed stuff plants, elevators and other grain processing enterprises of Ukraine and South of Russia have shown over 100 kinds of granary pests were found in the researched objects. The most wide-spread insects are representatives of families as Curculionidae, Tenebrionidae Dermestidae, Anobiidae and Cucujidae. Besides, grain and grain products are infected to a great extent with spores of microscopic fungi and bacteria. HF-irradiation influence on Sitophilus granarius L., S. Oryzae L., Tenebrio molitor L., Alphitobius diaporium Pz. Were carried out on devices of Kharkov Institute of Physics and Technics and State Aerospace University "KhAI". Several ranges of wavelength with different power values of the generator were investigated. Grain contamination intensity has reached near 100 pests per 1 kg. Experiments were conducted in 5-6 repeats in a stationary regime. With the usage of generator operating in an impulse regime (frequency 47-48 MGz) the biological influential effect was connected with amplitude of field intensity in the zone of sample. Exposition time doesn't practically influence on increasing of mortality rate of insects. Raising a voltage in a region of sample the mortality rate of insects was being expanded. During the effecting of HF-irradiation with frequency 900-2450 MHz the mortality rate of insects immediately was correlating with exposition and temperature factor. Exposition increasing of grain processing from 5 to 45-60 seconds facilitated the raising of dead insect quantity from 68% to 100%. Grain temperature during this process didn't exceed 45-50°C. The obtained data witness about the fact that in a presence of plasma discharge insects begin to lapse into a shock state /nock-dawn/, and than sometimes after several days their depth occurs. In a case of plasma discharge it was succeeded to obtain entire depth of insects for 3-8 seconds. So, the conducted researches allowed defining new parameters of physical influential factors on insects not connected with heating effect. Authors thank to the Scientific Technical Center of Ukraine for the support in the limits of the project 447 "Grain-Crops Microwave Protection at Agricultural Enterprises of Ukraine"

Index terms: Physical bases, plasma, vacuum, feeds, Lepidoptera.

[0292] NEW TRAPPING METHOD FOR PENTATOMIDAE, COREIDAE AND OTHER HETEROPTERA

<u>R. F. Mizell</u>, NFREC-Monticello, University of Florida, Rt 4, Box 4092, Monticello, FL 32344., USA, E-mail rfm@gnv.ifas.ufl.edu.

Stink bugs (Pentatomidae) and plant bugs (Coreidae) are important pests of a myriad of fruit, nut, vegetable and seed crops throughout the world. Sweep nets, light traps and baits are often used to collect these species. Monitoring methods for this pest group suitable for estimation of population parameters are limited to labor-intensive sampling methods such as limb jarring, sweep net or chemical knock-down using volatile insecticides. New methods are needed to facilitate pest management decision-making. Several recent breakthroughs have led to development of a more promising and efficient monitoring method for stink and plant bugs. The Florida stink bug trap was invented as a modification of the pyramidal (Tedders) trap now used for monitoring many Curculionidae. The trap bottom is pyramidal in shape, 1.22 m in height, and made from 4 mm Masonite sheeting. The pyramidal bottom is painted bright yellow (Glidden 4540 Safety Yellow) which is visually attractive to the bugs. The trap top which serves as the collection device is made of fine wire-mesh window screen and is designed similar in shape and size to the top (collector) portion of the Helicoverpa spp. pheromone trap. The top differs from the Helicoverpa trap top in that it has a flared skirt about 5-8 cm in width around the bottom of the funnel. The entry hole in the screen funnel fits over the trap bottom at its top and enables the bugs to walk into the collection device and traps them. While the trap functions by visually attracting bugs, a pheromone of Euschistus spp. is available and greatly increases trap efficiency for monitoring this genera. Traps baited with pheromone also collect selected parasites (Tachinidae) of stink bugs. In addition to about 15-20 species of phytophagous and predacious Pentatomidae and Coreidae, many species of Reduvidae, and Miridae are also collected in the trap. The trap's design, use and limitations along with some results from monitoring stink bugs in a variety of crops will he discussed.

Index Terms: Euschistus servus, monitoring, stink bug, plant bug

Casilla 555, Santa Cruz, Bolivia: cetabol@daitec.scz.com

[0291] INSECT PESTS ON MACADAMIANUT TREES IN COLONIA SAN JUAN DE YAPACANI, SANTA CRUZ DISTRICT, BOLIVIA

<u>V. Miyasato</u>, O. Mochida, I. Guaman, Y. Hatta & T. Mori, ¹CETABOL, Casilla # 555, Santa Cruz, Bolivia: cetabol@daitec.scz.com

Some seeds of macadamia nut trees (Macadamia integrifolia) were introduced from Hawaii into the Colony in 1965, 1967, & 1971, respectively. CAISY (Cooperativa Agropecuaria Integral San Juan de Yapacani) has commercialized the seedlings to its member farmers since 1989. As of the end of 1999, fiftysix farmers grew the nut trees in 315ha of the colonial area. One of the biggest constraints is insect pests. Some 10-50% nuts were damaged by the sucking of Coreid (Leptoglossus spp., & Sphyctyrtus stral) & Pentatomid bugs (Loxa, Antiteuchus, etc.) in fields. The eggs and nymphs of both Loxa & Sphyctyrtus were found on leaves of macadamia nut trees. However, adults of all these bugs suck on not only the nut seeds of macadamia but also seeds of other plants and survive for longer than one month. They seem to have some host plants other than macadamia. Leptoglossus and Loxa adults attack even mature nuts with hard shells but Sphyctyrtus ones appear to prefer flowers or soft and young seeds. Sphyctyrtus is observed from flowering through harvest, while Leptoglossus is frequently found in seed maturity period. Many seeds damaged by bugs fall in earlier stages before harvesting time (Table 1). Additionally, some species belonging to Isop., Homop. (Aphididae, Coccidae, Diaspididae, Membracidae), Coleop. (Scarabaeidae, Ipidae, Platypodidae, Curculionidae, Cerambycidae, Bupresidae, Chrysomelidae), Hymenop. (Meliponidae), & Lepidop. (Pyralidae, Lycaenidae) were recorded as minor pests. Ants & paper wasps (Vespidae, Polistinae) are frequently troublesome in operation.

IN CENTRAL KALIMANTAN, BORNEO, INDONESIA IN WET SEASON 1997/98 O. Mochida^{1,2}, K. Nakasono¹, Arif R¹, & K. Ueda¹, ¹JALDA, Syuuwa-Siba Paaku-Bldg B 13F., Siba-Kouen 1-2-4, Minato-ku, Tokyo-To, Japan, 105-0011 ² Present address:

102931 YIELD LOSS ASSESSMENT OF UPLAND RICE DUE TO INSECT PESTS

Field trials were conducted at JALDA (Japan Agricultural Land Development Agency) farm (3°58'50''S and 114°53'46''E) at Jorong, C. Kalimantan. The cultivar, Dodokan, was seeded in plots (7.5x5.75m each) with 4 replications under randomized block design Dec 16, 1997 & harvested Apr 7, 1998. Cultural practice was followed to the usual ways carried out at the farm for last 4 years; N, P2O5, & K2O of 69; 46; & 30kg/ha except for insecticide applications. All the experimental plots were covered with nets for preventing bird damages. Heading & maturity were on Mar 18 & Apr 18, \Box 1998, respectively. Four insecticide treatments were tested: no application as untreated check (U), & other three treatments (T1-3) with carbofuran 3G (34 kg/ha) together with or without bensultap 50WP (0.5 kg/ha) for foliar spray certain days after sowing (DAS) as shown in Table 1. When the yield of T3 (maximal protection plots) was 1.84 t/ha or 100 in relative value, that of U plots was only 1.01 t/ha or 54.9. It means that 54.9% of the potential yield was harvested but the other or 45.1% was lost by insect pests, when no insecticide applications, fluctuating between 1.01 & 1.84 t/ha or 54-100% in relative values. Otherwise, yield losses were assessed to be 0 to 44%. Nezara viridula (Het., Pentatomidae) & Sesamia inferens (Lep., Nuctuidae) were major pest species. Leptocorisa oratorius (Het., Alydidae), Conocephalus longipennis (Ort., Tettigonidae), Hysteroneura starine (Hom., Aphididae), Megymenus spinosum (Het., Dinidoridae), etc. were collected as minor pests.

[0294] EFFICIENCY OF SOME CHEMICALS TO CONTROL WHITE FLY, BEMISIA ARGENTIFOLII IN PUMPKIN CUCURBITA MOSCHATA, IN SAN FRANCISCO VALLEY – BRAZIL

J.O.T. Moreira¹ & M. R. Lavorenti², ¹ Dept. de Tecnol. e Ciências Sociais/Univ. do Est. da Bahia, C. Postal 171, CEP 48900-000 Juazeiro-BA-Brasil, E-mail: osmateles@bol.com.br, ² Dept. Técnico da Novartis Biociências S.A. – R. Domingos Ferreira, 222 - sala 101 CEP 51.020-030 Recife-PE-Brasil. E-mail: cleber-oliveira@cp.novartis.com.

The white fly, from Bemisia complex is one of the worst pests in the 20th century. Its spread, in the world, have been happening very fast. Today more than 700 plant hosts are known and the damage are around some billion dollars and Bemisia argentifolii causes the most serious damages in Northeast Brazil. One of the most damaged plant families are the cucurbitaceae, and the pumpkin the most sensible specie, with serious direct and indirect damages. To evaluate some chemicals efficiency in B. argentifilii control in the pumpkin crop Cucurbita moschata, ev. "jacarezinho" a trial was done in an experimental area in Bahia State University in Juazeiro – BA – Brazil. The chemicals were Thiametoxan (ACTARA 250 WG) 400 g/ha squirted; Pyridaphenthion (OFUNACK 400 CE) 150 ml/100 1 H2O; Acethamiprid (SAUROS PS) 50 g/100 1 H2O and 25 g/100 H2O; Imidacloprid (CONFIDOR 700 GRDA) 360 g/ha squirted; Mineral oil (ASSIST) 1.000 ml/100 H2O; Thiametoxan (ACTARA 250 WG) 400 g/ha squirted, followed by weekly aplications intercalating the chemicals: Acephate (ORTHENE 750 BR) 100 g/100 i H₂O; Buprofesin (APPLAUD 250) 150 g/100 i H₂O; Fenpropathrin (MEOTHRIN 300) 30 ml/100 i H₂O and Pyriproxifen (CORDIAL 100 CE) 75 g/100 i H₂O and Carbosulfan (MARSHAL 200 SC) 200 ml/100 | H2O mixed with Bifenthrin (TALSTAR 110 CE) 20 ml/100 1 H2O and a control. There were weekly evaluations, examinating 10 leaves/plot, registering white fly eggs, nynphs and pupae numbers. From the results, was concluded that ACTARA 250 WG a single aplication followed by weekly aplications alternating the cited products was the most efficient treatment to control the white fly, and in the second place CONFIDOR 700 GRDA, ACTARA 250 WG applied each 20 days showed the same efficiency and SAUROS PS in the highest rate. Index terms: pumpkin, Cucurbita, white fly, Bemisia

[0296] EFFICACY EVALUATION OF KARATE ZEON 50 CS FOR THE CONTROL OF Dilobopterus costalimai, INSECT VECTOR OF CVC IN CITRUS

O. Nakano¹, R. K. Atarassi¹ & A. C. P. Florim¹, ¹Dept. of Entomology, Fitopatology and Agricultural Zoology, Univ. of São Paulo - ESALQ/USP, Av. Pádua Dias 11, P. O. Box 9, Piracicaba, São Paulo, Brazil.

Citrus Variegated Chlorosis (CVC) has become one of the main phytossanitary problems of Brazilian citriculture today. In 1987, the disease was observed in the center of the main citrus growing region in Brazil and losses for the last 5 years (Fundecitrus) are estimated in, at least, 360 millions of dollars. Up to the moment, 11 species of leafhoppers that transmit this disease (Xylella fastidiosa - bacteria) were found. A possibility to avoid this disease consists in the elimination of the leafhoppers, of which D. costalimai is one of the main species. However, for a more efficient and economical control it is necessary to control this pest at the adequate moment, since it occurs during the whole year, mainly during sprouting, from which they suck the sap. Citrus plants sprout 4 to 5 times a year and the first sprouting occurs after winter and so, insecticide spraying during spring can interrupt the leafhoppers cycle and prevent F2 generation and successive infestations. Such handling is viable because the biological cycle of the leafhoppers is relatively long, of about 50 days. Due to its performance, Karate Zeon 50 CS (Lambdacyhalothrin) is one of the viable insecticides to control this species of leafhoppers. This is because its acaridstatic effect, that is, it does not cause an unbalance favoring phytophagous acarids, which are very common on citrus plantations. Moreover, it is a microencapsulated product, resulting in less toxicity during application and higher residual effect, providing improved contact efficacy in the long term. The tests were conducted at the doses of 10-20-30 and 40 ml of the commercial product for 100 L of dilution, using ECHO motor knapsack spray, fitted with 3 conic nozzles, model X-6, at the pressure of 75 lb/pol², and at the flow rate of 1000 L/ha. Each parcel consisted of 5 adult leafhoppers inside tulle bags, on the sprouts, 4/treatment. Deaths were evaluated through direct contact of the spray with the adults and through indirect contact at 1-3-8 and 12 days after spraying. The results showed that Karate Zeon 50 CS was highly efficient through direct contact 3 days after spraying, even at the lowest dose, 10 ml of the commercial product/100 L of spray. This is a bacterium transmitting pest and therefore, the residual effect is necessary for a lasting control. The dose of 40 ml of the product/100 L of dilution can be recommended to be sprayed onto the sprouting, a point of frequent access of adults, with the residual of up to 12 days. Key words: citrus, leafhoppers, control, Lambdacyhalothrin

[0295] BIOLOGICAL ACTIVITY OF ORANGE MOTII, *ECDYTOLOPHA* AURANTIANUM, WHEN SUBMITED TO THE PHYSIOLOGICAL INSECTICIDE - METHOFENOZIDE

O. Nakano¹, F. C. Rutkósky¹ & A. C. P. Florim¹, ¹Dept. of Entomology, Fitopatology and Agricultural Zoology, Univ. of São Paulo - ESALQ/USP, Av. Pádua Dias 11, P. O. Box 9, Piracicaba, São Paulo, Brazil.

The orange moth, from the Lepidoptera Order, Family Oleuthretidae, has a larva which is known to damage the citrus fruit. It's been found also, but not so often in lichy and guava. The population in citrus usually gets higher when the prices get lower, then the fruits are left in the orchard, exposed to the worm attack. When there is a large population the control becames harder, once the worm doesn't need much time to penetrate the fruit. Once inside the fruit, the worm is protected from the insecticide action. Because of it's sterilizing propriety on the moth, the physiological insecticides advent, allowed a rational pest control management. Males and females were isolated in cages treated with different dosages of Methofenozide (ecdise agonist hormone) during 48 hours, to assure the moth contamination. After that, males and females were placed together to reproduction. Another treatment consisted on direct insecticide pulverization over the adults. The treatment dosages were: 1)Methofenozide 240 SC - 18,75 ml/100l; 2)Methofenozide 240 SC - 37,5 ml/100l, both in total cage immersion; 3)Methofenozide 240 SC - 18,75 ml/100l, pulverized over the adults; 4)Check. During the every day eggs evaluation, 25 eggs were collected per parcel and placed in Petry box with filter paper to observe the moth eclosion. As soon as the moth was born, it was taken to an artificial diet to evaluate the treatment effect. The results demonstrated that 12 days after the emergence of adults the indirect contact of the insecticide over the adults killed 40% of the population when the lightest dosage was applied and 50% with the strongest dosage (check population lived 22 days). The adult pulverization (direct contact) did not show any difference from the check, in the indirect contact. No eggs production were found when the strongest dosage was applied and under the lightest dosage, eggs were displayed during the first 3 days, but 8 times minor than the normal population and no more eggs appeared after the third day. The direct contact treated moth produced eggs during the first 4 days, than stopped and presented a number of eggs 10 times minor than the check. Although the treatment reduced the egg production, the larva that made up to moth, also made up to pupae and emerged normally. The conclusion was that the physiological insecticide Methofenozide, when applied as recommended, acts quite efficiently over the adult of Ecdytolopha aurantianum, either by direct or indirect contact, with only 1.17% of viable eggs. Key words: Ecdytolopha aurantianum, methofenozide, citrus, sterilizing

[0297] EFFECT OF DIFFERENT DOSAGES OF NOVALURON (RIMON 100 EC) FOR SPODOPTERA FRUGIPERDA CONTROL IN CORN AT LONDRINA - PR -BRAZIL

<u>P. J. Neves</u>¹; M. U. Ventura¹ & M. Cassinelli², Depto. Agronomia, Univ. Est. de Londrina, C.P. 6001, Londrina, PR 86051-970, Brazil. E-mail pmojneve@uel.br;² Milenia Agro Ciências S/A R. Pedro Antônio de Souza 400 Londrina – Pr 86031-600 – Brazil.

The army worm Spodoptera frugiperda is the most important pest of corn in Brazil. This pest promote significantly yields reductions under severe infestation. This research was carried out to evaluate the efficiency of different insecticides for *S. frugiperda* control in corn. Cultivar Premium was used. Plots size were $(0.90 \times 6m) 5.4 m^2$. The experiment was carried out at the School Farm of Univ. Estadual de Londrina. The treatments used were : Novaluron (Rimon 100 EC) in the dosages of 7,5; 10; 15 and 20 g a.i /ha, Lufenuron (Match 50 EC) - 75 and 150 g a.i./ha, Clorpiryphos (Clorban EC) - 288 g a.i./ha, Clorfluazuron (Atabron 50 EC) - 500 g a.i / ha, and the control (only water). Lufenuron (Match 50 EC) and Clorpiryphos (Clorban EC) - were the standard treatments. Six plants per plot were assessed before and 3, 5, 7, 9, and 13 days after spraying. The worm number was divided in small worms (<1,5 cm) and big ones (>1,5 cm). For big worms significant differences were obtained from 5 to 13 days after spraying among all insecticide treatments and the control. All products kept the big worms under control. (Match 50 EC) - 150 days after spraying, levels of 80% control efficiency (Abbott) or bigher were observed for Novaluron (Rimon 100 EC) in all dosages and for Lufenuron (Match 50 EC) - 150 g, a.i./ha. Novaluron (Rimon 100 EC) in the dosages of 7,5; 10; 15 and 20 g. a.i. fha had efficiency levels equivalent with the standard products. Index terms : insect; growth regulaters, ecdyse inhibitors, army worm.

<u>O. Nakano¹</u>, C. F. Poletto¹ & G. G. F. B. de Oliveira¹, ¹Dept. of Entomology, Fitopatology and Agricultural Zoology, Univ. of São Paulo - ESALQ/USP, Av. Pádua Dias 11, P. O. Box 9, Piracicaba, São Paulo, Brazil.

In 1987 some citrus orchards in the State of São Paulo was striked by a bacterial disease classified as Xylella fastidiosa, the bacterium responsible for "CVC". One of the manners to control the disease is it's vectors elimination, known to be at least 11 different sharpshooters species. It usually happens to find a large adult population in a citrus orchard, but we do not find a similar nymph population, and at the same it's noticed that when we have a forest near by the orchards the populations is always larger than in orchards without contact with forests, what make us believed that the procreation take locations in other hosts. Due to this it's been developed a way to sterilize the adults. Some different insecticides were tested, on 3 different sharpshooters species: Acrogonia terminalis; Dilobopterus costalimai and Oncometopia facialis. The treatment dosages were: 1)Applaud 250 PM (Buprofezin) - 1,5 g; 2) Interpid 240 SC (MethoGenozide) - 0,27 ml; 3) Match 50 g/L (Lufenuron) - 1,20 ml; 4)Cordial 100 CE (Pyriproxifen) - 0,75 ml; 5)Neem 4000 (Azadiracthin) - 40,0 ml (tested only on D. costalimai). All of those dosages are correlated to 1 liter of water; 5) Check. The A. terminalis specie has shown a greater mortal rate when submited to Match followed by Applaud and Cordial. The D. costalimai happened to be more sensible to Neem than to the Intrepid. For the O. fascilais the best result was from Cordial, than Applaud, than Match. While that D. costalimai has not been affected by the insecticides, except for Neem and Cordial, either for adults or nymph. Cordial affected the A. terminalis adults, but to the nymph control, Applaud, Cordial and Match demonstrated better results. Finally, O. fascialis seemed to live even better when applied Cordial and Intrepid, only Match could affect the nymphs. Key words: physiological insecticides, sharpshooters, CVC, citrus.

[0299] BIONOMY OF THE BOLL WEVILL REARED ON ARTIFICIAL DIET

<u>S. D. N. Nobre</u>, E.R. Sujii, F. G.V. Schimidt, S. Dias; R. Lauman, O.B. Oliveira Neto, M.F. Grossi de Sá & R. Monnerat, Embrapa Recursos Genéticos e Biotecnologia, SAIN Parque Rural, Caixa Postal 02372. Brasília, DF, e-mail: rose@cenargen.embrapa.br

Studies about the bionomy of the boll wevill, Anthonomus grandis (Col.: Curculionidae) reared on artificial diet are fundamentals to obtain standardized individuals in adequate quantities for evaluation of microorganisms as potential biological control agents. The mass rearing is being developed on insectarium with temperature of 25°C, relative humidity of 60% and photophase of 12h. The insects are fed with the artificial diet that consists on a mixture of soybean crumb, seed of wheat, glucose, cotton seed crumb and supplement of minerals and vitamins. The life cycle of boll wevill was 5,47 days in average for the egg stage and 15 days for the stages of larvae and pupae. On the adult stage, the average period of pre oviposition was 5,6 days, oviposition 60,6 days and post oviposition 15,12 days for the females. The oviposition started four days after adults emergency, noticing that, in average, the population produced more than 90% of the eggs until 73 days after the emergency. The average number of eggs produced were 129,64 with variation range between 11 and 260 eggs. The average longevity of the adult stage was 80 days for the females and 61,96 days for the males and sexual ratio of 0,4313 (females/males +females). Based on the survival curve of the boll wevill, the intrinsic growth rate of the population was 5,24. It was observed an increase in adaptation of the insects to the artificial diet, considering the improve of their fitness through the generations

Index terms: Anthonomus grandis, life cycle, biological control

[0300] PROSPECTS FOR BIOLOGICAL CONTROL OF THE WHITEFLY BEMISIA TABACI WITH PHYTOSEIID PREDATORS

<u>M. Nomikou</u>, A. Janssen, R. Schraag & M. W. Sabelis, IBED, Univ. of Amsterdam Post box94084, 1090 GB Amsterdam, The Netherlands. E-mail: nomikou@bio.uva.nl.

Bemisia tabaci is a relatively new pest in greenhouses in the Netherlands (Fransen, 1994) and the currently used Biological Control Agents (BCA's) of whitefly are either insufficient or economically unfeasible (Szabo et al. 1993, Drost et al. 1998, Hoddle et al. 1999). Predatory mites of the family Phytoseiidae have been reported to feed and/or oviposit on whitefly prey (Teich 1966), yet have never being used as BCA's of whitefly. We investigated the possibility of using predatory mites against B. tabaci as they are associated with this prey, they are cheap and easy to rear and they have proven to be successful BCA's against various other pests *e.g.* spider mites, thrips. We collected predatory mites that co-occur with whiteflies in the Middle East area and 5 different species were identified, with one to six different strains of each species. Six selection criteria were formulated in order to evaluate phytoseiid mites as BCA's of whitefly: their capacity to suppress local whitefly populations; their efficiency at detecting local whitefly populations; their ability to control whitefly throughout a greenhouse; their ability to use alternative food; their compatibility with other natural enemies; and their ability to control a similar pest e.g. Trialeurodes vaporariorum, the greenhouse whitefly. Here, we present results from laboratory tests and small-scale greenhouse experiments with the collected predators and we discuss the perspectives of biological control of B. tabaci with predatory mites

[0301] SUBIRRIGATION APPLICATION OF IMIDACLOPRID FOR CONTROL OF BEMISIA ARGENTIFOLII

<u>R. D. Oetting</u>¹ & M. W. van Iersel¹, ¹Dept. of Entomology, ¹Dept. of Horticulture, Univ. of GA, GA Exper. Stn., 1109 Experiment St., Griffin, GA 30224, USA

Subirrigation systems can be used to apply systemic pesticides to greenhouse crops without pesticide runoff and with reduced worker exposure. However, there is little information on the plant uptake or efficacy of pesticides applied by subirrigation. The objective of this study was to determine whether silverleaf whiteflies, Bemisia argentifolii, on poinsettia, Euphorbia pulcherrima, can be controlled with imidacloprid applied by subirrigation. In experiment 1 different amounts of imidacloprid solution uptake by the growing medium were obtained by not watering the subirrigated plants for 0, 1, 2, or 4 days before the imidacloprid application. These treatments were compared with untreated control plants and plants that were treated with a standard drench application (100 ml) to the top of the growing medium. There was a reduction of imadacloprid in plant tissue from 3 days to 63 days after application with the standard drench treatment. The amount of imidacloprid increased during the same period with subirrigation. All imidacloprid treatments resulted in a significant decrease in both the survival of adult whiteflies and number of immature whiteflies on the plants. Subirrigation treatments resulted in better control of adult and immature whiteflies than the drench application. Withholding water for 2 or 4 days before the imidaeloprid application by subirrigation improved control of immature whiteflies. In a second experiment 100 ml of imadacloprid solution was applied either to the surface of the potting medium or by subirrigation. The plants were watered by the same method as application. Leaf tissue analysis and efficacy were determined for leaf tissue at different levels in the plant architecture. At the end of the experiment, imidacloprid was more concentrated in the Joan architecture. At the end of the experiment, imidacloprid was more concentrated in the lower plant tissue when applied to the medium surface and in the upper leaves when applied by subirrigation. Survival of adult and immature whiteflies was low with both application methods but lowest with subirrigation application. This indicates that the application of imidacloprid to poinsettia by subirrigation is a practical and efficient method to control silverleaf whiteflies. Index terms: Silverleaf whitefly, ebb-and-flow, systemic insecticide, insecticide application.

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[0302] INSECTS ASSOCIATED WITH TOBACCO CULTURE WITHOUT CHEMICAL MANAGEMENT IN MISIONES ARGENTINA

D. V. Ohashi, C. L Fernandez Diaz, R. A. Vallejos, J. Verón, F. Mamani & M. Ledesma, Convenio CoTTaProM-FCEQyN. FCEQyN. Univ. Nacional de Misiones, Felix de Azara nº 1552. (3300) Posadas, Misiones, Arg. Tel: 0054-3752-422186. Fax: 0054-3752-425414. E-mail: ecologia@fceqyn.unam.edu.ar

Tobacco (Nicotiana tabacum) culture is widely spread around the province. There are 17.239 tobacco's farmers with 1,5ha each approximately, in many of the cases tobacco production is the most important money income for them; that is why it needs a lot of basic studies for efficient insect management. The objetive is to start studies knowing the entomofauna associated with tobacco culture and to know interactions between perjudicial and beneficial insects without any agrochemical management. We installed and compared two parcels with different management (without any agrochemicals and a conventional one) in three farmlands in southwest of Misiones (Feltan's farm, Cooperativa's farm and Melzew's farm). We made direct observation from september, 17th to december 16th of 1997. Here we will present the first one because there we were able to observe perjudicial and natural enemics interactions. Leaf damage: Caeporis stigmula, Cerotoma sp., Colaspis aemula, Diabrotica speciosa, Epitrix sp. y Lema biliniata? (Coleoptera: Chrysomelidae), Epicauta atomari (Coleoptera: Meloidae), Jalisus sobrinus (Hemiptera: Neididae), Dichelops furcatus, Edessa meditabunda y Nezara viridula (Hemiptera: Pentatomidae), Macrosiphum euphorbiae, Myzus persicae y Myzus nicotianae (Homoptera: Aphididae), Manduca sp. (Lepidoptera: Sphingidae), Spodoptera frugiperda (Lepidoptera: Noctuidae), Chromaeris speciosa y Ommexechia vitens (Orthoptera: Acrididae) y Thrips tabaci, (Thripidae: Thysanoptera). Inferior part of the stem damage: Agrotis ipsilon (Lepidoptera: Noctuidae), Conoderus sp. (Coleoptera: Elateridae), Faustinus cubae (Coleoptera: Curculionidae), Lagria villosa (Coleoptera: Lagriidae) y Neocurtilla hexaductylla (Orthoptera: Gryllotalpidae). Flower damage: Jalisus sobrinus (Hemiptera: Neididae), Myzus persicae y Myzus nicotamae (Homoptera: Aphididae). Natural enemies: Nimphs and adults of Cosmoclopius nigroanulatus (Hemiptera: Reduviidae) as Epitrix sp.'s predators. Complex of aphids (Myzus persicae, M. nicotianae and Macrosiphum euphorbiae) predated by larvae of Allograpta oblicua? (Diptera: Syrphidae), larvae and adults of Cicloneda sanguinea, Eriopis connexa, Hippodamia convergens (Coleoptera: Coccinelidae) and, nimphs and adults of Zelus sp. (Hemiptera: Reduvidae). Larvae of Manduca sp. parasited by Cotesia sp. (Hymenoptera: Braconidae). Some natural enemies were also found in the conventional management parcel, but with less density. Index terms: Nicotiana tabacum, biological control, pest, natural enemies.

[0304] PERFORMANCE AND FEEDING PREFERENCE OF NYMPHS AND ADULTS OF *PIEZODORUS GUILDINII* (HEMIPTERA: PENTATOMIDAE) ON SOYBEAN PODS AT DIFFERENT DEVELOPMENTAL STAGES

E.D.M. Oliveira¹ & A.R. Panizzi², ¹Universidade Estadual de Londrina, Departamento de Agronomia, Caixa Postal 6001, Londrina, PR, 86051-970, Brasil. E-mail: emerson@enpso.embrapa.br. ²Embrapa-Soja, Caixa Postal 231, Londrina, PR, 86001-970, Brasil. E-mail: panizzi@enpso.embrapa.br.

A study was conducted in the laboratory to test the suitability of soybean (Glycine max) pods at different phenological stages of development (R3-R8) on the performance of nymphs and adults of the small green stink bug, *Plezodorus guildinii* (Hemiptera: Pentatomidae). In the field, a survey was carried out to determine the population fluctuation of this stink bug with relation to the soybean plant phenology. In the laboratory, nymphs showed a better performance when fed soybean pods during the podfilling stage (R5-R6), compared to the remaining stages of pod development. Despite nymphs required similar time to complete development and attained similar body weight at adult emergence, mortality was smaller at stage R6 (47.5%) than on the remaining stages of pod development. On soybean pods without seeds (R3-R4) and on soybean pods mature (R8) nymph mortality was 100%. On soybean pods beginning maturation (R7) and on soybean seeds mature, mortality reached 81.7 and 76.7%, respectively. When pod pilosity was removed, nymph mortality on soybean pods at R6 increased to 60.0%, and decreased to 35% on soybean pods at R6 with pilosity. P. guildinii adults showed better performance on soybean pods at stages R5 and R6, compared to soybean pods at R3, R4, R7, R8, and mature seeds (R8MS). Females and males showed greater longevity when fed on soybean pods at R5; 50% of females oviposited when fed on soybean pods at R5, and no females oviposited when fed on soybean pods at R3 or R4; at R7, 20%; at R6 45% of the females oviposited; at R8, 10%, and on R8MS, 5% of the females laid eggs. Preoviposition period was shorter when females fed on soybean pods at R6 and longer when they fed on soybean pods at R7. Mean number of egg masses and total number of eggs was greater for females fed on soybean pods at R5; greater female body weight was observed on soybean pods at R6 at day 29 of adult life. P. guildinii showed greater feeding activity on soybean pods at R5, and visited more often soybean pods at R6, than soybean pods at R3, R7 or R8. Adults colonized soybean from the beginning of pod filling (R5), and nymphs from the period pods were completely filled (R6); both, nymphs and adults peaked at maturation (R8). These results indicate that P. guildinii nymphs and adults show a better performance when fed on filling soybean pods, and, when the pods are elongating or maturing, the performance is less satisfactory.

Index terms: Heteroptera, Glycine max, stink bug, biology

[0303] INSECTS RELATED TO BEAN AND CUCUMBER INTERCROPPING CULTURE IN MISIONES, ARGENTINA

D. V. Ohashi^{1,2} & E. Steger², ¹Fac. of Exact, Chemical and Life Sciences (FCEQyN – UNaM). Felix de Azara 1552, (3300) Posadas, Misiones, Argentina. Fax: 03752-425414. E-mail: ecologia@fceqyn.unam.edu.ar.² Agricultural Experiment Station Cerro Azul INTA, C.C. Nº 101, L.N. Alem, Mnes., Arg. Tel/fax: 0054-3754-22787. E-mail: vitrocultivo@cerro.inta.gov.ar

Horticulture grew up in the state of Misiones (Argentina) from 10,58ha during 1995 to near 22ha in 1997. Horticulture Project at EEA Cerro Azul INTA started with culture experience, where entomological observation were made for the necessary basic needs of farmers. So, a bean (Phaseolus vulgaris) and cucumber (Cucumis sativa) associated culture was installed inside a greenhouse, looking for cultures not interfering between them when used in the same greenhouse without sanitary troubles. The objective was to identify harmful and beneficial insects in relation to the intercropping system. Weekly samplings using direct and indirect observations (Moericke traps) were made in a mixed bean and cucumber culture, from March of 1997 to March of 1998. The harmful insects associated with bean culture were: Picturaphis brasiliensis (Homoptera: Aphididae); Calliothrips phaseoli (Thysanoptera: Thripidae); Diabrotica speciosa, Cerotoma sp., Maecolaspis sp., Epilachna cacica (Coleoptera: Chrysomelidae); Dichelops furcatus, Nezara viridula (Hemiptera: Pentatomidae); Lagria villosa (Coleoptera: Lagriidae) and Urbanus proteus (Lepidoptera: Hesperiidae). Associated with cucumber were: Aphis gossypii (Homoptera: Aphididae); Diaphania nitidalis (Lepidoptera: Pyralidae); Pseudoplusia includens (Lepidoptera: Noctuidea); Frankliniella schultzei (Thysanoptera: Thripidae), Anastrepha grandis (Diptera: Tephritidae), Idiysus sobrinus (Heniptera: Neididae); Diabrotica speciosa, Epitrix sp. and Cerotoma sp. (Coleoptera: Chrysomelidae). The natural enemies against P. brasiliensis at the bean culture were Pseudodorus clavatus, another unidentified hoverfly (Diptera: Syrphidae) and Symmus argentinicus (Coleoptera: Coccinelidae). Predators of Aphis gossypii in cucumber culture were P. clavatus, Ocyptamus antiphates, Syrphus phaeostigma (Diptera. Syrphidae) and S. argentinicus (Coleoptera: Coccinelidae). As parasitoid we found: Diaeretiella rapae (Hymenoptera: Aphidiidae). Both cultures can grow in the same greenhouse, because the only common harmful insects were D. speciosa and Cerotoma sp. They are poliphagous and they do not produce important damages to those cultures, apart from that, P. clavatus and S. argentinicus were common natural enemies for both. Index term: harmful insects, beneficial insects, mixed cultures.

[0305] CICADELLIDAE (INSECTA-HOMOPTERA) SPECIES RICHNESS AND ABUNDANCE ON MAIZE IN ARGENTINA

S. Paradell¹, E. G. Virla² & A. Toledo¹, ¹ Dept. Cient. De Entomología, Fac. de Cs. Naturales y Museo de La Plata, Paseo del Bosque s/nº (1900) La Plata, Argentina, E-mail: paradell@museo.fcnym.unlp.edu.ar, ² CONICET. "INSUE", M. Lillo 205 (4000) S.M. de Tucumán, Argentina, E-mail: evirla@infovia.com.ar

Among the plant virus vector taxa known, 80% belongs to the Suborder Homoptera and between them, 70% correspond to the family Cicadellidae. Leafhoppers affect diverse cultivation, and particularly the maize (Zea mays), whose production is severely diminished by diseases of diverse etyology. Among these, the most important diseases are the "Corn Stunt Spiroplasm" and several phytoplasms that are transmitted, in persistent form, by leafhoppers of the genera *Dalbulus*, *Baldulus*, *Exitianus*, *Stirellus* and *Graminella*. In Argentina, the only known Cicadellidae species with vector capacity is Dalbulus maidis, an important pest in tropical and subtropical areas of America; but surely there are several other species involved in the epidemiology of the corn spiroplams or phytoplasm-bored diseases. Due to the importance of the diseases and the lack of information about the leafhopper fauna that inhabits maize crops in Argentina, a survey was carried out in order to know the species communities composition. The leafhoppers collected with entomological nets in 33 localities of 11 provinces of Argentina, during 1993-94, 94-95, 95-96 and 98-99, were examined in terms of species richness and abundance. Overall, 17 species were detected. The most abundant species is Empoasea curveola with (23%) of relative abundance, followed by Exitianus obscurinervis (20%), Haldorus sexpunctatus (19%), Dalbulus maidis (16%), Syncharina punctatissima (9%), Agalliana ensigera (4%) and Graminella puncticeps (1%). The study determines differences between areas, and fenological stages of maize; the information is shown in tables and maps. The known geographical distribution of Dalbulus maidis is enlarged. Index terms: Leafhoppers, maize, pests species.

Symposium and Poster Session

[0306] CHEMICAL CONTROL OF THE BOLLWEEVIL, ANTHONOMUS GRANDIS, WITH PYRETHROIDS

A. Pasini, M. U. Ventura & P. M. O. J. Neves, Depto. Agronomia, Univ. Estadual de Londrina, C.P. 6001, Londrina-PR, CEP 86051-970, Brasil. E-mail: pasini@uel.br

This study was conducted in a school farm at the State University of Londrina, Paraná, to verify the efficiency of pyrethroids in the control of bollweevil, Anthonomus grandis. The cotton variety IAC-22 was planted on 10/4/1996. It was employed the randomized complete block design with four replications and five treatments. Experimental units of 9 m by 8 m long with 0,9 m between rows was used. The following products were tested: Karate 50 CS (lambdacyhalothrin,15 g a.i./ha), Karate 250 CS (15 g a.i./ha), Karate 50CE (15 g a.i./ha), Decis 50 SC (Deltametrina, 10 g a.i./ha), Decis 25 CE (10 g a.i./ha). The applications was accomplished on 11/29/1996, 12/6/1996, 12/13/1996, 12/19/1996 and 1/3/1997. Data were submitted to analysis of variance and the means were classified by Tukey's multiple range test at 5% probability level. All the treatments with pyrethroids were efficient to control the bollweevil. However the largest efficiency were showed by the products: Karate 250, Karate 50 and Decis 50, employe in the formulations CS and SC, respectively.

Index terms: pyrethroids, Anthonomus grandis, cotton, chemical control.

[0308] MACROFAUNA OF THE SOIL IN DIFFERENT TILLAGE SYSTEMS, IN OXYSOL OF PARANÁ, BRAZIL

A. Pasini, N. P. Benito & E. P. Melo, Dept. of Agronomy, State Univ. of Londrina, P.O.BOX 6001, Zip Code 86051-970, Londrina, Paraná, Brasil. E-mail: pasini@uel.br

A study was conducted to analyze the biomass and the spineless macrofauna populational density of soil in different agricultural tillage systems, in an area with oxysol (latossolo roxo) in Bela Vista do Parafso, PR. The treatments were: conventional, no tillage and an area with forest. Sampling has been done using the method recommended by the Tropical Soil Biology and Feitility Programme. Five monoliths of soil (25x25x30 cm) were taken at regular 10 m intervals; each soil monolith was separated in three layers: 0-10cm, 10-20cm and 20-30cm, in two seasons of the year (wet and dry). The taxonomic groups more frequent were Oligochaeta, Hymenoptera, Coleoptera, Isoptera, Diplopoda, Chilopoda, Diptera, Hemiptera, Arachnid and Molluse. In the forest, the biomass and populational density, were superior statistical to the other treatments. However, conventional and no tillage systems were similar to each other.

Index terms: soil macrofauna, land management, latossolo, taxonomic richness.

[0307] CHEMICAL CONTROL OF THE VELVETBEAN CATERPILLAR, ANTICARSIA GEMMATALIS WITH PYRETHROIDS

A. Pasini, M. U. Ventura & P. M. O. J. Neves, Depto. Agronomia, Univ. Estadual de Londrina, C.P. 6001, Londrina-PR, CEP 86051-970, Brasil. E-mail: pasini@uel.br

Field experiments were conducted in Parana State, at the State University of Londrina, in Brasil to evaluate the efficiency of pyrethroids in the control of the velvetbean caterpillar, Anticarsia gemmatalis (Lepidoptera: Noctuidae). The variety BR-4 was planted on 10/22/96. Experimental units of 6m by 15m long, with 0.4m between rows was used. The applications was accomplished on 11/18/1996, in the vegetative stage. The following treatments were used: Karate 50 SC (lambdacyhalothrin, 3,75 g a.i./ha), Karate 250SC (3,75g a.i./ha), Karate 50 CE (3,75 g a.i./ha), Bulldock 125 SC (Betacyfluthrin, 2,5g a.i./ha) and Corsair 500 CE (Permethrin, 15,0 g a.i./ha). Four samples were taken in the central rows of each plot, being used ground cloth method. Data were submitted to analysis of variance and the means were classified by Tukey's multiple range test at 5% probability level. All the treatments with pyrethroids were efficient in the control of velvetbean caterpillar.

Index terms: pyrethroids, chemical control, Anticarsia gemmatalis, soybeans.

[0309] PEST IDENTIFICATION AND MONITORING ON A IRRIGATED AGRICULTURAL SYSTEM AT BAIXO ALENTEJO (PORTUGAL)

M. I. Patanita¹ & M. M. Pereira¹, ¹Escola Superior Agrária de Beja, Rua Pedro Sores, Apartado 158, 7801-902 Beja Portugal. E-mail: ipatanita@esab.ipbeja.pt

Changing the present extensive agricultural systems existing in Alentejo, into new and more productive irrigated systems, implies a deep knowledge of the crop systems used, its sequence in time and the local agricultural techniques in order to provide a greater profit to local farmers. The success of a well adapted crop system, for well-known climatic conditions and landscape structure is prone to imply, the correct knowledge of crop pests forecasts, its natural enemies and also about the multiple interactions that may be detected in such crop systems, between the crop, the crop enemies, their antagonists and their habitat. Integrated in a project of the technical and the economic viability of an irrigated crop system with cereals and field vegetable crops, which was based on Integrated Production guidelines, we have developed a fieldwork in order to: identify the most important pests problems for the crops considered in that project (tomato, wheat, sugar beet, maize and one cruciferous crop) and its natural enemies; and to study their populations dynamics, including the crop-pests -beneficial organisms-habitat interactions. For these purposes, we have monitoring the crops pests and their natural enemies using a lot of insect trap types, according to the insects features, the visual observation to detect the first infections, and also some of the existing and validated forecasting models for pests activity. The methodology used in this field followed as much as possible, the guidelines, the methods and the models published and approved by the International Organisation for Biological and Integrated Control of Noxious Animals and Plants/ West Palaearctic Regional Section (IOBC/WPRS) for Integrated Production.

Index Terms: irrigated crops, crop enemies, Integrated Production, pest monitoring.

[0310] LITCHI INSECT PESTS RESEARCH AND CONTROL

T. X. Peng ' & J. L. Xu², 'Guangdong Academy of Sciences, 100 Xian lie Rd. C.,Guangzhou 510070, China, E-mail txpeng@gis.sti.gd.cn; ²Guangdong Institute of Entomology, 105 Xingang Rd. West, Guangzhou 510260, China, E-mail jlxu@gei.gis.sti.gd.cn

The litchi tree is from China originally, and China has the history that the litchi is planted more than 2000 years. At present, no matter planting area of litchi and output, China all is the first in the world. In China, the litchi insect pests have 83 species which belonging to 7 orders, 30 families according to the investigations. Among them the important species are Tessaratoma papillosa, Aristobia testudo, Amplophora chinessis, Conopomorpha sinensis, Eriophyes litchii, Lepidarbela dea, Oxyodes scroliculata, Orgyia postica etc. The dominant litchi pests are belonging to Coloeptera, Heminoptera, Lepidoptera and Acarina which cause loss rate reaching 20 - 30% . A large number of insecticides used in the past many years for control litchi pests and the big areas of litchi trees linking planted, that makes the change of insect component in litchi garden. Some secondary pest rise to the primary position. Population dynamics of litchi pests changed obviously following seasons. Dominant species degree index D reaches to 0.8 or more from March to September every year and the highest value of diversity index H'= 4.1 by May and June ... The measurement of diversity index indicates that leaf surface>flower and fruit>trunk>underground pests , and H 'value of leaf surface reaches 4.0 .Most of insect pests concentrates occurring in new tip period , florescence and fruit period , thus influences to output seriously. China is the earliest country to study and use biological control for litchi pests. At the initial of 60's successfully has used Anastatus japonicas to control Tessaratoma pupillosa, and has established 1 set of method to culture and release Anastatus. At 80's in China Anastatus has been cultured with the artificial eggs and has been produced by machine. Entomopathogenic nematodes Steinernema carpocapsae has been used to control Aristobia testudo, Lepidarbela deu ,Zeuzea coffeae in a large area successfully, control efficacy reached to 80 - 96%. Recent years, the integrated pest management has been emphasized in the control of litchi pests , such as protecting natural enemies, improving agriculture ecosystem, reasonable using insecticides etc.

[0312] TOMATO LEAF SIZE AND CONSPECIFIC INTERACTION EFFECTS ON TUTA ABSOLUTA (MEYRICK) (LEPIDOPTERA: GELECHIDAE)

P. Perevra, Centro de Estudios Parasitológicos y de Vectores, Univ. Nacional de La Plata-CONICET, 2 No.584 (1900) La Plata, Argentina.

The leaf miner Tuta absoluta is a major pest of tomato crops in La Plata, Argentina. Intraspecific competition is an important cause of mortality for many microlepidopteran leaf miners as well as other sources of vertical mortality. The objective of this work is to explore whether or not the tomato leaf size influences intraspecific competition among individuals of this species. In particular I examine how variation in leaf size influences the abundance of larvae and mines, and how the density affects survival, pupal weight and developmental time. Tomato leaves (var. Platense) of various sizes were collected in the field and width, length and area of each leaf were measured. Tomato leaf areas were estimated from length and width of the leaf using the formula of the triangle area (R²=0.948; P<0.001; n=94). Significant positive correlations between the number of mines and leaf size (P< 0.001) and between the number of larvae and leaf size (P<0.001) were found. Leaf size, however explained 25,2 % of the variation in mines density per leaf and only 3.6 % of the variation of larval number per leaf. I also performed an experiment whereby females were allowed to oviposit on tomato plants with different leaf sizes. Individuals were followed until pupation and regression analysis were done to determine whether there were relationships between densities of eggs and larvae (number/per leaf cm²) and the survival, larval developmental time and pupal weight of individuals reared on leaves of known size. Density of eggs showed a negative relationship with larval survival $(R^2= 0.19, P < 0.05)$. Survival of larvae was not correlated with larger leaves $(R^2=0.03, P < 0.05)$. P>0.5). Pupal weight regressed on density of eggs showed a negative but non significant trend ($R^2 = 0.05$, P > 0.05). Larval developmental time showed a positive but non significant relationship with density of larvae (R²=0.10, P>0,05). Other regressions showed no relationships (i.e. larval density with pupal weight). Results from this analysis indicate that with increasing density of eggs, density-dependent mortality may be imposed by competition, in early instars among co-occurring larvae. However, results of correlation analysis of mines and larvae on leaf area showed that individuals of T. absoluta are not sedentary enough to be vulnerable to effects of intraspecific competition and they appear to be able to avoid nearby individuals leaving the mine and feeding in another one. Tomato leaf size does not appear to affect the performance of T. absoluta and could not be considered as a predictor of tomato susceptibility.

Index terms: Lycopersicum esculentum, tomato leaf miner, intraspecific competition, survival

[0311] EVALUATION OF POSSIBLE PLANT ASSOCIATIONS WITH STRAWBERRY: EFFECT ON THE TWO-SPOTTED MITE IN THE LABORATORY

<u>P. Perevra¹</u> & N. Greco¹, ¹Centro de Estudios Parasitológicos y de Vectores, Univ. Nacional de La Plata-CONICET, 2 No.584 (1900) La Plata, Argentina. E-mail: Erro! Indicador não definido., ngreco@netverk.com.ar.

Tetranychus urticae is an important pest of the strawberry crop in greenhouses in La Plata, Argentina. Chemical control of this pest is ineffective and promotes environmental and health problems. Associate host-plants to a main crop may contribute to increase diversity and to decrease herbivore pressure. In order to find an alternative control measure to acaricide use, the object of this study was to assess the effect of strawberry, onion, parsley, leek and chrysanthemum as possible intercropped plants, on the offspring and short distance movements of the two-spotted mite. The following experiments were performed using discs of leaves (1.8 cm diam): assessment of fecundity and maximum number of individuals / female, oviposition preference (number of eggs laid in a choice test), permanence of individuals (fate of females after 24 h) on different host-plants; and movements from strawberry leaves to other host-plants leaves and viceversa. Mean fecundity and maximum number of individuals of all developmental stages / female were higher on strawberry and lower on onion and leek (P<0.05). The choice test also showed a preference for strawberry followed by parsley, not only for the oviposition but in the persistence of the females as well (P<0.05). No displacements were found from strawberry to any other host-plant, but mites did migrate from leek to strawberry (P<0.05). The experiments showed that T. urticue performed better on strawberry leaves than on any other associated host-plant. However, it showed some preference for parsley, indicating that populations of the pest night be maintained on this plant. Parsley therefore does not appear to be a good associate host-plant since it can support the reproduction and development of the two-spotled spider mite. Neither could it be considered a crop trap because it is not more attractive than the main crop. Onion, chrysanthemum, and leek seem not to be suitable for the development of T. urticae. Chrysanthemum and onion need to be more deeply evaluated as host-plants. Mites did migrate from leek to strawberry, suggesting that leek should be rejected as associate host-plant. Onion seems to be a good associate host-plant: mites had a poor performance on it, and it did not promote migrations to strawberry. This study tries to explain the effect of the four associate host-plants as a whole, if they are cultivated with strawberry. Assays of this kind are useful for an early evaluation of possible associate host-plants to a main crop, since not all plants seems to be suitable for intercropping for a more sustainable crop production.

Index terms: Tetranychus urticae, Fragaria chiloensis x Ananassa, herbivory, intercropping, diversity

[0313] POPULATION DYNAMIC OF SCARLET MITE, *BREVIPALPUS PHOENICIS* AND ITS PREDATOR IN TEA AREA WHICH TREATED AND NON TREATED BY PESTICIDES

A. D. Permana¹, H. Pratiknyo² & S. Sastrodihardjo¹, ¹Department of Biology, Institut Teknologi Bandung, Ganesa 10, Bandung 40132, Indonesia. e-mail : agus@bi.itb.ac.id ; ²Faculty of Biology, University of Jenderal Soedirman, Purwokerto, Indonesia.

Brevipalpus Phoenicis Geijskes is one of the tea important pests in Indonesia. The economic injury level of this pest is 24 mites/tea-leaf. In this study, the diversity of predatory mites were identified, and the effect of pesticides on the population of scarlet nuite and predatory mites was investigated. The relative density of *B. Phoenicis* was also analyse. Result of this study indicated that six predatory mites were: Amblyseius deleoni Muma & Denmark; Proprioseiopsis cuflagelatus Karg; Phytoseiulus crinitus Swirski & Sheehter; Phytoseiulus persimilis Athias-Henriot; Zetzelia javanica Ehara & Oomen; Agistemus terminalis Quayle. The abudance of scarlet mite and predatory mites were higher in the area treated by pesticides than those in the area non-treated. Relative density of scarlet mite was not significant to the tea-leaf damage ($r \le 0.57$). This study also showed that the relative density of predatory mites was lower than that of scarlet mite, however, the tendency of the population dynamic of predatory mites succeeded the population of the scarlet mite, and naturally, the predatory mite could controlled the *B. Phoenicis*.

Index term: Brevipalpus Phoenicis, Amblyseius deleoni, Proprioseiopsis euflagelatus, Phytoseiulus crinitus, Phytoseiulus persimilis, Zetzelia javanica, Agistemus terminalis.

Session 02 - AGRICULTURAL ENTOMOLOGY

[0314] IDENTIFICATION OF PROTEOLYTIC ACTIVITY IN *BEMISIA TABACI* B TYPE (HOMOPTERA: ALEYRODIDAE)

T. Pham, D. R. Frohlich & <u>R. C. Rosell</u>, Biology Department, University of St. Thomas, 3800 Montrose Blvd., Houston, TX 77006 USA. Email: rrosell@stthom.edu.

Digestive system physiology is an important component in the ability of whiteflies to persistently transmit Begomoviruses to host plants. Whiteflies ingest phloem which contains sugars, amino acids, and free proteins, and, in virus-infected plants, proteincoated virus particles. Acquisition and passage of the infective virion in the whitefly digestive system is a critical component of begomovirus transmission. The transmissible form of Begomovirus is, as yet, unidentified. However, it has been shown that the coat protein is necessary for successful transmission, thus, the virion is postulated to be the transmissible form. As virions move through the digestive system of the whitefly, they may never encounter digestive system proteases, or if proteases are present, may in someway be protected from digestion or resistant to the vector's proteases. Recent studies have reported that whiteflies ingest and metabolize plant proteins which suggests that proteolytic activity is present in the whitefly digestive system. We used casein substrate plate assays to identify enzymatic activity in whiteflies and found that proteolytic activity was detectable and quantifiable in whole body whitefly extracts. Preliminary studies demonstrated protease activity at pH 5.5, but not at pH 7.4, and no inhibition with several trypsin and chymotrypsin inhibitors: N-α-p-tosyl-L-lysine chloromethyl ketone (TLCK), soybean trypsin inhibitor (SBTI), bovine pancreas trypsin inhibitor (BPTI), lima bean trypsin inhibitor (LBTI), and chicken egg white trypsin inhibitor (CEWTI). Because proteolytic activity of whitefly extracts was detected at pH 5.5, we suspected that the observed enzymatic activity was cysteine proteinase-like. Cysteine proteinases are common in the midgut of Hemiptera and Heteroptera. Based on these data and comparable information from other Homoptera, a putative identification of cysteine protease was made. Herein we report spectrophotometric and inhibitor data with specific cysteine protease substrates and inhibitors.

Index terms: whitefly, proteases, cysteine proteases, virus-vector

[0316] SAMPLING DISTRIBUTION PATTERNS OF *RACHIPLUSIA NU* (LEPIDOPTERA: NOCTUIDAE) AND DESIGN OF SAMPLE PLANS

M. C. Plazas, J. D. Edelstein, E. V. Trumper & M. A. Linares, Sección Entomología, E.E.A. Manfredi, INTA, Ruta Nacional 9 Km 636, (5988) Manfredi, Córdoba, ARGENTINA, E-Mail: etrumper@arnet.com.ar

Rachiplusia nu (Lepidoptera: Noctuidae) is one of the most common defoliating larvae present in soybean crops in Córdoba Province, Argentina. Its incidence fluctuates over different growing seasons but it frequently motivates the application of insecticides to prevent economic losses. An economic threshold has been proposed but sampling protocols have not been developed yet to make precise assessment of pest abundance, neither for estimating density nor for decision making. The aim of this work was to describe the sampling distribution of R. nu larval stages and to develop and evaluate sampling plans. An intensive sampling program was carried out during three growing seasons in soybean fields in a central area of Córdoba Province, Argentina. The vertical cloth technique was used. On each sampling date, 30 to 40 sampling units were collected at random. More than one hundred samples were taken along the three growing seasons. Larvae were grouped according to size in three stages: small, medium and large. Taylor's power law (TPL), Iwao's patchiness regression model (IPR) and Bliss & Owen's technique (BO) were used to describe the distribution of sample data. The following parameters, were estimated: a and b (TPL); α and β (IPR) and $1/K_c$.(BO). The last four parameters are regarded as describers of sample distribution patterns. a, b, α and β were used to obtain minimum sample size curves and sequential sampling critical lines, with known predicted precision levels, according to Green's and Kuno's models. Iwao's β and Taylor's b ranged between 1.15 and 1.39 and 1.13 and 1.3, respectively, suggesting a slight aggregation pattern of sample data. The estimated $1/K_c$ for medium and large larvae were used to calculate Wald's Sequential Probability Ratio Test critical lines. Operating Characteristic and Average Sample Numbers functions were obtained to analyse the performance of sampling plans. Validation of sampling plans is preliminary assessed with independent data, using a resampling software.

Index terms: Soybean looper, distribution patterns, sequential sampling.

[0315] RELATIONSHIP BETWEEN THE ARTIFICIAL INFESTATION OF DIATRAEA SACCHARALIS EGGS AND THE DAMAGE IN SUGARCANE STALKS

<u>A. de S. Pinto¹</u>, J. R. P. Parra² & H. N. de Oliveira², ¹C. U. Moura Lacerda, Ribeirão Preto-SP, Brazil, E-mail aspinn@uol.com.br; ²Dep. Entomol., Fitop. e Zool. Agrícola, ESALQ-USP, 13418-900, Piracicaba-SP, Brasil.

The relationship between the artificial infestation of *Diatraea saccharalis* eggs (Fabr., 1794) and the damage in sugarcane stalks was studied in commercial sugarcane fields in Piracicaba and Araras, SP, Brazil from 1996 through 1998 in different varieties and phenological stages of the plant. Three experiments were set up at different times. A direct relationship occurred between the number of eggs of the sugarcane borer per unit area and the intensity of damage in stalks, with the latter being influenced by several factors such as egg predation and weather conditions. Predation was directly proportional to the number of eggs on artificial infestation of D. saccharalis under field conditions. The studies on artificial infestation of the sugarcane borer must use areas with infestation points with low egg density, which can be achieved by using older females in the cages attached to the plants in which they lay fewer egg masses.

Index terms: sugarcane borer, sugarcane pest, IPM

[0317] MASS REARING AND RESISTANCE SCREENING TECHNIQUES FOR HE BEAN STEM MAGGOT (*OPHIOMYIA* SPP.)

H. du Plessis₁ & U. du Plessis₂, ARC - Grain Crops Inst., Private Bag X1251, Potchefstroom, 2520, South Africa. E-mail: hanalene@igg2.agric.za.

The common bean (Phaseolus vulgaris) is an important source of protein in Africa, but is prone to severe attacks by bean stem maggot (BSM). Yield losses of up to 100 % have been reported. Three species of BSM occur in Africa, namely Ophiomyia phaseoli, O. spencerrella and O. centrosematis. The distribution and importance of the three species vary with location and season. Resource-poor farmers suffer most as they have limited access to additional inputs such as insecticides and fertilisers. There is, therefor an urgent need for high-yielding pest resistant varieties. However, breeding for resistance is slow as plant breeders have to rely on natural infestations of BSM only. Mass rearing of BSM could provide sufficient numbers of insects for infestation of breeding material and accurate screening for resistance. The aim of the study was to develop techniques for mass rearing of BSM as well as to develop screening techniques. Collection of BSM was done by cutting off bean stems infected with larvae and pupae beneath the leaves. These stem cuttings were kept in cages in a greenhouse and moistened daily. Emerging flies were collected, transferred to an outdoor cage and reared on cowpea (Vigna unguiculata). These cages of different sizes provided for different screening options that included preliminary screening of beans in pots to estimate feeding preference under field conditions. Seedlings in trays placed in the rearing cage were infested by flies from the mass rearing colony and subsequently planted into a screening cage, where they were screened for tolerance. Beans planted directly in screening cages could be inoculated by a specific number of flies collected from the stock colony in the rearing cage and screened for tolerance under field conditions. The advantages of these techniques are that they are cost-effective, not labour intensive, do not need skilled people as with artificial rearing under laboratory conditions and screening for resistance can be conducted under field conditions. Key words: Ophiomyia spp., Phaseolus vulgaris, resistance breeding

[0318] *NYSIUS NATALENSIS (HETEROPTERA: LYGAEIDAE*) – A NEW PEST OF SUNFLOWER (*HELIANTHUS ANNUUS* L.) IN SOUTTI AFRICA

H. du Plessis ARC - Grain Crops Inst., Private Bag X1251, Potchefstroom, 2520, South Africa. E-mail: hanalene@igg2.agric.za.

Nysius natalensis (Heteroptera: Lygaeidae) is a new pest of sunflower in South Africa. The genus Nysius is cosmopolitan and attacks a wide variety of cultivated plants and weeds, but different species are confined to specific regions. A few species is known to damage grain crops. Nysius huttoni damages wheat in New Zealand. Sunflower is damaged by N. vinitor as well as N. clevelandensis in Australia and N. inconspicuus in India and Pakistan. In South Africa, occurrence of N. natalensis populations is sporadic and unpredictable. The insects occur on weeds such as Portulaca oleracea and Amaranthus hybridus from where invasion of sunflower occurs during the budding stage and from anthesis onwards. Damage concurs with those inflicted by other Nysius species in Australia and Pakistan. During the budding stage, some plants wilt and die while others appear unharmed. Damage to seeds results in a reduction of yield, oil content and poor germination of damaged seeds. South African sunflower producers are remunerated according to oil content of their crop and damage by these insects therefore results in a direct loss. Sunflower seed producers experience biggest losses because their total harvests are unacceptable as seed. The most vulnerable period of sunflower to attack by N. natalensis is from anthesis onwards, which is also the period when pollination by bees is important. Problems are experienced with chemical control on sunflower seed multiplications due to the toxicity of most insecticides to bees. Key words: Nysius natalensis, Helianthus annuus, damage

[0319] THE ECOLOGICAL ROLE OF NATURAL HEDGES ON LEAFHOPPERS POPULATIONS IN VINEYARDS OF CENTRAL ITALY

L. Ponti & C. Ricci, Dept. of Arboriculture and Plant Protection, Faculty of Agriculture, Univ. of Perugia, Borgo XX Giugno, 06121 Perugia, ITALY, E-mail cricci@unipg.it.

Hedges and other landscape features have received significant attention in Europe regarding their effects on arthropod distribution and abundance in adjacent fields. In many cases natural vegetation around crop fields harbours alternate host or prey for natural enemies, thus providing seasonal resources to bridge gaps in the life cycles of entomophagous insects and crop pests. As regards the green grape leafhopper Empoasca vitis and its egg parasitoid wasp Anagrus atomus, wild vegetation is hypothesised to enhance the effectiveness of this parasitoid. In fact natural vegetation around vineyards provides an alternative leafhopper to A. atomus during the winter. E. vitis is considered a severe problem in the vineyards of northern Italy, but it is not a major pest in central Italy. This difference seems to be linked with a loss of floral diversity and landscape features in northern Italy. Our study is the first that compares population dynamics of leafhoppers and their natural enemies both within vineyards and in natural hedges. During two years monitoring of the adults was carried out weekly by mean of yellow sticky traps, while nymphs were sampled every week by direct count on leaves. Movement of the leafhopphers and their parasitoids between natural vegetation and cultivated fields were also studied, by the only mean of yellow sticky traps. We surveyed different types of natural edges, mainly Rubus sp. and Ulmus sp. Our data show that these hedges act as natural biofactories in agroecosystems. We also describe non-ampelophagous leafhoppers species supported by natural hedges. These leafhoppers bridge the gaps in biological cycles of ampelophagous ones, providing alternative hosts to egg parasitoids. Our study highlights the key role played by Zygina rhamni, which is correctly called the true Italian grape leafhopper, and Rubus sp. hedges, in reducing damage by E. vitis. In this way we confirm the hypothesis of a pre-agriculture grape-Rubus association. Our data suggest that existing diversity in the agroecosystem is more likely to have an influence for stability than newly created diversity, adding importance to the study of traditional agriculture in order to design agroecosystems that are both productive and resource conserving. Index terms: Empoasca vitis, Zygina rhamni, Anagrus atomus, hedges, landscape

[0320] STATUS OF PEST CONTROL IN CENTRAL EUROPE

R. Pospischil, Bayer AG, Animal Health, R & D, Clinical Development, 51368 Leverkusen, Germany

The living standard has changed dramatically since the middle of the 20th century in Central Europe with increasing prosperity and progress. Modern buildings with central heating, carpet floors and insulation are responsible for a constantly warm temperature conditions. Extensive food production areas and an intensive world trade are also responsable for the establishment of tropical pests in the temperate zones. Hygiene pests were introduced to Europe with man thousands of years ago. However, due to the cold temperatures in winter time most species could not easily establish. Modern life style with constantly convenient temperatures indoors even in winter gave many tropical and subtropical species a chance to survive after their introduction to Europe. Disease transmission grew to a severe problem especially in sensitive areas like the food processing industry and in hospitals. Allergic reactions to indoor pests (eg cockroaches, house dust mites) have become more and more important over the last thirty years. Due to their high reproduction rate and fast development some hygiene pest have become resistant to commonly used insecticides (eg Musca domestica). Modern pest control has to recognize this situation and to keep an eye on new invadors. In the past the pest control operator had to focus on pest control only - now his task is to manage pest problems according to the rules of integrated pest management. His main task should be to prevent pest problems with monitoring, sanitation and physical systems. When control is required, the PCO has to develop a strategy, which does not harm the environment, e.g. in sensitive areas like hospitals or food processing industry. Control strategies are discussed using the example of cockroaches, which have become an immense problem on the European continent. Modern pest control strategies against these species include products which were especially developed for sensitive areas. Such areas include restaurants, supermarkets, hospitals, nursing homes, schools, hotels, food processing industry, aircraft and others. The sprays which were used in the last decades are now being replaced more and more by cockroach gels, cockroach baits which are offered in special bait boxes, and larvicides. Cockroach gels allow a very targeted application close to the cockroach population. Very little active ingredient needs to be applied to achieve an amazing result. Modern gels have a residual efficacy which lasts up to one year or longer. Pest management will continue to be an important task with prevention being the most important aspect. PCO's should be aware of the fact that introduction and establishment of new species may occur at any time. Pest control should be carried out with an appropriate formulation which was developed for the pest species and situation. Mallis A (1997): Handbook of pestcontrol, 8th edition, Mallis Handbook & Technical Training Company, 1456pp; Pospischil R (1998): Einschleppung von Schädlingen nach Mitteleuropa. Pest Control

[0321] EGG DEVELOPMENT IN *DIATRAEA SACCHARALIS* (LEPIDOPTERA: PYRALIDAE) UNDER DIFFERENT TEMPERATURE REGIMES

M. J. Prola, M. Moré, F. Fava & <u>E. V. Trumper</u>, Sección Entomología, E.E.A. Manfredi, INTA, Ruta Nacional Nro. 9 Km 636, (5988) Manfredi, Provincia de Córdoba, ARGENTINA, E-mail: etrumper@arnet.com.ar

Diatraea saccharalis (Lepidoptera: Pyralidae) is one of the most damaging pests to corn crops in most of the maize growing areas in Argentina. Apart from the recent, availability of transgenic hybrids that cover a small proportion of the cultivated area, traditional management tactics include early harvest, rotations with non host crops and the most frequently recommended, chemical control based on a nominal egg incidence of about 20% as a decision rule. However, insecticides have been regarded as inefficient so far. Chemical control could be significantly improved provided a better understanding of the pest dynamics is gained. One aspect on which a quantitatively based tactic can be designed is the precise estimation of time remaining to egg hatch from a field sample. This work concentrate on the temperature dependent development of eggs. Through maturation, eggs show changes in pigmentation and "colour sub-stages" can be identified. It was assumed that these colour sub-stages take constant time from oviposition, at a given temperature regime. The objective of this work was to estimate the temperature-dependent development time of the complete egg stage and each colour sub-stage. Adult females were captured with light traps and maintained in paper bags to induce deposition of egg masses, which were then carefully collected and put in Pert dishes, in climatic chambers at different constant temperatures. Additional sets of eggs put in small green carton cards were clipped on corn leaves in the field (fluctuating temperature regime). All eggs were observed daily. Changes in colour and egg hatch were recorded. At each temperature, development times were fairly constant, although some variability was observed both within and between egg masses. Different empirical and biological models were fitted to describe the variation of the mean time from egg deposition to yellow, orange, and brown sub-stages and complete mean egg development time, as a function of temperature, with high correlation coefficient. The potential contribution of these results to optimisation of chemical control timing is discussed.

Index terms: corn borer, development rate, developmental models, maize.

[0322] DIFFERENT PESTICIDE APPLICATION METHODS IN CONTROL OF WHITEFLY AND LEAFMINER ON TOMATO PLANTS UNDER VINYL HOUSE

C. G. Raetano¹, F. J. Bengozi¹ & M. R. Kobayashi¹, ¹Dept. of Crop Production, State Univ. of São Paulo, P. O. Box 237, Botucatu, SP, 18603-970, Brazil, E-mail raetano@fca.unesp.br

The objective of this works was to contrast the effects of two insecticide application methods, conventional spraying (400 to 800 L/ha) and reduced-volume application (90 L/ha) in control of Bemisia sp. and Tuta absoluta on tomato plants under vinyl house. The experiment was conducted in two adjacent commercial vinyl house, with 0.05 ha each, located in Botucatu, SP, Brazil. Four different insecticides tank mixture treatments were applied with a hand held knapsack sprayer (Jacto SA) consisting of a simple lance three Db hollow nozzle type at the end on plants under one vinyl house and a thermal fog generator, Swingfog SN 50 type, another vinyl house. The treatments: imidacloprid + betacyflutrin (21.0 + 2.50 g), imidacloprid + teflubenzuron (21.0 + 3.75 g), acephate + betacyflutrin (75.0 + 2.50 g) and imidacloprid + methomyl (21.0 + 21.5 g) of a. i./100 L of water were applied at the seventeen days of October, 1997 and replicated at three days intervals with nine applications in the total. Samples, consisted of twenty five leaflets each, were randomly removed from the upper third of the canopy of the plants from each vinyl house for these insects evaluations. The number of whitefly nymph per leaflets were evaluated on underside surface in the upper third of the canopy in two application conditions. Similarly the number of actives miners inside leaf mines were monitored in this position of canopy in two vinyl house. The different application methods showed equivalent control levels of whitefly at 33 days after the first application, but the greatest control levels were obtained with conventional spraying (93.3 and 84.7%, respectively) at 7 and 14 days. The efficiency in control of leafminer with thermal fog generator was greater than in the conventional spraying during the most period of the experiment, but your maximum efficiency was 68.7%.

Index terms: Bemisia sp., chemical control, Tuta absoluta, spraying.

[0323] INFLUENCE OF DIFFERENT APPLICATION METHODS AND DOSAGES OF THIAMETHOXAM IN THRIPS CONTROL

C.G. Raetano¹, W.R. Kuwahara¹, R.R. Vinchi¹ & M.R. Kobayashi¹, ¹Dept. of Crop Production, State Univ. of São Paulo, P. O. Box 237, Botucatu, SP, 18603-970, Brazil, Email raetano@fca.unesp.br.

The thrips *Frankliniella schultzei* Trybom (Thysanoptera: Thripidae) is one of the most important vector species of tomato spotted wilt tospovirus (TSWV) in Brazil. Two different pesticide application methods were evaluated with thiamethoxam (Actara 250 WG) insecticide in thrips control on tomato field. A completely random experiment was set up to evaluate this purpose. One knapsack sprayer was used in the thiamethoxam application with a simple lance one JD 14-2 hollow nozzle type or modified lance at the end for spray or drench application, respectively. Dosages of 150 and 200 g of a. i. were used in just one drench application and 50 g of a. i. per hectare (ha) sprayed at weekly intervals, fourty eight days after seeding. The efficacy of this insecticide was compared with diafenthiuron (400 g of a. i./ha), profenofos + cypermethrin (320 + 32 g of a. i./ha, respectively) and methamidophos (60 g of a. i. per hectolitre of water) in spray application. The mean cumulative number of plants with tospoviruses did not permit the identification of significative differences between thiamethoxam application methods and dosages on *F. schultzei* twenty four days after application, showing advantage for just one drench application. The efficacy of thiamethoxam insecticide tor 93 to 95% for this vector thrips of TSWV, independent of the application method and doses. Diafenthiuron and profenofos + cypermethrin showed less efficacy (78 and 88%, respectively) but greater than those with methamidophos (71%). The products and doses in the test did not lead to verification of phytotoxicity symptoms in tomato plants.

Index terms: Frankliniella schultzei, chemical control, drench application.

[0324] BT CORN IN CONTROLING ECB IN CROATIA

<u>E.Raspudiœ</u>¹, M.Ivezić¹ & I. Lovrinčević², ¹Univ. of J. J. Strossmayera in Osijek, Faculti of Agriculture in Osijek, Trg sv, Trojstva 3, 31000 Osijek, Croatia, e-mail remilija@suncokret.pfos.hr ²Croatian Agricultural Extension Service, Valpovačka ulica 2, 31222 Bizovac, Croatia.

In Croatia corn is grown on approximately 350,000 ha and ECB is one of the permanent corn pests. Attack intensity was 58% in the period 1995-1999. Its control has practically not been carried out. In 1998 and 1999 Bt corn hybrids of selection firm Pioneer were subjected to the investigation carried out on several localities in Eastern part of Croalia. Hybrids Landia Bt, Evelina Bt, Clarica Bt were under study and compared to the same hybrids without built-in gene. In the maturity stage period corn dissection was carried out aining at determination of ECB attack intensity, number of tunnels and caterpillars per plant, stem damage length and obtained yield. In 1998 ECB attack intensity with Landia hybrid amounted to 98%, Landia Bt 21%, and Evelina 51% whereas Evelina Bt was not attacked by ECB. In 1999 hybrids Evelina and Clarica were investigated on two localities. Average ECB attack with Evelina was 87%, Evelina Bt 11%, Clarica 89% and Clarica Bt 7%. Hybrid Landia had 5 tunnels and 1 caterpillar per plant wheres stem damage length was 21 cm. Only 0.25 tunnels and 0.04 caterpillar per plant were determined with hybrid Landia Bt whereas stem damage was 0.45 cm. Average stem damage on hybrid Evelina was 3 cm with two tunnels and 0.42 caterpillar in 1999. As for hybrid Evelina Bt, the stern damage amounted to 0.29 in length, with 0.93 tunnels and 0.012 caterpillar. Hybrid Clarica with average ECB attack of 89%, per stem had 2 tunnels and 0.52 caterpillar whereas damage length was 6 cm. Clarica Bt had attack intensity of 7%, 0.73 tunnels and 0.008 caterpillar per plant whereas damage stem amounted to 0.23 cm. Corn kernel yield with Eveline Bt and Landie Bt was higher whereas with Clarica Bt it was lower by 36 kg/ha compared to standard hybrids. Bt corn hybrid use showed attack intensity decrease of ECB and other plant damage parameters. In our country there are no legal regulations of transgenic plants use since many organizations are against transgenic plants spreading. Index terms: Ostrinia nubilalis, GMO, intensity of attack

[0325] SAMPLING PARASITIC EGGS OF PHYTOPHAGOUS STINKBUGS IN SOYBEAN [*GLYCINE MAX* (L). MERRIL] CROPS IN THE SOUTHWEST REGION OF GOIAS

<u>J.F. Rattes¹</u>, Fesurv/Esucarv. Caixa Postal 104. Cep: 75901-970 Rio Verde-GO. E-mail: rattes@fesurv.br.

Eggs of phytophagous stinkbugs were sampled in soybean crops in the southwest area of Goiás. It was performed in Rio Verde, Jataí and Santo Antônio da Barra counties in February and March, during the planting season of years 1995/96, 1996/97 e 1997/98. Natural incidence of parasitoids, its host preferences, population fluctuation and the main species occurring in the area were evaluated. High rates of natural parasitism were verified. The scored results were 77,34% (1995/96); 77,48% (1996/97); 61,49% (1997/98) for the host species Euschistus heros and 63,83% (1995/96); 78,27% (1996/97); 61,86% (1997/98) for the host species Peizodorus ghildinii. Among the parasitoid species sampled, Telenomus podisi (Scelionidae) was the most common, achieving parasitism levels of 95% and 100% (1995/96); 85,5% and 97,0% (1996/97); and 95,8% and 95,5% (1997/98) for *E.* heros and *P. guildinii*, respectively. The determined frequencies of *Neorileyn* sp. (Eurytomidae) parasitism in host eggs were 100% for N. viridula, 14,5% for F. heros and 3% for P. guildinii in 1996/97. Frequencies of Trissolcus brochymenae and Trissolcus basalis (Scelionidae) were small, lower than 5%. The average indexes of natural parasitism observed in the region were 65,88% in 1995/96; 73,73% in 1996/97 and 61,80% in 1997/98. It demonstrates the high potential for biological control, showing that this natural control must be preserved in soybean crop areas. It might be achieved by the adoption of cultural and phytosanitary practices which affect as less as possible the population of these biological agents.

Index terms: Insecta, biological control, paraside

[0326] ENHANCED CHEMICAL CONTROL OF NEZARA VRIDULA USING UNCONVENTIONAL SPRAYING TECHNOLOGY

C.C.M.Resta, Departamento de Agronomia, Universidade Estadual de Londrina, Caixa postal 6001, Londrina, PR CEP 86051-990, Brasil, E-mail cesarmarre@hotmail.com

The stink bug Nezara viridula (Heteroptera: Pentatornidae) is one of the most relevant pests in soybeans. Its chemical control is sometimes unsuccessful due to its habit of being hidden inside soybeans foliage. Besides, it presents high mobility in the crop. The present study aimed to evaluate the efficacy of insecticides in the control of stink bug by two types of nozzles : conejet visiflo steel (TXVS 4 - hollow cone) and twinjet (TJ 11002 - even double fan). Two experiments were carried out in Sertanopolis PR, Brazil, in 1998 following strictly the guidelines and official recommendations from Brazilian Soybeans Research Committee according to the integrated pest management (IPM) procedures. Each field trial was sprayed with the same insecticides and doses but with different nozzles. After the sprayings, periodic evaluations were done by counting live stink bugs (nymphs larger than 0.5 cm long and adults) collected in 2 meters long between soybeans rows by using a cloth with two sticks attached by its edges (pliable cloth). The treatments were endosulfan 35% EC at 437.5 and 525 g of a.i. / ha, endosulfan 50% SC at 400 and 500 g of a.i. / ha, monocrotophos 40% EC at 150 g of a.i. / ha and control. The best results were obtained with TJ 11002 nozzles decreasing drastically the pest population. TJ 11002 nozzles improved the efficacy of all insecticides taking into consideration their mode of action. No fitotoxicity was observed. Index terms : soybeans, insecticides, conejet, twiniet, behavior.

[0328] BASIL-TOMATO INTERCROPPING EFFECT ON MACROSIPHUM EUPHORBIAE (HEMIPTERA: APHIDIDAE) ABUNDANCE

S. M. Rodríguez, ¹, P. I. Carrizo³, S. Clemente¹, A.M. Folcia¹, S.Panzardi¹ & M.Yaber Grass³, ¹Cátedra de Zoología Agrícola, ² Cátedra de Química Orgánica Fac. de Agronomía, Univ. de Buenos Aires. Av. San Martín 4453 (1417). Be. As. Argentina. 3 Cátedra de Zoología Agrícola, Fac. de Ciencias Agrarias y Forestales, Univ. de La Plata. Calle 60 y 119 (1900) La Plata, Bs. As., Argentina. E-mail: silro@mail.agr.uba.ar

Intercropping may reduce herviborous population on crop, in relation to single crop, by means of direct or indirect effects. If mixture has an aromatic species, essential oils might add its influence on main crop pests. The aim of this work was to determine the influence of basil on *Macrosiphum euphorbiae* (Hemiptera: Aphididae) abundance on tomato. It was analyzed in two levels: for aromatic presence itself, and because of essential oil. The trial was carried out in experimental plots - free from weeds and mites - at Agricultural Faculty. They were two treatments: T1: basil-tomato intercropping, and T2: tomato (n=5); plots were $9m^2$, and a completelly randomized design. Samples were taken weekly and sampling unit was a single plant. ANVA was performed (α =0,05 y 0,01), for total aphids/plant, by each sampling date. In order to determine essential oils, there were taken basil plants - one by plot and sampling date The extraction was carried out for disillition with vapor. Meaningful differences were obtained only in first sampling date (T1:10 aphids / plant; T2:6,4 aphids / plant). In earlier samplings, the amount of essential oils seemed to produce some effect on aphids abundance. It was not possible to establish any relationship for later sampling dates.

[0327] IMPACT OF *DIURAPHIS NOXIA* (HOMOPTERA: APHIDIDAE) ON WHEAT YIELD

M.E. Reviriego¹, L.R. Descamps¹& <u>A.A. Suarez²</u>, ¹Univ. Nac. Del Sur, San Andrés S/N, (8000) Bahía Blanca, Argentina, e-mail Errol Indicador não definido. ²E.E.A.INTA Anguil, Ruta Nac. N°5 Km 580, C.C. 11, (6326) Anguil, La Pampa, Argentina; e-mail Errol Indicador não definido..

Russian wheat aphid (RWA) is an important pest in the wheat growing aerea of Argentina. The objective of this experiment was to determine the impact of RWA on wheat yield under field conditions. A randomized complete block design with four replications was used. Plots were treated with Clorpirifos 48% (400cc/ha) at different wheat growing stages. The treatments were: control (no insecticide application), always treated (insect free) and treated from a)tillering, b)jointing, c)boot stage, d)heading, c) milk and f)dough. Aphid numbers, grain yield, spiklets per head, kernels per head, seed weight, seed germination and protein content were determined for each plot. The data obtained were analized using PROC ANOVA and means were compared using Means / LSD test (P=0.05) (SAS Institute, 1988). RWA infestations reduced wheat yield, seed protein content, seed weight and number of seeds per head. Index terms: Russian wheat aphid, damage, wheat.

[0329] SPATIAL DISTRIBUTION OF THE COFFEE BERRY BORER HYPOTHENEMUS HAMPEI ON COFFEE TREES, ANS ITS IMPLICATIONS FOR SAMPLING

R. Ruiz¹, A.E. Bustillo¹ & P.S. Baker², ¹Centro Nacional de Investigaciones de Café, A.A. 2427, Manizales, Colombia. E-mail: rreardeu@carpa.ciagri.usp.br ; ²CABI bioscience, Silwood Park, Ascot SL57TA, UK

An important aspect of controlling any insect is to understand their movements. The coffee berry borer (CBB) is one of the most serious pests of commercial coffee, threatening a production of about 15 billion dollars per year worldwide. A descriptive analysis on the distribution of its attack along 4 years (1995-98) in a coffee plot censused monthly, located in the central colombian zone, allowed to identify several phases into the advance of the infestation; so, at the plot level, infestation started very slowly, and the proportion of infested trees was below 5% for the first 7 months of observation. However, during next two months, infestation increased very quickly as much in percentage of perforated fruits, as in the proportion of infested trees, the latter increasing it to 70%, promoved probably for horers arriving from plots which were cut down for those days, located at least at 300 m from the experimental area. The highest level of infestation was reached at sept/97 (98.2% of infested trees), after of lowest rain and humidity periods generated by "El niño". Counts of bored fruits fitted the negative binomial distribution in 29 of 40 dates, with k values ranging between 0.0129 and 1.3511, but it was not possible to find a k common value for all dates; besides it was discontinuity in the fitting through consecutive dates. Fitting of counts to Taylor's power law was significative in all cases showing a spatial pattern generally aggregated (b values between 1.25 and 2.18). Variability study for both, total and bored fruits, at both, tree and branch level, was always significantly bigger (F<0.05) for the latter. It was a explicit trend of CBB to distribute it as following the distribution of coffee berries through the time, which occupy a progressively greater space as the tree produces more branches and nodes, constituting one of the fundamental problems of controlling this pest. Significantly higher density of CBB were found on the nodes nearest to main stem in each branch. A function describing the behavior of infestation in agreement with the age of berries was fitted following a geometric model. In conclusion, the spatial and temporal pattern of CBB attack is predicated upon the complex architecture and phenology of coffee plant, and the unpredictable rainfall pattern, which determine flowering and development of fruits. Index terms: Dispersion, IPM, Scolytidae, Taylor's power law.

[0330] PRESENCE OF HYPSIPYLA GRANDELLA IN THE STATE OF TAMAULIPAS, MÉXICO

<u>E. Ruíz-Cancino¹</u>, J.M. Coronado-Blanco¹ & L. Durán-Estrada², ¹UAM Agronomía y Ciencias, UAT. Cd. Victoria, Tam., 87149. México; ²SEDUE, Gobierno del Estado de Tamaulipas, Cd. Victoria, Tam., México.

One of the most important species of tropical wood is the red cedar Cedrella odorata (Meliaceae), this tree is present in the Gulf of México states and southern Mexican states. In Tamaulipas, this species has been used by several decades in the South zone of the state and now the State Goverment is promoting the cultivation. C. odorata has several pest species in México, the most important is Hypsipyla grandella, the red cedar borer. Moreover, the ant Atta cephalotes, the termites Coptotermes crassus and Heterotermes aureus convexinotatus, the bark beetles Xyleborus volvulus and X. ferrugineus, and the buprestid Chrysobothris yucatanensis are also present. Earlier, H. grandella was recorded from the following states: Veracruz, Tabasco, Campeche, Yucatán, Chiapas, Oaxaca and Quintana Roo. This pest attacks also Carapa guianensis, Guarea tonduzzi, Sweitenia humilis, S. macrophyla, and Trichilia spp. The last tree, was recorded from Gómez Farías, Tamaulipas, but without H. grandella attack. In August, 1999, small red cedar plants from the State Goverment nursery were detected with some borer damage. Then, the plants were taked to the Laboratory of Biological Control in the UAM Agronomía y Ciencias, UAT, where were put under observation in cages to wait the emergence of the adult pest. H. grandella typical damage was observed in the apical shoot: the larva bored the stem and take out the excrement, involving them with silk at the top of the tunnel, the shoot is folded and later dries. Two weeks later the moth emerged, being determined as H. grandella. So, this is the first record of the presence of H. grandella in Tamaulipas, and also the northernmost record about its distribution in the country. This material is deposited in the Insects Museum of UAM Agronomía y Ciencias, UAT, in Cd. Victoria, Tam., México.

Index terms: Lepidoptera, Pyralidae, red cedar borer

[0331] SCALE INSECTS OF CITRUS IN ITALY (HOMOPTERA COCCOIDEA)

<u>A. Russo</u>, S. Longo, G. Mazzeo & P. Suma, Dip. di Scienze e Tecnologie Fitosanitarie, Univ. di Catania, Via Valdisavoia 5, 95123 Italy, E-mail agarusso@mbox.unict.it

The number of scale insects living on Citrus in Italy is still increasing, in relation to a better taxonomic knowledge and continuous introductions of exotic species. Targioni Tozzetti (1881) listed 4 species, subsequently Silvestri (1933) reported 11, Lupo (1959) 13, Barbagallo (1980) 17 and Longo et al. (1994) 24 taxa respectively. They are: 1 Monophlebidae, 5 Pseudococcidae, 9 Coccidae and 9 Diaspididae, but only a few of them are really injurious in citrus orchards. The most dangerous scale insect in Italian citrus cultivation is the California red scale, Aonidiella aurantii (Maskell), restricted for a lot of years to lemon but now widespread on orange and mandarin. Pheromone traps for males flights monitoring together with climatic data have been recently used in I.P.M. programs, in order to produce forecasting models useful to define a good period for spraying insecticide; inundative releases of the parasitoid *Aphytis melinus* De Bach have been also done. As to the other armored scales, Lepidosaphes gloverii (Packard) is still a problem only in restricted coastal areas where the entomophagous Encarsia herndoni (Girault) is not present. Aspidiotus nerii Bouchè is a pest of lemon, bergamot and cedar. Less important are Parlatoria pergandei Comstock, P. zizyphi Lucas, Aonidiella citrina (Coquillet), Lepidosaphes beckii (Newmann) and Unaspis yanonensis (Kuwana). Chrysomphalus dictyospermi (Morgan) is now very rare on citrus. Among the mealybugs, Planococcus citri Risso infests all citrus cultivar, reaching high population level during late summer. Actually a successful biological control has been achieved with the introduction of exotic natural enemies as Leptomastix dactylopii (Howard), spraying at the same time chemicals in the ants nests. For this species, males flights have been also monitored in I.P.M. programs. Pseudococcus affinis (Maskell), Ps. calceolarie (Maskell), Ps. longispinus Targioni Tozzetti are occasionally present in low density and produce no damages. Phenacoccus madeirensis Green is a recently introduced species recorded also on ornamental citrus plants. The Coccidae Ceroplastes rusci (L.) and C. sinensis Del Guercio, reach sometimes high infestation level in citrus orchards, while C. japonicus Green is fortunately restricted to the Northern and Central part of Italy where citrus are not so diffused. The other soft scale Coccus hesperidum L., C. pseudomagnoliarum (Kuwana), Saissetia coffeae (Walker) and S. oleae (Oliver) are not primary pests. Parthenolecanium persicae (F.) and Pulvinaria floccifera (Westwood) are only occasionally recorded in citrus orchards. The Monophlebidae *Icerya purchasi* Maskell could be a problem only where I.G.R. have been used, reducing the ladybird *Rodolia cardinalis* (Mulsant) activity. Index terms: Monophlebidae, Pseudococcidae, Coccidae, Diaspididae, I.P.M.

[0332] ATTRACTION OF SHOOT BORER, CHILO INFUSCATELLUS, DAMAGED SUGARCANE TO THE BRACONID COTESIA FLAVIPES

K. P. Salin, N. Mukunthan, R. Nirmala & Y. S. Goud, Sugarcane Breeding Institute, Coimbatore - 641 007, India E-mail: sugaris@md3.vsnl.net.in

The attractancy of sugarcane plants damaged by the shoot borer, Chilo infuscatellus and its frass to Cotesia flavipes, an oligo parasitoid of sugarcane internode borer, Chilo sacchariphagus indicus and sorghum borer Chilo partellus, was examined in the laboratory. The experiments were conducted in 20cm dia petriplates and a 'Y' tube olfactometer with freshly emerged mated females of C. flavipes reared on C. infuscatellus over ten generations. In one set of experiment in 'Y' tube fresh shoot borer frass and cotton wool (control) formed the treatments and in the second set of experiments shoot borer damaged plants and undamaged plants formed the treatments. A total of 935 females were subjected to observation. Behavioural observations in the petriplates were conducted with fresh frass and cotton ball impregnated with extracted plant volatiles, one at a time. Results indicated that significantly (p=0.025) more number of parasitoids were attracted towards both frass (62.2%) and damaged plants (57.6%) implying involvement of chemicals derived from the salivary secretions and faecal matter in the frass and active production of synomone by the herbivore damaged plants. The parasitoid exhibited distinct behavioural response of increased turning movements and antennal drumming when it came very close to the frass. Behavioural response to the plant volatiles extracted using adsorbents was similar except that the tendency to tunnel through the plant volatile, in cotton wool, was absent. The parasitoid seems to use the highly volatile synomone produced by the plant as a long distance cue to locate the damaged plant in a mosaic of damaged and undamaged plants and on landing the damaged plants, the frass derived low volatile chemicals serve as short distance cue to home in on the host larva actively feeding inside the plant. C. flavipes parasitises the larva feeding inside the tunnel. The chemicals in the frass induce the parasitoid to tunnel through the frass and parasitise the host larva. High parasitisation rate is often associated with the corresponding high host density. In high host density situations the chances of encounter with host is high, thus increasing the parasitoid efficiency. In situations where host density is not adequate to retain and increase the foraging, augmentation of the chemical cues by external application or by engineering the plants to produce synamones in response to the synamone produced by the damaged plants might increase the parasitisation rate.

Index terms: Cotesia flavipes, Chilo infuscatellus, C. sacchariphagus indicus, C. partellus.

[0333] BUMBLEBEE FORAGING ACTIVITY AT GREENHOUSE TOMATO CROP WITH DIFFERENT POLLINATOR DENSITY

E. Salvado¹, S. Albano¹, F. Amaro² & A. Mexia³, ¹Instituto Superior de Agronomia, DPPF, Secção de Protecção Integrada, Tapada da Ajuda, 13449-017, Lisboa, Portugal; ²Instituto Nacional de Investigação Agrária, Estação Agronómica Nacional, DEESA, Quinta do Marquês, 2780 Oeiras fernandamaro@isa.utl.pt; ³Instituto Nacional de Investigação Agrária, Estação Agronómica Nacional, Quinta do Marquês, 2780 Oeiras amexia@isa.utl.pt

General aspects of hive activity and behavioural foraging of bumblebecs (Bombus terrestris) had been compared in two greenhouses with different densities of pollinators (1 hive/900m² and 1 hive/1600m²). The number of foragers in activity on the crop did not differ significantly (α =0.05) in the two greenhouses, as well as the number of visits received by each flower. In the greenhouse with higher density, all the resources were explored along the day in the intense way. However, in the greenhouse with lesser pollinators density the foraging activity showed a higher frequency of visits to the upper clusters during the hours of the day when the availability of pollen was higher (beginning of the day). In the afternoon period it was registered an exchange forwards the inferior clusters flowers. Each colony adjusted his activity in accordance with available resources in each one of the greenhouses: the total number of hive entrances and the number of hive entrances with pollen baskets were significantly higher in the greenhouse with smaller density. Concerning the individual behaviour of foragers, no significant differences were detected either in duration and number of visits per minute or interflower time. In the greenhouse with higher pollinators density, the colony development and longevity was affected by the smaller amount of available pollen to the colony. Index terms: Bombus terrestris, pollinator efficiency

[0334] PATTERN OF BUMBLEBEE VISITS TO GREENHOUSE MUSKMELON FLOWERS

E. Salvado¹, S. Albano¹ & J. Cadima², ¹Instituto Superior de Agronomia, DPPF, Secção de Protecção Integrada, Tapada da Ajuda, 13449-017, Lisboa, Portugal; ²Instituto Superior de Agronomia, Departamento de Matemática, Tapada da Ajuda, 13449-017, Lisboa, Portugal.

The characterisation of visits made by bumblebees (Bombus terrestris) must be based on quantitative aspects as well as some qualitative aspects. In that order, the time spent per muskmelon flower was recorded and the scraping movements of the mouthparts during each visit was also registered, whenever visible. Other information about the forager were recorded, like presence/absence of pollen baskets on posterior legs, kind of visit (directed towards the nectar or not) and type of visited flower (staminate or hermaphroditic).The high number of visits directed towards the nectar (99.10%) and high number of individuals visiting flowers without presenting pollen baskets (71,40%) indicated that the main resource collected in muskmelon flowers was the nectar. The mouthparts scraping behaviour, detected in 11.32% of the visits, was more frequent in the morning (21.80%) that in the afternoon (18.10%). This fact can indicate that the morning visits involves the processing of higher quantities of pollen. This behaviour can be advantageous to the plants, especially during the period of higher stigma receptivity (morning), because it facilitates the pollen dropping on them. The average of time per flower was 3.89 ± 0.10 s. In spite of the higher volume of nectar presented by hermaphroditic flower presents, it was observed that time per flower is significantly smaller (α = 0.05) in this case than in staminate flowers. Under the studied conditions, during the sampling process, each bumblebee should record information about nectar level in the surrounding flowers and, since depletion was never accentuated, the bumblebees adopted to make more frequent visits other than to invest on longer visits to the few hermaphroditic flowers. Visit durations decreased along the day as a result of depletion that occurs in the flowers, during the day. In the afternoon, each bumblebee increased its pollination rate decreasing time per visit and increasing the number of visited flowers per minute. The highest time per visit occurred in the first days of this study decreasing in the following days as far as the pollinators did learn the better way of muskmelon for exploitation of muskmelon flowers. Index terms: Bombus terrestris, Cucumis melo, pollinator behaviour.

[0336] FACTORS AFFECTING QUALITY OF ALFALFA-LEAFCUTTING BEE COCOONS IN SOUTHERN BUENOS AIRES PROVINCE, ARGENTINA

E. San Román¹, <u>N. J. Cazzaniga</u>¹ & E. C. Santamaría², ¹Depto. de Biología, Bioquímica y Farmacia, Universidad Nacional del Sur, San Juan 670, RA-8000 Bahía Blanca, Argentina, E-mail: sanroman@criba.edu.ar, ficazzan@criba.edu.ar; ²Vicente López 160, RA-8000 Bahía Blanca, Argentina.

More than 10 000 tons of alfalfa seeds are sown per year in Argentina, but despite the availability of wide areas suitable for alfalfa production, the country is still far away from self-sufficiency. Annual crops of 500 kg/ha were common 50 years ago at Hilario Ascasubi, in the South of the province of Buenos Aires; yields have reduced to about 60 kg/ha afterward as a consequence of the decimation of wild pollinators. The introduction of the alfalfa-leafcutting bee, Megachile rotundata, in the 70's promised the reversal of this decreasing trend. Since then, local farmers attempted to produce bees with variable results, but they have not been able to increase, or even maintain their populations for several years, so that they have to import new pre-pupae from USA or Canada almost every year; this increases production costs and causes reduced and/or late emergence of the bees, because the transportation from North to South hemisphere determines a shortening of the necessary period of low temperature storage. We present here the results of analyses conducted during the last three years, to determine the quality of cocoons obtained locally from uni- and bivoltine lines of Megachile rotundata, as compared to the imported ones. Cocoons were opened and inspected under binocular microscope and their contents were assigned to one of ten categories: healthy pre-imaginal bee; parasitized; discolor; attacked by nest destroyers; chalkbrood disease (caused by Ascosphaera aggregata); moulds; empty cell; second generation adult; pollen ball; other causes. In the first year, a high incidence of chalkbrood (18 %), and of second generation adults (14 %) was detected in bivoltine leafcutter bees reared locally; these values had decreased significantly two years later as a result of improved management procedures, though viability is still well below that of imported pre-pupae. Multivariate analysis showed that the factors responsible for the poor quality of local cocoons do not define a clear pattern, and that the sanitary condition of the univoltine bees remained closer to the high quality imported cocoons.

Index terms: Megachile rotundata, Hymenoptera, pollinators, management

[0335] EVALUATION OF DOSES OF IMIDACLOPRID AND THIAMETHOXAN AS SEED TREATMENT ON APHID CONTROL IN WHEAT

J.R. Salvadori, Embrapa-National Wheat Research Center, Cx. P. 451, 99001-970 Passo Fundo, RS, Brazil. E.mail jrsalva@cnpt.embrapa.br

Although wheat aphids (Hemiptera, Aphididae) are well controlled by biological agents in Brazil, especially by microhymenopterous parasitoids, they can still cause direct damage in some wheat cropping areas and indirect damage, mainly as vectors of Barley Yellow Dwarf Virus. Two experiments with two seed dressing treatments, imidaeloprid and thiamethoxan insecticides, were carried out in 1999 to evaluate aphid control, yield, and other agronomic characteristics of wheat. Both experiments consisted of seven treatments, i.e., three doses of each insecticide (24.5, 35.0, and 52.5 g a.i./100 kg of seeds) and a control without insecticide, replicated four times. The first experiment was conducted in greenhouse conditions. The experimental unit consisted of one jar with ten plants, in a completely randomized design. The jars were infested with five-winged adult aphids (Schizaphis graminum) per plant at 7, 14, 21, 28, 35, and 42 days after plant emergence. At each period of seven days the number of aphids was counted and the jar reinfested. At each fourteen-day period the jars were replaced by new ones with the same treatments. The second experiment was carried out in the field in a complete randomized block design. The wheat plots measured 6.0 m x 6.4 m. Aphid infestation was natural and consisted of Metopolophium dirhodum, Sitobion avenae, and Rhopalosiphum padi. The results were submitted to analysis of variance and the means compared by Tukey test. Although the greenhouse results showed differences between doses, both insecticides were efficient in controlling S. graminum up to 49 days after plant emergence. The field experiment showed no statistical difference between treatments probably due to the low number of aphids observed in the experiment.

Index terms: Metopolophium dirhodum, Schizaphis graminum, Sitobion avenae, Rhopalosiphum padi, insecticides. [0337] STUDY OF SIMULIIDAE (DIPTERA: NEMATOCERA) AND ITS BREEDING AREAS IN A STREAM OF THE MUNICIPAL DISTRICT OF "SANTO ANTÔNIO DO TAUÁ", STATE OF PARÁ, EASTERN AMAZONIA, BRAZIL

E. M. Santos¹ & I. S. Gorayeb², Dept. of Zoology, Museu Paraense Emílio Goeldi, Av. Perimetral 1901, Belém, Pará, Brazil. E-mail: ¹ emerson@museu-goeldi.br; ² gorayeb@museu-goeldi.br.

The black flies are of great importance under the bioecological, medical, and veterinarian point-of-views. The objectives of this study are to register the species of simulids and its breeding sites, besides the associated aquatic fauna and flora in the Tauá stream, municipal district of Santo Antonio do Tauá, Pará, Brazil; to characterize the abiotic factors of the water; to study the activity and abundance of anthropophilics species; and to correlate with microclimate parameters. These data will be obtained in two times of the year, characteristics of the rainy and dry seasons. For the rainy period, we made a collection in the stream and registered the occurrence of the following species: Simulium quadrifidum, S. perflavum and S. aequifurcatum (= incrustatum), and we made the checklist for the aquatic entomofauna, with registrations of: Chironomidae (Diptera), Hydropsychidae (Trichoptera), Perlidae (Plecoptera), Coenagrionidae and Libellulidae (Odonata), Naucoridae and Gerridae (Hemiptera), Corydalidae (Megaloptera), Baetidae (Ephemeroptera). The small vegetation strips adjacent to the course of the stream samples great wealth and prevalence of Leguminosae and Melastomataceae, besides the individuals occurrence within vertical stratum of high dossel (25 to 30m) and a total of 116 species. It was also observed among the bed flora the predominance of aquatic macrophytes as Urospatha sagittifolia (Araceae), Cabomba aquatica (Cabonaceae), Ninphaea gardineriana (Ninphaeaceae), vegetation that functions as substratum and influences the habitat for the existence of many immature forms, mainly that of black flies. We noted the periodicity of S. aequifurcatum (= incrustatum) in attack activity to the man, in elapsing of one day, with anthropophilic peaks correlated to a temperature around 26°C, relative humidity of the air in 99% and high brightness, with two main peaks, one in the morning and another in the afternoon, without the interference of rains. Index terms: Simulium, bioecology, entomofauna, abjotic factors

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[0338] BASELINE SUSCEPTIBILITY OF SPODOPTERA FRUGIPERDA (LEPIDOPTERA: NOCTUIDAE) POPULATIONS TO LUFENURON IN BRAZIL

F. B. Schmidt, R. B. Silva & C. Omoto, Depte. de Entomologia, Fitopatologia e Zoologia Agrícola, Escola Superior de Agricultura "Luiz de Queiroz", Av. Páduas Dias, 11, 13418-900 Piracicaba, SP, Brasil, E-mail: fbschmid@carpa.ciagri.usp.br.

Lufenuron is a newly benzoylphenyl urea chitin synthesis inhibitor insecticide. The use of this compound to control Spodoptera frugiperda, a major corn pest in Brazil, has increased significantly in the last years. This increase can be attributed to its high activity against S. frugiperda and to the reduction of efficacy due to resistance to some traditional insecticides (such as organophosphates, carbamates and pyrethroids) recommended for controlling this pest. In this study, a baseline susceptibility data of S. frugiperda populations to lufenuron were obtained for implementing a proactive resistance management program. An artifical diet treatment surface bioassay was used to characterize the response to lufenuron in a susceptible strain. Third instar larvae were exposed to the treated diet up to 4 days. Diagnostic concentrations of 3.2 and 10.0 up of lufenuron/mL of distilled water were chosen for monitoring resistance. Field populations of S. frugiperda were collected from major corn-growing regions located in the States of Rio Grande do Sul, Paraná, São Paulo, Goiás and Minas Gerais. Preliminary results showed some significant differences in susceptibility to lufenuron among S. flugiperda populations. Laboratory selection studies are in progress in attempt to isolate lufenuronresistant individuals for characterizing the intensity of the resistance. These findings indicate the urgent need for an implementation of resistance management strategies to preserve the lifetime of lufenuron for controlling S. frugiperda in Brazil. Index terms: fall armyworm, insecticide resistance, insect growth regulator

[0340] SURVEY OF ARTHROPODS IN TWO SEEDING SYSTEMS OF SORGHUM (SORGHUM BICOLOR (L.) MOENCH)

R.C.A.S. Seffrin¹ & <u>E.C. Costa</u>¹, iDepto. de Defesa Fitossanitária. Centro de Ciências Rurais -- Universidade Federal de Santa Maria, Campus Universitário, prédio 42, 1º andar, 3225 -- CEP 97105-900 -- Santa Maria -- RS -- Brasil -- e-mail: eccosta@ccr.ufsm.br.

This work had as objetive the quali-quantitative survey of arthropods in conventional and no till system of sorghum (*Sorghum bicelor* (L.) Moench). This research was conducted during 1996/97 season in "Campus" at University of Santa Maria, Rio Grande do Sut, Brazil. The population of arthoropods was collected by soil trap, soil extractor, sweeping trap, packing of panicles, atractive coloured trays and visual evaluation of insects in plants. The total number of arthropods was 14.512. They were classified into five classes, 12 orders, 35 families and 43 species. The Insecta was the most significant class in both conventional seed planting and no till system. Both systems showed no influence on total number of arthropods. However, the population of arthropods was most expressive in the no till system.

Key words: collect methods; no till system; tillage systems

[0339] CHANGING POLICIES AND PRIORITIES: THE EVOLUTION OF LOCUST MANAGEMENT PRACTICES FOR AFRICA

A. C. Schroeder

Locust and other emergency pest management policies have changed over the past 100 years. This is particularly true in Africa, where the lion's share of the world's emergency pest and locust management resources are spent, and where the risk from over-dependence on pesticides is high. Locust plagues can be prevented but rarely controlled. New policies aim to reduce the amounts spent on emergency management measures by preventing outbreaks from occurring. African Ministries of Agriculture staff and farmers are better trained to identify and report upsurges. New environmentally friendly biological control agents are nearing the end of the research pipeline, and may soon be used to control primary outbreaks, and replace older generation pesticides. Donor countries are requiring more and better verification of the severity of damage due to outbreaks as well as the potential for impacts on farmer and national food security. Economic analyses are being required to justify the investment in large and expensive pesticide and material-dependant campaigns. Donor coordination through the United Nations' Food and Agriculture

Organization has improved with the development of new rapid response mechanisms in the descrt locust primary breeding areas. Donors, such as USAID are in the process of cleaning up stocks of obsolete pesticides left over from past campaigns. Africau Ministries of Agriculture are in the process of drafting regulations and training staff on the safe import, handling and use of pesticides, with the aim of using the most environmentally benign pesticide for each situation. And,

improvements in infrastructure, local policy, and communications assist in the rapid assessment of outbreaks and their damage, to determine the best means of control needed, if any.

Index: management of migrant pests, plagues, farmer training

[0341] THIAMETHOXAM USED AS SEED TREATMENT (CRUISER[®]/ADAGE[®]), OR AS SOIL APPLICATION (ACTARA/PLATINUM[®])

R. Senn, D. Hofer, F. Brandl, L. Zang & A. Morcos, Novartis Crop Protection AG, CH-4058 Basel Switzerland, E-mail: robert.senn @cp.novartis.com, dieter.hofer@cp.novartis.com

Thiamethoxam is a novel broad-spectrum insecticide currently marketed by Novartis Crop Protection. The molecule belongs to a new chemical class - the neonicotinoids. Neonicotinoids have a new mode of action interfering with the nicotinic acetylcholine receptor of the nervous system of insects. Thiamethoxam is highly active on a broad spectrum of insects. Compared to the most important competitor in the same chemical class, thiamethoxam can be used at lower dose rate to achieve the same or even higher level control effects with longer lasting activity. The main features that clearly differentiate thiamethoxam from its competitors are the ideal water solubility of 4100 mg/l and the negative log P value of -0.13. Thiamethoxam is neither adsorbed to the organic matter nor affected by normal soil pH values of 5.5 to 8.1 nor by organic matter content of 2-20%. Thiamethoxam is used as seed treatment under the trade names CRUISER® /AGADE® or as soil and foliar application under the trade names ACTARA[®]/PLATINUM[®]. The unique technical advantages of CRUJSER[®]/AGADE[®] may be separated into 3 general areas: robust performance under different climatic conditions; strong initial crop vigor which results in increased yield effects; and carryover of treated seed. Each of these unique technical advantages provides added value to crop genetics, farmers and environment. CRUISER®/AGADE[®] shows excellent performance of seed safety on seeds carried over from one season into the next. Canola seed for example can be stored for at least 18 months without loosing viability and germination power. ACTARA®/PLATINUM® used as soil application methods such as into drip irrigation system injection, in furrow spray, drench after transplanting, side dress or seedling dip, are suitable methods to control broad spectrum of insect pests over an extended period. The best placement of thiamethoxam is in the root zone, which means 2-4 cm below the sowing line at planting. In order to reach the root zone, thiamethoxam should be incorporated. Product placement and irrigation have to be combined in a way that the water will lead the compound to the root zone. Main advantages of ACTARA®/PLATINUM® used in any soil application method are the long time protection, the protection of the whole plant including the new growth and its convenient application.

Index terms: Thiamethoxam, Cruiser, Actara

[0342] COMPARISON OF CITRUS SPECIES AS HOSTS FOR CITRUS LEAF MINER *PHYLLOCNISTIS CITRELLA* (LEPIDOPTERA: GRACHLARIDAE)

A. A. Serai, Plant Protection Department, Shahid Chamran University, Ahvaz, I. I. Iran.Email: aseraj@ahvazuni.neda.net.ir

The relationship between ovipositional preference of *Phyllocnistis citrella* (Lepidoptera: Gracillaridae) and host plant suitability on seven citrus species: *Citrus aurantifolia* (Rutales: Rutaceae), (Mexican lime), *C. sinensis* (Valencia orange), *C. sinensis* (L.) Osbeck Siavaraze Variety, *C.reticulata* Blanco King Variety) *C. reticulata* Blanco Willowleaf Variety (Kinnow mandarin), Citrus volkamerina (Volkamer lemon), Citrus *aurantium* (Sour orange), *Citrus paradisis* Macf. Red Blush Variety (Grape fruit) were determined by measuring numbering larvae per 10 leaves and percentage of mined leaves after adult female moths were given a simultaneous choice and non choice of all citrus species for oviposition. All studies were performed under ambient conditions. *P. citrella* istinct hierarchical ordering in the ovipositional preference with mexican lime, sour, valencia and siavaraze oranges and kinnow mandarin being preferred overall others. Index terms: Grapefruit, lime, citrus leaf miner, sour orange. [0344] STALKBORER DAMAGE AND ESTIMATION OF LOSSES CAUSED BY SESAMIA SPP. (LEPIDOPTERA: NOCTUIDAE) IN KHUZESTAN SUGARCANE INDUSTRY

A. A. Seraj, Ali Asghar Seraj, Plant Protection Department, Shahid Chamran University, Ahvaz, I. I. Itan. E-mail: ascraj@ahvazuni.neda.net.ir

Sesania spp. (Lepidoptera : Noctuidae) are serious pests of sugar cane in the Khuzestan and damage about 20% of stalks annually. Field studies on S. cretica Led. damage and potential crop losses on two important cultivars in the region, NCo 310 and CP 57-614 were carried out at southern Khuzestan state between 1998-1999. CP 57-614 showed greater mean percentage of bored nodes and internodes (20.7%) than in NCo 310 (11-2%). Apart from the direct losses in cane weight (cane yield) due to boring from the larvae, cane juice quality is also adversely affected, resulting in lower recovery of sucrose in the factory. Sugar per ton also was greater in NCo 310 (132 kg) than in CP 57-614 (110 kg). Estimated sugar losses were 0.11 tones ha⁻¹ for every 1% bored and rotting stalks. Other indirect losses are also discussed.

Index terms: Sesamia cretica, sugarcane, pol., brix.

[0343] EFECTS OF SOME INSECTICIDS AND PETROLEUM SPRAY OILS ON THE CONTROL OF CITRUS LEAF MINER IN KHUZESTAN STATE AND REVIEW OF ITS IPM

<u>A. A. Seraj</u>, Ali Asghar Seraj, Plant Protection Department, Shahid Chamran University, Ahvaz, I. I. Iran. E-mail: aseraj@ahvazuni.neda.net.ir

Citrus leaf miner (CLM) Phyllocnistis citrella control in citrus integrated pest management was evaluated during three years (1995 - 98) in Khuzestan district on different citrus cultivars as follows: Citrus sinensis (Rutales: Rutaceae), C.reticulata Blanco King Variety, C. reticulata Blanco Willow leaf Variety C. aurantifolia and C. paradisi Macfadyen Red Blush Variety. Five species of eulophid wasps were reared from the larvae and pupae of CLM. Low levels of parasitism were recorded in sprayed treatments compare to control. Permethrin, Danitol and Carbaryl provided good control for CLM within two weeks after spray, but Diazinon was no more effective. Chemical control of CLM adults would be difficult because of their prolonged and overlapping emergence and may require multiple sprays. Oils significantly suppressed leaf miner infestations. Mean number of larvae per 10 leaves in 0.5%, 2% (v/v) oils treatments and control in different citrus cultivars were respectively as follows (1st week after spray): Lime: 0.15, 0.17 & 3.2, Grapefruit: 0.1, 0, & 1, Valencia orange: 0.5, 0.3, & 2.1 and Kinnow mandarin: 0, 0, & 2.1. Combining the oil with pesticides did not reduce its efficacy against the pest. The ability to mix them will allow spray application costs to be reduced Index terms: natural enemies, lime, Phyllocnistis citrella

[0345] USE OF PETROLEUM SPRAY OILS FOR CONTROL OF CITRUS LEAF MINER AND SAP-SUCKING PESTS OF CITRUS IN SOUTHERN IRAN

<u>A. A. Scraj</u>, Plant Protection Department, Shahid Chamran University, Ahvaz, I. I. Iran. E-mail: aseraj@ahvazuni.neda.net.ir

Oils are an essential component of integrated pest management programs for citrus based on the use of natural enemies. The efficacies of 0.5% and 2% (v/v) petroleum spray oils (volk oil) for the control of citrus leaf miner (*Phyllocnistis citrella* Stainton were determined in spring 1997. Both oils significantly suppressed leaf miner infestations to similar levels. Mean number of larvae per 10 leaves in 0.5%, 2% oils, copper oxychloride 35% wp + oil and control treatments in different citrus cultivars were respectively as follows (1st week after spray): Sour Lime: 0.15, 0.17, 0 & 3.2, Grapefruit: 0.1, 0, 0 & 1, Valencia Orange: 0.5, 0.3, 0.14 & 2.1 and Kinnow Mandarin: 0, 0, 0 & 2.1. Combining the oil with copper fungicide did not reduce its efficacy against the leaf miner. The ability to mix them will allow spray application costs to be reduced. Oils are used to control pests such as scale insects, aphids, and mites when natural enemies are ineffective. Oils offer 4 major advantages over broad-spectrum pesticides: They may be handled without protective clothing; they have low toxicity to vertebrate animals; they have little detrimental effect on beneficial insects and pests cannot develop resistance. Petroleum oils act as an ovipositional deterrent to the pests.

Index terms: Petroleum spray oils, copper fungicides

[0346] BIOLOGY AND REPRODUCTIVE ASPECTS OF *PIEZODORUS GUILDINII* (HEMIPTERA: PENTATOMIDAE) UNDER LABORATORY CONDITIONS

G. Serra¹ & <u>N. C. La Porta</u>¹, ¹ Dep. of Vegetal Protection, Faculty of Agricultural Cs., Univ. of Córdoba, C. C. 509, 5000 Cba, Argentina, E-mail Erro! Indicador não definido.

Piezodorus guildinii is an important pest on many vegetable species including soybean and alfalfa crops. A cohort study was conducted under controlled laboratory conditions: $24,9 \pm 0.5 \,^{\circ}$ C; $53,6 \pm 7.9 \,^{\circ}$ R RH and 16 h L. Insects were fed with fresh fruits of *Phaseolus vulgaris*. Aspects of the life cycle, reproduction and mortality of this hemipterous were evaluated. The following parameters were estimated: the net reproductive rate (Ro), the generation time (T), the intrinsic rate of natural increase (r), reproductive value (V_x) and the finite rate of increase (λ). The following results were obtained: first - instar nymphs hatched from eggs in 4.91 \pm 0.22 days and the percentage of emergence was $87 \pm 17 \,^{\circ}$; nymphs completed their development in 27 days, showing a mortality of 60.1 $^{\circ}$, the greatest occurring in the fifth nymphal instar. Mean number of eggs per female was 43,4; mean fecundity was 4.4 egg masses per female with an average of 9.5 eggs per mass. Adult longevity averaged $58,2 \pm 41,3$ and $67,2 \pm 48,8$ days, for males and females, respectively. No significant differences (p=0.05) were observed between sexes. Other results were Ro= 7,48 females/ female; T=95,9 days; r= 0,0209 / day; λ = 1,02 females/ female. The reproductive value (V_x) showed two definite peaks: 22,1 and 24 at 77 and 133 days, respectively, from egg hatch.

Index terms: Piezodorus guildinii, biology, survival, reproduction

[0348] CHEMICAL CONTROL OF "WHITE FLY", *BEMISIA ARGENTIFOLII* (HEMIPTERA: ALEYRODIDAE) WITH CALYPSO 480 SC (THIACLOPRID), CONFIDOR 700 GRDA (IMIDACLOPRID0) E CONFIDOR 200SC (IMIDACLOPRID) IN EGG PLANT CROP, *SOLANUM MELONGENA*

A.C. Silva¹, R.S. de Mendonça² & L.O. Salgado¹, ¹ Agroteste-Pesquisa e Consultoria, P.O.Box 201, Lavras, MG, Brazil, Zip Code 37.200-000, E-mail: agrotest@ufla.br, ² Inst. de Ciências Agrárias, Univ. de Alfenas/UNIFENAS, P.O. Box 23, Alfenas, MG, Brazil, Zip Code 37.130-000, E-mail: fileni@artefinal.com.br

A serious damage occur in Brazil due to "white fly" in many crops, including cgg plant crop. This way, the efficiency of the farm chemicals Caypso 480 SC, Confidor 700 GRDA and Confidor 200 SC to control white fly *B. argentifolii* on egg plant was evaluated at Uberlândia City, Minas Gerais State, Brazil. The trial was set up during February up to April, 1998. The experiment design was the randomized blocks with 9 treatments and 4 replications. Each plot had 32.4 m^2 with 36 plants. Three application in spray method were realized to the treatments 1, 2, 3 and 8 and just one application in sidedress method was realized to the treatments 4, 5, 6 and 7. The efficiency of the treatments was evaluated according to the number of alive nymphs per samples of 12 leaves per plant. It was used the Abbott formula as a measure of efficiency and means were separated by Tukey test (p<0,05). As a whole of five evaluations where done during the observation period. Index terms: Hemiptera, Aleyrodidae, insecticides, white fly

[0347] CHEMICAL CONTROL OF "WHITE FLY", BEMISIA ARGENTIFOLII (HEMIPTERA: ALEYRODIDAE) WITH CALYPSO 480 SC (THIACLOPRID), CONFIDOR 700 GRDA (IMIDACLOPRID) E CONFIDOR 200SC (IMIDACLOPRID) IN PAPRIKA CROP, CAPSICUM ANNUUM

A.C. Silva¹, R.S. de Mendonça² & L.O. Salgado¹, ¹ Agroteste-Pesquisa e Consultoria, P.O.Box 201, Lavras, MG, Brazil, Zip Code 37.200-000, E-mail: agrotest@ufla.br, ² Inst. de Ciências Agrárias, Univ. de Alfenas/UNIFENAS, P.O. Box 23, Alfenas, MG, Brazil, Zip Code 37.130-000, E-mail: fileni@artefinal.com.br

White fly became an important pest for several crops in Brazil so the focus of this study was to evaluated the efficiency of the commercial product (c.p.) Calypso and Confidor to control *B. argentifolii* in paprika crop. The trial was set up at the Uberländia City, Minas Gerais State, Brazil, during December, 1998 up to February, 1999. The experiment design was the randomized blocks with 9 treatments and 4 replications. Each plot had 16.80 m² with 24 plants. The efficiency of the treatment was evaluated according to the numbers of alive nymphs per samples of 15 leaves per plot. It was used the Abbott formula as a measure of efficiency and means were separated by Tukey test (p<0,05). As a whole of three evaluation were done during the observation period and the results are presents in the Table 1.

Index terms: Hemiptera, Aleyrodidae, insecticides, Capsicum annuum.

[0349] EVALUATION OF THE THIAMETHOXAN IN THE CONTROL OF "RICE WATER WEEVIL" ORYZOPHAGUS ORYZAE (COLEOPTERA-CURCULIONIDAE)

<u>R.F.P.</u> da Silva¹ & J.V.Oliveira², ¹Dept. de Fitossanidade, Univ. Federal do Rio Grande do Sul, Cx.P. 776, Porto Alegre,RS, CEP 90001-970,Brasil, E-mail: rogeriop@vortex.ufrgs.br; ²Instituto Riograndense do Arroz/EEA, Cx.P. 29CEP 94930-030, Cachoeirinha,RS, Brasil

Considering the Brazilian agriculture as whole, the culture of rice gets prominence not only by its social, economic and commercial importance, by also by its area of cultivation, both in flooded and dry farming systems. The breeding cultivars for flooded system showed potential for grain yield up to seven tons/ha in the last fifteen years. However, the damaging effects may negatively impact rice production. Insect pests have contributed significantly to decrease the grain yield by qualitative and quantitative damage to this culture. The "rice water weevil" Oryzophagus oryzae is an important pest of rice. It's control, due to the aquatic behavior, usually requires high amount of toxic insecticides, The objective this work is to encounter news alternatives with low toxicity to superior animals and efficient to pest. The research was carried out on the crop season of 1999/2000, at the experiment station of Instituto Riograndense do Arroz, Cachoeirinha, RS. The rice cultivar IRGA-417, very susceptible to O. oryzae, was sown in nov.16.1999. Each plot consisted of 11 rows with 2-m lenght and 0.2 m spacing, covered by an iron structure with 2.0x2.0x0.3 m. The design was randomized blocks with four replicates. The area was irrigated 23 days after sowing and level of water kept at 15 cm to facilitate the chemical's dilution. The thiamethoxan insecticide was applied in three formulation. Actara 250 WG was sprayed before irrigation and applied by "benzedura" method three days after irrigation, using about 200 and 40 L of mix/ha, respectively. The formulation granulate (Actara GRI) and standard (carbofuran), were mixed to 100 g of fine sand and spread through the plots with saltcellar, 27 days after irrigation. The treatment with thiamethoxan was applied to seeds too by planting time. Evaluation was done at four and 13 days after applying granulated products, corresponding to 31 and 37 days after irrigation. In this procedure, a method adapted from Tugwell and Stephen(1981) was used, consisting of the extraction of four cylindrical soil and roots samples per plot, using PVC tubes 8.5 cm high and 10 cm diameter. To release the larvae, samples were shaken and washed with water through a nylon screen sieve. The results showed that all formulations and application methods of thiamethoxan were highly efficient in the control of the rice water weevil, with a control index higher than 80% in all the evaluation. Index terms:Insecta, Erirbininae, rice, chemical control

[0350] WHITEFLIES (HOMOPTERA: ALEYRODIDAE) ON SPECIES OF MEDICINAL HERBAL PLANTS

A. M. Simmons¹, G. S. McCutcheon², R. J. Dufault², R. L. Hassell² & J. W. Rushing², ¹USDA-ARS, U.S. Vegetable Lab., 2875 Savannah Hwy, Charleston, SC 29414, USA, Email asimmons@awod.com; ²Coastal Research and Ed. Center, Clemson University, 2675 Savannah Hwy., Charleston, SC 29414, USA.

Whiteflies are destructive worldwide pests on many plant species of economic importance. A study was conducted on the production potential of selected medicinal herbal plant species as new crops suitable for cultivation in South Carolina, USA. Whiteflies (Bemisia argentifolii Bellows and Perring) were found in an experimental production field infesting 5 perennial species of medicinal herbal plants (feverfew, Tanacetum parthenium (L.) Schultz-Bip.; St. John's wort, Hypericum perforatum L.; purple coneflower, Echinacea pallida (Nutt.) Nutt. and E. purpurea (L.) Moench; and common valerian, Valeriana officinalis L.). Whiteflies have not been previously reported in the literature on these plant species. The density of whiteflies was greater on some of the species than on others. Relative abundance based on capture of adult whiteflies on yellow sticky cards agreed with the relative density of immatures among the plant species. Adult capture on sticky cards was high in plots of E. purpurea compared with plots of the other 4 species, and adult counts were elevated in the highest (440 kg N/ha) of 3 fertility rates in E. purpurea. Likewise, laboratory tests agreed with the observation of a higher population of B. argentifolii on E. purpurea compared with the other 4 plant species. The whitefly completed development on all 5 plant species, and whitefly associated parasitoids emerged from field leaf samples of each plant species. These perennial plants can help support over wintering populations of B. argentifolii in mild climates. Commercial use of these plants dictates restrictions on the use of traditional insecticides. Hence, biological control would be especially attractive for use in a pest management system on these herbal medicinal crops

Index terms: Bemisia argentifolii, parasitoid, fertility, host plant, population.

[0351] MOLECULAR CHARACTERISATION AND QUANTITATION OF THE AMPLIFIED CARBOXYLESTERASE GENE ASSOCIATED WITH ORGANOPHOSPHORUS INSECTICIDE RESISTANCE IN THE BROWN PLANTHOPPER, *NILAPARVATA LUGENS*

G.J. Small¹, J.G. Vontas¹, S.H.II.P. Karunaratne², J.C. Morgan¹ & <u>J. Hemingway¹</u>, ¹School of Biosciences, Univ. of Wales Cardiff, P.O. Box 915, Cardiff CF10 3TL, UK, email: Hemingway@cardiff.ac.uk. ²Dept. of Zoology, University of Peradeniya, Sri Lanka.

Widespread resistance to organophosphorus insecticides (OPs) in Nilaparvata lugens, a major pest of rice in Asia, is associated with elevation of carboxylesterase activity. The underlying mechanism of resistance to these insecticides is elevation of carboxylesterases. A cDNA encoding a carboxylesterase, NI-EST1, has been isolated from an OP-resistant Sri Lankan strain of N. lugens. The full-length cDNA codes for a 547-amino acid protein with high homology to other serine hydrolases. NI-EST1 has an N-terminal hydrophobic signal peptide sequence of 24 amino acids which suggests that the mature protein is secreted from cells expressing it. The nucleotide sequence of the homologue of NI-EST1 in an OP-susceptible, low esterase Sri Lankan strain of N. lugens is identical to NI-EST1. Southern analysis of genomic DNA from the Sri Lankan OP-resistant and susceptible strains shows that NI-EST1 is amplified in the resistant strain. Therefore, OP resistance in N. lugens is through amplification of a gene identical to that found in susceptible insects. Quantitative real-time PCR was used to demonstrate that NI-EST1 is amplified 3-7-fold in the genome of resistant compared to susceptible planthoppers. Expression levels were similar to amplification levels, with 1-15-fold more NI-EST1 mRNA in individual insects and 5-11-fold more NI-EST1 mRNA in mass whole body homogenates of resistant females compared to susceptibles. These values corresponded to an 8-10-fold increase in esterase activity in the head and thorax of individual resistant insects. Although amplification, expression and activity levels of NI-EST1 in resistant N. lugens were similar, there was no linear correlation between esterase activity and NI-EST1 mRNA levels in individuals of the resistant strain. The lack of a direct correlation between esterase activity and esterase gene amplification levels in individual females and in pooled homogenates of females may be due to variation in the localisation and stability of the amplified esterase in the planthoppers with physiological state or with age. The stability of NI-ESTI may be influenced by differential glycosylation of this protein, which results in a diffuse band on native polyacrylamide gels in contrast to the sharp bands seen with the amplified esterases of both aphids and mosquitoes.

Key words: Gene amplification, quantitative PCR, head separation

[0352] POPULATIONAL STUDIES OF LEPTOGLOSSUS. ZONATUS (HETEROPTERA: COREIDAE) ON CORN (ZEA MAYS) IN BRAZIL

<u>C. E. P. Souza^{1, 2, 3}</u>, **B. F. Amaral-Filho^{1, 3} & A. Mafra-Neto^{1, 2}**, 1- Fac. Filos. Ciênc. Letras de Ribeirão Preto, Univ. de São Paulo, Av. Bandeirantes, 3900, Ribeirão Preto, São Paulo, Brazil,14040-901; 2- 100A Chapman Hall Univ. of California-Riverside, Riverside, United States, 92521; 3- Univ. Est. de Campinas- Depto. de Zoologia, caixa postal: 6109, Campinas, São Paulo, Brazil.

The fluctuation of a population of the leaf-footed bug *Leptoglossus zonatus* was monitored in corn fields for two seasons (1997/98). The fields were located in the farm Santa Elisa/Instituto Agronômico de Campinas, Campinas (22°55' of South latitude, 47°04' of West longitude and 650 m of altitude), São Paulo, Brazil. The first occurrence of adults was during the vegetative development of corn, $41,0\pm5,57$ days after planting (minimum 21 and maximum 55 days, n=5 fields). The density of nymphs and adults increased continuously with the development of corn ears until the harvest, when the corn was completely dry. We will discuss the effects of the maturation of the crop and natural environmental conditions on fluctuations of the population density of the leaf-footed *L*. *zonatus* as well as the potential use of natural enemies and pheromones in alternative management strategies.

Index terms: Leptoglossus zonatus, leaf-footed bug, coreid bug, fluctuation, corn

[0353] POPULACIONAL APPRAISAL OF OWLET MOTHS (LEPIDOPTERA, NOCTUIDAE) AND THEIR NATURAL ENEMIES IN MORNING AND NIGHT COLLECTIONS IN THE RYEGRASS CULTURE, WITH NET SWEEPING

A. Specht^{1,2} & E. Corseuil², ¹ Curso de Agronomia, UNISUL, Av. José Acácio Moreira, 787, CEP 88704-900, Tubarão, SC, Brasil, E-mail spechta@puers.br; ² PPG Biociências, PUCRS, Av. Ipiranga, 6681, C. Postal 1429, CEP 90619-900, Porto Alegre, RS Brasil, Email corseuil@puers.br.

The populational control levels of Noctuidae in cereal cultures are limited on the defoliate percentage, without regarding the caterpillar population. These traditional indexes are obtained subjectively, what brings about an array of environmental and economical potential risks. These are expanse use of agricultural defense products, decrease of efficiency due to poor knowledge of target species, elimination of natural enemies and unnecessary environmental contamination. This work aims to supply subsidies to the development of a methodology of populational evaluation of noctuid caterpillars and agents of its natural control that can be applicable to several cereal crops. The work was conducted in two ryegrass areas (Lolium multiflorum), in Salvador do Sul, RS. The collections, in number of 17, were weekly, beginning on July 22, 1994, using sweeping net in the morning (10:00) and night (22:00). The caterpillars were counted, being considered small when up to 1.5cm, mean between 1.5 and 2.5cm and big when larger than 2.5cm. A total of 2,044 caterpillars were analyzed. The number collected in the daytime was smaller than a tenth of that collected in the night. The variance analysis evidenced interaction between shift, size and dates. Out of 523 caterpillars bred in laboratory 11 species emerged, being the community composed by the plague key Pseudaletia sequax representing 78% of the individuals and the accessory species, Dargida meridionalis 11%, Anicla ignicans 6%, Spodoptera frugiperda 2% and the others 3%. The proportion of P. sequax, in relationship the other species, was larger at night, especially in the reproductive and maturation phases of the ryegrass. In relationship to the organisms related to the natural control of Noctuidae, 387 spiders, 577 microhimenopterans and 983 insects distributed in 8 orders and 19 families were collected. It was obtained significant differences among averages of week collection for Carabidae, Tachinidae, Forficulidae, Vespidae, microhimenopterans and Araneae. These results indicate the convenience of using sweeping net for an populational more accurate evaluation of both Noctuidae and its agents of natural control in cereals crops.

Index terms: Ecology, Population dynamic, Pest control.

[0354]PHOSPHAMIDON 40SL AGAINST SUCKING PESTS OF RICE, COTTON AND BRINJAL

S.Suresh & T.Srinivasan, Department of Agricultural Entomology, TamilNadu Agricultural University, Coimbatore- 641 003

Due to the toxic effect to natural enemies and other related problems like high mammalian toxicity use of Phosphamidon 85SL is banned from April, 2000 though this one of the chemicals being used by the farmers widely for the control of sucking pests and stem borer of rice. A new formulation with 40SL was evaluated for the first time in India against sucking pests of rice, cotton and brinjal. Phytotoxicity and toxicity to natural enemies in the field condition were also tested.

Two field trials in rice, two in brinjal and one in cotton laid out indicated that Phosphamidon 40SL sprayed @ 250 g ai /ha for brinjal and ,350 g ai/ha for rice and cotton was found to be effective in reducing the population brown planthopper, green leafhopper and white backed plant hopper for a week in rice and white files, leafhopper, thrips and aphids for ten days in brinjal and cotton respectively. Yield was also comparable with Phosphamidon 85SL.Triple the dose tested for phytotoxicity indicated that there was no phtotoxicity. It was comparatively safer to natural enemies though for initial three days there was a slight reduction in population. Among the three doses, tried 250g ai/ha for brinjal and 350 gai/ha for rice and cotton were found effective.

[0356] GENETIC VARIATION AND GENE FLOW AMONG POPULATIONS OF THE COTTON BOLLWORM *HELICOVERPA ARMIGERA* (LEPIDOPTERA: NOCTUIDAE) IN CHINA

S. J. Tan, X. F. Chen, S. P. Li, R. Y. Liu, Y. Wang & D. M. Li, The State Key Lab of Integrated Management of Insect Pests & Rodents, Institute of Zoology, Chinese Academy of Science, Box 70, Beijing 100080, P. R. China, E-mail Lidm@panda.ioz.ac.cn

The cotton bollworm Helicoverpa armigera is one of the most serious agricultural insect pest in China. It has adapted to many different host crops and occurs in Asia, Europe, Africa and Australia and caused huge damage to cotton production in recent years. Although much research has been conducted on the ecology and population biology of this pest, the dispersal and migration patterns of the cotton bollworm are not well understood. The forecast of Cotton bollworm's population density is difficult, and one of the reason is the absence of information about the migration among geographic populations. As direct field study on the migration of insects is usually very costly and difficult, analysis of the population genetic structure becomes an important information source for studying gene flow among populations, Genetic variation among different local populations of the cotton bollworm in China, and possible migration or gene flow pattern of the insect were studied, using genetic marker data. High rate of gene flow occured among local populations in China, which supported the migration hypothesis of Helicoverpa armigera. The genetic distance was not found to be correlated significantly with geographic distance of the populations, and the Fst/(1-Fst) did not shown a linear correlation with the logarithm of geographic distance, which suggested that the migration and gene flow of *Helicoverpa amigera* in China conform to the island model. The Fst estimated from gene frequency data and the F' from the band sharing data are quite close, which means that these two indexes could both be used to measure the division of genetic variation within and among populations.

Index terms: Genetic variation, gene flow, Helicoverpa ar

[0355] THE FIELD EXPERIENCES OF MOSQUITO'S (*DIPTERA, CULICIDAE*) CONTROL IN SOME AREA IN PIEDMONT (ITALY)

<u>A. Talbalaghi ¹</u>, ¹Freelance Consultant for Urban Pest Control, P. Gubellini St., 4, 40141 Bologna (BO) I, E-mail dom2034@iperbole.bologna.it

In Italy the problem of mosquitoes, historically linked to malaria, has in recent years returned to forefront. This due to increases in the mosquitoes themselves as well as the populations' greater sensitivity due to improved and therefore expected high standards of living. In 1995 the region of Piedmont introduced a law to favor initiatives to combat biologically culicidi. In light of the law, some municipality agreed to the joint program. In this area, of roughly 210.000 hectares, that a feasibility was completed, to investigate the breeding sites and to quantify the problem. The territory is mainly agricultural with many large inhabited centers. In order to increase productivity, in the warm season the fields are flooded. The water is left for several days in the fields, nonetheless the puddles formed last for a sufficient period for the complete life cycle of 2 lethal mosquitoes which lay their eggs in the earth and hatch after the prolonged flooding: Aedes caspius (Pallas) and Aedes vexans (Meigen). This due to Ae. caspius which their eggs hatch after flooding of chambers not enough time to release the mosquito fish Gambusia sp. After the first flooding, the larvae of Aedes caspius are gathered on the edge of chambers, so that's sufficient to spray BTI on one meter of chamber's perimeter. Just after the 2nd flooding of chamber (mainly 3 flooding), the treatments are done up to September on 5 meters of perimeters of chambers. The over-infestation of chambers by Culex modestus (Ficalbi), Culex pipiens (L.) and Anopheles maculipennis s.l. Meigen, during the latest flooding is usual. In this case generally during of July and August , because of advanced growth of crop and others particular conditions, the toughest way is the release of mosquito fish into chambers up to 1-2 kilometers distance from inhabited centers. After 5 years from the beginning of this plan, no longer active larval breeding sites are reported. Nonetheless, the high presence of Acdes caspius adult during July 1999, are raised everywhere because an overall raising of the average of temperature in this month, (even 3-4 C°) raising temperature, enough to contribute so high level of infestation. Due to inborn attitude of Aedes caspius, to very long distance flight, come from those neighborhood where, up to now, there is generally not any mosquito's control plan on larval breeding sites and the Aedes caspius one are not treated, thus, are still dramatically active. The information, that inhabitants of cities have received to how combat the mosquito's micro-breeding site in their own private area, during 5 years of this on going plan, have supported further good results. Besides, technical approaches to mosquito's control, the knowledge of any single inhabitants, is been always highlighted. Index terms Aedes caspius, Rice-field, Urban p

[0357] SPATIAL AND TEMPORAL DISTRIBUTIONS OF PREDATORY INVERTEBRATES WITHIN, AND DISPERSING FROM, OVERWINTERING REFUGES IN UK CEREAL FIELDS

S.R.Thomas¹, D.Goulson¹ & J.M.Holland², ¹Biodiversity and Ecology Division, School of Biological Sciences, University of Southampton, Bassett Crescent East, Southampton, Hampshire SO16 7PX, ²The Game Conservancy Trust, Burgate Manor, Fordingbridge, Hampshire SP6 1EF, UK, Email: st3@soton.ac.uk.

The importance of polyphagous predators in providing biological pest control has been increasingly appreciated over the last few decades. There are currently many incentives to boost their populations and counteract problems such as pesticide-induced mortality and habitat loss caused by agricultural intensification. These invertebrates, with other species, are now also considered important in providing prey for farmland birds, which are in serious decline in the UK. Some beneficial invertebrates are able to live and reproduce within fields all year round, but others have been found to migrate from uncultivated field boundaries into the crop in spring, and return after harvest. Beetle banks, raised grassy strips positioned mid-field in arable crops, provide suitable overwintering refuge for such field-edge sheltering carabid and staphylinid beetles and spiders (Sotherton, 1995). They were designed to lessen the distance that these spring-dispersing species must travel in order to reach all areas of a field, allowing maximum pest control in this context. Invertebrate spatial distributions have not been fully researched because of the need for intensive sampling regimes, and statistical methodologies used have often been inadequate. Much work examining predators in cereals has merely sampled transects or small areas and extrapolated densities and distributions to cover the whole field, but many species have actually been found to be heterogeneously distributed, according to diet and microhabitat preferences. Recently developed techniques can measure the amount of spatial pattern in spatially-referenced count data (Perry, 1998) and can be further modified to detect non-random clusters of invertebrate counts (Perry et al. 1999). This research evaluated densities of polyphagous predators within established beetle banks, before, during and after the period of expected dispersal into UK cereal fields. It also examined the within-field distribution of these invertebrates at regular intervals over the period of January to July, 1998, comparing those species which are known to be permanently field resident with those known to have invaded during spring from the beetle banks. Destructive turf sampling and barriered pitfall trapping over extensive field-scale grids were used to collected invertebrates, which were identified and analysed used SADIE (spatial analysis by distance indices). Results are discussed in relation to the efficacy of the sampling and analysis methodologies, potential pest control benefits, and future developments and applications for the farmer.

Index terms: polyphagous predator, SADIE, beetle bank, biological pest control, spring colonisation.

[0358] EFFICIENCY OF INSECTICIDES TO CONTROL ADULTS OF STERNECHUS SUBSIGNATUS IN SOYBEAN

<u>G. L. Tonet</u>, Embrapa – National Wheat Research Center, BR 285, km 174, 99001-970 Passo Fundo, RS, Brazil. E-mail: gabriela @ cnpt.embrapa.br.

Sternechus subsignatus Boheman, 1836 (Coleoptera, Curculionidae), has been cited for many years as a pest on soybean in southern Brazil. The damage of adults on young plants may cause death of them, resulting in low stand and low crop yield. The larvae damage results in weak plants due to the insect feeding on the stems, which could break by the action of wind and may die. The pest remains in the infested area and soybean cropping may become unprofitable in the following season if control strategies are not taken. As just metamidophos insecticide has been officialy registered in Brazil to control this pest, an experiment was done at Embrapa - National Wheat Research Center, in the locality of Coxilha, RS, in 1998/99 crop season. The aim of the experiment was to evaluate the efficacy of deltamethrin (Decis 25 CE and Decis 50 SC, both 5.0 and 7.5 g a.i./ha), metamidophos (Tamarom BR, 480.0 g a.i./ha), and permethrin (Tifon SC, 37.5 g a.i./ha) sprayed on soybean plants to control the pest. The results showed that deltamethrin (Decis 50 SC) at 7.5 g a.i./ha at three and five days after insecticide application had 82 % and 81 % of pest control, respectively, but there was no statistical difference between insecticides and doses tested. The reduction in the number of insects has resulted in 14 % and 17 % less damage on plants with deltamethrin, while the control plots had 41 % and 62 % of plants damaged at three and five days after application, respectively. No insecticide reached 80 % of efficacy after five days from date of insecticide application. Index terms: Chemical control, deltamethrin, metamidophos, permetrin, soybean pest

[0360] FIRST EVIDENCE OF *COPTOTERMES HAVILANDI* IN CAMPOS DOS GOYTACAZES (RJ), BRAZIL

A.A. Trindade¹; A.L.O.S. Nunes¹; V.S.G. Silva¹; F.C. Freitas¹ & <u>E.B. Menezes</u>¹, ¹CIMP "CRG"/ UFRRJ, BR 465 – km 7, Seropédica, RJ 23890-000, Brazil, E-mail ebmen@zaz.com.br.

The Asian subterranean termite Coptotermes havilandi (Isoptera: Rhinotermitidae) was introduced in Brazil between 1915 and 1923. It's the most serious pest in urban areas in Brazil, mainly in its metropolises, such as São Paulo and Rio de Janeiro. The objectives of this study were to detect them and observe their behavior foraging in buildings, and to evaluate the efficiency of curative/preventive treatments for eradication of this termite. In a city called Campos dos Goytacazes, belonged to Rio de Janeiro State, we found the first focus of this termite's genus. There were two buildings, one far from each other, and we confirmed the altack in both. The first one to be inspected had 12 floors and two apartments by floor. All of the apartments had damages done by the C. havilandi, and it was confirmed in beds, doors, etc. We observed that the termites moved upward to the top floors through the electrical installations from the soil. In the other building the only difference is that it had one floor less than the first one, then 11 floors. In the majority of the buildings, C. havilandi constructed secondary nests mainly in apartments of the top floor. In urban areas, subterranean termites are usually controlled by insecticides. We used these products as curative and preventive treatments. The chlorpiriphos was applied by spraying and forced injection. New inspections were done and we verified that the result was positive. It means that the got the control of the termites.

Index terms: Coptotermes havilandi, urban areas, curative/preventive treatment, infested buildings

[0359] INSECTICIDE EFFICACY TO CONTROL STERNECHUS SUBSIGNATUS ON SOYBEAN SEED TREATMENT

<u>G. L. Tonet</u>, Embrapa – National Wheat Research Center, BR 285, km 174, 99001-970 Passo Fundo, RS, Brazil. E-mail: gabriela @ cnpt.embrapa.br.

Sternechus subsignatus Boheman, 1836 (Col., Curculionidae) was found in 1973, as a secondary pest problem in the State of Rio Grande do Sul (southern Brazil). Nowadays it is a major pest on soybean in the region. Damages are caused by adult insects on seedlings and young soybean plants and by larvae that penetrate branches causing "galls" that reduce sup circulation. Damaged plants may die or branches may breake down, reducing yield potential. Cultivating host plants sprayed with insecticides on the border of cropped areas and crop rotation with no-host species are alternatives to diminish pest population. Very few insecticides are efficient to control the pest at seedling and young plant stages, as adult insects emerge from soil during long periods. For this reason insecticide spraying should be repeated several times. Therefore, seed treatment with insecticides can be an efficient pest control strategy. A field experiment was done at Embrapa-National Wheat Research Center, in Passo Fundo, RS, Brazil, in 1998/1999 soybean season. The aim was to test three infesting periods after planting and three doses of thiamethoxam (Cruiser 700 WS), compared of doses of imidaclopride (Gaucho 600 PS), thiodicarb (Semevin 350 RA), carbofuran (Furadan 350 SC), and carbosulfan (Marshal 400 SC). The results showed that thiamethoxam 210 g a.i./100 kg of soybean seed and carbofuran 1050 g a.i./100 kg of soybean seed were efficient in controlling adults of Sternechus subsignatus, resulting in low population of larvae and high crop yields. Carbosulfan 1200 g a.i./100 kg of soybean seed was efficient in controlling adults when infested 14 days after emerging of plants. Imidaclopride and thiodicarb were not efficient to control the pest in all periods tested, resulting in high survivability of adult insects and larvae and low soybean yield.

Index terms: Seed treatment, soybean pest, thiamethoxam, carbofuran, chemical control

[0361] ARMADILLIDIUM VULGARE (CRUSTACEA: ISOPODA). NEW PEST TO SOYBEANS IN ARGENTINA?

E. V. Trumper¹, M. Linares¹, F. Fava¹ & M. Battán², ¹Sección Entomología, EEA Manfredi, INTA, Ruta Nac. 9 Km 636, 5988 Manfredi, ARGENTINA, E-Mail: etrumper@arnet.com.ar; ²Cat. Diversidad Animal I, Fac. Cs. Exactas, Físicas y Naturales, U.N.C., Av. Vélez Sársfield 299, 5000 Córdoba, ARGENTINA.

The influence of low or zero-tillage on soil related fauna has been documented, including changes of diversity, and density of particular species. In Argentina, cutworms, grasshoppers, ants and slugs are among the organisms that show a clear increase of density as a result of more abundant refuges, higher levels of moisture and more stable microenvironments. An unexpected new consequence was identified in zero-tillage soybeans, particularly in irrigated fields. At the beginning of the last two growing seasons, newly established crops begun to show patches of increasingly weak plants, or decreasing plant density. No factors such as mechanical failure during sowing, herbicidal phytotoxicity, plant diseases or nutrients deficiencies could be associated with these symptoms, nor could the injuries observed in plants be attributed to any insect species present in those fields. Due to the unusually high abundance of isopods in those soybean crops, and in spite of their known detritivorous feeding habits, the working hypothesis that these crustaceans were the proximate cause of the damage observed was claimed. Essays and sampling were initiated to test this preliminary hypothesis. Soybean seeds were sown in pots with presence of different numbers of isopods per pot and a control with no isopods, and kept in a glasshouse for two weeks. The presence of isopods in the pots was associated with injuries on different parts ofd the seedlings, while no damages were observed in seedlings with no isopods present. The characteristics of injuries were very similar to those observed in the field. Different types of injuries will be illustrated. Similar essays were carried out in the field, with equivalent results. A sampling technique is proposed consisting of a 50 X 50 cm. frame which is dropped on the ground and isopods inside are collected for 5 minutes. Isopods density and seedling injuries were sampled along a transect in a soybean field. Percentage of seedlings damaged were highly correlated to isopods density (R2=0.62; P<0.01). The influence of seed quality on these results will be discussed. Index terms: soybean, zero-tillage, arthropods.

[0362] ALLOCATION OF ARTHROPODS IN WINTER WHEAT CROP AND AROUND IT

W.B. Tshernyshev, A.V. Timokhov, O.V. Timokhova, R. R. Seifulina, I.I.Soboleva-Dokuchaeva, V.M. Afonina & A.V. Sujazov, Dept. of Entomology, Faculty of Biology, Moscow State University, 119899, Moscow, Russia, E-mail tshern@3.entomol.bio.msu.ru

The investigations were carried out in Moscow region for 3 years and in Krasnodar region (the Northern Caucasus) for 1 year. The areas of the fields were 12-14 ha and 64 ha respectively. We used entomological sweeping and pitfall traps from March- April till harvest. Regular samples were taken in the field centre, on its edges, on grassy field margins and in adjoining biotopes. The distances of sites from field margin were: edge -7-10 m; halfway to the centre- 200 m (Krasnodar); centre - 170 m (Moscow) and 400 m (Krasnodar). Both the maximal number of all arthropod species and their maximal abundance were found on field margins and minimal - in the centre. However, the allocation of separate species was different. The number of species of carabid- beetles and spiders was the same in the centre and in the "halfway" but some other insects could distinguish these sites. The carabids more evenly colonise the field than spiders, the most drastic decrease of abundance towards the centre was observed in spiders, inhabiting plants. Very abundant in Moscow region carabids, Poecilus cupreus and Harpalus rufipes colonised the field from its margins and concentrated then in its central part. H. rufipes replaced P.cupreus in margins in spring and in the field in summer. In Krasnodar, groundbeetles Brachinus spp. emerged at first on margins and in forest belts. Later they occupied the edge of the field and then the whole surface of the field. Anchomenus (Agonum) dorsalis appeared there in forest belts in early spring and later on the margins, it was absent in the field. Spiders Tetragnatha extensa and Xysticus ulmi moved to the field from its margins. Later the former distributed evenly all over the field and its margins whereas the latter preferred field edges and margins. Hypsosinga pygmaea was found in the field mainly in its centre from spring and avoided its margins and forest belts. Ground dwelling spiders, Lycosidae, preferred the central part. There were many carnivorous red mites Trombidiiformes in spring in Krasnodar, especially in the centre. Chrysomelids *Phyllotreta* and flies *Oscinella* colonised the field at once and preferred its central parts. Chrysomelid beetles, Lema melanopus, concentrated on field margins in spring and later colonised the field edges. Aphids, Macrosiphum avenae as well as bugs, Eurygaster integriceps and Lygus rugulipennis. began to colonise the field from its edges. However, their offspring was abundant in the centre. Allocation of the majority of aphidophagous insects and aphids is the same.

Index terms: agroecosystem, pests, natural enemies, migrations, arthropods.

[0363] SPINOSAD - A NEW BIOMOLECULE FOR MANAGEMENT OF BOLL WORM IN COTTON ECOSYSTEM

<u>S. Uthamasamy</u> & S. Raguraman, Department of Agricultural Entomology, Agricultural college and Research Institute, Tamil Nadu Agricultural University, Madurai 625 104. India, E-mail: uthamasamy99 @hotmail.com.

Spinosad is a mixture of spinosyn A and spinosyn D which are naturally derived group of insect control molecules from a new species of actinomycetes, Saccharopolyspora spinosa (characterized as a bacterium) developed by Dow Elanco, USA. Spinosad demonstrated excellent control of many pests of crops. It acts as both contact and stomach poison. We tested the formulated product of spinosad 48 SC at 25, 50, 75 and 100 g a.i./ha along with three other insecticides viz., chlorpyriphos 20 EC, quinalphos 25 EC and endosulfan 35 EC against the boll worm, Helicoverpa (=Heliothis) armigera (Hubner) in cotton ecosystem in three consecutive seasons. The studies were conducted during 1999-2000 with SVPR 2 and MCU 10 cotton varieties. The results revealed that spinosad 48 SC at 75 and 100 g a.i./ha effectively contained the damage caused by larvae of H. armigera. Laboratory evaluation of spinosad revealed that 25 and 50 g a.i./ha were safe to egg parasitoid, Trichogramma chilonis Ishii. Spinosad did not show any phytotoxic symptom on cotton leaves at all the concentrations tested. Harvest time residue studies indicated below detectable levels of spinosad even at 150 g a.i./ha in/on cotton lint, seed, oil and soil samples 10 days after foliar application. It is concluded that spinosad is a compatible component in IPM in cotton for the management of Helicoverpa armigera.

Index terms: Spinosad, bioefficacy, Helicoverpa annigera, phytotoxicity, residues, cotton ecosystem.

[0364] WHITEFLY IMPACT ON IRRIGATED AGRICULTURE IN SEMI-ARID REGION OF BRAZIL: THE FARMER'S PERSPECTIVE

<u>S. D. Vasconcelos</u> & M.A.S. Bezerra, Mestrado em Biologia Animal, Depto, de Zoologia, Universidade Federal de Pernambuco, Av. Prof. Moraes Rego, s/n, Recife - PE, 52040-150, BRAZIL E-mail: simao@npd.ufpe.br

The whitefly known as Bemisia tabaci (B. tabaci strain B or B. argentifolii) (Hemiptera: Aleyrodidae) was first detected in the Northeast of Brazil in the end of 1995 and has, since then, established itself as the most important pest in irrigated agriculture. Its damage includes mainly transmission of geminiviruses in tomato and serious losses in the productivity of melon. While research has been speedy in finding new chemical insecticides and new technologies for pest control, an important component in integrated pest management seems to have been forgotten, namely the transfer to and use of technology by the small area farmers, responsible for most of food production in Northeast Brazil. This study was conducted in 1999 and had the objective to assess the impact of whitefly on the economics of irrigated agriculture under the farmers' point of view. To achieve that, interviews were conducted with farmers in the Petrolina-Juazeiro region, Northeast of Brazil. According to the answers, the average losses on yield for tomato and melon are around 40%; chemical control is still the most used method - despite of serious misuse of insecticides, and most farmers are replacing melon with other crops. Less susceptible varieties are beginning to be used by the farmers, as part of a technological package designed by local tomato industries. The losses in 1999 appeared to be less intense than in 1998, and, interestingly farmers seem to believe that the impact of the pest will diminish in the next years. When asked about what they needed to fight the pest, most of suggestions were related to training and technical orientation, especially about alternative methods of control. It seems, from this study, that a substantial production loss could be avoided if a serious, constant extension programme were being carried in that region.

[0365] SCARABAEIDAE S. STR. (COLEOPTERA: SCARABAEOIDEA) FROM VICOSA, MINAS GERAIS STATE, BRAZIL

F. Z. Vaz-de-Mello¹, C. Lopes-Andrade¹, S. A. Falqueto¹, J. N. C. Louzada², J. II. Schoereder¹ & E. R. Lima³, ¹Lab. Ecologia de Comunidades, Dept. Biologia Geral, Univ. Fed. Viçosa, Niçosa MG 36571-000, Brazil. E-mail scarab@insecta.u(v.br. ²Dept. Biologia, Univ. Fed. Lavras, Lavras MG 37200-000, Brazil. ³Dept. Biologia Animal, Univ. Fed. Viçosa, Viçosa MG 36571-000, Brazil. The last part of this work has been supported by FAPEMIG.

Viçosa region has a primitive habitat of Tropical Semideciduous rainforest, that has been largely cut for wood, and after for coffee plantations and pastureland. This resulted in a mosaic of habitats, with a pastureland matrix, patched with mainly secondary and disturbed forests, coffee plantations and a few other cultures. Durying eight years (1992-1999), all region has been sampled for scarabs, mainly in forest fragments, and sometimes also in pastureland. In the first five years, the aim of this sampling was to verify effects of fragmentation on Scarabaeidae communities, and, in the last years, to verify habitat and food segregation, and to evaluate all regional richness of species. The collecting techniques used were: pitfall traps baited with a variety of resources (human, cow, horse, monkey, dog or pig dung, various kinds of vertebrate carcass, roting fruits, dead or live millipeds, dead insects, snail dung, humus, etc.), canopy traps (baited with human dung, carcass and rotten fruits), flight intercept traps, incandescent, mercury and ultra-violet light traps, manual collecting, on the soil, leaves, termite and ant nests. As a primary result of such work, a total of about 100 species have been collected, included in the genera (approximate number of species in parenthesis) Agamopus (1), Anomiopus (6), Ateuchus (5), Canthidium (12), Canthon (8), Canthonella (2), Chalcocopris (1), Coprophanaeus (3), (1), Ontherus (4), Onthophagus (4), Pedaridium (1), Phanaeus (1), Scatonomus (1), Sinapisoma (2), Sulcophanaeus (1), Sylvicanthon (1), Trichillum (7) and Uroxys (4). Four species, in the genera Pedaridium and Trichillum, are currently being described as new, and 30 species could not be identified, includying genera poorly studied and some potentialy new species. Index terms: dung beetles, fragmented habitat, Tropical Semideciduous rainforest, inventory of species.

[0366] ASSESSING AREAS OF CLIMATIC STRESS FOR CERATITIS CAPITATA (DIPTERA: TEPHRITIDAE) IN ARGENTINA

M. T. Vera¹², R. Rodriguez³, D. F. Segura¹ & J. L. Cladera¹, ¹Inst. de Genética, INTA Castelar, CC 25, Castelar (1712), Bs. As., Argentina. ²Depto. Biología, Univ. Bs. As., Pab II, Ciudad Universitaria (1428), Bs. As., Argentina. ³Inst. de Clima y Agua, INTA Castelar, CC 25, Castelar (1712), Bs. As., Argentina. E-mail: tvera@enia.inta.gov.ar

Dynamic simulation models combining meteorological databases with the biological constrains for development imposed by abiotic factors are used to determine the potential risk of establishment of exotic pests. In areas where the pest is already present they may give an idea of which are the potential abiotic stress factors and their probable effect on population dynamics. The assessment of areas under climatic stress for the Mediterranean fruit fly Ceratitis capitate, in Argenting was attempted here with the simulation program CLIMEX, combining the potential population growth for a given range of temperature and soil moisture and the negative effect on growth (stress) during adverse conditions. In addition to using CLIMEX, areas under stress were determined by considering the duration along the year of the period with extreme temperatures and humidities (duration of extreme conditions, DEC). Summer and winter precipitation levels were also included in this second analysis as potential deleterious factors. CLIMEX and DEC were run using a meteorological database of 24vr-average recordings from 152 meteorological stations located along the country. Both approaches showed areas where C. capitata should not be present due to excess of cold during winter, and suggested that Argentina could be divided into unfavorable, marginal and favorable areas, but CLIMEX predictions seemed to over estimate winter mortality. With respect to variables other than cold (soil moisture, heat stress), CLIMEX output showed no detrimental effect, whereas DEC revealed possible reductions in abundance due to summer rainfall in two areas and winter precipitation in one of these areas. It also revealed areas with deficit in humidity and areas with excess of heat. When daily meteorological information was used to analyze both seasonal and interannual variation in some particular locations, the detrimental effect of relative humidity, precipitation and heat was shown to be important also by CLIMEX. Additionally indexes values presented a great variability among years. In conclusion, the two approaches used here show habitat heterogeneity and suggest that winter or summer temperatures, precipitation and deficit of humidity can be stressing factors in different areas of Argentina. This information may be used to improve pest control efforts, especially considering the climatic variability among years within areas.

Index terms: Medfly, CLIMEX, climatic stress assessment, population dynamics.

[0367] POPULATIONAL FLUCTUATION OF ARTROPODS EDAPHICS ON TILLAGE AND NO TILLAGE SYSTEMS IN THE AREA OF DOURADOS - MS

M.H. Vieira¹ & II. R. Santos², ¹DEB/UFMS, Cx. P. 322, CEP-79825-070 Dourados-MS E-mail: mhvieira@zaz.com.br. ²DCA, cx.P. 533 Dourados-MS, UFMS E-mail: hrsantos@ceud.ufms.br.

This research has been developed outdoors and also at the Laboratory of Entomology of the NCA/UFMS in Dourados, MS. The main objective was to study the populational fluctuation of Edaphic Artropods on tillage and no tillage Systems. The area measured 1.5 hectare, of which 0.750 hectare was utilised for no tillage systems and the 0.750 hectare remainder for tillage cultivating system. The esperiment was been led in entirely random deliceation, according to and factorial project 12x2, with three repetitions. The field gatherings were held from July 1996 to June 1997, using the Funnel of Berlese (modified). Afterward, these samples were submitted to na extracting process, during seven days time, for the collection of artropods. After identified, based on the results obtained and in the conditions the experiment was led, it's possible to conclude that the greater number of gups of edaphic Artropods, studied, was Acari, followed by Insecta, Collembola and Miriapoda. The population fluctuation had similar behavior in all crops, in tillage, with drastic effects as result from this cultivating method. In the no tillage system, the greatest decrese may be related to abiotic factors. Despite the high density of Acari, this group, Collembola and Miriapoda, showed up susceptible to the ambient alterations. Index terms: Artropods edhafics, Tillage no tillage

[0368] FRUIT FLY (DIPTERA: TEPHRITIDAE) QUARANTINE PROCEDURES FOR EXPORT OF AVOCADOS FROM ARGENTINA TO CHILE

M.E.Villagrán¹, N.Isola², <u>E.Willink¹</u>, M.L.Fonalleras², N.Vaccaro³, C.Grignola⁴ & R.N. Rodriguez Prado⁴, ¹ Estación Experimental Agroindustrial Obispo Colombres, C.C.n°9, Las Talitas, (4101) Tucumán, Argentina. E-mail: saneeaoc@tucbbs.com.ar, ² Dirección Cuarentena Vegetal, SENASA, Paseo Colón 367, 7º Piso, (1063) Buenos Aires, Argentina, ³ INTA, Concordia, C.C. n° 34, Estación Yuquerí, Concordia, (3200) Entre Ríos, Argentina, ⁴ Delegación Tucumán, SENASA, Haití 117, San Miguel de Tucumán, (4000) Tucumán, Argentina.

To export avocados, Persea americana cy. Hass from Tucumán, Argentina to Chile, 2 quarantine measures were established between the Phytosanitary Services of both countries in 1998: a) fumigation with methyl bromide or funigation with methyl bromide followed by cold treatment, as quarantine treatments for Ceratitis capitata, and b) a systems approach for Anastrepha fraterculus, that comprises risk mitigation measures such as varietal resistance, monitoring adult and larval populations in the field, and postharvest sampling. To monitor adult populations, 76 McPhail traps and 76 Jackson traps were distributed in a 36 ha avocado field (32 traps in the 10 exportation plots, and the other 44 in the neighbouring areas). A maximum value of 0,14 was established for the FTD (flies/trap/day). The traps were checked every week from April to July during 1998 and from April to August during 1999. In 1998 A.fraterculus only exceeded its FTD limit in 1 exportation plot during 2 weeks in June and in 6 plots, during the 2 last weeks of July; whereas in 1999 it remained below the FTD limit in all plots studied. During 1998 only 3 adult C.capitata were trapped, and 8 in 1999, always during April. To monitor larval populations, every 20 days all the fallen fruit from 12 pre-established sites was collected, along with 10 avocados cut from the trees. The fruit was placed in individual containers, kept in rearing chamber at 25°C and checked for pupae every 2 days. During 1998, seven hundred and twenty avocados cut from the trees were examined for pupae, and 1020 during 1999. One hundred and fifty avocados that fell from the trees were examined in 1998 and 316 in 1999. No fruit fly larvae or pupae were found in any of these fruits. The postharvest examination of 2% of the fruits in the packing line resulted in 6156 fruits checked in 1998 and 7528 in 1999. No live or dead fruit flies larvae were found. Considering that the adult populations of A.fraterculus and C.capitata were very low during the exportation period, and that no live or dead larvae were found in the fruits checked, it is believed that there is no risk of introduction of fruit flies with avocados exported from Argentina into Chile, even without a quarantine treatment. Anastrepha fraterculus, Ceratitis capitata, quarantine

[0369] EFFICIENCY AND RESIDUAL OF DIFFERENT ACEPHATE FORMULATIONS IN CONTROL OF GREEN-PEACH APHIDS ON PEPPER'S CROP

R.R. Vinchi¹, W.R. Kuwahara¹ & <u>C.G. Ractano¹</u>, ¹Dept. of Crop Production, State of Univ. of São Paulo, P. Box 237, Botucatu, SP, 18603-970, Brazil, E-mail ractano@fca.unesp.br.

The occurrence of aphid Mizus persicae (Sulz.), on pepper's crop is very important in Brazil by direct damage as well as vector aphid of viroses. With objective to check the efficiency of acephate insecticide at two different formulations: WP (Orthene 750 BR) and WG (Evolution) in control of green-peach aphid on this crop, a experiment was conducted in experimental farm located in São Manoel, SP. The experimental design was randomized bloks with 8 treatments and 4 replications in period between February to June, 1999. The treatments used were: acephate WP (Orthene 750 BR) at doses of 56.25 and 75.00 g. a. i./ hL; acephate WG (Evolution) at doses of 48.50 and 58.20 g. a. i./ hL, and a without insecticide treatment. One hand held sprayer equipped with simple lance one JD 14-2 hollow nozzle type at the end was used in this experiment. Before of insecticide applications was made a previous evaluation of aphids in both leaf's surface. During evaluation of insect population, before and after application, was established a grade scale for different number of green-peach aphid: zero: absence of aphids, one: 1 to 5 aphids, two: 6 to 10 aphids, three: 11 to 20 aphids and four: up 20 aphids. The evaluations were made at weekly intervals from 8 to 85 days after the initial application. At the end of spraying, fifty days after initial of them, the evaluations were realized with the purpose of to verify the residual effect of products. The acephate formulations wettable powder and water dispersible granule at doses in test showed excellent results (100% of efficiency) in control of green-peach aphids on pepper's crop, independent of the formulation utilized along the all evaluation period. Highly residual effect of acephate was proved until 85 days after initial spraying.

Index terms: Mizus persicae, chemical control, insecticide formulation,
[0370] EFFICIENCY OF FENPROPATHRIN AND CHLORFLUAZURON IN CONTROL OF *NEOLEUCINODES ELEGANTALIS* (LEPIDOPTERA: PYRALIDAE) ON TOMATO'S CROP

W. R. Kuwahara¹, R. R. Vinchi¹ & <u>C. G. Raetano¹</u>, ¹Dept. of Crop Production, State of Univ. of São Paulo, P. Box 237, Botucatu, SP, 18603-970, Brazil, E-mail raetano@fca.unesp.br

The tomato fruit borer have been considered one of the important pests on tomato fruits in State of São Paulo, Brazil. Now don't have been proved good levels of this insect control with commercial insecticides. The objective of this works was to check the insecticide efficiency of fenpropathrin and chlorfluazuron when apply isolated and in mixture, in control of tomato fruit borer, on tomato's crop. The experiment was conducted in São Manoel experimental farm, SP between January to May, 1999. The experimental design was randomized bloks with 8 treatments and 4 replications. In the mixture of application was added the adjuvant Extravon 0.01%. The treatments used were: chlorfluazuron (Atabron 50 CE) at doses of 3.75 and 5.00 g. a. i./ hL, cartap-cloridrato (Thiobel 500) at dose 100.00 g. a. i./ hL, fenpropathrin (Meothrin 300) at doses of 7.50 and 15.00 g. a. i./ hL, lufenuron (Match CE) at dose of 4.00 g. a. i./ hL; chlorfluazuron + fenpropathrin at doses of 3.75 + 7.50 g. a. i./ hL, respectively. The applications, in number of eight and at the weekly intervals were accomplished with hand held knapsack sprayer equipped with one JD 14-2 nozzle type (35 to 75 psi). The evaluations in the 1st, 2nd, 3rd and 4th stalk, were made with 32, 39, 48 and 55 days after initial spraying. The evaluations were consisted in to collect and cut of 20 fruits/plot and to account the number of attacked fruits. The most efficiencies 32.14% (1st stalk) and 81.82% (4th stalk) were obtained with the nuxture of chlorfluzzuron + fenoropathrin at doses of 3.75 + 7.50 g. a. i/ hL. When application wasn't in mixture the products chlorfluzzuron at dose of 3.75 + 7.50 g. a. i/ hL. When application dose of 7.50 g. a. i./ hL, showed intermediary results in control of tomato fruit borer, with efficiency of 57.57 and 60.61%, respectively at the end evaluation (55 days). The products chlorfluazuron at dose of 5.00 g. a. i./ hL and fenpropathrin at dose of 15.00 g. a. i./ hL showed good efficiency of control, with 66.67 and 75.76% has been comparable with the efficiency (72.73%) of cartap-cloridrato at dose of 100.00 g. a. i./ hL for the evaluation in 4th stalk. The lufenuron insecticide showed your maximum efficiency (48.48%) in control of tomato fruit borer at the end of experimental period.

Index terms: tomato fruit borer, chemical control, insecticid

[0371] MIGRATION-RELATED CHARACTERS OF THE BROWN PLANT-HOPPER, NILAPARVATA LUGENS, COLLECTED IN EAST AND SOUTHEAST ASIA

T. Wada¹, K. Ito² & A. Takahashi³, ¹Kyushu Natl. Agr. Expt. Stn., Suya 2421, Nishigoshi, Kumamoto 861-1192, Japan, E-mail twada@knaes.affrc.go.jp; ²Hokkaido Natl. Agr. Expt. Stn., Hitsujigaoka, Toyohira-ku, Sapporo 062-8555, Japan; ³Hokuriku Natl. Agr. Expt. Stn., Inada 1-2-1, Joetsu, Nigata 943-0193, Japan

The brown planthopper (BPH), *Nilaparvata lugens* (Homoptera: Delphacidae) is a serious pest of rice in tropical and temperate Asia. It does not hibernate in Japan and Central China. It invades Japan every year in early summer from Mainland China through Monsoons. We compare physiological characters of BPH populations collected in Japan, China and Indochina Peninsula. Laboratory experiments showed that 1) macropterous female adults of subtropical North Vietnam and temperate Japanese BPH populations matured slower than females of tropical populations, 2) newly-emerged macropterous adults of subtropical and temperate populations (virulence to BPH resistant rice 48 hr. feeding on rice, 3) the biotype compositions (virulence to BPH resistant rice distributed in subtropical and temperate East Asia. These BPHs with long pre-ovipositional period and starvation resistance are adapted for long-distance migration. There is a seasonal migration area of BPH in East Asia and BPHs there are isolated from tropical populations, which are adapted for fast multiplication.

[0372] SPATIAL RELATIONSHIPS BETWEEN A PREDATOR AND PEST INFESTATION IN WINTER RAPE AND RELEVANCE TO INTEGRATED PEST MANAGEMENT STRATEGIES

D. J. Warner', L. J. Allen-Williams¹, I. H. Williams² & J. N. Perry², ¹ Dept of Environmental Sciences, Univ of Hertfordshire, Hatfield, HERTS AL10 9AB, UK. Email warnerd@bbsrc.ac.uk; ² IACR - Rothamsted, Harpenden, HERTS AL5 2JQ, UK.

There is considerable interest in spatio-temporal distribution patterns of pest and beneficial insects in agro-ecosystems, both of which are important for the development of Integrated Pest Management (IPM) strategies. A knowledge of these patterns may allow temporal and spatial targeting of insecticides, which can enhance insecticide efficiency while conserving beneficial insects that may have an important role as natural agents of pest control. The brassica pod midge (Dasineura brassicae (Winnertz)) is an important and widespread pest of winter and spring oilseed rape in the UK, where it has two generations on winter rape and one on spring rape. D. brassicae oviposits into the developing rape pod in which its larvae develop. Infested pods split, prematurely releasing seeds, and the *D. brassicae* larvae drop to the soil before burrowing beneath to pupate. At this stage in its lifecycle D. brassicae is potentially vulnerable to predation by epigeal predators foraging on the soil surface. Carabid beetles are recognised as important generalist predators in agro-ecosystems, particularly in cereal crops, but little is known of their importance in oilseed rape. This is the first study in the UK to focus on the role of carabid beetles in the oilseed rape crop. The spatio-temporal distributions of both the larvae of D. brassicae upon dropping to the soil from the crop canopy and of adult carabid beetles active on the soil surface were investigated in two consecutive years. Insect samples were collected from spatially referenced sampling points across each crop. Counts of insects were mapped, analysed and the degree of spatial association between predator and prey determined using a novel statistical technique, Spatial Analysis by Distance IndicEs (SADIE). Carabid species abundant and active during peak drop of first generation D. brassicae larvae included Agonum dorsale (Pont), Amara similata (Gyllenhal), Harpalus rufipes (DeGeer) and Nebria brevicollis (Fabricius). Spatially, the larvae of D. brussicue had a marked edge distribution within the crop. SADIE analysis revealed significant spatial association between larvae of D. brassicae and adult H. rufipes (P<0.05) in 1998, but none with adults of A. dorsale, A. similata or N. brevicollis. However, strong spatial association existed between larvae of D. brassicae and adult A. dorsale (P < 0.01) in 1999. N. brevicollis adults aggregated in areas of high D. brassicae larval drop in 1999, but spatial association was not significant. The distributions are discussed in terms of their relevance to IPM strategies and spatial targeting of insecticides.

Index terms: D. brassicae; Carabidae; natural enemy; spatial association; insecticide targeting

[0373] EFFECTIVENESS OF METHYL BROMIDE ALTERNATIVES AGAINST POTENTIAL PESTS THAT MIGHT BE IMPORTED TO THE UNITED STATES ON CHILEAN LOGS

B.R. White, R.I. Gara¹, D. Lanfranco, H. Peredo, P. Montes², G.K. Smith & D. Bridgwater³, ¹College of Forest Resources, University of Washington, Box 352100, Seattle, WA 98195-2100; ²Facultad de Ciencias Forestales, Universidad Austral de Chile, Valdivia, Chile; ³USDA Forest Service, Forest Pest Management, 1 Oak Plaza, 331 1st Ave., Portland OR 97208.

We studied the effectiveness of alternative pesticide treatments to methyl bromide furnigation in controlling high-risk Chilean forest pests that could be imported to the United States on logs. Various treatments have been proposed as alternatives to current regulations requiring methyl bromide furnigation. Little data, however, was available concerning the effectiveness of proposed treatments on Chilean insects or pathogens of risk to United States forest tree species. Scientists from Chile and the United States collaborated in evaluating the efficacy of biocides in Chile in order to identify promising alternatives to methyl bromide for treatment of whole logs destined for the United States. Initial studies were conducted using radiata pine bolts (28 cm X 0.75 m) from which the best treatments were identified. Further field studies were conducted to test these pytosanitary products on export-sized logs that were handled under industrial conditions. Results showed that a combination surface treatment of "Timber-TreatTM" and "NP-1TM" effectively protected debarked logs against hitchhiking bark beetles and blue-stain fungi for three months. The addition of either methyl bromide or a "VikaneTM" fungigation treatment following the surface treatment had no observable effect over the surface treatment alone.

[0374] CORN ROOTWORM AREAWIDE MANAGEMENT IN KANSAS

<u>G. E. Wilde¹, R. J. Whitworth¹ & R. A. Shufran¹, ¹Dept. of Entomology, Kansas State Univ., Waters Hall, Manhattan, KS 66506-4004, USA, E-mail gwilde@oz.oznet.ksu.edu, USA.</u>

The effect of areawide management of western corn rootworm was assessed in north central Kansas from 1997-2000. Populations of corn rootworm beetles in a managed area were controlled with a semiochemical insecticide when they exceed treatment thresholds. Overall, populations in the managed area were significantly reduced compared to an unmanaged area where conventional soil insecticides were used. Index terms: *Diabrotica virgifera virgifera*, insecticides, corn

[0375] STRESS BY SUBLETHAL DOSES OF PYRETHROIDS ON THE DEVELOPMENT, SURVIVAL AND WEIGHT OF SUPPUTIUS CINCTICEPS (HETEROPTERA: PENTATOMIDAE)

<u>T.V. Zanuncio¹</u>, **R.N. Guedes¹ & J.C. Zanuncio¹**, ¹Dept. de Biologia Animal, Univ. Federal de Viçosa, 36571-0000, Viçosa, MG, E-mail zanuncio@email.ufv.br.

Pentatomidae bugs such as Supputius cincticeps, commonly found in many ecosystems, is a generalist species which feed mainly on larvae of Lepidoptera and Coleoptera. Since insecticides are used in such areas, the susceptibility of predators to them has been studied aiming to use selective products and to reduce negative effects on these natural enemies. The purpose of this research was to evaluate the effect of different subletal doses of permethrin and deltamethrin, in topical application, on 3^{th} instar nymph of *S. cincticeps.* Effects of these insecticides were assessed on nymph development, survival, and weight gain of this predator since stressful chemicals can stimulate organisms to increase their hability to respond and to adapt to new environment. Nymphs of S. cincticeps were individualised, conditioned in 40 ml plastic glasses, fed with pupae of *Tenebrio molitor* (Col.: Tenebrionidae) and maintained in at $25.0 \pm 0.5^{\circ}$ C and $75.0 \pm 5.0\%$ of RH. The technical grade insecticides permethrin and deltamethrin were diluted in acetone to obtain the concentrations used $(10^{-3}; 10^{-4}; 10^5; 10^{-6}, 10^{-7} \text{ and } 0 \text{ mg a.i./ml})$ and topically applied on the back of each nymph of S. cincticeps. Each one of them received 1 µl of the insecticide solution while those of the control treatment 1 µl of acetone. Deltamethrin in the doses of 10⁻⁵ and 10⁻⁶ favored the survival of S. cincticeps nymphs (F=66.58; P< 0.0001) but the length of all development stages were similar in all concentrations. None effect of insecticide was found on weight of nymphs which originated females (F=643.92; P<0.0001) or males (F=317.17; P< 0.0001). Weight increase was solely due to age increase of this insect. The permethrin in the doses of 10⁻⁶ and 10⁻⁷ increased survival of the nymphs of *S. cincticeps* (F=41.83; P<0.0001). Duration of 3^{th} (F=7.23; P<0.005) and 4^{th} (F=4.01; P<0.005) instars was longer at the doses of 10^3 and 10^4 and of 10^3 and 10^5 of this insecticide, respectively, for nymphs which originated females. Permethrin at the doses of 10⁻³ and 10⁻⁴ reduced weight gain of nymphs that originated females (F=394.68; P<0.0001) and of those that orginated males (F=387.57; P<0.0001). There was no insecticide effect on weight gain of 5th instar insects. The results obtained indicate only mild effects of sublethal doses of pyrethroids on S. cincticeps with higher doses (10⁻³ to 10^{-3}) negatively affecting the insect development and lower doses (10^{-3} and 10^{-6} mg deltamethrin/ml and 10^{-6} and 10^{-7} mg permethrin/ml) actually favoring the insect survival. Further studies should be carried out to assess the reproductive impact of pyrethroids dose on S. cincticeps.

Index terms: Predator, pyrethroids, sublethal, Supputis cincticeps.

[0376] NEW APPROACHES TO CREATING GLOBAL SPECIES DATABASES IN ENTOMOLOGY

M.J. Scoble, ¹Dept. of Entomology, The Natural History Museum, Cromwell Road, London SW7 5BD, UK, E-mail: m.scoble@nhm.ac.uk.

Global species databases are, broadly speaking, computerised taxonomic catalogues. Databases have, however, the capacity to be more extensive than catalogues, and they are much more effectively searched. They can also be networked. It is increasingly evident that the kind of information inherent in traditional taxonomic catalogues is of value beyond the systematics community. In particular, it forms the basis for such products as life-lists, biodiversity surveys and inventories, which are needed to meet certain requirements under the Convention on Biological Diversity. The main difference between creating global species databases for insects and most other groups of organisms is that of the size of the task. In this paper I give an example of the steps in creating one such database (on geometrid moths) and the hardcopy catalogue that was derived from it. Although a great deal of effort was required to complete the database in a timely fashion, such large compilations are quite possible given appropriate facilities and the right people. Key features in the production of the work, both material and in terms of human effort, will be discussed. Some other insect databases will be cited. These examples have been created from just a subset of extensive archival sources in natural history museums. Attempts are now being made by the University of Essex and The Natural History Museum, London, to build a Versatile Interactive Archive Document System (VIADOCS). The project proposes a novel interactive method of archive conversion by extending a current commercial optical character recognition system for completing forms. A demonstration interactive conversion system utilizing a particular Lepidoptera index-card archive (on Pyraloidea) will be developed, and evaluated against current manual conversion methods, and in interactive use 'on demand' over the Internet. The aim of producing this system is to provide a means of making accessible extensive quantities of data trapped in typed and hand-written archives. All these efforts should be seen in the broader context of computerising biological data typically associated with biological collections.

Index terms: taxonomic information, catalogues, archival data

[0377] THE INVENTORY OF THE WORLDS INSECT BIODIVERSITY: DOING THE POSSIBLE

E. S. Nielsen, CSIRO Entomology, GPO Box 1700, Canberra ACT 2601, Australia (ebbe.nielsen@ento.csiro.au).

Biodiversity is the total variety of all life on Earth. Biodiversity provides all our foods, most of our medicine, most ecosystem services and much of the quality and joy of life. Biodiversity is therefore arguably the most precious resource on Earth. At the same time, at most 1.8M of the 5-10M multi-celled organisms are named, and we have little effective access to the information associated with the estimated 3B specimens in the world's biological collections. Indeed, it can be argued that scientific knowledge and its use is not advancing as rapidly as the irreversible decline of biodiversity. We need to analyse why the inventory of biodiversity does not attract the same level of support as genomics, health and astronomy. Based on the assumption of 10M species, E.O. Wilson in 1985 estimated that a complete survey of Life or Earth would require 25,000 professional lifetimes. Since then we have witnessed rapid development in our ability to share information and training as well as new technologies that assist in nearly all aspects of systematics, taxonomy, field work and curation. In particular biological and biodiversity informatics has revolutionised our ability to capture, maintain and use information from research and collections. We have seen the development of concepts such as the All Taxa Biodiversity Inventory (ATBI), All Biota Taxonomic Inventory (ABTI) and Systematics Agenda 2000. New initiatives are also being established: recently the OECD Science Ministers have endorsed the establishment of the Global Biodiversity Information Facility (GBIF) as recommended by the OECD Megascience Forum, and the Conference of the Parties is likely during this year to endorse the recommendation to establish the Global Taxonomy Intitiative (GTI) under the Convention on Biological Diversity (CBD). If institutions with the mission to inventory Life on Earth maintain their focus, collaborate and coordinate resources and responsibilities, if we can share a vision for a concerted effort and if the resources are made available to collect, curate and research the world's flora and fauna, then Wilson's vision can be more readily fulfilled and be more beneficial to all than ever before.

Index terms: biodiversity inventory, taxonomy, systematics, Life on Earth

[0378] REPRESENTATION, PREDICTABILITY AND ROBUSTNESS IN ECOLOGY: IMPLICATIONS FOR BIOINDICATION

M. A. McGeoch, Dept. of Zoology and Entomology, Univ. of Pretoria, Pretoria 0002, South Africa. E-mail: mamcgeoch@zoology.up.ac.za

Ecological indicators, that are sensitive to environmental stressors and that demonstrate the effect thereof on other taxa, are by definition indicative of both environmental and biotic state. The requirements that an ecological indicator should satisfy are threefold. It should (i) readily reflect environmental state, (ii) represent the response of other taxa to environmental state, and (iii) the previous two relationships should be temporally and spatially robust within the context of the bioindication objective. Ecological indicators thus require predictability at multiple levels. The response of the bioindicator to the stressor should be clear and consistent. In addition, the relationship between the response of the bioindicator and the response of at least a subset of other taxa in the environment must be significant and strong. The essence of bioindication is these correlative complexes that exist as a result of direct and indirect causal relationships between environmental parameters and the state of, and change in, biota. The presence of significant correlations is however insufficient to be of practical value to bioindication, statistically strong relationships are necessary to provide the level of predictability that is required. In addition, the robustness of these relationships (predictability of the predictability) has to be established. Bioindication is not divorced from the rest of ecology in the degree to which it is able to identify relationships, and make predictions from these. Indeed, there is no shortage of generalities and strong relationships in ecology, but rather an absence of tests of the robustness of these. The shortage of robust, predictable relationships in the field may be attributed to what are among at least two possible explanations: (i) ecology is generally not a field of science from which immediate results are demanded, and predictability may thus not be a priority, or (ii) relationships between and within biotic and abiotic variables are fuzzy and non-linear. Identifying the reasons for the lack of predictability in ecology will inform both direction and priority setting in the field of bioindication.

Index terms: generality in ecology, ecological bioindicators, environmental change,

[0379] HABITAT CONSTRAINTS AND PATTERNS OF DIVERSITY

I. Ribera¹, G. N. Foster² & A. P. Vogler¹, ¹Department of Entomology, The Natural History Museum, Cromwell Road, London SW7 5BD, UK, and Department of Biology, Imperial College at Silwood Park, Ascot SL5 7B, UK, E-mail ignr@nhm.ac.uk; ²Environmental Division, The Scottish Agricultural College, Auchineruive, Ayr KA6 5HW, Scotland, UK.

Certain large-scale patterns in species richness (e.g. latitudinal gradients, species-area relationships) are well known and robust ecological regularities. Most of the many explanations that have been proposed depend on geographical variables correlated, ultimately, with area and latitude. However, these explanations typically fail to identify underlying causal mechanisms and, equally, to demonstrate a connection between the scale at which diversity is varying with the scale at which the supposed processes affecting the diversity operate. In Europe, two contrasting types of freshwater habitat can be identified, with markedly different persistence values. Rivers and streams persist over relatively long periods, and are semi-permanent features of the landscape. In contrast, small to medium-sized stagnant water bodies are short-lived, and discontinuous in time and space. Most water beetles inhabit only one of these two habitat types, with a minority able to live in both (in western Europe the overall proportions are: 43% of species in running water, 38% in stagnant, and 19% in both). Running water species have smaller range sizes than stagnant water specialists, and this is explicable on habitat persistence as a constraint on the evolution and ecology of these insects. A model for water beetles in 15 areas in western Europe, based solely on total area, minimum latitude and a measure of mainland "connectivity", predicts with great accuracy the total number of species per area. However, when this beetle pool is divided into running water and stagnant water specialists, the results are very different. For running water species within each area, minimum latitude (seen as a surrogate for proximity to glacial refugia) is the variable with the highest correlation. For stagnant water species, the main explanatory variable is connectivity. These differences remain essentially the same when the data are divided amongst the four main phylogenetic groups represented (Hydradephaga, Hydrophiloidea, Hydraenidae, Dryopoidea). Thus, when species are separated according to a biologically significant variable (e.g. habitat persistence), their differing requirements and responses can be inferred to be the very processes that generate the observed overall patterns of diversity. An improved ability to understand these underlying causal mechanisms will enable us to make much better predictions about the extent and distribution of diversity, especially in poorly known or under-worked areas.

Index terms: diversity gradients, habitat persistence, water beetles, Hydradephaga, Hydrophiloidea, Hydraenidae, Dryopoidea, species richness, diversity models, prediction.

Symposium and Poster Session

[0380] NATIONAL SCIENCE FOUNDATION

Yates, T

ABSTRACT NOT RECEIVED

[0381] MODELLING DISTRIBUTIONS AND MAKING COMPARISONS: CAN WE PREDICT RELATIVE GAPS IN OUR KNOWLEDGE OF INSECT BIODIVERSITY MORE ACCURATELY?

R.I. Vane-Wright¹, M. Araújo¹ & P. Williams¹, ¹Biogeography and Conservation Laboratory, The Natural History Museum, Cromwell Road, London SW7 5BD, UK.

The ideal indicator for conservation area selection would predict precisely the extent and distribution of all other, unsampled elements of biodiversity. If we had such a perfect indicator, it could be used "in reverse", to locate areas that would hold the most unknown or unsampled diversity of poorly known groups, and thus help direct efforts for diversity exploration. At present such a pipe-dream seems quite unrealistic, due to the supposed low correlation of diversity among various taxonomic or indicator groups, the paucity of empirical data on distribution that is available for cross-group evaluation, and a lack of well-developed techniques for making such comparisons appropriate and informative. However, because of the second and third failings, any conclusions about the general lack of bioindicator properties between groups, or among sets of groups, are almost certainly premature. Various methods have been described for extrapolating and interpolating limited empirical data on the distribution of individual species, and these methods will be reviewed briefly. However, before resorting to modelled multi-species data, we should endeavour to assess indicator relationships using well sampled groups (e.g. certain bird and butterfly families) to develop techniques for the comparison of patterns of species richness and, more importantly, patterns of complementarity (taxon turnover), across different groups. If such techniques can be developed successfully, they would not only help in the search for better bioindicators for conservation priorities, but could also identify regional gaps or low-points where high, unsampled, complementary biodiversity can be anticipated, and thus direct our efforts for the exploration and discovery of insect diversity more effectively in the future.

Index terms: biodiversity indicators, modelling distributions, species richness, complementarity, exploration, discovery, prediction.

[0382] SOIL BIODIVERSITY: THE NEED FOR A GLOBAL INITIATIVE

<u>P. Eggleton¹</u>, ¹Soil Biodiversity Programme, The Natural History Museum, Cromwell Road, London SW7 5BD, UK, E-mail: pe@nhm.ac.uk.

Soil biodiversity and associated soil ecological processes are a neglected area of biological research. Although healthy soils are clearly vital for a range of processes including global biogeochemical cycles, plant growth, and habitat stability, the biological basis for these processes is poorly understood. A very good example of this is studies of the soil macrofauna. A few studies from a range of scattered localities have begun to suggest the critical influence of the soil fauna on plant growth. However, there is an almost complete lack of synthesis of information from such studies which might provide the subject with a rational framework. In this talk I will discuss, in the context of the soil macrofauna, how such weaknesses might be overcome and propose a series of possible steps, considered at a global level, that might contribute to their amelioration. These include: Standardisation of sampling methods. These methods should be developed in flexible ways that take into account diversity anomalies in patterns of co-existing soil fauna across all biogeographical regions. Proper measurements of soil properties and processes involving extensive soil multidisciplinary collaboration with botanists, mineralogists, physicists, microbiologists, and other soil scientists. Multi-taxon studies, both correlative and manipulative, examining the covariation of taxa across wide biogeographical and environmental gradients. These studies will be particularly helpful to clarify the combined compensatory effects of soil macrofauna on vital soil processes. Of particular interest will be the degree to which soil macrofaunal mass-effects diverge or converge within similar habitats across biogeographical regions. I believe that a global multi-taxon view of soil biodiversity is necessary to allow us to discover if there are general ecological laws controlling the influence of diversity on soil processes. Without such studies conducted by many groups across the World, soil biodiversity studies will remain disparate and of limited synthetic value.

Index terms: soils, soil biodiversity, soil processes, soil fertility, macrofauna, sampling methods, multi-taxon studies

[0383] APPROACHES TO MEGADIVERSITY GROUPS: LESSONS FROM PARASITOIDA

<u>Quicke, D.</u>

ABSTRACT NOT RECEIVED

[0384] APPROACHES TO MEGADIVERSITY AREAS: THE NEOTROPICS

[0386] A NEW PROGRAM FOR SYSTEMATICS: THE CONVENTION ON BIOLOGICAL DIVERSITY'S GLOBAL TAXONOMY INITIATIVE (GTI)

ABSTRACT NOT RECEIVED

I. D. Cresswell, United Nations Convention on Biological Diversity Secretariat, 393 St. Jacques Street, Suite 300, Montreal, Quebec H2Y 1N9, CANADA, E-mail ian.cresswell@biodiv.org.

The lack of taxonomic knowledge of biological diversity has been recognized worldwide as a significant problem in decision-making for conservation and sustainable use of our natural resources. In response the Convention on Biological Diversity (CBD) has created the Global Taxonomy Initiative (GTI) to facilitate the filling of known gaps in systematics, the training of new taxonomists and curators, and finding new ways of using our knowledge base to increase our ability to conserve, use and share the benefits of our biological diversity. The need for fundamental taxonomic knowledge of biological diversity to underpin the key objectives of the CBD is wide ranging. The CBD deals with diversity at all levels of the biological hierarchy; from genes, species, populations, communities, ecosystems to landscapes. The GTI must assist international funding agencies, national and sub-national governments, and non-government bodies address the need for adequate taxonomy as part of the worldwide demand for up-to-date biodiversity information. To do this requires the advancement and renewal of taxonomy associated with the protection and maintenance of our natural heritage. For the GTI to be effective in a timely way a major increase in partnerships need to be quickly formed between the world's natural history institutions in the developed and developing worlds. Increasing the world's taxonomic activity will need to be focused to ensure the results are not only scientifically correct but also provide practical, implementable information that is available to managers and decision makers. The developing training programmes, the strengthening of infrastructure for biological collections in countries of origin, the building the capacity for taxonomic research, and increasing the worldwide availability of taxonomic information are high priorities. The overall need has been identified and a new commitment to action has been agreed. Yet this paper asks more questions than it answers: what should be our work priorities, how should we get agreement on who does what, how can each individual make a difference to the overall goals of conservation and sustainable use? This paper will present the decisions from the 5th meeting of the Conference of the Parties (the political body of the Convention) held in Nairobi, May 2000, and will attempt to illustrate the way forward, including how the ICE can help implement the GTI.

[0385] BEFRI, GLOBIS AND THE MSEF INITIATIVES—INTERNATIONAL ENTOMOLOGICAL APPROACHES TO CBD, GTI AND GBIF

T. Bourgoin¹ & H. Hoch², ¹Museum national d'Histoire naturelle, Lab. Entomologie, ESA 8043 CNRS, 45 rue Buffon, F-75005, Paris, France, E-mail bourgoin@cimrs1.mnhn.fr; ²Museum für Naturkunde, Humboldt-Universität, Institut für Systematische Zoologie, Invalidenstr. 43, D-10115 Berlin, Germany, E-mail hannelore.hoch@rz.hu-berlin.de.

International agreements such as CITES (International Trade in Endangered Species), Convention on Biological Diversity (CBD), obligate nations to take action relating to a biological diversity, notably regarding its conservation and use, and the equitable sharing of benefits. However, for hyperdiverse organisms such as insects, the present levels of taxonomic knowledge and available expertise are inadequate even to start this process, let alone provide the basic scientific support necessary to meet such obligations and agreements. Since 1994, the Major Systematic Entomological Facilities (MSEF) group has worked towards the formulation of collaborative work programs to address some of these problems. In 1998, during its annual meeting in Copenhagen (Denmark), the Hemiptera Fulgoromorpha were selected as one of the target groups to help fulfil the objectives of the Global Taxonomy Initiative (GTI) and, potentially, GBIF. The project "Biodiversity and Evolution of Fulgoromorpha, a global Research Initiative" (BEFRI) is now underway (together with other MSEF projects, such as GloBIS, the "Global Butterfly Information System", all of which have comparable aims but vary in their focus and priorities). The aims of BEIRI are to promote Fulgoromorpha systematics through an international collaborative network, as a specific model to meet international needs and objectives. General objectives of BEFRI are: to give to the scientific community a tool to develop perspectives in discovering, describing and understanding biodiversity in terms of evolutionary scenarios, i.e. to promote systematics in the broadest sense; to shorten the time between discovery and delivery, i.e. to disseminate information efficiently, for scientific, public and administrative demand (this includes development and management of collections within a computerised framework); to promote Fulgoromorpha as a pertinent model to explore and understand biodiversity, by e.g. facilitating networking among experts, and organising student training in planthopper studies; and to attract funding to expand knowledge of the group. The three phase action plan that has been drawn up (Describing biodiversity, Organising Fulgoromorpha knowledge, Disseminating information), with the explicit intention of meeting the criteria and scientific perspectives required by the CBD, will be outlined. BEFRI invites all people working with Fulgoromorpha to express their interest and to participate in this project.

[0387] CANOPY ARTHROPODS OF THE WESTERN AMAZON BASIN

<u>T. L. Erwin</u>, Megadiversity Group, Department of Entomology, Smithsonian Institution, Washington DC 20560

Canopy insect populations are remarkably stable relative to each other across seasons and years with the exception of Diptera which dramatically increase in abundance in the rainy season. Fungus Gnats (Mycetophilidae) account for the super-abundance of Diptera in the rainy season. Combined data from soil, litter, understory, and canopy indicate that there are about 6.4 x 10¹² arthropods per hectare in Amazonia. Equatorial terra firme forests in west Amazonia contain at least 60,000 species per hectare. Initial β -diversity data suggest some species, particularly larger ones are widespread, while smaller and/or more specialized canopy species show complete species replacement at intervals of about 200 km latitude. Only two longitudinal samples are available with nearly 100% complementarity, therefore a pattern cannot be discerned across Amazonia yet. Considering that the average length of a canopy beetle is 3mm and species replacement of small forms is high, it can be expected that overall richness across Amazonia would be marked. Further, it can be predicted that when vast tracts of forests are lost or converted, extinction rates of smaller forms of life will be high.

[0388] DIVERSITY AND BIOGEOGRAPHY OF UPPER AMAZON BUTTERFLIES (LEPIDOPTERA)

<u>G. Lamas</u>¹, ¹Museo Nacional de Historia Natural, Universidad Nacional Mayor de San Marcos, Apartado 14-0434, Lima-14, Peru.

The richest communities of butterflies in the world are found in Western Amazonia (west of the north-south axis formed by the Negro and Madeira rivers), where >1300 species may coexist in sites $<5 \text{ km}^2$ in area. Roughly one-third of the species in these communities are Hesperildae, one-third Lycaenidae + Riodinidae, and one-third Papilionidae + Pieridae + Nymphalidae. Distribution patterns of rainforest-dependent butterflies conform closely to endemism centers postulated by proponents of the "Pleistocene Refuge Hypothesis" of species diversification, but such endemism centers correspond mostly to areas of occurrence of distinctive populations of mimetic butterflies (usually regarded as parapatric subspecies); distribution patterns of full species appear instead to have been shaped by landscape evolution during late Caenozoic palaeogeographical changes.

[0390] DIVERSITY AND LIFE HISTORY TRAITS OF TIGER BEETLES (COLEOPTERA: CICINDELIDAE) FROM CENTRAL AMAZONIA (BRAZIL)

M. Zerm¹, J. Adis⁴, W. Paarmann² & C.R.V. da Fonseca³, ¹MPIL, Postfach 165, 24302 Plön, Germany; ²FH Hildesheim/Göttingen, Büsgenweg 1A, 37077 Göttingen, Germany; ³INPA, CPEN, Caixa 20stal 478, 69011-970 Manaus/AM, Brazil.

With 26 tiger beetle species presently known to occur in the environs of Manaus, Central Amazonia, this region presents one of the most diverse tiger beetle fauna worldwide. Species distribution is characterized by restriction of most species to only one type of biotope: Eleven species inhabit floodplain areas, 16 species terra firma upland sites, and only two occur in both. Species from floodplains and/or terra firme uplands either occur in forests or in open areas. Seven floodplain species are solely found in whitewater areas (várzea), two only in blackwater areas (igapó), and another two in both floodplain types. Interspecific and intraspecific differences in microhabitat and activity patterns contribute additionally to the diversity and segregation of species. Studies on phenology and larval development in common species from uplands and floodplains revealed a variety of life cycles. Most species studied up to now are univoltine with a clear seasonality regarding larval and adult stages. Species with a long lifespan in larvae, of which some show a dormancy period, have short-living adults. This is characteristic for several species in uplands and for a few species from floodplains with larvae surviving the aquatic phase in tunnels in the soil. Most floodplain species have a short larval lifespan. The adult beetles have a long lifespan and survive through the high-water period of several months duration, with females often showing a gonad dormancy, and reproduce solely during the nonaquatic phase.

Index terms: life cycle, survival strategy, floodplain, terra firme, dormancy

[0389] SPATIAL PATTERNS OF SPECIES RICHNESS: TIGER BEETLES OF NORTHWESTERN SOUTH AMERICA (COLEOPTERA: CICINDELIDAE)

D. L. Pearson & S. S. Carroll, Dept. of Biology, Arizona State Univ., Tempe, AZ 85287-1501 USA

Species richness patterns of tiger beetles (Coleoptera: Cicindelidae) were analyzed using a grid of 407 squares (137.5 Km or 1.2 degrees per side) across northwestern South America (Guyana, Venezuela, Colombia, Ecuador, Perú, Bolivia and western Brazil). Reliable data on species numbers were available for only 149 of the squares. Using a trend surface model (a model used to represent the mean of a spatial process by a polynomial function of spatial coordinates) as well as altitudinal range, precipitation and biogeographical influence for each square, we were able to predict the number of tiger beetle species likely to occur in intermediate squares for which no or unreliable data were available. The resultant spatial patterns of species richness were compared to similar analyses for temperate areas of North America and differences should be useful in developing understanding general diversity patterns and in the environmental management of species richness.

[0391] GROUND BEETLE COMMUNITIES (COLEOPTERA, CARABIDAE) AT FRUIT FALLS IN A TERRA FIRME RAINFOREST NEAR MANAUS (AMAZONIA) - A FIRST REVIEW

W. Paarmann¹, J. Adis², N.E. Stork³ & C.R.V. da Fonseca⁴, ¹FH Hildesheim/Holminden, Büsgenweg 1A, 37077 Göttingen, Germany, ²MPIL, Postfach 165, 24302 Plön, Germany, ³Rainforest CRC, James Cook University, POBox 6811, Cairus QLD 4870, Australia, ⁴INPA, Caixa Postal 478, 690-970 Manaus/AM, Brazil.

During a field study about the ground beetle communities at fruit falls in the 'Reserva Florestal A. Ducke' near Manaus (1991-1996), we collected data on community structure, population dynamics, and migration patterns of these beetles at different fruit falls, observing also fruit fall duration, and the abundance of seed fall. We also tried to determine the development of larval populations. In laboratory studies we recorded the number of seeds consumed by single adults of the seed feeding species, according to sex and stage of gonad development. Breeding experiments informed us about host tree specificity of the ground beetle species, the amount of food (seeds) necessary to complete larval development, and the quality of seeds of the different host species. Seed feeding specimens dominated the ground beetle communities (n=8,926, 92% at fig fruit falls). They represent eight species of the genus Notiobia. Two species were fig seed specialists: N. pseudolimbipennis and N. flavicinctus. Of N. disparilis, we collected four immature females on fig fruit falls only. The other five species appeared at fig fruit falls, but did not reproduce there. N. nebriodes was found to be specialized on fruit falls of Vismia (Clusiacaceae) and Coussapoa (Cecropiaceae), while the other four species reproduced at fruit falls of Melastomataceae trees: N. maxima at Bellucia and Loreya, N. umbrata and N. aulica at Miconia, and N. glabrata at all three. From the results of the field studies it is clear that figs are a key stone tree group for the whole guild of spermatophagous carabid species, either for reproduction (two species) or as 'stepping stones' during migration between other host trees. From the results of our laboratory studies we expected -1) a complete understanding of the food supply for adults and larvae at the observed fruit falls, -2) the relation between fruit falls and adults of the spermatophagous guild as well as the development of its larval population. First results show that there is no food shortage for the beetles of the founder population. However, their rising larval population depend on seeds left by the adults. Predatory or cannibalistic behavior among larvae is low as long as there are enough seeds available. At the end of a fig fruit fall or thereafter seed shortage might result in predatory (cannibalistic) behavior: larger larvae killing smaller ones. The new beetles hatch in a seed exhausted area and start their migration flight while starving. terms: Notiobia, Ficus, seed feeding, population dynamics.

[0392] DUNG BEETLES OF CENTRAL AMAZONIAN FLOODPLAINS

<u>J. Adis¹</u>, W. Paarmann² & B. Ratcliffe³, ¹MPIL, Postfach 165, 24302 Plön, Germany, ²FH Hildesheim/ Göttingen, Büsgenweg 1A, 37077 Göttingen, Germany, ³Univ. of Nebraska, W-436 Nebraska Hall, Lincoln, Nebraska 68588, U.S.A.

Central Amazonian floodplains in the vicinity of Manaus are annually inundated for 5-7 months and up to several meters in height. Their fauna is adapted to this monomodal flood pulse. Dung beetles (Coleoptera: Scarabeidae) have been monitored for up to 18 months on the soil, tree trunks, and macrophytes. Of the total 1,900 specimens, about 40 morphospecies were recorded in a blackwater inundation forest near the Rio Negro and about 30 morphospecies in a whitewater floodplain (inundation forest and macrophytes of non-woody areas) at the Rio Solimões-Amazonas. Only one morphospecies occurred in both biotopes. The phenology is presented for common species and compared between biotopes. Three of the survival strategies found are that adult beetles pass the flood period in the trunk/canopy of inundation forests (black- and whitewater), in adjacent upland forests (blackwater) or in a gonad dormancy on aquatic macrophytes (whitewater).

[0394] PATTERNS OF TERMITE DIVERSITY ACROSS RECENTLY ISOLATED LAND-BRIDGE ISLANDS IN FRENCH GUIANA

G. Davies¹, L. M. Hernàndez¹ & P. Eggleton¹, ¹Dept. of Entomology, The Natural History Museum, Cromwell Road, London SW7 5BD, UK, E-mail ried@nhm.ac.uk.

Forest fragmentation is a key process affecting Amazonian biodiversity. The trajectories of community change and biodiversity loss within fragments are influenced by the nature of the matrix habitat. Termites are likely to be an important component in the changes in trophic structuring of collapsing tropical forest ecosystems, as they are the major arthropod decomposers. A previous study of termite assemblages in forest fragments surrounded by cleared land in Brazil, showed a decline in species richness in fragments compared with continuous forest, six years after fragment isolation (De Souza & Brown 1994). This decline affected soil feeding species more strongly than wood and litter feeders. We investigated patterns of termite assemblage diversity and feeding group composition across land-bridge islands and mainland forest at a dam site in French Guiana. Sampling was carried out 3.5 years after the original flooding, coinciding with the period when the rate of tree die-off accompanying biomass collapse is thought to be maximal (Laurance et al. 1997). Environmental data were collected to evaluate the extent of micro-habitat changes and tree die-off on forest islands. Results were similar to those of the Brazilian study in revealing the same proportional shift towards wood and litter feeding species in fragments. However, there was no overall decline in species richness on small islands, and abundance and diversity of wood and litter feeding species appeared to increase. The three smallest island sites showed the greatest dissimilarities in species compositions in comparisons amongst all sites. The results are discussed in the light of evidence for changes in micro-habitat and availability of dead wood on islands, and in terms of the community dynamics of land-bridge islands compared with other forest fragmentation systems.

Index terms: feeding group, forest fragmentation. De Souza, O. F. F., and Brown, V. K. 1994. Effects of habitat fragmentation on Amazonian termite communities. J. Trop. Ecol. 10: 197-206.

Laurance, W. F., Laurance, S. G., Ferreira, L. V., Rankin-de Merona, J. M., Gascon, C. Lovejoy, T. E., 1997. Biomass collapse in Amazonian forest fragments. Science (Wash: D. C.) 278: 1117-1118.

[0393] MODELLING THE ROLE OF TERMITES IN THE CARBON CYCLE OF NEOTROPICAL FORESTS

C. Hanne¹ & C. Martius¹, ¹ Center for Development Research (ZEF Bonn), Walter-Flex-Strasse 3, D-53113 Bonn, Germany, E-mail: c.martius@uni-bonn.de

Termites (Insecta; Isoptera) are important decomposers of plant material in tropical ecosystems. They play one of the key roles in the turnover of dead phytomass, since they exclusively feed on organic material. Their biomass is much larger than previous estimates suggest, since they are based on soil fauna asessments. Therefore, termites in arboreal and epigeal nests and those in standing dead tree trunks have not been considered. Current ecosystem models that deal with carbon pools are often based on abiotic factors (i.e. relative evapotranspiration) solely, and do not include faunal data. The integration of faunal data in carbon models, however, is imperative, as macrofauna determines the initial decomposition rates, and hence, the turnover time of carbon in terrestrial ecosystems. We provide respiration measurements for termite species from over 20 termite genera from a central Amazonian primary forest, which will allow to specify the role of termites in the carbon cycles of these ecosystems. With these data, the extrapolation and application of data to larger scale amazon ecosystem models is possible. In this contribution, genus-, caste-, and size-specific respiration rates will be discussed, and together with data on diversity, distribution, and biomass, a model on the quantitative contribution of termites to the carbon cycle in these systems will be presented.

Index terms: Isoptera, respiration, rainforests, ecosystem-model.

[0395] FACTORS AFFECTING TERMITE DISTRIBUTION AND DIVERSITY IN NATURAL AND MANAGED CENTRAL AMAZONIAN FOREST ECOSYSTEMS

C. Martins¹, ¹ Center for Development Research (ZEF Bonn), Walter-Flex-Strasse 3, D-53175 Bonn, Germany, E-mail: c.martius@uni-bonn.de

Termites are the most dominant group of decomposers organisms in soil arthropod assemblages in tropical rainforests. Litter and soil termites were collected in a primary forest site, a secondary forest site and two sites of a polyculture plantation system in central Amazonia. Termite genus diversity, abundance and biomass all were highest in the primary forest. The values in the secondary forest were half those of the primary forest, and they were lowest in the plantation systems, indicating that the latter sites may suffer from functional constraints concerning the process of organic residue decomposition. The average termite biomass of the sites was positively correlated to dead wood volume on the forest floor, but the termite biomass of the individual samples was not related to the wood in the litter layer of the sample. The possible correlation to other factors is discussed. In a second study, nest-building termite density was recorded in undisturbed primary forest site, and compared to the density in forest sites subject to selective logging. Only one genus, Nasutitermes, showed a (positive) correlation to increased logging impact, indicating that it is a group of species that follow forest disturbance. The implications of these findings for monitoring programs and for ecosystem management are discussed. Index terms: Isoptera, distribution, diversity, agroforestry, land use systems

[0396] HYMENOPTERA OF LOWER AMAZONIA: WILL THIS BE THE CENTURY WHEN WE GET IT TOGETTIER?

W. L. Overal¹ & A. Y. Harada¹, ¹Dept. of Zoology, Museu Paraense Emílio Goeldi, Caixa Postal 399, 66.017-970 Belém, Pará, Brazil, E-mail overal@museu-goeldi.br & ayharada@museu-goeldi.br

The Hymenoptera fauna of the lower Amazon is among the most diverse in the world, but our full appreciation on this high species richness is hampered by the still unconsolidated state of the taxonomy of many families and incomplete collecting throughout most of the region. At the same time that hymenopterans are increasingly seen as important indicator species for zoogeographical, ecological, and faunal studies, as well as for conservation, pollination, and biological control, the ranks of our taxonomists are being depleted by retirement or death. Incentives for taxonomists are marginal, and the Amazon currently boasts more resident molecular biologists than systematists. Since most end-users of hymenoptera taxonomy are untrained in morphology and taxonomy and require accurate species identification for access to the (often-scattered) associated biological information, dissemination of illustrated keys, check-lists, synoptic catalogs, and biological data bases through the internet would represent a major advance. Leaving aside the Symphyta (potentially identifiable in the Amazon) and Parasitica (not so identifiable), Amazon faunal studies are at least possible for the Bethylidae, Chrysididae (new book!), Tiphiidae, Scoliidae, Mutillidae (only 7 South American species with host records!), Formicidae (skip Crematogaster and Pheidole but try to do the Camponotus), Vespidae (Mischocyttarus now being revised), Eumenidae (with help from our friends), Pompilidae (avoiding the small species), Sphecoidea (with the big blue book), and Apoidea (if not too small, solitary, or unrevised). What has been lacking, for the most part, is scientific manpower (and concomitant financing and support). No complete faunal lists are available for any Amazonian locality, even the best collected ones, for any major hymenopteran family. The city of Belém, that served for over 300 years as the traditional portal to the Amazon for naturalists of all countries, does not have a complete list of its ant species, although this is in the works (>600 spp.) and will only be complete when the total surpasses the Manaus figure. Other Amazon ant faunas range upwards to 450 species, but the idea has taken root that beta, rather than alpha, diversity is what we should be looking at, since mosaics are surely occurring. Social wasp faunas are seen to be more locally diverse in areas of ecotonal contact between forest and savanna, and they are hard to sample during field trips of short duration. Not all bees come to baits, either, and Euglossini and Meliponini may not be representative of total apoid diversity in Amazon habitats. To avoid working in areas subject to human modification, researchers at the Goeldi Museum in Belém have begun to survey the hymenoptera of the Caxiuana National Forest. The future holds both promises and challenges. Index terms: Hymenoptera, Amazon, biodiversity, taxonomy,

[0397] COMPARATIVE ANT SPECIES DIVERSITIES IN INTACT AND LOGGED AMAZONIAN RAINFORES'IS

<u>S. M. Ketelhut</u> & A. Y. Harada, ¹, ¹Museu Paraense Emílio Goeldi, Depto. Zoologia, Entomologia. Cxp 399 - 66040-170. Belém, PA, Brazil. E-mail: sktelhut@inpa.gov.br

A comparative study of ant fauna communities was made in a primary forest and in two kinds of logging systems (Managed and Traditional) located in a tropical rainforest area, near Paragominas, Pará state, Brazil. In each area, ants were sampled using pitfall traps during December 1997 and March 1998 on six 200 m transects, separated from each other by 100 m. Differences in ant fauna diversity among the sites were tested using diversity indexes (Shannon, Simpson and Fisher's Alpha) and richness estimates protocols (e. g. Colwell & Coddington 1994). Species composition was evaluated through affinity analysis (Scheiner 1992) and similarity indexes (Jaccard and Morisita-Horn). A total of 134 ant species belonging to seven subfamilies and 42 genera could be identified in the entire area. Of these, 90 species were found in primary forest, 90 in managed and 84 in the traditionally logged forest. Differences between habitats could be detected comparing diversity and similarity indices among different transects. There were no differences in indexes when absolute values were compared for each site. Results from richness estimates protocols also indicate that ant faunas were similar between sites and suggest that ant faunas were still underestimated. The richness and abundance of ants were different between the months, and it does not affect the diversity patterns in the areas as a whole. High mosaic diversity could be detected using affinity analysis, and it is suggested that the communities were composed by very complex gradients. Thus, differences in ant composition would be due to heterogeneity at smaller scales.

Index terms: Logged systems, Hymenoptera, Formicidae, Biodiversity, Amazon, Estimates.

[0398] HOW FAR NORTH AND SOUTH DOES THE APIFAUNA OF AMAZONIA REACH, ESPECIALLY THE BEE SPECIES VISITING MASS-FLOWERING TREES

W. Engels^{1,4}, B. Harter^{1,4}, A. Köhler^{1,4}, W. Wilms^{1,2,4} V.L. Imperatriz-Fonseca². Betina Blochtein¹, R. Thiele^{3,4} & A. Zillikens^{1,4}, ¹LPB, PUCRS, Porto Alegre, Brazil; ²Depto. de Ecologia Geral, IB, USP, São Paulo, Brazil; ³COSEFORMA-GTZ, San José, Costa Rica; ⁴Inst. Zoology, Uni. Tübingen, D-72076 Tübingen, Germany, e-mail wolf.engels@unituebingen.de.

The mass-flowering syndrome is widely distributed amongst angiosperm trees in the Neotropics. In many rain forest habitats, these trees represent dominant species of the arboreal flora, and are often also important targets of timber logging. The flowers of these trees provide rich nectar and pollen resources for visitors which are mainly bees. However, the period of full blossom is always rather short, thus the question arises, which bees are using such resources and, at the same time, are pollinating the millions of flowers. To answer this question, canopy studies have to be carried out. We did this by using two approaches: netting bees at inflorescences by means of long poles from the ground, and climbing trees and performing observations and sampling within the canopy. Study sites were in the lowland rain forest of Costa Rica, and at different locations in the Brazilian Atlantic rain forest (Mata Atlântica), including the montane Araucaria forest of Rio Grande do Sul. The results show that highly abundant bees are the principal foragers on the flowers of mass-flowering trees, and that medium-sized stingless bees are the dominant visitors. Social bees are evidently the only force of pollinators available in sufficient numbers to provide pollen transport between conspecific tree individuals in the forest. We compare the spectrum of meliponids recorded on mass-flowering trees at the various sites north and especially south of the Amazon. Usually this guild of pollinators comprises less than ten species per site. The flowers of the many taxa of mass-flowering trees represent unspecialised florescences, mostly lacking bright colors, Studies on the bee-attracting flower signals were also carried out. The close relations between the trees and their pollinating bees in Neotropical rain forest ecosystems are interpreted as the result of diffuse coevolution. The biogeographical distribution of the bee taxa involved in the pollination of rain forest trees is discussed under aspects of evolution and ecosystem impact

Index terms: Meliponinae, mass-flowering trees, pollinating bees, Neotropical rain forests, diffuse coevolution

[0399] SOCIAL INSECTS AND THE KAYAPÓ INDIANS OF THE BRAZILIAN AMAZON: INDIGENOUS APPRECIATION AND NOMENCLATURE OF BIODIVERSITY

W. L. Overal¹ & D. A. Posey², ¹Dept. of Zoology, Museu Paraense Emílio Goeldi, Caixa Postal 399, 66.017-970 Belém, Pará, Brazil, E-mail overal@museu-goeldi.br. ²Oxford Centre for the Environment, Ethics & Society, Mansfield College, University of Oxford, Mansfield Road, Oxford OX1 3TF, U.K., E-mail darrell.posey@mansfield.ox.ac.uk

Among the Kayapó Indians of southern Pará state in the Brazilian Amazon, social insects are important in cosmogony (social wasps), mythology (termites), medicine (ants and wasps), agriculture (termites, ants and wasps), social organization (wasps), ritual (wasps), and warfare (wasps). Bee keeping and honey raids in the Kayapó village of Gorotire involve more than 15 species of stingless bees and a social wasp species. Informants were able to recognize and name 35 species of social wasps of the 68 species collected, although nest shape and size were needed clues to wasp identity in many cases. 42 species of ants were consistently given the same or similar names by informants, especially when habitat information was available. Only 4 common names were found for the numerous (>35) termite species present, but descriptive terms were often added to these names in order refer to specific forms. As was the case with social wasps, nest architecture is important in termite species recognition. Building on this taxonomic base, the Kayapó possess biological, behavioral, and ecological data on social insects demonstrably vaster and more detailed than those of acculturated (non-tribal) Amazonian rural dwellers. Their use of Azteca ants in fruit trees as control organisms for leaf-cutter ants (Atta), their use of termite nests (Nasutitermes spp.) as fertilizer, and their use of ant volatile compounds in human and veterinary medicine attest to their knowledge of social insect attributes. Keen observers of nature, they noted the arrival in the Amazon of the Africanized honey bee a full year before it was reported in the literature. The case of the Kayapó Indians is certainly not unique among Amazonian Indians, and it reinforces the urgent need for systematic soundings of indigenous and folk populations for information on the faunal elements with which they share the region. The inclusion of indigenous information in research (perhaps in the form of hypotheses to be tested) will require our stepping down from the high horse of ethnocentrism, but this is a small (and perhaps not the only) price to pay for the accumulated data base of peoples for whom natural history is a life-or-death matter.

Index terms: Amazon, Kayapó Indians, social insects, folk taxonomy.

[0400] THE AMAZONIAN TABANIDAE AND PIPUNCULIDAE (DIPTERA)

<u>J. A. Rafael¹</u> & A. L. Henriques², ¹Instituto Nacional de Pesquisas da Amazônia, Caixa Postal 478, 69011-970, Manaus, Amazonas, Brazil. ²Bolsista do CNPq. Email: jarafael@inpa.gov.br

Tabanidae. In the Neotropical region there are 65 genera and 1,172 catalogued species and subspecies, representing 47% of the 137 genera and 27% of the 4,300 species known worldwide. In the Amazon Basin 27 genera and 239 species representing 41% and 20% of the Neotropical genera and species were recorded. 156 species are endemic with the at the occidental half, 7 at the Central area, 7 at the oriental half and the remaining are restricted to one side of the Amazon River being 19 in the north and 11 in the south. In addition to the endemic species 83 recorded species also occur beyond the Amazon Basin, some of them widespread in the Neotropical region or in South America. The places in the Amazon Basin with more number of recorded species are 1) Ducke Reserve, Manaus with 80 species; 2) Tambopata, Peru, with 73 species and 3) Parque Nacional do Jau, low Rio Negro with 69 species. Some Amazonian tabanids have shown specific preference for hosts like caimans and birds. Pipunculidae. In the Neotropical region there are 16 genera and 235 species and subspecies, representing 69% of the 23 genera and 20% of the 1,200 species known worldwide. In the Amazon Basin it was registered 12 genera and 68 species, representing 75% of the genera and 30% of the species. Pipunculids are poorly represented in collections. Most Amazonian species were described in the last 15 years and are only known from their type localities. Less than 5% of all Amazonian species were recorded in other regions. Only one genus is endemic with two described species still not described. Biology and hosts are unknown.

Index terms: systematics, distribution, diversity, Amazon Basin.

[0402] ABUNDANCE, DIVERSITY AND SEASONALITY OF ARTHROPODA ASSOCIATED WITH THE SAPOTACEAE AND LECITIHIDACEAE TREE CANOPIES AT THE ADOLPHO DUCKE FOREST RESERVE, MANAUS, AMAZONAS, BRAZIL. PRELIMINARY FINDING

J. C. H. Gerrero, C. R. V. Fonseca, P. Hammond & N. E. Stork

ABSTRACT NOT RECEIVED

[0401] SPHINGIDAE OF THE BRAZILIAN AMAZON

C.S. Motta, INPA, CPEN, Caixa Postal 478, Manaus, Amazonas, Brasil 69011-970

In the Neotropical region there are about 200 genera and 1200 catalogued species of hawkmoths (Lepidoptera: Sphingidae) representing over 60% of the species known worldwide. Of the 124 species collected in the Brazilian Amazon, 116 species (from 28 genera) have been recorded in four areas in the state of Amazonas IItacoatiara, Jaú, Querari, Urucu]. The highest number of species was registered in the primary forest areas of Jaú (79 sp.), Urucu (78 sp.), Querari (69 sp.) and the lowest species diversity was in the disturbed forest area of Itacoatiara (63 sp.). The species of Dilophonotini predominated (55 sp.). The Macroglossini included 20 species of Xylophanes followed by the the Sphingini with 15 species of Manduca and 10 species of Isognathus. The species Manduca clarki, Manduca aff. brontes brontes, Perigonia stulta and Baniwa yavitensis were represented by only one specimen. Of the nine species known to be endemic to the Hylaea 4 were collected in the four areas of the state of Amazonas: Cocytius mortuorum (Urucu), Manduca clarki (Itacoatiara), Nyceryx stuarti (Jaú, Querari and Urucu) and Xylophanes cosmius obscurus (Urucu). Several species were collected at other sites within the Brazilian Amazon: Manduca prestoni (Rondônia), Madoryx b. bubastus (Rondonia and Anavilhanas), Nyceryx alophus (between Tonantins and Jutai), Eumorpha triangulum (Presidente Figueiredo), Xylophanes ploetzi (Alter do Chão and Manaus), X. sarae (Pico da Neblina), X. n. neoptolemus (Pacaraima) and Phanoxyla hystrix (Manaus). Of these species, M. prestoni and P. hystrix are also considered as endemic to the Amazon. Index Terms: Lepidoptera, Bombycoidea, hawkmoth, Amazonas, Brasil

[0403] LATIN AMERICAN ENTOMOLOGICAL SOCIETIES AT THE DAWN OF A NEW CENTURY—A TIME FOR INVENTORY

G. J. Hallman¹ & A. R. Panizzi², ¹United States Dept Agriculture, Agric. Research Service, 2301 S. International Blvd., Weslaco, TX 78596. E-mail ghallman@weslaco.ars.usda.gov. ²Centro Nacional de Pesquisa de Soja, EMBRAPA, Caixa Postal 231, Londrina, PR 86001-970, Brasil, E-mail panizzi@cnpso.embrapa.br.

Eight years ago we published an article in *American Entomologist* (38:22-32) on entomological societies in Latin America. At that time there were 15 societies, although some were inactive. Many published research journals and were very involved in educating interested parties about entomological topics, especially in economic areas. The highest per capita membership was about 28 members per million people in Peru, while most countries with entomological societies had about 10 members per million people.

During this symposium which explores what entomological societies are doing and might do to preserve biodiversity we revisit societies in the region. In the seven years before our 1992 article 3 new entomological societies were born, and the prospects for other societies forming in countries that did not have them looked good. But as this is written (Jan. 2000), we have not been able to verify that any new society has been established since the Asociacion de Entomologos de Costa Rica was in 1991. Worse, other societies have become inactive and membership has declined across the region. Given the great tasks facing entomologists in Latin America in such areas as pest control, preservation of biodiversity, and entomological nomenclature, the survival and constructive work of entomological societies where the bulk of entomological diversity occurs is a desirable objective.

Index words: Latin America, biodiversity

[0404] INSTITUTO NACIONAL DE BIODIVERSIDAD (INBIO) HELPING TO CONSERVE COSTA RICAN BIODIVERSITY

J. A. Ugalde-Gómez, Instituto Nacional de Biodiversidad, INBio, Apartado Postal 22-3100, Santo Domingo, Heredia, COSTA RICA, E-mail jugalde@inbio.ac.cr.

The Instituto Nacional de Biodiversidad (INBio) was established in 1989 as a non-profit scientific institution, with a social orientation and for the public welfare. His mission is to promote a new awareness of the value of biodiversity, and thereby achieve its conservation and use to improve the quality of life. All the programs: National Biodiversity Inventory, Bioprospecting, Information Management, Development for Conservation and Social Outreach are joint by a central process based in generation, processing and transference of knowledge, as well as the strategic alliances with national and international institutions and organizations, have contributed with the conservation of Costa Rican biodiversity. The National Biodiversity Inventory program is organized in Taxonomic Working Groups integrated by parataxonomists, technicians, curators and international taxonomists, all of them working together with the Ministry of Environment and Energy, specifically with the National Conservation Areas System (SINAC) which generate information about Costa Rican biodiversity in data bases and Basic Information Units at the species level, both with free access across Internet. Also scientific articles, field guides and educational materials are being produced in order to promote the use of biodiversity information in different areas such as: conservation, national planning, industry, education, science, agriculture, forestry, and ecology.

Index terms: Conservation, Latin America, Costa Rica.

[0406] BRAZILIAN ENTOMOLOGICAL SOCIETIES PRESERVING BIODIVERSITY

A. R. Panizzi', 'Centro Nacional de Pesquisa de Soja, EMBRAPA, Caixa Postal 231, Londrina, PR 86001-970, BRASIL, E-mail panizzi@cnpso.cmbrapa.br.

There are two entomological societies in Brazil. The first society is the Sociedade Brasileira de Entomologia (SBE) which was founded on July 17, 1937, by a small group of entomologists at the Instituto Biológico de São Paulo. There are currently 350 members. The SBE meets as part of the annual congress of the Sociedade Brasileira de Zoologia (SBZ). It publishes the Revista Brasileira de Entomologia three times a year, with a not fixed periodicity. It contains mostly, papers on taxonomy and biology. Approximately 50 articles are published each year in Portuguese, English, or Spanish. The Boletim da Sociedade Brasileira de Entomologia was published nine times from 1948 to 1958, and is now inactive. The second society, Sociedade Entomológica do Brasil (SEB) was founded on February 22, 1972, in Itabuna, Bahia. A number of attendants at an agricultural entomology meeting launched the society because they felt that the existing SBE dedicated little attention to economic entomology. The SEB quickly grew to become the largest entomological society in Latin America with about 1300 members. The SEB is divided in 17 regions which allows a high level of involvement by the members in the affairs of the society. A national congress is held every 18 months. A journal, Anais da Sociedade Entomológica do Brasil is published quarterly on a fixed periodicity (March. June, September, and December). The Society publishes also a newsletter (*Informativo da Sociedade Entomológica do Brasil – ISEB*) every four month, on April, August, and December, which contains SEB news, book reviews, editorial notes, etc. The contributions of the Brazilian entomological societies to promote biodiversity will be discussed. Our view is that both societies should interact with each other and with other organizations to promote preservation of biodiversity in the country and in the continent. Cataloguing insects, similar to the BIOTA-FAPESP project, that aims to record all the living organisms in the state of São Paulo, should be estimulated, and the societies should get involved with such projects. Also, issues related to biodiversity should be part of the constitutions of the societies, to promote this subject among the members and the public in general. Index terms: Entomological societies, Latin America, Brazil.

[0405] SOCIEDAD ENTOMOLÓGICA ARGENTINA AND THE PURSUIT OF ENTOMOLOGY

<u>M. Lizarralde de Grosso</u>, Instituto Superior de Entomología, Universidad Nacional de Tucumán, Miguel Lillo 205, 4000 Tucumán, Argentina. Tel. ++54-381 423-0056 FAX++54-381-423 5291. E-mail instililo@infovia.com.ar.

The Sociedad Entomológica Argentina (SEA) was founded in 1925 and since this time has been an active society; about one third of its members have postgraduate studies, mainly Ph.D.s, which enables them to attain sufficient human resources to manage advanced research programs. Many members of the SEA are from others countries such as Australia, Bolivia, Brazil, Colombia, Chile, Ecuador, Perú, Uruguay, and Venezuela. Most members work in universities and research centers of pure and applied entomology, especially in agriculture, medical, and veterinary areas. Entomology is the most developed zoological speciality in Argentina. The main research centers are: La Plata: Facultad de Ciencias Naturales y Museo de la Universidad Nacional de La Plata, Instituto de Limnología de La Plata (ILPLA), and Centro de Parásitos y Vectores (CEPAVE)-UNLP-CONICET. In Buenos Aires there are the Museo Argentino de Ciencias Naturales and the Universidad Nacional de Buenos Aires. In Tucumán: Instituto Superior de Entomología (INSUE), Universidad Nacional de Tucumán and Fundación Miguel Lillo. These are the principal foci for training of researchers, where most members are, and contain the three most important, in numbers and diversity, entomological collections in the country. There are also other institutions of entomological studies, with important developments occurring in recent years. Since 1987, the National Congress of Entomology has taken place every three years in Tucumán, Córdoba, Mendoza, and Mar del Plata, respectively. The next Congress will be in Buenos Aires in 2001. Argentine entomological activity is reflected in these events with such topics as biodiversity, biological control, medical and veterinary entomology, genetics, physiology, ethology, and ecology. Since 1925 the SEA has edited, once a year, the Revista de la Sociedad Entomológica Argentina, the oldest active entomological journal in Latin America, and also at the present, twice a year, a bulletin with additional information for the membership. SEA and its members also contribute to the development of biodiversity taking part in international meetings and publications. The SEA has a library located at the Museo de La Plata and maintains working relationships with a great number of institutions throughout the world, exchanging publications and pursuing funding.

Index terms: entomological societies, Latin America, biodiversity.

[0407] CONSERVATION OF THE BIODIVERSITY OF INSECTS IN CHILE

L. E. Parra, V. Jerez, T. Zaviezo, A. Cammouscight & D. Lanfranco, Casilla 21132, Santiago 2, Chile. Telephone: +56 2 6814095; Fax: +56 2 6817182; e-mail luparra@udec.el; URL: http://abulafia.ciencias.uchile.cl/sche.

The Chilean entomofauna is characterized by poor diversification of genera (many are monotypic), large number of species with primitive characters, high level of endemism, and prolonged geographic isolation. These characters, because of their scientific importance, constitute a unique attribute that promotes, as a priority, their study and In Chile, there are more than 12,000 described species, although an conservation. estimation of the undescribed species would total approximately 24,000. There are three important entomological collections that represent the diversity of the country's entomofauna: the Museo Nacional de Historia Natural and the Instituto de Entomología at the Universidad Metropolitana de Ciencias de la Educación, both located in Santiago, and the Museo de Zoología at the Universidad de Concepción in Concepción. The knowledge of the biodiversity of insects in Chile is dispersed throughout the literature, primarily in the Revista Chilena de Entomología, Acta Entomológica Chilena, Gayana Zoología, Boletín de la Sociedad de Biología de Concepción, Bosque and international journals. The members of the Chilean Entomological Society are the principal generators of information, represented by numerous published studies in diverse Chilean and international journals. Amoung books the efforts of Luis E. Peña standout. He published Los Insectos de Chile (2 editions) and recently Las Mariposas de Chile (the butterflies of Chile). Other important works are: González, 1989 Insectos y Acaros de Importancia Agrícola y Cuarentenaria (insects and mites of agricultural and quarantine importance) and Artigas, 1994 Entomología Económica contained in two volumes. Finally, in Simonetti et al., 1995 (eds.) Diversidad Biológica de Chile, the state of conservation and knowledge of the Chilean entomofauna is given. The Chilean Entomological Society promotes educational activities that tend to better understand, protect, and conserve the entomolauna of the country. Furthermore, Chile maintains a number of protected areas (national parks and reserves) dedicated to the conservation of the floristic and faunistic biodiversity including insects.

Index terms: entomological societies

[0408] THE SOCIEDAD COLOMBIANA DE ENTOMOLOGIA PRESERVING BIODIVERSITY

M. T. Gonzalez, CENICAFE, Bogota, Colombia, E-mail: fcmgon@cafedecolombia.com.

The Sociedad Colombiana de Entomologia (SOCOLEN) was founded in 1973 by 26 members, and membership has grown to over 500. SOCOLEN has been a very active society during its 27 years of existence, carrying out an annual congress in various cities of the Republic and seminars, workshops, etc. on diverse topics during the year. To better serve entomological interests throughout Colombia, SOCOLEN is divided into 10 Regional Committees. The *Revista Colombiana de Entomologia*, currently in its 25th volume, publishes research articles on a broad array of entomological topics, while the *Entomologo* is an informative bulletin. Memoirs of annual congresses and proceedings of conferences are also printed. To stimulate entomological research several prizes are awarded annually. This talk will concentrate on how SOCOLEN's efforts positively affect biodiversity. Visit our web site at: http://www.socolen.com.co/index.html. Index words: entomological societies, Latin America, Colombia

[0410] SOCIEDAD ENTOMOLÓGICA DE PUERTO RICO PRESERVING BIODIVERSITY

M. F. Linberas & A. Pantoja, Gerente de Sistemas de Control de Vectores, HD Hudson Manuf, Co., Jacksonville, FL 32222-0156, E-mail Lluberas@aol.com; University of Puerto Rico-Mayaguez Campus, Department of Crop Protection, P.O. Box 9030, Mayaguez, Puerto Rico 00681, E-mail Pantoja: a_pantoja@rumac.upr.clu.edu.

This paper discusses the role, efforts, and accomplishments of members of the Sociedad Entomológica de Puerto Rico in studying and preserving the rich biodiversity of the neotropical Caribbean island of Puerto Rico. Index terms: Entomological societies, Latin America

[0409] BIODIVERSITY AND THE SOCIEDAD ENTOMOLOGICA DEL PERU

A. Lizárraga¹, L. Vuldiviezo² & G. Lamas³, ¹Ex President of The Sociedad Entomologica del Peru, Action Network for Alternatives to Pesticides, RAAA, Postal Address 1144 - Lima 11 - Peru, raaaper@terra.com.pe; ² President of The Sociedad Entomológica del Perú, National Program of Biologic Control - Servicio Nacional de Sanidad Agraria, SENASA, senasa@esan.com.pe; ³ Ex President of The Sociedad Entomológica del Perú, Natural History Museum, San Marcos National University, Postal Address 14-0434, Lima 14, Peru, gerardo@musm.edu.pe

The Sociedad Entomológica del Perú (Entomological Society of Peru) is based in Linua and currently has over 300 active members. Since its foundation in 1956, 41 scientific meetings have occurred and, 41 issues of the Revista Peruana de Entomología have continuously been published. In addition, 6 volumes of The Boletín Informativo have also been edited. The primary goal of The Entomological Society of Peru is disseminate information regarding entomological research through meetings and publications, stressing the importance of biodiversity and its preservation. Apparently, the first descriptions of insects in Peru were based on the collections of Humbolt and Bondpland in 1802. Since then, a great many researchers and investigators have made collections of insects in Peru, most of which were identified and preserved in European museums. With the inception of the Entomological Society of Perú, the importance of the entomological research in relation to Peruvian biodiversity has been promoted. One popular estimate is that there are 1,13 million species of insects in Peru, the most important orders of which are: Coleoptera, Hymenoptera, Lepidoptera, Diptera, Hemiptera + Homoptera and Orthoptera. The extensive number of species reported and estimated gives an idea of the vast importance of biodiversity in different Peruvian ecosystems. The History Natural Museum of San Marcos National University has made major studies of the group Lepidoptera. These reports, developed in relation to the diversity of species (especially of agricultural interest), have provided important contributions to the knowledge of this important insect order. Entomologists at the La Molina Agrarian National University have used these reports as a basis for entomological research. Other diverse universities, related to agronomy and biology, have also developed contributions, most of them of great importance toward establishing the magnitude of Biodiversity in Peru. Index terms: Peru, entomological societies biodiversity.

[0411] NATURAL HISTORY, CULTURE AND STATISTICS: CRITERIA FOR SELECTING BIOINDICATORS FOR MONITORING AND INVENTORY

D. L. Pearson, Dept. of Biology, Arizona State Univ., Tempe, AZ 85287-1501 USA

If bioindicators are to be used in conservation efforts, they must be chosen rigorously to meet both expectations of scientists and usefulness in communication with non-scientists. The level of natural history known for the proposed indicator, its usefulness to the public, a clear understanding of the need for indication, proper statistical methods, and an unambiguous way of reporting the results to scientific colleagues and the public are mandatory if bioindicators are going to be reliably used in planning and management. At a minimum, the proposed bioindicator must meet the criteria of: 1) established taxonomy, 2) natural history well known, 3) easily observed and/or manipulated, 4) broadly distributed, 5) biologically specialized, 6) some evidence of correlations of patterns with other related and unrelated taxa, and 7) some economic importance. Also, distinguishing whether the bioindicator is to be used in inventory, monitoring or some other use will dictate the significance of these criteria as well as how management plans will be reported to the scientific community and the public.

104121 PROSPECTS FOR MAXIMISING CONSERVATION OF MADAGASCAN BIODIVERSITY BASED ON KNOWN DISTRIBUTIONS AND GEOGRAPHY

D.C.Lees, Biogeography and Conservation Laboratory, The Natural History Museum, Cromwell Road, South Kensington, SW7 5BD.

It is often assumed that if we had highly detailed information on taxonomic groups, including the distribution and land-use of the dominant primate, we would be able to use that data to suggest an efficient and wise plan for conservation of the maximum number of species in the target, if not other taxa, in a minimum number of areas. Indeed, in many parts of the world and for limited taxon sets, there is evidently considerable redundancy and enough biodiversity information to render such a plan conceivable. In Madagascar, there is poor knowledge of most elements of biodiversity, there are outstanding levels of macro and micro-endemism and fragments of remaining forest are quite limited in extent, whilst many important areas that often connect the patchwork of existing reserves have no official protection. To rely on biodiversity data at all for conservation planning today, we are forced to use presently available, taxonomically and distributionally reliable data, with a bias towards better known groups, either directly or via models of their distribution that draw on spatially more reliable geographic data. Here, I examine the inter-predictive relationships between four invertebrate and six vertebrate groups with different range size frequency distributions and mobility responses to the landscape, and the form of their overall cumulative area representation curve. Differences in the distributional properties of different clades and levels of currently understood micro-endemism in certain Madagascan taxa suggest that such an indicator group approach is fatally flawed, and rather we need to assimilate biodiversity data, starting with already published data, in very many and different groups and to make predictive mapping more efficient and informative by capitalising on detailed geographical and human land-use data. I highlight a new regional databasing facility that is designed to help readily provide people and organisations in Madagascar with much needed baseline information in a spatially explicit context that draws on detailed geographic data, and to help promote the conservation of the island's extraordinary diversity in a rational way.

Index terms Indicator groups, priority areas analysis, Madagascar

[0413] PLURALITY OF SPECIES, ECOLOGICAL GUILDS, SINGLE SPECIES AS BIOINDICATORS TO ASSESS RURAL LANDSCAPES: PROBLEMS AND TOOLS

M.G. Paoletti, Department of Biology, Padova University, 35100 Padova, Italy, E-mail paoletti@civ.bio.unipd.it.

Species number, abundance, ecology, physiology are among the key factors that permit bioindication. Developing an appropriate selection of organisms to assess landscape quality is the target of any project aimed at improving environmental quality and environmental health. The strategy is linked to the personal knowledge and sensibility, the available information and training. Adopting just a few specie or adopting many larger taxa, using ecological guilds, microcosms or directly study in the field is linked, in most cases, to personal sensibility and skill. Appropriate identification tools and good or good taxonomic expertise can make the adoption of plurality of species as target instrument of assessment. Morphotype sorting can be a very interesting tool especially in situation in which taxonomists and taxonomy tools are not easily available, this is the case for most areas to be assessed in the tropics. Ecological guilds can be appropriate in some cases where environmental impacts are very high. Making preliminary assessment in most cases can offer the best mix of ideas to properly operate. Discussion and practical considerations will be made regarding: on different input orchards and a power plant in Italy, of rural landscapes in China and forest-savanna cline in Amazonas, Venezuela. Comparison among different portions of the target landscape are the simplest way to work. Seasonal variability and spacial uncertainity make important the personal sensibility in planning and developing the project.

[0414] TESTING AN ECOLOGICAL BIOINDICATOR SYSTEM: DUNG BEETLES IN NORTHERN KWAZULU-NATAL, SOUTH AFRICA

M. A. McGeoch & B. J. van Rensburg, Dept. of Zoology and Entomology, Univ. of Pretoria, Pretoria 0002, South Africa, E-mail: mamcgeoch@zoology.up.ac.za

The use of terrestrial insects as indicators of habitat quality and environmental change has little empirical support in the form of taxa that have been quantitatively identified and then independently tested to confirm their usefulness as bioindicators. In addition, indicator species have mostly been assumed to fulfil both the role of indicator of environmental change, as well as detecting the direction in which change is occurring. We suggest that ecological indicator species are unlikely to provide information on the direction of change because of their high degree of habitat specificity and comparatively high vulnerability to environmental change. Rather, detector species, that span a range of environmental states, are likely to be better able to fulfil this role. Here we test the responses of dung beetle (Coleoptera: Scarabaeidae) indicator and detector species, previously identified in Tembe Elephant Park, South Africa, on an independent data set. Using the quantitative Indicator Value (IndVal) Method, a method for the selection of species indicative of the direction in which environmental change is occurring (detector species) is outlined and tested. IndVal was shown to be sensitive to inter-annual species abundance changes, although the IndVals of species with high indicator values of > 70 % changed comparatively little between studies. The indicator species first identified were largely supported by testing. Detector species, for which a third of the selected species responded as predicted, were shown to provide information complementary to that provided by indicator species, and are thus a potentially useful group of ecological bioindicator. A suite of dung beetle indicator and detectors species were thus confirmed as bioindicators for habitats in and around Tembe Elephant Park, and these species can now confidently be used for monitoring environmental change in the area. The testing of ecological indicators in this way is imperative to the progress of the field of bioindication.

Index terms: detector, environmental change, monitoring, indicator value.

[0415] INDICATOR GROUPS FOR BIODIVERSITY ASSESSMENT: RESULTS AND PERSPECTIVES OF A STRATEGY

G. Halffter¹ & C. E. Moreno², ¹Depto. Ecología y Comportamiento Animal, Instituto de Ecología A.C., A.P. 63, Xalapa, Ver. 91000, México, E-mail halffter@ecologia.edu.mx; Centro de Investigaciones Biológicas, Universidad Autónoma del Edo. de Hidalgo, A.P. 69 Plaza Juárez, Pachuca, Hgo. 42001, México, E-mail claudia@ecologia.edu.mx.

Species richness can be quantitatively expressed from different perspectives depending on the aspect (or function) under study, and on the spatial and temporal scales at which the study is carried out. In the XX ICE, in Florence (August 1996), the first author (G.H.) proposed a strategy to assess within community (alpha), between communities (beta) and landscape (gamma) diversities on the mesoscale through the use of indicator groups. Here, we present the first results of this approach and some perspectives of research derived from our work. To date, we have used three families of dung beetles: Scarabacidae (Scarabaeinae and Aphodiinae), Geotrupidae and Silphidae; as well as two families of neotropical bats (Microchiroptera: Phyllostomidae and Mormoopidae). Taking into account ecological processes at the landscape level, alpha diversity has shown to be a more difficult concept to measure than it was when communities were studied as isolated spatial units. Dispersal processes associated to landscape structure, such as movement of species from suitable adjacent areas to communities with low species richness (mass effect), may considerably increase alpha and decrease beta diversity. We have also found that some communities have high species turnover in time, a phenomenon that we have called "temporal beta diversity". When this occurs, alpha diversity measured as the mean species richness during sampling period is lower than the alpha diversity measured as the cumulative number of species during such sampling period. Mass effect and temporal beta diversity might be very frequent in non-stable communities. An indicator group strongly influenced by such stochastic processes is inadequate for monitoring biodiversity. Our results have encouraged us to redefine what alpha diversity really means and how should it be measured. This redefinition must consider the limits of communities, in terms of space and time. At the landscape level, gamma diversity should be assessed considering the proportional contribution of alpha and beta diversities. This approach gives the possibility of measuring and predicting the effects of alterations resulting from human activity in landscapes; whether these are modifications resulting in the fragmentation of communities or changes to them.

Index terms: Scarabaeidae; bioindicators; alpha, beta and gamma diversities.

[0416] EVALUATING PRACTICAL METHODS FOR SAMPLING INVERTEBRATE BIOINDICATORS

D. T. Jones & P. Eggleton, Department of Entomology, The Natural History Museum, Cromwell Road, London, SW7 5BD, UK. E-mail dtj@nhm.ac.uk.

Increasing effort is being directed towards investigating and evaluating the use of invertebrates as biological indicators (e.g. McGeoch, 1998; Paoletti, 1999). The basic requirement of a bioindicator is to indicate a relationship with another biotic or abiotic variable. Any relationship is, however, only as good as the sampling method employed to callect the data on the "target" group (i.e. the taxa being collected). If a sampling method cannot reproduce a reliable picture of the target group, then attempts to use the results to infer relationships with other variables is likely to lead to spurious conclusions. Therefore, an important preliminary question that must be addressed before a target group can be used as a bioindicator is: How well does a sampling protocol characterise the composition and structure of the target group? For practical purposes, a sampling protocol must also involve a trade-off between trying to minimise the size of the samples in order to reduce the time spent collecting, sorting, and identifying specimens, against the need for samples that are large enough to be representative of the local assemblage. We describe a transect sampling protocol designed to assess termite species richness and functional composition in tropical forests (Jones & Eggleton, 2000). Samples were calibrated against the total known local termite assemblage. The taxonomic and functional group composition of the transect samples did not differ significantly from the known local assemblage. Results suggest that the protocol is a robust, rapid and cost-effective sampling method that offers good replication and relatively low levels of pseudoturnover. Building on these lessons, we will present preliminary results from our Darwin Initiative project to develop and test rapid sampling protocols for beetles, ants and earthworms in tropical forests.

[0417] ASSESSING ANTHROPOGENIC IMPACTS ON BIODIVERSITY USING CARABIDS: A GLOBAL NETWORK

J. Niemelä & J. Kotze, Dept. of Ecology and Systematics, P.O. Box 17, FIN-00014 University of Helsinki, Finland. Niemelä, J., J. Kotze, A. Ashworth, P. Brandmayr, K. Desender, T. New, L. Penev, M. Samways, and J. Spence. 2000. The search for common anthropogenic impacts on biodiversity: a global network. J. Ins. Cons., in press.

Landscape change through human impact is a massive unplanned experiment creating modified land types across the world, yet we lack information on how these changes impact on biodiversity in various parts of the world. Thus, a global programme that assesses these human-impacted landscapes so that global patterns and effects can be distinguished from local ones is needed. However, the assessment of landscape modification is not the endpoint, but a means for making decisions as how to best manage the landscape for production, yet at the same time, maintaining biodiversity. My aim is to describe a global research and assessment programme that uses a common methodology (GLOBENET) (Niemelä et al. 2000). GLOBENET has the following objectives: (1) to use the same group of organisms (initially carabid beetles), one methodology (pitfall trapping), and the same human-influenced landscape (urban-rural gradient) in different parts of the world in studying the effects of human impact, (2) to develop simple tools and protocols for assessing ecological effects of human-caused landscape changes, which could help sustainably manage landscapes for biodiversity and for human requirements, and (3) to maintain a web-site as an information centre (http://www.helsinki.fi/science/globenet/). Evidence points to carabid beetles being sufficiently varied (morphologically, taxonomically, behaviourally and ecologically), abundant and sensitive to environmental changes worldwide to be used as bioindicators. Carabid assemblages from different countries will be analysed in the same way to determine common denominators (global and regional effects) as opposed to specific differences (local effects). Results so far include development of a standardised sampling protocol (Niemelä et al. 2000), and field work in three countries (Finland, Canada, Bulgaria). Results are presented by Johan Kotze in this congress, and they are available in the web site. To conclude, the initial GLOBENET programme will focus on providing consistent inventory and description of biological communities in an attempt to better understand biological diversity at landscape or larger scales. In the future, we hope to be able to expand the network and include as nany countries in the world as possible. Researchers interested in contributing to GLOBENET are advised to follow the Internet web-site for instructions and results. Key words: Carabidae, global change, bioindicators, biodiversity

[0418] CARABID BEETLES (COLEOPTERA, CARABIDAE) ACROSS URBAN-RURAL GRADIENTS IN BULGARIA, CANADA AND FINLAND; AN INTERNATIONAL COLLABORATIVE EFFORT

J. Niemelä¹, <u>D. J. Kotze</u>¹, L. Penev² & J. Spence³, ¹ Dept. of Ecology and Systematics, ^P O Box 17, FIN-00014, Univ. of Helsinki, Finland, ² Central Laboratory for General Ecology, 2 Gagarin Street, 1113 Sofia, Bulgaria, ³ Dept. of Biological Sciences, CW405A, Biological Sciences Building, Univ. of Alberta, Edmonton, Alberta, Canada.

Landscapes, worldwide, are changing rapidly through human intervention, and a need exists to assess these human actions on the native fauna and flora. GLOBENET, a global network of scientists evaluating human impacts on the environment, using a common methodology, has been established. Jari Niemelä will discuss the GLOBENET theoretical background and aims at this conference. GLOBENET has the following methodology: to sample carabid beetles, using standard size pitfall traps, across urban-rural gradients. For further information see http://www.helsinki.fi/science/globenet. In 1998 we collected arabid beetles across urban-rural gradients in Sofia (Bulgaria), Edmonton (Canada) and Helsinki (Finland). The highest number of carabid species were captured in Bulgaria, ca. 72 species in 7 035 individuals, followed by Canada (41 species in 15 543 individuals), and then Finland (25 species in 2 203 individuals). In the Canadian study, however, four species captured, representing 76.7% of total catch, were introductions from Europe (Carabus granulatus, C. nemoralis, Clivina fossor and Pterostichus melanarius). Consequently, analyses were performed on the 3 628 native individuals, but we also discuss the possible effects of these introductions on the native fauna. Standardised beetle abundance changed little across the three gradients, but rarefied species richness did change significantly across the Canadian gradient; here significantly more species were captured at the rural than urban end of the gradient. Biomass changes across these gradients were investigated. It is hypothesised that disturbed habitats support a carabid fauna of lower biomass. However, little evidence was found to support this statement as biomass changed without pattern across these urban-rural gradients. Three basic wing forms are identified in ground beetles; macropterous, brachypterous and dimorphic Although proportions of wing forms changed significantly from urban to rural environments for all three cities sampled, these changes were neither the same, nor consistent from one city to the next. These initial results demonstrate that human-induced landscape changes influence biodiversity in different ways, in different parts of the world Possible future avenues for research are discussed.

Key words: Urban-rural gradients, Carabidae, global landscape change

[0419] SUMMARY: SCIENTIFIC APPROACHES TO BIOINDICATION

M. A. McGeoch, Dept. of Zoology and Entomology, Univ. of Pretoria, Pretoria 0002, South Africa, E-mail: mamcgeoch@zoology.up.ac.za

Within 17 months, between August 1998 and January 2000, three independent reviews of bioindication appeared in the literature (McGeoch 1998, Caro & Doherty 1999, Hilty & Merenlander 2000). This suggests that the field of bioindication is ripe for a synthesis of past achievements, and that there is a need to set future directions for the field. Indeed, all three reviews concur strongly on three issues. First, the requirement for bioindicators is reemphasized, second the superiority of invertebrates over vertebrates as indicator taxa is acknowledged, and third, the field of bioindication is seen as lacking scientific rigour and well established methodologies. A symposium on scientific approaches to bioindication could therefore not be better timed. We have now moved beyond the debate on criteria for the selection of bioindicators, and it is largely agreed that the most appropriate criteria are prescribed by the specific objectives for which the bioindicator is to be used. Furthermore, it is recognised that multiple taxa will be needed to address not only the variety of alternative bioindication objectives, but frequently also singular objectives. Here multiple taxa provide complementary information and increased security, ensuring the detection or effective monitoring of environmental change. The focus of bioindication now lies on the clear definition of bioindication objectives, and the development of new and more quantitative methods for the identification, testing and application of bioindicators. As is evident from the papers presented in this Symposium, much closer scrutiny is being given to the quantitative assessment of the robustness of bioindicators. This is true irrespective of whether the broad objectives of bioindication concern identification of the level of a stressor in an environment, the impact of that stressor on biota, or reflection of the biodiversity of a given area. Recent developments in ecology, for example better understanding of mechanisms underlying species responses to disturbance, and models for the effective extrapolation of species densities across scales, are also likely to better inform the predictive tools that are so vital to bioindication. Comparative as well as more rigorous approaches detailed in this Symposium will enhance both the applied value of bioindicators and the confidence with which they can be used.

Index terms: methods for indication, environmental change, biodiversity.

Session 03 – BIOGEOGRAPHY AND BIODIVERSITY

[0420] TERMITE DIVERSITY AND LAND USE CHANGES: LESSONS FOR FUTURE GENERAL BIODIVERSITY STUDIES

<u>P. Eggleton</u>¹, ¹Dept. of Entomology, The Natural History Museum, Cromwell Road, London SW7 5BD, UK, E-mail: pe@nhm.ac.uk.

Termites are not only the most important arthropod decomposers in tropical forests, they are also extremely sensitive to the effects of forest clearance. Complete degradation of forests will often lead to the almost total destruction of termite assemblages, with a potentially enormous concomitant loss of ecosystem services. Termites would therefore seem to be extremely good target organisms both as indicators and as direct mediators of coclogical processes. In this talk I will critically evaluate the problems of using termites as indicators of land use change, especially those due to variation in sampling technique, analytical procedures and biogeographical history. Generalising to studies with a wider remit I conclude that many of the studies that assume simple disturbance responses in species richness are flawed, often by an overemphasis on catch-all parameters, especially species richness and diversity indices. Compositional (multivariate) approaches are likely to be much more informative and far more sensitive to the complex but subtle changes increasingly being observed in disturbed biotas.

Index terms: Isoptera, land use changes, species richness, analyses of assemblage composition

[0422] INSECTS AS INDICATORS OF CHANGING LAND USE IN ALPINE ENVIRONMENTS

J.R.Haslett, Inst. of Zoology, Univ. Salzburg, Hellbrunner Str. 34, A-5020 Salzburg, Austria, E-mail: john.haslett@sbg.ac.at.

Mountain environments are characteristically extremely heterogeneous over a wide range of spatial scales. These nested, complex habitat mosaics are being altered, often irreversibly, by changes in mountain land use. In Europe, problems arising from demands of agriculture and winter tourism are particularly prevalent. Here I explore responses of selected insects, particularly Orthoptera and Diptera, to variations in mountain habitat mosaic stucture in the Austrian and German Alps. Results reveal that insects may be sensitive to patch border complexity as well as to patch content, including microclimate. Individual behaviour, populations, and species assemblage structure may be affected. Key words: Diptera; Orthoptera; habitat mosaics; European Alps

[0421] CHANGES IN CARABID POPULATIONS IN RELATION TO HISTORICAL AND RECENT FOREST ECOLOGY

K. Desender, Dept. Entomology, RBINSc, Vautierstr. 29, B-1000 Brussels, Belgium, Email: kdesender@kbinirsnb.be

Most woodlands in Flanders (Belgium) nowadays are highly fragmented or degraded, mainly due to excessive human interference in the past. Forests now cover less than 10% of the total surface only, but are rather well known concerning their historical ecology. Several efforts have recently been directed towards increasing our knowledge on distribution, ecology and genetics of forest organisms, in particular ground beetles. A short review is given on carabid beetle diversity, ecological assemblages and population genetics in forests of Flanders. Within the context of studying effects of forest history (fragmentation and its effects on beetle diversity and population genetics), or forest quality in general (assemblages of ground beetles in archaeological as compared to recent samples, Red data book- species), several regional projects and impulse programmes have been launched, (some case studies will be illustrated on posters during the ICE). A recent baseline study deals with the occurrence and bio-indicative values of ground beetles from 56 forest stands, distributed in 40 forests. In another study, extensive data on the recent carabid beetle fauna occurring in woodlands of Flanders are compared to a unique archaeological dataset of a post-Roman forest. Integration of these data reveals that during medieval forest degradation and fragmentation, most woods must have been impoverished to a high extent with respect to their stenotopic woodland beetle fauna. Typical woodland beetles show a reduced dispersal power (constant brachyptery) and appear to be powerful indicators for larger ancient woods. A next case study has evaluated beetle diversity in relation to forest size (fragmentation) and history. Apparently, ground beetle diversity has increased in smaller forest fragments, mainly due to increasing influences of surrounding habitats (edge effects). Larger ancient forests therefore yield lower diversity estimates. although having much higher values for conservation. Finally, we have recently used several carabids as model organisms in population genetic studies on forest fragmentation. Population genetic results invariably show significant genetic differentiation between populations. Some of the brachypterous species show geographical isolation by distance. High FST-values are obtained for some rare and brachypterous species. Smaller values of genetic differentiation are found in common and more mobile species from inundation and valley forests. Genetic erosion in small populations is indicated for some very rare and brachypterous carabids, which are known indicators for ancient forests. Based on our results, a number of recommendations can be given for regional nature conservation. Index terms: fragmentation, ecological indicators, diversity, population genetics

[0423] BUTTERFLIES AS INDICATORS FOR CONSERVATION IN FRAGMENTED LANDSCAPES IN THE NEOTROPICS

K. S. Brown Jr, Dept. De Zoologia and Museu de História Natural, Inst. de Biologia, Univ. Estadual de Campinas, C.P. 6109, Cidade Universitária, Campinas, SP 13.083-970 BRAZIL. Financial support: CNPq, FAPESP, CIFOR, PDBFF, BSP.

Insects, the most diverse ecotaxonomic group of macroorganisms, dominate most Neotropical environments. A single locality can have nearly 2000 recognized species of butterflies, 300 of dragonflies and 500 of ants (three better-studied groups with wide niche variations in food, space, time, chemistry, and structure). Fast-breeding insects with short generation time, readily observed, easily recognized, and quickly evaluated for abundance and variation, are especially useful for rapidly monitoring directional changes in the local resources and diversity. In low-productivity systems in the deep tropics (Manaus), rich systems near the Andes (Rondônia and Acre), and complex landscapes in the Atlantic forests, fragmentation and diversity patterns have been studied over several decades, using butterflies and other insects. In general, species richness increases locally with mild disturbance, probably as a result of multiplication of niches and their occupants. Certain types of species disappear early, but richness only decreases when anthropic intervention exceeds natural levels of disturbance (often involving 10-30% of the system, sometimes much greater in bamboo forests, mountainsides and river valleys). Genetic and species diversity depend on landscape or habitat heterogeneity in almost all groups and sites examined, while resource richness may even decrease species diversity. The size of a fragment is less relevant than edge effects and habitat diversification in predicting local richness, persistence, and redundancy patterns. Factors that contribute to heterogeneity or connectivity (especially topography, climate, and disturbance) show clear correlation with the richness of insects, while other factors, including vegetation, soils, latitude, and permanent surface water, have low predictive values. This is typical of disturbance- or heterogeneity-driven diversification on many spatial and temporal scales, with groups responding, through their abundance, disappearance, or immigration, to changes in microenvironment of a fragment or a habitat patch. The monitoring of these indicator groups, though not sufficient per se, is a necessary and effective component in effective landscape conservation in the Neotropics.

Index terms: Richness, heterogeneity, resources, diversification, disturbance.

[0424] TERMITES AS INDICATORS OF HABITAT FRAGMENTATION IN THE CERRADO IN BRAZIL

<u>O. DeSouza</u>, Depto. Biologia Animal., Univ. Fed. Viçosa, 36571-000 Viçosa MG, Brazil, E-mail: og.souza@mail.ufv.br

Being detritivores, termites (Insecta: Isoptera) neither control directly the rate at which their resources are made available, nor restrict the ability of the resources to regenerate. Consequently, they do not mask the ecosystem depletion caused by any sort of ecological pressure, and, therefore are theoretically reliable bioindicators. A field test is performed aiming to show that changes in termite community/population parameters vary consistently with environmental alterations promoted by habitat fragmentation in Brazilian savanna ("Cerrado"). In addition, other criteria for selection of bioindicators are objectively evaluated using termites. It is shown that termites respond to environmental stresses caused by habitat fragmentation in a readily detectable and statistically tractable way. Moreover, data collection for such analyses can be simple, quick, and inexpensive. In addition, termites present wide geographical range, covering precisely the areas of the globe where habitat fragmentation is an important issue. Finally, some termite populations may attain significant pest status, which could ease the quest for sponsorship of scientific research. Termites, however, present some traits which pose problems for their use as bioindicators. After balancing the pros and cons, it is concluded that termites are a reliable taxon to be used as bioindicators of habitat fragmentation and, possibly, bioindicators of more general environmental stresses.

Index terms: Isoptera, bioindicators, environmental stress

[0425] INSECTS AS INDICATORS OF SUBTLE, CLIMATE-INDUCED HABITAT FRAGMENTATION

<u>G. J. Masters</u>¹, V. K. Brown¹, I. P. Clarke¹, S. P. Riberio², R. G. Booth¹ & J. B. Whittaker³, ¹CABI Bioscience, UK Centre, Silwood Park, Ascot, Berkshire, SL5 7TA, UK, E-mail: g.masters@cabi.org; ²Dept. de Biologia Geral/ICB, Universidade Federal de Minas Gerais, CP 486-CEP 30160-970, Belo Horizonte, MG, Brazil & ³Institute of Environmental & Biological Sciences, Lancaster University, Lancaster, LA1 4YQ, UK.

Climate can have direct effects on insects (e.g. temperature-dependent phenological change) and indirect effects, where the response is mediated by the host plant or the immediate biotic community. Variability in macro- or microclimate can lead to subtle physiological responses within host plants and/or changes in their community structure and function, with knock-on effects for the associated insects. Insects are good biological indicators of climate-induced alterations in their host plants, through their relatively short generation times, life-history strategies and mobility/dispersal. Additionally, the majority of insect groups can be easily monitored at regular intervals. A manipulative field experiment, using novel, non-intrusive technology to change local climate, was initiated in 1993 and is on-going. Two climate change scenarios were simulated in the field; warmer winters (by 3°C from Nov. to the following April) with either dryer or wetter summers (complete drought during July and Aug. and 20% supplementation of the long-term average rainfall, from June to Sept. respectively). These treatments have produced a dramatic fragmentation of the grassland habitat, with adjacent plots having very different communities. Insect populations have been monitored throughout this period; in particular the Auchenorrhyncha, leaf-miners, Collembola and Coleoptera, and data from these groups will be used to illustrate climate-induced fragmentation of the habitat. Wetter summers led to an increase in insect abundance, tracking vegetation cover. However, summer drought led to certain insect groups maintaining or increasing their abundance while the vegetation suffered a decline. This was attributed to drought stress leading to greater nutrient availability. All landscapes have inherent spatial heterogeneity, which will lead to variability in the impact of climate. At a local scale, landscapes will have patches that are, for example, wetter/dryer and warmer/colder. Certain insect species will be sensitive to this variation, and thus could be candidates for biological indicators of climate-induced change within the landscape.

Index terms: calcareous grassland, climate change, drought stress, eco-physiology, spatial heterogeneity

[0426] INSECTS AS INDICATORS OF THE RESTORATION OF AGRICULTURAL LAND

S. R. Mortimer, R. G. Booth & V. K. Brown, CABI Bioscience, Silwood Park, Ascot, Berkshire, SL5 7TA, UK, E-mail: s.mortimer@cabi.org

Much of Europe's biological diversity is associated with agricultural ecosystems. Increases in the intensity of agricultural management in recent decades have led to erosion of this biodiversity. In particular, increases in agrochemical inputs and the widespread use of forage crops have led to the destruction of large areas of species-rich grassland. Recent policy changes (Convention on Biological Diversity, EU Agri-environment Regulation, EU Habitats Directive) have provided incentives for restoration of these habitats associated with low intensity agricultural practices. Insects make good biological indicators of changing agricultural land use as a result of their short life-cycles, mobility and sensitivity to small scale environmental conditions. Indeed, insects can be better indicators of the health of a plant community than the plant species themselves. The insect fauna is a product of both plant community composition and vegetation structure. Therefore, changes in management (e.g. grazing pressure) which result in alterations in canopy structure may affect the insect community long before changes in plant community composition are manifested. However, the presence of adults does not mean that a population exists at the site. Whereas plant species are comparatively easy to identify, with insect taxa there is a trade-off between ease of identification and their value in predicting the success of a restoration scheme. Approaches include the comparison of insect assemblages at restoration sites with those of existing areas of pristine habitat using similarity indices or multivariate analysis techniques. Data on the species composition of the fauna of particular insect groups can be used to identify key environmental or management variables which promote the restoration of the community. Such approaches allow recommendations to be made on the most appropriate management for a particular site, and also allow targeting of resources for restoration schemes on those sites likely to yield the best results. Multivariate techniques can also be used to define potential indicator species, which must combine ease of identification with predictive power, allowing evaluation of the success of restoration management. The use of insects as indicators of the success of restoration management will be illustrated using examples from the restoration of lowland calcareous grasslands in the UK. Restoration management scenarios include the diversification of agriculturally-improved grassland, the re-creation of grasslands on ex-arable land and the restoration of abandoned grasslands after scrub encroachment.

Index terms: agro-ecosystems, biodiversity, calcareous grassland, conservation management, habitat management.

[0427] AN EVALUATION OF ARTHROPODS FOR POSSIBLE USE IN COMPLETION CRITERIA FOR MINESITE REHABILITATION

J. D. Majer¹ & L. Bisevac¹, ¹School of Environmental Biology, Curtin University of Technology, GPO Box U 1987, Perth WA 6845, Australia. E-mail imajerj@info.curtin.edu.au.

Completion Criteria, also known as Success Indicators, are measures used to help identify when minesite rehabilitation has reached a benchmark standard in order to allow it to be relinquished by the mining company. Appropriate levels must be attained before declaring the restoration a success and, where relevant, release of bonds. The most common approach to using such criteria for rehabilitation of former minesites is based on physical and soil factors and also various measures of plant communities in the area. Fauna is not usually measured, since animals are presumed to return with the re-establishment of flora; the casualty of this relationship has seldom been demonstrated. Furthermore, if fauna is included, generally only vertebrate animals are considered. As explained elsewhere in this Symposium, invertebrates are ideally suited for conveying information about the environmental health of an area. There is therefore an opportunity to use measurements of invertebrates as indicators of the success of rehabilitation and to include these in the schedule of Completion Criteria. This presentation makes a comparison of the logistics of performing: 1) vegetation, 2) vertebrate and 3) invertebrate surveys in the monitoring of rehabilitation. Using data from the Iluka mineral sand mine at Eneabba, Western Australia, it presents evidence that invertebrates can provide a cost-effective means of generating information on the environmental status of an area.

Index terms: Mining, success indicators, bioindicators, insects, arachnids

[0428] URBAN FOREST RESERVES IN BRAZIL

K. Brown

ABSTRACT NOT RECEIVED

[0430]CONSERVATION OF GRASSLAND BUTTERFLIES IN AN URBAN LANDSCAPE IN THE UK

B.C.Wood¹ & A.S.Pullin², ¹School of Biosciences, Univ. of Birmingham, Edgbaston, Birmingham, B15 2TT, UK, Email B.C.Wood@bham.ac.uk.

Urban green areas are a valuable refuge for wildlife in cities. As urban development increases, green space is often reduced in area and fragmented into smaller, more isolated patches. Although permanent green space exists in most cities, some of the urban landscape is in a dynamic state of flux, with patches being continually created whilst others are lost. Insects use these patches as both stable breeding habitats and as transient patches facilitating dispersal. This study investigates a suite of four grassland butterfly species, along putative wildlife corridors, in the fragmented network of grassland habitat in two conurbations in the West Midlands, UK. These butterfly species range in mobility from the highly mobile Pieris napi, to the intermediary Maniola jurtina and Pyronia tithonus, and the sedentary Coenonympha pamphilus. Allozyme electrophoresis was used to determine the extent of geographic structuring and the level of gene flow between populations along and between habitat corridors. It was hypothesised that lowest levels of gene flow and therefore greatest geographic structuring would exist between populations of the most sedentary species, C. pamphilus and no geographic structuring would be found between the highly mobile *P. napi* populations, at this spatial scale. Little geographic structuring was found for all species, although higher mean Fst values were found for C. pamphilus and P. tithonus than P. napi and M. jurtina. Bootstrapped Reynold's distance measures (generated from allele frequencies) between populations and resulting unrooted consensus neighbour-joining trees show that populations are no more connected when situated on the same putative habitat corridor, than when situated on different corridors. No correlation was found between geographic distance and the genetic distance between populations. These results suggest that the distribution of these butterfly species is governed by the distribution and persistence of suitable habitat, rather than the relative mobility of species and the connectivity or isolation of habitat patches. Conservation strategies for these grassland species in the urban landscape, therefore, should focus on the appropriate management and creation of suitable habitat for these species.

Index terms: Coenonympha pamphilus, Maniola jurtina, allozymes, Lepidoptera, geographic structuring

[0429] HOST-SPECIFICITY IN MACULINEA ALCON: A LARGE BLUE BUTTERFLY CONSERVATION ISSUE IN EUROPE

D.R. Nash¹, T.D. Als², R. Maile³, H. Jungnickel³ & <u>J.I. Boomsma¹</u>, ¹Dept. Population Ecology, Univ. of Copenhagen, Unversitetsparken 15, DK-2100 Copenhagen, Denmark, E-Mail DRNash@zi.ku.dk; ²Dept. Genetics and Ecology, Univ. of Aarhus, DK-8000 Aarhus C, Denmark. ³Dept. Chemistry, University of Keele, Keele, Staffordshire. ST5 5BG. UK.

The large blue butterflies (genus Maculinea) are rare, endangered or locally extinct throughout Europe. All large blue butterflies have an unusual life-cycle. They initially feed on the flowers of one or a few specific host plants, but in the last larval instar they become aphytophagous parasites of ant colonies of the genus Myrmica. The combined requirement for specific host plants and specific host ants is a major restriction on the suitable habitats available for these butterflies, and their socially parasitic lifestyle puts a further restriction on population sizes. Recent changes in agricultural land use have led to the restriction of suitable habitat to small, widely dispersed patches, and there have been frequent local extinctions, even in apparently suitable habitat. There is therefore currently much conservation effort to preserve and expand existing habitat and to reintroduce large blue butterflies into areas from which populations have become extinct. The key to the success of these endeavours is likely to lie in the understanding of the host ant specificity of large blue butterflies. Reintroduction into areas that are populated with, or measures that encourage, the wrong species of Myrmica are doomed to failure. We have been studying the population ecology and host specificity of the Alcon blue butterfly, Maculinea alcon. This species is unusual in that it is known to use different Myrmica species as host in different parts of Europe. Danish populations of M. alcon are particularly interesting because they lie between populations in Sweden that are known to use exclusively Myrmica rubra as a host, and those in The Netherlands that use Myrmica ruginodis. Our work has shown that both Myrmica rubra and Myrmica ruginodis are used as hosts in Denmark, but not in a simple cline as we had originally predicted. The majority of Danish populations seem to use both host ant species simultaneously. We have examined the surface hydrocarbons found on caterpillars of M. alcon and those on the their host ants. From this it seems that *M. alcon* caterpillars gain access to, and survive in, their host ant nests by mimicking the surface chemistry of the host ant larvae. Different populations of the butterfly differ in how closely they match the larvae of the different host species, and this is reflected in their host use in the field. Cross-infection experiments have demonstrated some local adaptation to host ants. These results have implications both for the conservation of large blue butterflies and for studies of parasite-host coevolution in general.

[0431] CONSERVATION GENETICS OF A THREATENED EUROPEAN BUTTERFLY EURODRYAS AURINIA IN THE FRAGMENTED AGRICULTURAL LANDSCAPE OF THE UK

D. A. Joyce & A. S. Pullin¹, ¹ School of Biosciences, The University of Birmingham, Edgbaston, Birmingham B15 2TT, UK. E-mail d.a.joyce@bham.ac.uk.

Euphydryas aurinia is protected in Europe under the Bern Convention after a dramatic decline throughout the continent. The UK is thought to be a major stronghold for the species, but even here it is declining at the rate of at least 11.5% per decade. This is due to loss of suitable habitat, either through destruction or mismanagement. The remaining populations are separated from one another by large expanses of unsuitable habitat leading to a sparse distribution of fragmented populations of the butterfly. Our work aimed to investigate the genetic diversity in the remaining UK population to assess the effect that fragmentation of habitat is having on the population structure and levels of gene flow in the species. We examined the structure of the UK population from a historical perspective using allozyme electrophoresis and mitochondrial DNA to see whether a) the species exhibited geographical structuring of genetic diversity, and b) we could infer anything about the post-glacial colonisation of the butterfly into the UK. Mitochondrial cytochrome b sequence data (400 base pairs) from 63 individuals, revealed low haplotype diversity throughout the UK. This included two individuals from an extinct population that we were able to sample using museum specimens. We compared data obtained from French and Portuguese butterflies and concluded that colonisation is likely to have been one event possibly from the Iberian peninsula. We can therefore treat E. aurinia in the UK as a single ESU. Allozyme data (11 loci, mean n = 20) showed that there was no isolation by distance, and very few populations contained private alleles. There seems to be a history of extensive gene flow in the species, but alleles at all loci did significantly differ in frequencies between populations, likely to be an effect of the relatively recent isolation of populations from one another. Also, populations were found to be most closely related to those geographically nearest to them, suggesting there has been gene flow between them. Heterozygosity levels are lower than would be expected if the population was mating entirely at random. Our evidence suggests there was once far more gene flow than in recent times, as would be expected at a time when agriculture was less intensive. It seems likely, especially in the light of the population fluctuations and regular bottlenecks that E. aurinia colonies are known to undergo, that gene flow is extremely important to maintain diversity in populations and prevent inbreeding. It is therefore vital that fragmentation of remaining populations is halted, and habitat restoration / creation considered a priority in order to counteract the negative effect that further isolation will have.

Index terms: Myrmica, Parasitism, Mimicry, Coevolution.

[0432] LANDSCAPE MANAGEMENT FOR THE LARGE COPPER BUTTERFLY, LYCAENA DISPAR BATAVUS

A.S. Pullin & C.N. Nicholls, School of Biosciences, The University of Birmingham, Edgbaston, Birmingham B15 2TT, UK. E-mail: a.s.pullin@bham.ac.uk

A threatened species throughout Europe, L. dispar has declined rapidly over much of its range, particularly in northern regions where the univoltine subspecies L. dispar batavas occurs. The latter's wetland habitat is amongst the most severely degraded and urgent need for conservation action is recognised by the species inclusion in appendix II of the Berne Convention and in the European Union's Habitats Directive. Field research has identified elements of the ecology of *L. dispar batavus* that suggest a more extensive form of conservation management is required than the site-based approach used successfully with some other butterfly species. Site management to provide open fenland areas and sufficient abundance of its larval foodplant, *Rumex hydrolapathum* is vital but this is unlikely to be enough. The species occurs at low density and is capable of rapid dispersal, appearing to have an opportunistic strategy enabling exploitation of ephemeral open wetland habitats. Consequently populations are unlikely to be stable, local extinctions will be frequent and must be matched by colonisation. This suggests that conservation and restoration will require networks of suitable habitat connected by 'corridors/stepping stones' facilitating colonisation. This may be a general problem to be faced in conserving many rapidly declining butterflies in European agricultural landscapes. Using one of the last remaining sites of L. dispar batavus, the Weerribben National Park (The Netherlands) as a habitat template, comparative studies carried out on a hierarchy of spatial scales has enabled an assessment of contemporary habitat suitability at prospective re-introduction sites in the Broadland region of eastern England. Evaluation of preliminary results suggest that currently Broadland provides insufficient amounts of open fenland that characterizes much of the butterfly's native habitat, and that those suitable areas that do exist are probably too small and too isolated to support a viable population. Targeted restoration management, based on identification of key habitat features, should, nevertheless redress this situation, eventually enabling implementation of a full-scale re-introduction programme.

Index terms: conservation, fragmentation, wetland, fen, habitat connectivity

[0433] COLEOPTERA

P. hammond

ABSTRACT NOT RECEIVED

[0435] DIPTERA F. C. Thompson ABSTRACT NOT RECEIVED

[0434] LEPIDOPTERA

N. P. Kristensen

ABSTRACT NOT RECEIVED

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[0436] DICTYOPTERA

P. Eggleton

ABSTRACT NOT RECEIVED

[0438] HYMENOPTERA

ABSTRACT NOT RECEIVED

[0437] HETEROPTERA

<u>C. W. Schaefer</u>, Department of Ecology and Evolutionary Biology University of Connecticut U-43 Storrs CT 06269-3043 USA. schaefer@uconnvm.uconn.edu

The number of described (36,700) and of undescribed (25,000) species in the hemipteran suborder Heteroptera were very roughly estimated from catalogs and from responses by authorities to my inquiries. Of these species, 55% belong to the infraorder Cimicomorpha, and 35% to Pentatomomorpha (including Aradidae); the remaining 10% of species are divided unequally among the remaining five infraorders. The cimicomorphan families Miridae and Reduviidae are the largest (10,000 and 6500 species respectively); the pentatomomorphan families Pentatomidae and Lygaeidae are "tied" for third, with about 4150 species each. Considerable progress has been made towards cataloging heteropteran species, and this in turn has led to some fine systematic and phylogenetic work. However, the biologies (including immature stages) and ecology of most species are completely unknown. There are far too few workers on heteropteran biology, and the number diminishes every year. There are even fewer working on systematics, and the remarkable progress made so far is the result of the fine work of these few students of Heteroptera.

[0439] THE CONVEBTION ON BIOLOGICAL DIVERSITY

C. Samper

ABSTRACT NOT RECEIVED

[0440] A NEW PROGRAM FOR SYSTEMATICS: THE CONVENTION ON BIOLOGICAL DIVERSITY'S GLOBAL TAXONOMY INITIATIVE (GTI)

<u>I. D. Cresswell</u>, United Nations Convention on Biological Diversity Secretariat, 393 St. Jacques Street, Suite 300, Montreal, Quebec H2Y 1N9, CANADA, E-mail ian.cresswell@biodiv.org.

The lack of taxonomic knowledge of biological diversity has been recognized worldwide as a significant problem in decision-making for conservation and sustainable use of our natural resources. In response the Convention on Biological Diversity (CBD) has created the Global Taxonomy Initiative (GTI) to facilitate the filling of known gaps in systematics, the training of new taxonomists and curators, and finding new ways of using our knowledge base to increase our ability to conserve, use and share the benefits of our biological diversity. The need for fundamental taxonomic knowledge of biological diversity to underpin the key objectives of the CBD is wide ranging. The CBD deals with diversity at all levels of the biological hierarchy; from genes, species, populations, communities, ecosystems to landscapes. The GTI must assist international funding agencies, national and sub-national governments, and non-government bodies address the need for adequate taxonomy as part of the worldwide demand for up-to-date biodiversity information. To do this requires the advancement and renewal of taxonomy associated with the protection and maintenance of our natural heritage. For the GTI to be effective in a timely way a major increase in partnerships need to be quickly formed between the world's natural history institutions in the developed and developing worlds. Increasing the world's taxonomic activity will need to be focused to ensure the results are not only scientifically correct but also provide practical, implementable information that is available to managers and decision makers. The developing training programmes, the strengthening of infrastructure for biological collections in countries of origin, the building the capacity for taxonomic research, and increasing the worldwide availability of taxonomic information are high priorities. The overall need has been identified and a new commitment to action has been agreed. Yet this paper asks more questions than it answers: what should be our work priorities, how should we get agreement on who does what, how can each individual make a difference to the overall goals of conservation and sustainable use? This paper will present the decisions from the 5^{th} meeting of the Conference of the Parties (the political body of the Convention) held in Nairobi, May 2000, and will attempt to illustrate the way forward, including how the ICE can help implement the GTI.

[0441] THE SIGNIFICANCE OF INSECTS AND OTHER INVERTEBRATES IN MULTILATERAL ENVIRONMENTAL AGREEMENTS

N. M. Collin, World Conservation Monitoring Centre, 219 Huntingdon Rd, Cambridge CB3 0DL, UK

The five key multilateral environmental agreements (MEAs) concerning global biodiversity are the Convention on International Trade in Endangered Species (CITES); the Migratory Species Convention (Bonn Convention); the International Convention on Wetlands (Ramsar Convention); the World Heritage Convention; and the Convention on Biological Diversity (CBD). They seek respectively to maintain wildlife trade within sustainable limits; to protect populations and key habitats of migratory species; to identify and protect key wetlands of the world, including coastal areas; to identify and manage the world's principal natural and cultural sites; and to conserve, sustainably use and share the benefits arising from biodiversity. Insects and other invertebrates constitute the bulk of the world's biodiversity. But is this sufficiently recognised in these conventions? The author analyses the significance of insects and other invertebrates in the conventions, demonstrating that explicitly they comprise only a small part of the decisions and species listings (e.g. in CITES and the Bonn Convention), but that their importance is implicitly recognised. Scientific knowledge of insects and other invertebrates should play a larger role in implementing MEAs, but the entomological literature may be unsuited to analysis and presentation to policy-makers. Could this be improved? MEAs focus on both conservation and sustainable use. Nations wish to protect insects and other invertebrates for their own sakes, but also for their roles in maintaining ecosystem services and as potential sources of useful products and revenues. Entomologists should present their results accordingly. Research proposals need to speak directly to the aims of the MEAs. Government policy-makers need research that helps them directly to implement MEAs nationally. Entomologists should study national reports on MEAs and present their research in ways that serve these reporting needs. Insects and other invertebrates are undoubtedly fundamental to the ecological processes that MEAs seek to maintain. This must be presented more convincingly and accessibly, through use of spatial data, crosscomparison with other groups and through inclusion in conservation priority analyses being executed around the world. This will benefit not only the successful implementation of MEAs, but in turn increase the flow of research support to the entomological community.

Symposium and Poster Session

[0442] REGIONAL AND NATIONAL PROJECTS FOR CBD, THE OF SCIENCE

B. Dias

ABSTRACT NOT RECEIVED

[0443] BIOSPHERE RESERVES: A MODEL FOR THE ROLE OF TAXONOMIC SCIENCE IN BIODIVERSITY CONSERVATION

<u>P. Bridgewater</u>, Division of Ecological Sciences, UNESCO, 1 rue Miollis, Paris 75732 CEDEX, France

To manage, conserve, use and share biodiversity we must understand it - and that involves increasing efforts in taxonomy. Taxonomy provides this reference system for all known life. While we have thus the scientific framework, we are still a long way from knowing all the elements. Consequently, the governments of the world that recognize the Convention on Biological Diversity (CBD) have acknowledged the existence of a taxonomic impediment to sound management and conservation of biodiversity. Solving the taxonomic impediment is also essential to develop a balanced approach to protected area establishment and management, as without a strong taxonomic base protected areas simply remain ineffective paper proclamations. In the context of biodiversity conservation generally, such a balanced approach can be achieved through the ecosystem approach adopted by the CBD. The UNESCO-Man and Biosphere program seeks to implement the ecosystem approach at global, regional and national levels. A major objective of the program is the development of a World Network of Biosphere Reserves, which provides an integrating approach to biodiversity, through developing identification and monitoring of, and incentives for, the conservation, management and use of biodiversity. Our management of nature gives expression to our many human cultures. The taxonomic perspective, yielding a detailed understanding of biodiversity, helps comprehend how, in turn, the environment reshapes human culture through feedback processes. Throughout the world most landscapes are *biocultural* landscapes – blends of human activity with the expression of biodiversity. Biosphere Reserves are an on-ground attempt to help us understand better how human cultural activity has shaped the biodiversity of today. Solutions to key taxonomic impediments will require necessary funding to maintain existing collections, liberate information from them, and provide capacity building in developing countries, where national collections are absent, poor in quality and lack necessary maintenance standards. This also means activity at all levels of the taxonomic hierarchy, across all Kingdoms and subsidiary divisions. Blending people and nature, Biosphere Reserves are unique models to help resolve taxonomic impediments, while also delivering conservation outcomes.

[0444] ALIEN BUGS IN INTERNATIONAL CONVENTIONS

I.K. Waage, CABI Bioscience, Silwood Park, Ascot, SL5 7TA, UK, E-mail: j.waage@CABI.org

Article 8h of the Convention on Biological Diversity calls on countries to prevent, eradicate or control alien invasive species which threaten the environment. This has generated many new initiatives on alien invasive species, including the global Invasive Species Programme, which is described. Entomologically-based programmes of eradication, chemical and biological control of alien insects and weeds provide both models and cautionary tales in addressing this Convention obligation. There are exciting challenges in integrating existing agricultural and environmental Conventions into a common biosecurity approach to alien pest management, and specific issues to address, including the introduction of alien organisms for biological control. [0446 CHALLENGES AND OPPORTUNITIES IN UNDERSTANDING AND UTILIZING AFRICAN INSECT DIVERSITY

<u>S. E. Miller</u>, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560-0105 USA and International Centre of Insect Physiology and Ecology, Box 30772, Nairobi, Kenya

About 100,000 species of insects have been described from Sub-Saharan Africa. Because of the colonial history, Africa, in comparison to other tropical regions, is probably better known, but the information is harder to find. Few centres of expertise on insect diversity and systematics exist in tropical Africa, while most of the large collections are in South Africa, Europe and the United States. Recent surveys of in-country resources by ICIPE, CABI, and BioNET International show that human resources are also thinly distributed in tropical Africa. Yet, there is tremendous need for basic information on insect diversity for pest management related to plant, livestock and human health, as well as conservation and environmental management. Invasive (alien) species represent a newly recognised threat that cuts across traditional sectors. Recent work in Africa by several organisations shows the potential of different approaches to these challenges, including compilation and synthesis of pre-existing data and research targeted at strategic needs. Information can also be applied in novel ways to promote environmentally friendly income generating schemes such as silk worms, honey bees, ecotourism, butterfly farming and bioprospecting. The Global Taxonomy Initiative of the Convention on Biological Diversity provides an opportunity to expand these experiments to better meet the needs. Index terms: Africa, biodiversity, conservation, taxonomy, systematics

[0445] OVERCOMING THE TAXONOMIC IMPEDIMENT TO SUSTAINABLE DEVELOPMENT - BIONET-INTERNATIONAL, THE GLOBAL NETWORK FOR TAXONOMY

N. King, BioNet-International, Bakeham Lane, Egham, Surrey TW20 9TY, UK, T: +44 1491 829036/7/8, F: +44 1491 829082/100, e: bionet@cabi.org; n.king@cabi.org, http://www.bionet-intl.org

BioNet-International is a global network for capacity building in biosystematics for sustainable development. The network is comprised of a number of inter-linked regional LOOPs (Locally Organised and Operated Partnerships) of developing country institutions, supported by a consortium of developed country institutions. Its purpose, through South-South cooperation and North-South partnerships for institutional strengthening and human resource development, is to enable developing countries to achieve self-reliance in taxonomy to support regional and national programmes for eradication of poverty via sustainable agricultural development and use of natural resources, and conservation of biodiversity (including implementation of the Convention on Biological Diversity). The networks' success is attributable to two key components. The first is local ownership of the process, including governmental endorsement of the need for such a capacity building network whereby needs are identified and prioritised by member countries themselves. The second is a tried and tested mechanism whereby a lack of individual country capacity is overcome by pooling, optimising and sharing regional capacity on a reciprocal basis between member countries. It provides a very useful model for other capacity building initiatives in developing countries, as well as for North-South and South-South collaborative partnerships for capacity building.

Index Terms: capacity building, networks, south-south, north-south, partnerships, biosystematics, taxonomy

[0447] WEEVIL DIVERSITY IN AFRICA: EXTRAPOLATIONS FROM HOST SURVEYS AND SYSTEMATIC STUDY (COLEOPTERA: CURCULIONOIDEA)

R. G. Oberpricler, CSIRO Entomology, GPO Box 1700, Canberra ACT 2601, AUSTRALIA. E-mail Rolf.Oberprieler@ento.csiro.au.

Estimation of the species richness of diverse and speciose groups is notoriously difficult. In phytophagous taxa, this usually involves some assumption of host specificity that is generally not testable at current levels of information. Relatively intensive sampling and systematic study of the weevil fauna of southern Africa during the last two decades allows a more accurate estimate of total species numbers in that region and also extrapolation of the world species richness of Curculionoidea. In a selection of taxa with narrow host specificity, species numbers after targeted sampling and taxonomic study increased about 5-fold, while those of some non-hostspecific (oligophagous to polyphagous, but generally habitat-specific) taxa increased 3-fold. In the former category, projection of the narrow host specificity to remaining (unsampled but suitable) host species indicates a total species richness of about 17 times the number of currently described species. In the latter category, total species numbers are estimated at about 5 times those of described species. By contrast, the total species richness of larger, terrestrial and better-sampled weevils is unlikely to reach double the number of currently described species. In consideration of the large and mostly host-specific but poorly sampled and studied southern African fauna of Ange and mostly noarspectre out poorly simple and build and the second secon species is likely. This calculates to about 13500 species for the region and 40000 for the entire African weevil fauna. The same ratio estimates the Australian weevil fauna at 20000 species (4192 described) and the South American and Oriental faunas at about 50000 each. With the smaller and better known faunas of North America and the Palacarctic region estimated at about 10000 each, the total world weevil species richness calculates to about 180000, or 3 times the number currently described. With weevils constituting about 20% of the entire world beetle fauna (18.7% in Australia), a total Coleoptera species richness of 900000 is indicated. This southern Africa case study therefore suggests a world weevil and beetle fauna of approximately 0.2 and 1.0 million species, respectively. Index terms: weevil and beetle species numbers

[0448] CARABIDS OF AFRICA: THE STATE OF THE ART, WITH BIOGEOGRAPHICAL HIGHLIGHTS (COLEOPTERA)

<u>A. V. Taglianti</u>, Dipartimento di Biologia Animale e dell'Uomo, Università di Roma "La Sapienza", Viale dell'Università, 32, I-00185 Roma. E-mail: vignataglian@axrma.uniromal.it

The carabidology of the Afrotropical Region is represented in the last two centuries mainly by French entomologists. The major contributions was those by C. Alluaud, R. Jeannel, L. Burgeon and particularly P. Basilewsky. So far, a definitive assessment at the specific level is not available for the whole African Region: the carabid fauna is rich although not comparable to that of other major biogeographical regions, particularly of the Holarctic one. For the major taxa (tribes/subfamilies) of carabids s.s. (tiger-beetles and Paussinae excluded) the estimates are more reliable. A total of 115 major taxa (49 in a lumper vision) out of 173 (79) recognised in the world Carabidae, represent nearly 60% of the world fauna. The nearly 15 endemic groups (13%) include very basal lineages. Although several widespread groups, such as Carabini, Cychrini, Nebriinae, Broscini, Patrobinae and many subtribes of Pterostichini are lacking, others display a remarkable radiation in Africa: Agonini, Oodinae, Callistinae, Panagaeinae, Lebiinae and Zuphiinae. This pattern can be reasonably explained as the result of very ancient radiation(s) in Gondwana, with several (albeit not numerous) colonizations by elements originating from subsequent Angarian radiations. At regional level good knowledge has been gathered for Southern and Eastern Africa. Particularly for the eastern regions (Ethiopia, Somalia and Tanzania) up-to-date check-lists are herein discussed. The fauna of this area seems to be the most highly diversified in Africa. For instance the nearly 800 species listed from Tanzania, include forest, savannah, mountain and desert elements, being thus evidently correlated with the landscape complexity. While the forest elements are mostly shared with Central and Western Africa, the others are endemics (ca. 30%) or with southern affinity; a significant Palaearcite component is present in the mountain areas. Index terms: Carabidae, biogeography, diversity.

[0449] DISTRIBUTION PATTERNS AND HOST PLANT RELATIONSHIPS WITHIN THE GENUS CERATITIS MACLEAY (DIPTERA: TEPHRITIDAE) IN AFRICA

M. De Meyer, Entomology Section, Koninklijk Museum voor Midden Afrika, Leuvensesteenweg 13, B-3080 Tervuren, Belgium, E-mail demeyer@africamuseum.be.

The Afrotropical genus Ceratitis MacLeay comprises about 80 species. Data indicate that the group as a whole, infests a wide spectrum of host plants. A number of well defined clades within the genus are however restricted to a narrow range of hosts, usually confined to a particular genus or family. These oligophagous or stenophagous clades are often confined in their distribution. Their distribution is compared with the known host plant range, and discussed in this respect. Polyphagous Ceratitis species (such as C. anonae, C. capitata, C. cosyra, C. fasciventris, C. punctata and C. rosa), attack a variety of exotic commercial and indigenous wild fruits. Different distribution patterns for those particular pest species are however observed. This implies that other hitherto unknown environmental parameters must definit their known distribution. The different patterns found are compared and discussed. Particular clades within the genus are phylogenetically well resolved. For these groups, the phylogeny is associated with the observed occurrence of the particular species within the clades.

Index terms: fruit fly, pest species, oligophagous, stenophagous, polyphagous

[0450] THE CADDISFLIES (TRICHOPTERA) OF LARGE RIVERS IN NAMIBIA: UNIFORMITY OR DIFFERENT FAUNAS?

<u>W. Mey</u>, Museum fuer Naturkunde, Humboldt-Universitaet, Invalidenstr. 43, D - 10115 Berlin, Germany.

The only perennial rivers in Namibia are those flowing along the northern and southern borders: Cunene, Kavango, Kvando, Zambezi and Orange. The caddisfly fauna of these large rivers is poorly known. Intensive collecting of aquatic insects has been performed during the first Namibian-German Expedition 1992 at different sites on the Kavango river (= Popa Falls), Kvando river (= Nakatwa) and Zambezi (= Katima Mulilo). The insects were attracted by mercury-vapour lamps run by a generator as the power unit. The lamps were in operation at each site for 4 hours after sunset in 4 consecutive nights. A total of 82 Trichoptera species were collected. More than 50 species are found in Namibia for the first time. Most of them are widespread afrotropical species. A qualitative comparison of the compiled species lists of the three rivers reveal, that: The potamobiontic caddisfly fauna of the investigated rivers is quite homogeneous. 1) The rapids at Popa Falls of the Kavango are the locality with the highest species diversity. This is due largely to the rocky riverbed which generates a large number of additional habitats for the larvae, 2) The faunal composition is dominated by species of the families Hydroptilidae, Hydropsychidae and Leptoceridae. A remarkable feature is the sympatric occurrence of many congeneric species (e.g. Hydroptila Dalman, Cheumatopsyche Wallengren, Ecnomus McLachlan, Oecetis McLachlan). The results are discussed concerning the differences of distributional patterns between aquatic and terrestrial faunas and its relevance to define hydrobiological regions.

Index terms: Trichoptera, riverine fauna, Africa, Namibia

[0451] BIODIVERSITY MEASUREMENT: THE SOUTH AFRICAN GRASSLAND INSECT EXAMPLE

<u>S. vdM. Louw</u>¹ & M. T. Seaman², ¹Dept of Zoology & Entomology, Univ. of the Orange Free State, P. O. Box 339, Bloemfontein 9300, South Africa. E-mail: LouwSvdM@dre.nw.uovs.ac.za; ²Centre for Environmental Management, Univ. of the Orange Free State, P. O. Box 339, Bloemfontein 9300, South Africa. E-mail: SeamanMT@dre.nw.uovs.ac.za

A bio-monitoring strategy for grassland ecosystems, central to which is a scoring system that optimizes accuracy and speed, is long overdue. While such systems have long been under development for rivers and other aquatic ecosystems, bio-monitoring of terrestrial ecosystems remains a cumbersome process. While the 'health' of a grassland habitat could be measured via the biodiversity of grasses themselves, or via faunal groups such as birds or mammals, we consider grassland insects to be a most appropriate group. This choice is based on the simplicity of sampling, the inherent species richness of insects themselves and the symptomatic nature of such a diverse group of consumers. On the other hand, we recognised that large numbers of species and identification problems could jeopardize analysis. Our solution is the use of functional feeding groups (FFG's) as operational units and we argue that FFG's are not biased and do not skew the analysis, but instead only reflect actual niche occupation. In a recent case study during the winter in the central Free State province of South Africa, 26 FFG's were identified, enabling us to identify adequate sample size and alpha and beta diversity with relative ease. FFG's were awarded values on a five-point scoring system that was linked to the probability of occurrence in a 'healthy' system. Resultant scores provide benchmark values that will allow comparison and evaluation over successive years. With this we propose to trigger the further development of a South African Grassland Scoring System (SAGraSS). Such a system would provide rapid, repeatable and user-friendly insect-based bio-monitoring methodologies for scientists, para-taxonomists, environmental impact assessment practitioners environmental managers alike.

Index terms: Bio-monitoring, functional feeding groups, SAGraSS.

[0452] BIOGEOGRAPHY AND RELATIONSHIPS OF AFROTROPICAL ACROCERIDAE (DIPTERA) TRUE ENDOPARASITOIDS OF SPIDERS

E.I. Schlinger, The World Spider-Parasitoid Laboratory, 1944 Edison Street, Santa Ynez, CA 93460 USA, E-mail: acrofly@silcom.com.

At present the Afrotropical Region contains no less than 60 species of *Acroceridae*, placed in 16 genera representing all three recognized subfamilies of *Acroceridae*. The relationships of these taxa will be discussed with particular reference to Madagascar and to the Neotropical Region. Biogeographic patterns of selected groups will be detailed on Gondwanan maps and compared with recent maps to clarify distribution assumptions of both the acrocerid parasitoids and their host spiders. Talk will be illustrated with colored slides of recent paintings of these colorful flies.

Index Terms: Acroceridae, Araneae, parasitoids, Gondwana

[0454] PHYLOGENY AND HOST-PLANT RELATIONSHIPS OF THE PECTINIVALVINAE (LEPIDOPTERA: NEPTICULIDAE)

R.J.B. Hoare, Landcare Research, Private Bag 92170, Auckland, New Zealand.

The Nepticulidae are a worldwide family of tiny moths, whose larvae mine in the leaves, stems or fruit of a wide range of angiosperm plants. Usually a single species of moth is restricted to a single host-plant species or to a few species in the same host genus. However, at the generic level this specificity tends to break down, and speciose lineages such as Stigmella attack a wide range of host-plant families. Two subfamilies are recognized within the Nepticulidae, the worldwide Nepticulinae, and the Pectinivalvinae, which have only been recorded from Australia. The type genus of Pectinivalvinae, Pectinivalva, is very common throughout Australia, and at least 160 species are known, with many more undoubtedly remaining to be discovered. All known host-plants for Pectinivalva belong to the Myrtaceae. A cladistic analysis of representative members of the genus revealed that it falls into three well-supported monophyletic groups, each with a more or less characteristic host-plant range. More basal members of two of the three groups are restricted to rainforest Myrtaceae, and it is suggested that these groups may have diversified onto the sclerophyllous myrtaceous flora that now dominates Australia as the climate dried out during the Miocene. The only other recognized genus of Pectinivalvinae is the recently described Roscidotoga, which is sister to Pectinivalva. Roscidotoga contains three known species, whose larvae feed on Cunoniaceae and Elaeocarpaceae, two related plant families in the Oxalidales. Like the Myrtaceae, these families are considered to be ancient elements of the Australian flora, which would have been present in Gondwanan times, before the break-up of the southern continents, and the relationship of the nepticulids with them is probably equally ancient. The two pectinivalvine genera are considered likely to be early Cretaceous in origin, and the possible reasons for their apparent absence from continents other than Australia will be discussed.

Index terms: Pectinivalva, Roscidotoga, Cunoniaceae, Myrtaceae, Gondwana.

[0453] BIOGEOGRAPHY OF AFROTROPICAL *MONOLEPTA* AND RELATED TAXA (CHRYSOMELIDAE; COLEOPTERA)

T. Wagner, Zoologisches Forschungsinstitut und Museum Alexander Koenig, Adenauerallee 160, D-53113 Bonn, Germany.

In recent studies on canopy arthropods in East African forests, *Monolepta* and related taxa (Galerucinae, Chrysomelidae), were found as an abundant and species rich group of canopy dwelling leaf beetles. Classification and taxonomic status of this group is very unsatisfactory, and a revision was started. About 300 species were described in *Monolepta*, *Candezea*, and *Barombiella*, mostly between 1880 and 1940. Genus names were not used constistently by the plural authors, and consequently previous allocation was para- and polyphyletic. The phylogenetic revision also allows insights into biogeographical aspects of this group. Highest species richness and high degree of endemism was found along the Central and East African Rift system, and especially in the Ethiopian Highlands. Lower centres of endemism are the Cape Region and the montane area of Cameroon. Speciation processes were probably strongly influenced by habitat disjunction during the strong quarternary climatical change in Africa. Index items: Africa, revision, speciation.

[0455] SPECIES DIVERSITY OF AMAZON RAINFOREST FRUIT-FEEDING NYMPHALID BUTTERFLIES: EFFECTS OF SPACE, TIME AND DISTURBANCE

P. J. DeVries, Center for Biodiversity Studies, Milwaukee Public Museum, 800 West Wells St., Milwaukee, Wisconsin 53233, USA

Butterfly diversity studies have been important to our understanding of community ecology and conservation biology, but they seldom measure diversity in multiple dimensions of space and time, or employ sampling methods that are comparable among areas. We used a standardized, long-term sampling regime in the canopy and understory at monthly intervals to show that in Amazonian forests fruit-feeding nymphalids are not randomly distributed in space and time. Partitioning total species diversity into additive components within and among community subdivisions (vertical, horizontal and temporal dimensions) showed that significant diversity existed in each dimension. We show that samples from a single habitat, height and time contain only a small fraction of the total community species richness, and temporal variation is an extremely important factor affecting measures of tropical species diversity. There is strong evidence that fruit-feeding nymphalid communities are divided equally between the canopy and in the understory, and that the species composition of the canopy and understory are distinct, therefore demonstrating the necessity of accounting for the vertical dimension when measuring forest diversity. Individual abundance and observed species richness was greater in more disturbed habitats, but due to disparate sample sizes, rarefaction analysis showed that such differences can be seriously misleading. Our study demonstrates the feasibility and necessity of performing long-term sampling in multiple dimensions for conservation. We emphasizes the need for similar data sets from other sites to accurately understand and compare species richness and diversity in tropical forest communities.

[0456] EUPTYCHINE SATYRID BUTTERFLIES: BIODIVERSITY, NOMENCLATURAL FRUSTRATION AND FUTURE PROMISE

L. D. Miller, Allyn Museum of Entomology, Florida Museum of Natural History, University of Florida, 3621 Bay Shore Rd., Sarasota, FL 34234, USA, E-mail c/o jmiller@virtu.sar.usf.edu.

Euptychiine Satyridae are a highly diverse group, centered in the Amazonian region, but with representative species being found from southernmost Canada to northern Argentina. These insects are usually drab, frequently are not attractive specimens and are under-collected by even knowledgable workers. There are nearly 300 species, apportioned among 30-40 genera, and these still remain to be categorized. Many species are widespread, perhaps reflecting a more catholic taste in foodplants, but other species are much more specialized in their choice of foodplant, as well as ecologically separate. They also may be isolated geographically; thus, there is a Mexican group of species, a southeastern Brasilian isolate and one centered in the sub-Andean part of Amazonia. That they are difficult to determine with certainty, is attested to by several species being recognized in various collections under a single name, even though these collections are internally consistent in their identifications. Often names are misapplied, and the same species may masquerade under several names, such as in Taygetis cleopatra C. & R. Felder, where most collections have this species identified as T. xenana Butler, a junior synonym, and the name cleopatra is applied to a form of T. laches (Fabricius). Similarly, confusion exists with the aberrant south Brasilian Coenoptychia boulleti Le Cerf, which was described three times in four years under three different generic names. Once these taxonomic problems are resolved, the way is cleared to allow these insects to serve as the excellent ecological indicator species that the admittedly limited biological data indicate they are.

Index terms: endemism, ecological indicators, Coenoptychia, Taygetis,,

[0458] PATTERNS OF BIODIVERSITY IN THE NEOTROPICAL CASTNIIDAE (LEPIDOPTERA)

J. Y. Miller, Dept. of Natural History, Allyn Museum of Entomology, Florida Museum of Natural History, University of Florida, 3621 Bay Shore Road, Sarasota, FL 34234, USA, E-mail jmiller@virtu.sar.usf.edu

The Castniidae are a pantropical group, geographically distributed in Australia, southeast Asia, and throughout the neotropics from Mexico to Argentina. Since several morphological features are usually attributable to both butterflies and moths in representative species, this family is exceedingly significant and has been considered a possible ancestral group for the Lepidoptera. There are currently 32 genera and 106 species recognized in the neotropical subfamily Castniinae, with a wide array of wing coloration and patterns, including some species involved in diverse minuery complexes. The larvae feed internally and are principally associated with monocotyledenous plants of economic importance (Musaceae, Arecaceae, Bromeliaceae, Orchidaceae), but detailed information on life history for most taxa is quite limited. With the exception of those species commonly associated with Poaceae (sugar cane) and Musaceae (plantino, banana), foodplant and other ecological requirements appear to be quite specialized. Most taxa are associated with semi-deciduous, humid, or tropical rainforests with a variety of available habitats and nicrohabitats. Based on recent field work and other comprehensive biodiversity studies, particularly in Lepidoptyera and associated plant groups, current distribution records suggest that the Castniinae are excellent bioindicators of areas of high species diversity and endemism in the neotropics. The majority of the taxa are represented geographically in Brazil (61%) with 7% found in Mexico and 4% in Argentina respectively. The significance of biodiversity patterns in the Castniinae in light of the current evidence and potential studies will be discussed. Index terms: endemism, rainforests, monocots

[0457] BIODIVERSITY OF PAPILIONOIDEA FROM MEXICO

A. Luis-Martinez, J. Llorente-Bousquets & L Vargas-Fernandez, Museo de Zoología, Facultad de Ciencias, UNAM. Ap. Postal 70-399, C.P. 04510 Mexico, D.F. MEXICO.Email: alm@hp.fciencias.unam.mx

In Mexico, studies on butterflies go back to the last century (Biologia Centrali-Americana) and since then knowledge has advanced significantly. More than 2000 subspecies included in 1,600 species grouped in five families, 20 subfamilies, 50 tribes and almost 500 genera have been already recognized. This information has appeared in more than one hundred monographs and books and in many papers published in at least 12 major periodical journals. The main synthetic results of this work are: (1) Mexico holds 10% of the Rophalocera of the world and ranks among the ten most rich countries in butterflies; (2) our country and neighbouring areas hold paleo and neoendemic groups of great interest, some of them relictuals, mainly in xeric parts of the north and west and in the mountain areas of the south; (3) the richness pattern is independent of the endemism pattern because the richest areas are tropical humid lowlands; (4) the areas with higher endemism and richness are those with the greatest physiographic, climatic and vegetational heterogeneity (e. g. Los Tuxtlas, Vercaruz and Sierra de Juárez, Oaxaca, each one with about 35% of the species richness), the conservation of butterfly diversity depends on habitat conservation because slight changes may induce local extinctions, but we still lack in depth and long term studies about these problems; and (5) Mexico presents several insular intracontinental patterns, which are the product of the disjunct and heterogeneity distribution of xeric and humid parts, which are the result from the complex biogeographical history of the country. Papilionoidea, Mexico, Biodiversity, Biogeography, Endemism

[0459] DIVERSITY OF PYRALOIDEA MOTHS ALONG A GRADIENT OF RAINFOREST DISTURBANCE IN NORTHERN BORNEO

<u>C. H. Schulze</u> & K. Fiedler, Dept. of Animal Ecology I, Univ. of Bayreuth, D-95440 Bayreuth, Germany, E-mail: christian.schulze@uni-bayreuth.de.

In this study we used Pyraloidea moths as target group to estimate the impact of human disturbance on a species-rich group of herbivores. To analyse patterns of diversity and abundance structure, we attracted moths by light at selected sites across a gradient of habitats, ranging from primary rainforest across different secondary forest types to cultivated areas. The study was conducted at Mt Kinabalu Park (Sabah, East Malaysia) because this reserve and its surroundings offers a wide range of habitats in a relatively small area. Therefore, geographical effects should not play a major role for explaining differences in species composition of studied sites. Sampling took place in 1997 and 1998 and covered different months of the year with different rainfall conditions. The Crambidae subfamily Acentropinae was analysed separately because the aquatic life habits of its larval stages may cause a different response of this taxon. On subfamily level, by far the most abundant and species-rich taxon at all sites was the subfamily Pyraustinae which represented 88.3-97.5% of all sampled non-Acentropinae specimens and 69.8-89.1% of the recorded species total. Williams' α for Pyraloidea (excluding Acentropinae) varied between 3.7 and 131.0. Highest alpha-diversity was found at the primary forest (α =131.0) and the old secondary forest sites (α =98.6 to 118.6). However, also at sites in cultivated areas with small patches of secondary scrub vegetation still a high diversity could be found (α =51.9 to 80.9). In contrast, diversity decreased dramatically at sites located within oil palm plantations (α =8.3) and cultivated meadow fields (α =3.7). In particular, the Pyralidae subfamily Epipaschiinae responded strongly to disturbance. While the number of recorded species decreased from 38 (canopy) and 29 (understorey) species, respectively, at the primary forest site to 3-15 at secondary forests and cultivated sites, the decrease in abundance was even more pronounced. At sites within large cultivated areas no Epipaschiinae moths could be recorded at all. Acentropinae diversity was not reduced at disturbed sites except of sampling plots in an oil palm plantation and a meadow field. Although environmental conditions in streams may strongly be affected by forest disturbance, we did not observe effects on the diversity of these aquatic moths at our sites close to (intact) forests. In general, as found in earlier studies, even within one taxon like the Pyraloidea, the diversity of different subtaxa responded in different ways to human disturbance. Since even strongly disturbed habitats in proximity to remaining forests exhibited a high diversity of Pyraloidea moths, this emphazises the potential of such areas to serve as buffer zones around nature reserves as well as for maintaining a high fraction of diversity in tropical cultivated landscapes.

Index terms: Epipaschiinae, Pyraustinae, Acentropinae, diversity, Malaysia

[0460] RICHNESS HOTSPOTS AND RARITY HOTSPOTS OF MEXICAN SATURNIIDAE (INSECTA: LEPIDOPTERA)

M. Balcázar-Lara¹ & I. J. Kitching², ¹Fac. de Ciencias, U. de Colima, Apdo. Postal No. 11, Colima, C. P. 28000, MEXICO, E-mail mabl@servidor.unam.mx; ²Department of ²Department of Entomology, The Natural History Museum, Cromwell Road, London SW7 5BD, U. K., Email iik@nhm.ac.uk.

Distribution maps for 115 endemic or quasi-endemic Saturniidae of Mexico were developed in order to find and study hotspots of richness and hotspots of range-size rarity. This information is necessary for finding sets of complementary areas which combined would include the greatest species richness. These previous figures are among the most often used in biodiversity conservation for choosing areas for in situ conservation management. The selected group Saturniidae, is among the best known groups of Lepidoptera in particular, and Insecta in general, in Mesoamerica from the point of view of its taxonomy. In addition, this family is specially rich in endemics in Mexico with about 8% of all the taxa described for the world. Species richness for the taxa studied were scored among 10 minute grid squares in Mexico, and analyzed using the program WorldMap ver. 4.19. The grid cells chosen by the richness hotspots method are in five mountainous areas. The first one is mainly along the Transvolcanic Axe in central Mexico, at medium altitudes on the southern slopes, close to or where it merges with the Balsas River basin. The next two areas are in the Oriental and Southern Sierra Madre, in both cases, the richest grids are those associated with cloud forest. The Highlands of Chiapas and the Sierra the Juárez in Northern Oaxaca State, again show the same pattern, but in both cases in ecotonal areas with the oak and pine forests. When we analyzed the rarity by inverse range size, a very similar pattern to that of the richness emerged, with one main difference: the cape area in Baja California.

Index terms: biodiversity, Mexico, distribution, endemics

104621 PRELIMINARY LIST OF STINGLESS BEES (APIDAE, MELIPONINAE) OCURRING IN ECOSSYSTEMS OF MARANHÃO STATE, BRAZIL

P. M. C. Albuquerque¹ & M. M. C. Rêgo¹, ¹Dept. of Biology, Univ. of Maranhão, Av. dos Portugueses, Campus do Bacanga, São Luís, Maranhão, 65080-040, Brazil, E-mail palbug@elo.com.br

Although many surveys of bee fauna have been done in various Brazilian regions, the great part of bee fauna diversity in the neotropical region remains nearly unknown. Differing from other Brazilian states, Maranhão is located in a transitional region between the amazon forest, in the cerrado vegetation of the central plateau and the caatinga of the Northeast. Due to this factor it has acquired great ecological importance. There is superposition and interactions among faunistic characteristics of these three regions leading to a phytogeographic mosaic. From a large previous work about the structure of bee communities involving diversity, relative abundance, phenology and interaction in floral resource utilization in varied ecosystems of Maranhão, a preliminary list of Meliponinae species that occur in the state was prepared. The main objective is to illustrate the taxonomic diversity of the region. Data from six surveys that used standardized and systematics samples performed in sand dunes, cerrado, secondary forest, pre-amazon forest and western low land of Maranhão were included. Alongside the data obtained in these surveys other specimens collected in the state were also analyzed and are available in the Biology department's collection - Federal University of Maranhão, Brazil The composition of species was as follows: Melipona compressipes fasciculata, M. puncticollis, M. rufiventris, M. melanoventer, Tetragona dorsalis, T. clavipes, T. truncata, Trigona fuscipennis, T. pallens, T. amalthea, T. branneri, T. fulviventris, T. spinipes, T. recursa, T. dallatorreana, T. williana, Cephalotrigona capitata, Celetrigona longicornis, Ptilotrigona heideri, Scaptotrigona flavisetis, Frieseomelitta aff. portoi, F. silvestrii, F. flavicornis, Partamona pearsoni, P. testacea, P. cupira, Oxytrigona tataira, Tetragonisca angustula, Scaura latitarsis, S. longula, Trigonisca nataliae, T. pediculana, T. ceophloei, Geotrigona aequinoctialis, G. aff. mombuca, Nannotrigona punctata, Plebeia alvarengai, P. minima. Apart from these species there are many others not yet identified belonging to the genders Aparatrigona, Leurotrigona, Melikerria and some new species. Index terms: Diversity, relative abundance, Meliponini.

GENUS AUSTROZELE BIOGEOGRAPHY OF THE THE [0461] (HYMENOPTERA: BRACONIDAE: MACROCENTRINAE)

C. van Achterberg, Curator of Hymenoptera & Diptera, Afdeling Entomologie, Nationaal Natuurhistorisch Museum, Postbus 9517, 2300 RA Leiden, Netherlands. E-mail: achterberg@naturalis.nnm.nl

The genus Austrozele Roman is medium-sized and has a mainly Palaeotropical distribution with some species in the Palacarctic and Nearctic regions. The members are nocturnal ("ophionoid facies") of which some are common and are at least some are parasitoids of pests, e.g. of Spodoptera exigua Hübner. The genus has been radiating recently; the species are very similar and vicariancy seems to have played a very limited rôle. Currently the genus is revised, up to now 32 species are known, which are mostly still undescribed and most species occur in the Indo-Australian region. The phylogeny and the dispersal events are discussed.

Index terms: biogeography, Braconidae, Macrocentrinae, Austrozele.

[0463] BIODIVERSITY OF AGROMYZIDAE IN CEREAL AND GRASS FIELDS AND THEIR BOUNDARIES

A. Andersen & II. Sjursen, The Norwegian Crop Research Inst., Plant Protection Centre, Høgskolev. 7, 1432 Ås, Norway.

The present is a preliminary report on a project running in spring barley and grass fields in southeastern Norway 1998-2000. Each year 5 fields on 3 farms are investigated: one cereal field on a conventional farm growing only cereals, one cereal field and one grass field on a conventional farm growing cereals and grasses, and one cereal field and one grass field on a biological farm. Three new farms are chosen every year, so a total of 15 fields will be investigated in the project. In each field 3 lines of 5 1x10m plots each are set up from the boundary and 30m into the field. In all the plots and along the boundaries of the chosen fields the agromyzids are caught with a net in a standardized way several times during the growing season. The following are some tendencies in the material from the first two years. A total of 7225 (1459 + 5766) specimens were caught, of which 6099 (84.4 %) belonged to the cereal and grass pest species Chromatomyia fuscula. Seventy-five species have been identified, of which 26 were caught both years. Twenty-five species (67 %) belonging to the following 5 genera were feeding in Gramineae: Agromyza (8 species), Cerodontha (8 species), Chromatomyia (3 species), Liriomyza (5 species) and Pseudonapomyza (1 species). Non-Gramineae feeding species were almost absent in the fields themselves, even if a large number of weed species occurred. In all, only 56 specimens (1.2%) of non-Gramineae feeders were caught in the fields. There was a tendency towards more non-Gramineae feeders in the biological fields (2.1%) than in the conventional fields (0.9 %). The non-Gramineae feeders dominated less in the boundaries. probably due to a large variety of plant species present there. In the two years 32.5 and 85.5 % of the specimens caught in the boundaries were Gramineae-feeders. The plant species in all the plots have been identified, and the distibution of the different agromyzid species will be compared with the distribution of their host plants. Index terms: Chromatomyia fuscula, Agromyza spp., biological farming.

Symposium and Poster Session

[0464] SIMPLIFYING ANT MONITORING: A CASE STUDY FROM THE AUSTRALIAN SEMI-ARID TROPICS

A. N. Andersen, Tropical Savannas Cooperative Research Centre, CSIRO Tropical Ecosystems Research Centre, PMB 44 Winnellie, NT, 0822, Australia. E-mail: Alan.Andersen@terc.csiro.au

Despite widespread recognition of the value of insects as bio-indicators, insects are usually ignored in land monitoring programs. This is largely because insect consuses traditionally involve specialist sampling techniques, the sorting of large numbers of specimens, and the identification of many taxonomically challenging species. My presentation will report on the reliability of results from a simplified ant sampling protocol that is readily incorporated into routine wildlife surveys. Ants are exceptionally diverse and abundant in Australia, and are the most widely used group of invertebrate indicators. A comprehensive ant sampling program was conducted as part of an assessment of the biodiversity impacts of SO2 emissions from a large copper and lead smelter at Mt Isa in northwestern Queensland, yielding a total of 174 species from 24 genera. The key findings were: 1.The two regionally dominant landforms support distinct ant faunas, with plain habitats being considerably richer in species than rocky ridges; 2. Ant species richness increases with distance from the smelter, corresponding with decreased levels of SO2; 3. Several common species show clear abundance patterns in relation to SO2, with some decreasing and others increasing; 4. Eyrean (arid-adapted) taxa were especially sensitive to SO2; 5. Ant functional group composition showed relatively little change in relation to SO2. Routine sampling of vertebrates was conducted as part of the broader assessment program, and included large, bucket-sized pitfall traps with drift fences. Ants were also collected from these traps to see if such greatly simplified sampling was sufficient to provide useful results. The sorting of morphospecies was also greatly simplified by considering only large (>4 mm) species, and analysis was simplified by considering only site presence/absence data. In this manner, the inclusion of ants in the assessment process required less than 10% of the effort demanded by the specialist ant sampling program. The extent to which these results recapitulate the findings from the comprehensive ant survey will be reported. Preliminary analyses indicate that the incidental captures of large species from vertebrate pitfall traps gave most if not all the key findings provided by the comprehensive ant sampling program. It therefore appears feasible to incorporate ant sampling in wildlife surveys as part of routine land monitoring and assessment programs.

[0465] BIOTYPIC AND GENOTYPIC DIVERSITY OF GREENBUGS: HOST ADAPTED OR CULTIVAR SELECTED

J. A. Anstead¹, **J. D. Burd² & K. A. Shufran²**, ¹Oklahoma State Univ., 127 Noble Research Center, Stillwater, OK, USA, 74078. E-mail janstead@pswcrl.ars.usda.gov; ²USDA-ARS, Plant Science and Water Conservation Lab., 1301 N. Western Rd., Stillwater, OK, USA, 74075.

Greenbugs are a considerable agricultural pest worldwide. They are limited to the graminae and cause economic damage on a wide range of crops including wheat, barley, sorghum, rice and rye. Greenbugs also utilize a large number of non-cultivated hosts. A number of host plant resistance sources against greenbug feeding damage have been found. However each has been overcome by the emergence of greenbugs able to overcome this resistance. Traditional theory suggested that these biotypes evolved in response to the selection pressure exerted by resistant cultivars in the field. Recent evidence suggest that this is not the case and it is hypothesized that variability in virulence to resistant lines plants pre-existed among greenbug populations on non-cultivated hosts. Greenbugs were collected from a number of cultivated and non-cultivated hosts in the central plains of the U.S. and clonal laboratory colonies were started with single aphids. They were biotyped using standard plant differentials. A 1.0kb portion of the mitochondrial Cytochrome Oxidase Subunit I gene was extracted, PCR amplified and sequenced. The DNA sequence data were subjected to maximum likelihood analysis and dendrograms were produced using the PAUP statistical package. These data supported previous conclusions that the greenbug species could be separated into 3 clades based on mitochondrial sequences. The distances between the clades appear to indicate divergence times of over 1 million years. Biotype I was found in all three clades indicating there is exchange of genes conditioning for virulence, and that biotypic status did not drive the divergence of these clades. A single clade contained almost all the greenbugs collected from crop hosts, indicating only a subset of the population is present in cropping systems. All 3 clades had substantial differences in their non-cultivated host range. This study conclusively shows that the deployment of resistant crop lines did not drive the formation of biotypes. It shows that divergence within this species was probably driven by non-cultivated host plant use, and that the greenbug species complex is comprised of a group of sub-populations adapted to different host species.

Index Terms: Schizaphis graminum, Biotype, COI, host plant resistance

[0466] DIFFERENT SEED TREATMENTS TO CONTROL THRIPS FRANKLINIELLA SCHULTZEI (THYSANOPTERA: THRIPIDAE), APHIDS APHIS GOSSYPII (HOMOPTERA: APHIDIDAE), VEGETATIVE DEVELOPMENT AND YIELD OF COTTON CROP

<u>S. Bellettini</u>, Departamento de Fitotecnia, Fundação Faculdade de Agronomia "Luiz, Meneghel", Br 369 km 54 C.P. 261 CEP 86360-000 Bandeirantes-PR, E-mail: bellettini@ffalm.br

It were evaluated, in Bandeirantes City-PR, different seed treatments to control thrips and aphids; vegetative development and yield of cotton crop. It were used following treatments and doses as a.i./100 kg of seeds: thiamethoxan (Cruiser 700 WS) 150, 210 and 300 g; imidacloprid (Gaucho) 140 g; carbofuran (Furadan 350 TS) 700 g; acephate (Orthene 750 BR) 750 g and control (with no insecticide). Experimental design was randomized blocks with 7 treatments, 4 replications and plots with 27 m². Evaluations were done by counting alive thrips number at 10, 15, 20, 25 and 30 days, on 10 randomized plants per plot; the number of alive aphids at 15, 20, 25, 30 and 35 days on 10 top randomized leaves per plot; plants height at 10, 20, 30, 40, 80 and 120 days after emergence, on 10 marked plants per plot and cotton seed production. Different treatments showed efficiency higher than 81% on thrips control till 30 days and 82% on aphids till 35 days after plants emergence. Insecticides thiamethoxan (Cruiser 700 WS) 210 e 300 g and imidacloprid (Gaucho) 140 g showed efficiency from 90 till 97,3% at evaluations, on thrips and aphids control. Treatments thiamethoxan (Cruiser 700 WS) 210 and 300 g and imidacloprid (Gaucho) 140 g showed 9,3; 17,3 and 11,8% heigher on plants height and 26,1: 30,7 and 25,9% on cotton seeds production, respectively, comparing with control. Used insecticides and doses had no plants toxicity. Index terms: cotton crop; thrips; aphids; chemical control.

[0467] INTRASPECIFIC GEOGRAPHIC VARIATION IN HOST-PLANT UTILIZATION OF BUTTERFLIES

¹<u>A. Bergstrom</u> & ¹S. Nylin, ¹Dept of Zoology, Stockholm Univ., SE-106 91 Stockholm, Sweden. Email anders.bergstrom@zoologi.su.se.

Traditionally, host-plant repertoires of butterflies have been thought of as being very conservative. Recent studies though have, on the contrary, shown that host-plant shifts can be very rapid under certain conditions, leading to high levels of intraspecific geographic variation in host-plant use. In my talk I will present examples on species that have shown rapid evolution of host-plant choice as well as species being conservative in their preferences. In doing this I will use examples from my own studies on geographic variation in local adaptations of host-plant utilization in response to variations in host-plant abundance. In addition, I will also use examples from other studies presented in the literature. This knowledge can be of importance for future conservation projects when decisions have to be made on which species to prioritise.

Session 03 – BIOGEOGRAPHY AND BIODIVERSITY

[0468] CICADA BIOGEOGRAPHY AND WALLACE'S LINE, DO CICADAS SING A DIFFERENT SONG?

<u>P. L. Th. Beuk¹</u>, J. P. Duffels² & A. J. de Boer³, Zool. Mus. Univ. of Amsterdam, Dept. of Entomology, Plantage Middenlaan 64, NL-1018 DH Amsterdam, Netherlands; E-mail ¹beuk@bio.uva.nl, ²duffels@bio.uva.nl, ³aboer@bio.uva.nl.

The biota of the Malay Archipelago can, simply speaking, be separated in components that appear to be related to Southeast Asian groups or to Australian groups. In the 19th century Wallace was the first to point this out. His division line between the 'Indo-Malayan' and 'Austro-Malayan' regions became known as 'Wallace's Line'. Other workers observed similar lines that could possibly serve as a division line. Wallace's Line coincides with a wide sea barrier that existed in geological times, and prevented the dispersal of organisms from West to East or vice versa. This barrier was not often crossed. However, botanical and zoological literature yield a number of instances where the barrier was taken. Most often it involves groups that have their main distribution on one side of the barrier and single species or small groups that dispersed to the other side and possibly speciated subsequently. When the wide sea barrier became much narrower in the middle of the Tertiary opportunities arose for crossing the barrier by 'island hopping'. However, considering the relatively low number of taxa occurring on both sides of Wallace's Line, crossing the barrier should be considered an exception rather than a rule. The question then arises whether taxa in the West Pacific with apparent Southeast Asian ancestry did cross the barrier. A monophyletic group of taxa of the cicada tribe Dundubiini, the subtribe Cosmopsaltriaria, does occur in the West Pacific but has a Southeast Asian ancestry. Phylogenetic analysis of the tribe revealed that the sister group of the Cosmopsaltriaria does occur on the Southeast Asian continent rather than in the Malay Archipelago. Groups of the Dundubiini found immediately west of Wallace's Line are representatives of different branches of the same monophyletic clade that includes the Cosmopsaltriaria and its sister group. From this it can be concluded that Wallace's Line was skirted on both sides rather than crossed. This alternative for crossing the barrier will be discussed in the light of biogeographic and geological evidence at hand.

Index terms: Cicadidae, Dundubiini, Cosmopsaltriaria, phylogeny, Indo-Pacific area

[0470] CONSERVATION IN ANTHROPOGENIC LANDSCAPES IN THE NEOTROPICS: RICHNESS, COMPOSITION, SIMILARITY, AND ENVIRONMENTAL CORRELATES OF BUTTERFLY FAUNULAS

K. S. Brown Jr. & A. V. L. Freitas, Dept. de Zoologia and Museu de História Natural, Inst. de Biologia, Univ. Estadual de Campinas, C.P. 6109, Cidade Universitária, Campinas, SP 13.083-970 BRAZIL, E-mail ksbrown@obelix.unicamp.br. Financial support: BIOTA-FAPESP, CNPq, PDBFF, BSP, CIFOR.

Direct comparisons at species, generic, and family levels of well-inventoried butterfly communities in a wide variety of partially anthropogenic Neotropical sites including from 250 to nearly 2000 species, by means of Sörensen's simple similarity index 2c/(a+b), Ward's minimum-variance clustering (Euclidean distances), Principal Components Analysis, and Canonical Community Ordination provides three lines of information useful for conservation evaluation and planning. First, ordination of sites by their faunulas clearly shows many distinct biogeographical regions, associated with different climate, vegetation, and disturbance types throughout the region. Second, ordination of the proportions of tribes, subfamilies and families against environmental factors shows that climate and disturbance predominate in shaping the community, with connectivity (in strongly fragmented landscapes) and soils (when very rich or very poor) also important. Third, positive or negative correlations of species richness in the various butterfly groups with environmental factors permits the identification of sensitive indicators for the variation of these factors in agricultural or urban systems. In general, non-urban anthropogenic landscapes containing as little as 10% of their area in natural fragments over 10 ha (0.01 km²) in size, with reasonably humid green connectivity (including most crops) for much of the year, can maintain highly diverse butterfly faunas similar to those of sites with complex mosaics of topography and vegetation, or with high levels of natural disturbance (like river valleys, steep areas, or bamboo forests). These communities may lack, however, certain larger or more specialized species, or those that naturally occur in highly dispersed populations (like many "hilltoppers"). The use of agrochemicals or fire, giving excessive modification of watercourses or soil biology, or intense urbanization (paving over, or planting of large structures), rapidly degrades these communities, strongly impeding their reconstitution for very long periods, even on good soils with favorable rainfall; their faunulas come to resemble those on poor lithic natural sites.

Index terms: CANOCO, PCA, Connectivity, Climate, Soils, Disturbance

[0469] BIODIVERSITY OF THE PARASITIC HYMENOPTERA IN A COASTAL MANGROVE FOREST OF BANGLADESII

B. A. Bhuiya, M. L Miah. & A. Zannat, Department of Zoology, University of Chittagong, Chittagong 4331, Bangladesh, E-mail babhuiya@ctgu.edu

A 10 month long fortnightly survey (January 1999 to October 1999) of Malaise trap collection from an aforested mangrove coastal area in the Moheshkhali Island resulted in a total of 9,309 parasitic Hymenoptera. The collection included 20 % Ichneumonoidea, 60 % Chalcidoidoidea and 20% other parasitic groups. Of the total collection of Ichneumonoidea the families Ichneumonidae and Braconidae included 25 % and 75 % respectively. The subrfamilies of the family Ichneumonidae were further studied for population. Under the family Ichneumonidae 12 subfamilies were determined. These are Anomaloninae, Banchinae Campopleginae, Cremastinae, Ichneumoninae, Labeninae, Mesochorinae. Metopiinae, Ophioninae, Phygadeuntinae, Pimplinae and Tersilochinae. Within these 12 subfamilies 31 genera were identified and their population was studied for seasonal abundance. A study of the population fluctuation throughout the period of study suggests that some members of the family Ichneumonidae are available round the year. A few of them are known to be very effective biological control agents elsewhere in investigation will help finding more specific parasitoids that may be utilized profitably against the pest insects of the mangrove forests in Bangladesh.

Index terms: Biodiversity, Parasitic Hymenoptera, Mangrove forest, Seasonal abundance, Bangladesh.

[0471] RESPONSES OF COLLEMBOLA COMMUNITIES TO LEAD SHOT DEPOSITIONS IN A HEATHLAND ENVIRONMENT

Luc De Bruyn^{1,2}, Frans Janssens², Frederik Hendrickx³ & Jean-Pierre Maelfail^{1,3}, ¹ Inst. Nature Conservation, Kliniekstr. 25, 1070 Brussel, Belgium; ² Dept. Biology, Univ. of Antwerpen, Groenenborgerlaan 171, 2020 Antwerpen, Belgium; ³ Lab. Ecology, Univ. of Gent, K.L. Ledeganckstr. 35, 9000 Gent, Belgium; E-mail : luc.de.bruyn@instnat.be.

It has been stated by several authors that the abundance, species diversity and life history characteristics of Collembola can provide information on environmental conditions. Because different collembolan species possess different sensitivities to metal pollution, an analysis of their community composition and organisation might provide an accurate tool to estimate soil pollution. In view of a project that aims to construct a multi-species test system for contaminated soils, a multitude of invertebrate taxa were collected in the heathland "Groot Schietveld" near Antwerp, Belgium. In this heathland area a elay pigeon shooting stand is situated. As a consequence, the soil in the target zone is heavily contaminated sites with comparable soil and vegetation structure as a control. Collembola were sampled with a core sampler (\Box =5cm; depti=10cm) and extracted with a modified McFayden apparatus. Soil lead content and additional soil parameters (humidity, carbon content, pH, ...) were related to differences in community structure and functionality.

Index terms: ecological indicator, heavy metal, pollution

[0472] WHICH IS AN ADEQUATE DIVERSITY INDEX FOR INSECT COLLECTIONS?

Luis Bulla & Rubén Candia, Instituto de Zoología Tropical, Facultad de Ciencias, Universidad Central de Venezuela. Apto 47058, Caracas 1041-A,m Venezuela. E-mail: rcandia@strix.ciens.ucv.ve. This work was financed by the ISC Programme of the European Commission, Project CT 94-0099 VE.

Insect collections have some peculiarities that make rather different from other biological assemblages. In the first place, they are characterized by an unusually high number of species. Collections of 100 or more species are the rule, and over 500 species are not exceptional. Secondly, They are seldom complete. Many species are not captured even in very big sample. As a consequence of this fact, most insect samples have a high abundance of species represented by only one or two individuals (singletons and doubletons, in Chao's terminology). Diversity indices are numbers that combine in a single value two attributes of the sample; its richeness or number of species present and its evenness, or the degree to which the abundances of the different species are similar. Insect samples have usually very heigh richness and comparatively low evenness values. Consequently, if a diversity index is going to be used with insect samples it would be desirable that it fullfills at least two conditions; 1) it has to be sensitive to increments in richness even if the number of species is very high; 2) it has to estimate adequately evenness even if it is very low. We will prove, throughout algebraic manipulation and the analysis of real samples that the usual diversity indices (Shannon's H', Simpson's 1-D, and Hill's N1 and specially N2=1/D) are markedly insensitive to changes of diversity when working with high richness communities, and strongly overestimate evenness if the value of this parameter is low. For this reason, we recommend the use of the "new generation" of diversity indices, that estimate diversity as the product of an evenness measure and the number of species (D=E x S were D is the diversity value, E an evenness measure and S the number of species). The difference among these indices is the type of evenness index used. Several options are available for the index E; among others Camargo's O and E'(1993), Bulla's E (1994), Smith & Wilson's E_{var} (1996) and Hill's E_{ma} (1997). The advantages of these indices over the classic ones are show using a collection of insect samples from seven different savannas that represent the changes that take place in the insect comunity trough the introduction of a pine forest on a natural savanna, its harvest and the recuperation of the system.

[0473] DIVERSITY OF TWO LOWLAND RAINFOREST BEETLE TAXA (IIISTERIDAE AND STAPHYLINIDAE: PSELAPHINAE) AT A WESTERN AMAZONIAN LOCALITY

C. E. Carlton, M. Dean & A. K. Tishechkin¹, ¹Dept. of Entomology, Louisiana State Univ., Baton Rouge, LA 70803 USA, E-mail: ccarlto@unix1.sncc.lsu.edu

To estimate beetle diversity at a single locality in Amazonian Ecuador, we analyzed collection from a two-month sampling effort at Yasuni Research Station (Napo Province). Collecting methods included Berlese sampling, flight intercept traps, light traps, and hand collecting from specific habitats (e.g., social insect nests). Histerid beetle diversity at the site was estimated to include 130 species among 2631 specimens. Pselaphine staphylinid diversity was 174 species among 898 specimens. We generated species richness and richness estimator curves to assess the thoroughness of our efforts. Using the proportion of target tax relative to total beetle diversity worldwide and at selected comparative sites, we calculated total potential beetle species richness at Yasuni. These data will be useful for continuing studies of regional insect diversity and site complementarity in the Amazon Basin.

Index terms: Coleoptera, Biodiversity, Species richness, Ecuador

[0474] THE INFLUENCE OF ORGANIC MATTER ON THE DIVERSITY OF SIMULIDAE ON THE MICROBASIN OF LAGEADO DOS FRAGOSOS IN CONCÓRDIA, SANTA CATARINA STATE, BRAZIL

L.C. Castro¹, D.P. de Paiva², M. N. Strieder³ & M. T. S. Padilha¹, ¹ Dept of Zootheenics. Federal University of Santa Catarina, Rodovia Admar Gonzaga, 1188, Itacerubi, 88034-901, Florianôpolis, Santa Catarina, Brazil, E-mail lucastro2000@ig.com.br; ² Dept. of Sanity, EMBRAPA/ CNPSA, BR 153, km 110, P.O. Box 21, 89700-000, Concôrdia, Santa Catarina, Brazil, ³ Dept. of Entomology, Unisinos, P. O. Box 275, 93022-000, São Leopoldo, Rio Grande do Sul, Brazil.

Peixe and Jacutinga rivers are responsible for the provisioning, drainage and agricultural activity in the area of the microbasin of Valley of Peixe river. In spite of having suffered a decrease of 15% from 1980 to 1991, the rural population represents 40% of the total population. Due to the socioeconomic prosperity initially reached, along the time, the inadequate use of the soil, the retreat of the vegetable covering and the intensive exploration of the agricultural activity collaborated for the environmental degradation that the area demonstrates now. The small watersources present different pollution degrees, as pouring out of animal dejections or fot the abusive use of agrotoxic in the husbandry. That fact is worse, for the uncomfortable presence of the blackflies (Simulium sp.), that are diptera, whose female is haematophagous and provokes serious damages, through its pricked, to the animals and the own producers. It was made collections in 12 points in Lageado dos Fragosos, affluent of Jacutinga river in the municipal district of Concórdia, Santa Catarina, Brazil to identification of the species. Three of those points were considered witness for they have presented not very degraded. After the removal of the immatures from the different substrata, these were placed in alcohol 90% and later on, in the laboratory, transferred for alcohol 70%, when they were quantified and identified under stereoscopic microscope; it was just used the last stadium's immatures. The found species were: Simulium (Chirostilbia) acarayense, Simulium (Inaequalium) travassosi, S. (I.) botulibranchium, S. (I.) nogueirai, S. (I.) subnigrum, S. (C.) pertinax, S. (Psaroniocompsa) incrustatum, S.(P.) anamarie(,) e S. (Thyrsopelma) orbitale with predominance in number of S. (C.) pertinax e S. (T.) orbitale. The diversity of simulidae species founded in some points, suggests an ecosystem in balance (ANDERSON & DICKE, 1960), which is a beneficial situation linclusively because of nor all the species were anthropophilic. However, five collection points showed the presence of only one specie In fact, those points were characterized, visually, as polluted, in the begginning of this research. The study of the influence of the levels of organic matter on the population of simulidae's immature should embrace, also, a larger period of time, to allow conclusions and extrapolation of the results.

Index terms: blackflies, Simulium pertinax, Simulium sp., organic matter, pollution, watersources

[0475] BEE FAUNA DIVERSITY OF BAIHA STATE, BRAZIL

M. S. de Castro¹ & B. F. Viana², ¹Exp. Unit of Bahia Enterprise of Agrie. Develop. EBDA, Salvador, Bahia and Dept. of Biology Sciense, State Univ. of Feira de Santana, Bahia. Dorival Caymi Av., 15.649 Itapuã Salvador, Bahia, Brazil 41.635-150. E-mail: marina@e-net.com.br; ²Dept. of Zoology, Biology Inst. Federal Univ. of Bahia-Salvador, Bahia, Brazil 40.170-110. E-mail: blande@ ufba.br.

Bahia is a large State located at Northeastern of Brazil ranging from latitudes 9°S to 18°S. The main biomes are Tropical Dry Forest/Woodlands – TDF ("caatinga" vegetation), Tropical Humid Forests - THF (Atlantic Rain Forest), Tropical Savanna – TS ("cerrado") and Semidecidous and Altitudinal Forests located on the Chapada Diamantina Plateau - SAF. In Brazil about 46 systematic surveys were done since they started at thirty years ago. In Bahia since thirteen years ago 9 studies were done: 4 on TDF, 2 on THF, 1 on TS and 2 on agroecosystem. Bee community diversity can be assessed for each survey by alpha diversity (number of species found in each area). Inventories in Bahia found from 31 to 150 species in single sites. The sites where fewer species were found are in "Caatinga" – plaeoquarternary sand dunes of the middle São Francisco river (42) both sites located at Northeast of Bahia latitudes 9° and 10°S. Surveys in "Caatinga" located at latitude 12°S resulted in the number of species of 80 and 94 species. The Tropical Savanna was the site where more species were found (150). In a small fragment of the Atlantic forest 70 species were found. The number of species found in surveys carried in Agroecosistems were 71 (various crops) and 95 (tropical and exotic fruits).

Index Terms: Biodiversity, Apoidea

[0476] BIODIVERSITY AND ECOLOGICAL IMPORTANCE OF WATER MITES (ACARI, HYDRACHNIDIA) IN ITALIAN SPRINGS

B. Cicolani & A.Di Sabatino, Dipartimento di Scienze Ambientali, University of L'Aquila, Via Vetoio 20, 67100 L'Aquila, Italy, E-mail: cicolani@aquila.infn.it. Research supported by grant of MURST, cluster 11

The paper summarizes the results of recent investigation on spring habitats in Italy, with particular reference given to the water mite taxocoenosis. 220 springs and spring systems were examinated over a broad geographic range (Sicily, Sardinia, Southern and Central Apennines and Alpine region). Globally, about 120 species of water mites were identified, some of which result endenic or with an interesting disjunct distribution. Our data clearly indicate water mites as one of the most characteristic groups inhabiting spring biotopes. Compared to other spring-dwelling invertebrates, water mites show a high level of species diversity and the highest proportion of crenobionts species (ranging from 40% to 60%). Further, the different assemblages of the water mite community have proved to be related to such environmental factors as: spring typology, altitude, human impacts and energetic inputs. Due to the complexity of their life cycle and the multilevel biocoenotic interactions (parasitism, predation, competition) water mites are well suited to detect any changes in natural condition of natural condition in these ecosystems are expected. Index terms: water mites, spring habitats, Italy, biodiversity.

[0478] AQUATIC INSECT BIODIVERSITY IN STREAMS OF DIFFERENT BASINS AT A REGIONAL SCALE

Corigliano M. del C.¹, E.A. Vallania², E. S. Tripole², M. A. Gil², P. A. Garclis² & A. I. Medina², ¹ Depto. de Ciencias Naturales, Univ. Nac. de Río Cuarto, X5804-BYA, Rio Cuarto, Argentina. ² Area de Zoología, FQByF, Univ. Nac. de San Luis, Chacabuco y Pedernera, 5700 San Luis, Argentina. E-mail: mcorigliano@exa.unrc.edu.ar.

The Sierras Pampeanas in Cordoba and San Luis provinces present similar characteristics at regional scale due their common orogeny. However, climatic and hydraulic conditions vary from east to west being San Luis, the western region, more arid and with streamflows lower. An inventory analysis with special emphasis in Ephemeroptera, Plecoptera and Trichoptera (EPT) was developed to assess and compare aquatic insect biodiversity in Sierras Pampeanas streams. Studied sites were localized in different altitudinal stretches of each basin. Macroinvertebrates from 28 locations were sampled with Surber net and identification and counts were performed. Environmental variables were measured. TWISPAN classification, detrented correspondence analysis ordination and cluster analysis were developed. Sites of the same altitude were ordinated and classified together independently of the hydric basin they belonged, but within each group, samples from consecutive reaches were more frequently nearest in cluster analyses. Sites and taxonomic associations were classified in higher altitudinal lower order streams, foothills and lowland reach. Baetis, Leptohyphes, Caenis and Tricorythodes were the more widespread association among Ephemeroptera and Marilia, Smicridea and Oxyethira among Trichoptera, as it has been reported in published data from rhithron conditions in Neotropical Region. Helicopsyche turbidae, Polycentropus joergenseni and Protoptila dubitans characterized higher altitudinal levels as well as Baetodes and Camelobaetidius penai among Ephemeroptera. Other species were rare and Anacroneuria was the single Plecoptera observed. EPT associations in Cordoba and San Luis have similar composition but they differ in their relative abundance. Ephemeroptera predominated in Cordoba while Diptera and Oligochaeta densities were higher in San Luis. In the most arid region the majorities of streams has lower discharge and are regulated by dams, which would determine the dominance of non-EPT groups. Considering regulations of rivers for dam constructions and other anthropic activities, EPT associations in Cordoba and San Luis streams are threatened and under risk.

Index terms: Baetis, Leptohyphes, Caenis, Trichorythodes, Marilia, Smicridea

[0477] GRASSHOPPER (ORTHOPTERA: ACRIDOIDEA) SPECIES DIVERSITY IN THE PAMPAS, ARGENTINA

<u>M. M. Cigliano¹</u>, M. L. de Wysiecki² & C. E. Lauge², ¹Depto. Entomología, Museo de La Plata, Paseo del Bosque s/n 1900 La Plata, Argentina. E-mail: lauge@mail.retina.ar, ² Centro de Estudios Parasitológicos y de Vectores (CEPAVE), Calle 2 Nro. 584, 1900 La Plata, Argentina.

A study was conducted to describe the major features of geographic and temporal variation in the diversity of grassland grasshopper species (Orthoptera: Acridoidea) in different sites of the Pampas, Argentina. Species richness and relative abundance were assessed at twelve sites in eastern La Pampa and western Buenos Aires provinces, from 1994 through 1999. Mean species richness at the regional level was ten, and thirty four grasshopper species were collected throughout of the study. Comparison with grasshopper species diversity from the Great Plains of North America is discussed. An evaluation of the proportions of species in each of the three distribution groups (broad, intermediate, and narrow) revealed that, over all sites, broadly distributed species made up 14.7 % of species composition and intermediately and narrowly distributed species made up 26.5% and 58.8%, respectively. Multivariate analyses summarized the evaluation of the top-ranked species collected on our study. The three top-ranked species in the studied sites appear to be Dichroplus elongatus, D. pratensis, and Staurorhectus longicornis. Results showed that, contrary to what it was expected, one of the widely distributed species in the region (i.e., Baeacris punctulatus) does not always constitute the most abundant species. Finally, the loss of one of the historically most common species in the Pampas, D. maculipennis, is also discussed.

Index terms: Dichroplus elongatus, Dichroplus maculipennis, Dichroplus pratensis, Baeacris punctulatus, Staurorhectus longicornis.

[0479] ADVANCES IN THE KNOWLEDGE OF HYMENOPTERA IN THE BIOSPHERE RESERVE "EL CIELO", MÉXICO

J. M. Coronado-Blanco¹ & E. Ruíz-Cancino¹, ¹UAM Agronomía y Ciencias, UAT. Cd. Victoria, Tam., 87149. México

Hymenoptera contains a great quantity of species with value as parasitoids and predators of insect pests. This is an interesting group in relation to biology, because is developed in a diversity of habitats and by the complexity of its behaviour, having some organization in some families of wasps, bees, and in ants. The Biosphere Reserve "El Cielo" is located in SW Tamaulipas, in the municipalities of Gómez Farías, Ocampo, Jaumave and Llera. Diurnal collectings (aerial and sweeping nets, Malaise traps, yellow pan traps and ligth traps) have been done in more than 25 localities with vegetation as oak forest, pine forest. cloud forest, subcaducifolious tropical forest and some crops. Few records were taken from papers of other authors (in Aphelinidae, Eulophidae and Formicidae). Most of the material is deposited in the Insects Museum of the "UAM Agronomía y Ciencias, UAT", in Cd. Victoria, Tamaulipas, México. We found 44 families of Hymenoptera, including 356 genera and 204 determined species, which had contributed to the knowledge of the Hymenoptera of this Reserve in the State of Tamaulipas. The major diversity of species have been found in the families Ichneumonidae (152 genera, 244 morphospecies and 124 determined species) and Braconidae (52 genera, 1 determined species). Moreover, other families are present in the Reserve: Formicidae (26 genera, 22 species), Encyrtidae (22 genera, 6 species), Vespidae (21 genera, 20 species), Sphecidae (17 genera, 8 species), Pompilidae (12 genera), Anthophoridae (8 genera), Apidae (6 genera), Chalcididae and Bethylidae (5 genera each), Aphelinidae, Halictidae and Megachilidae (4 genera each), Eulophidae and Chrysididae (3 genera each), Tiphidae (2 genera) and Pelecinidae, Ceraphronidae, Colletidae, Eucharitidae, Gasteruptidae, Leucospidae, Mutillidae, Mymaridae, Scoliidae and Signiphoridae (1 genera each). Also, there are undetermined specimens of other 18 families. Therefore, 23 species have been described in the last decade by authors from México (Ichneumonidae, Encyrtidae and Aphelinidae), USA (Braconidae and Aphelinidae), Russia (Encyrtidae, Ichneumonidae and Ceraphronidae), Turkmenistan (Aphelinidae) and Sweden (Eulophidae). Then, we found S6% of the families recorded for Hymenoptera in the American Continent. This situation reinforce the importance of the Biosphere Reserve System and their role in the conservation of beneficial insects

Index terms: Tamaulipas, wasps, diversity

[0480] LAKES, PONDS AND WETLANDS AS HABITAT FOR BEETLES (COLEOPTERA, ADEPHAGA AND POLYPHAGA)

D. Cuadrado & J. Garrido, Dept. of Ecology and Animal Biology, Univ. of Vigo. E-36200, Spain, E-mail jgarrido@uvigo.es.

In the following study we show the conclusions of a 4 sampling research during 1 year over 4 lakes in the NW of Spain (Galicia). Vixán, Xuño and Bodeira situated in the coast; the other one, Cospeito, in the inlands. In Vixán we found a salinity value of 27,3‰, in Xuño we didn't find salinity, and in Bodeira the value was 0,3‰. In Cospeito salinity was not found. We also measured other parameters: pH, oxygen saturation, oxygen concentration, conductivity, TDS (Total Disolved Solids) and temperature, We collected 52 species of water-beetles, using Analysis of Canonical Correspondences we found that beetles distribution was related to conductividity, we also observed the importance of water level in sampling zone and how variable was oxygen level according to the hour of the day, density in vegetation and degree of wind exposure. On the other hand we observed that this type of ecosistems was very variable, because a lake can be reduced to a pond or a welland with few centimetres of water. Index terms: water beetles, lakes, ponds, wetlands

[0482] THE ARGENTINEAN SPECIES OF THE ANT GENUS *LINEPITHEMA* (FORMICIDAE: DOLICHODERINAE)

F. Cuezzo, CONICET - Instituto Superior de Entomología "Dr. Abraham Willink" (INSUE). Facultad de Ciencias Naturales e Instituto Miguel Lillo. Miguel Lillo 205, 4000 San Miguel de Tucumán. Argentina. E-mail: institillo@infovia.com.ar.

The genus Linepithema (Formicidae: Dolichoderinae) was recently treated and re-defined at generic level by Shattuck (1992). Ants belonging to this genus are common in Argentine. One of its species, Linepithema humile, also known as the "Argentine ant", has received a lot of attention because is widely distributed around the world. It is assumed that it was probably exported from Argentine and Brazil to the rest of the world, where is considered a plague acting as a strong competitor of local ant fauna and causing damage to native plants. Although the significance of the genus, very few is known about the other species of *Linepithema*. No key for species are currently available. The genus is compound of 26 taxa (species, varieties and subspecies) with Central and South American distribution except for L. humile. Two more species are recognized from the fossil records, The material used in the present study belong to several personal field collections. Also a number nest series deposited in different Museum collections were examined. As a result of the present contribution 11 taxa are recognized, including one species new for the science. The rest of the taxa are redescribed considering the different castes (worker, male and female). A key for South American living species is provided and drawings of the main characters are made in order to help identifications. Patterns of geographical distribution and data of biology to several species inhabiting natural places in Argentine are given.

Index terms: ants, Hymenoptera, Linepithema, Taxonomy

[0481] NEOTROPICAL SPECIES OF THE ANT GENUS DORYMYRMEX (FORMICIDAE: DOLICHODERINAE), I. DORYMYRMEX FLAVESCENS COMPLEX

F. Cuezzo, CONICET - Instituto Superior de Entomología "Dr. Abraham Willink" (INSUE). Facultad de Ciencias Naturales e Instituto Miguel Lillo. Miguel Lillo 205, 4000 San Miguel de Tucumán. Argentina. E-mail : instililo@infovia.com.ar.

Dorymyrmex is an ant genus with American distribution that represents one of the most confusus cases in the systematic history of Formicidae. Several attempts to put in order the internal taxonomy of this genus were made in the past but no taxonomic review of Neotropical species were proposed. IN the past, the genus was subsequently divided into as much as 7 different subgenera by subsequent authors. These have been regarded as subgenera of *Dorymyrmex* or as genera related to it. The last attempt to reorder this genus was made by Shattuck (1992). In his paper, Shattuck considers 7 Neartics spp. and 72 in the Neotropics. He joined all species in one genus establishing characters to define Dorymyrmex at generic level. This conception is followed in the present paper. The neartic species were reviewed by Snelling (1995). The aim of this paper is to contribute to knowledge of the neotropical species of Dorymyrmex. More than 3000 exemplars belonging to several nest series were examined including types material of Museum collections and personal collections made through different areas of Argentina and Chile.As a result of a global analysis of the genus, a new arrange into nine species complexes of the neotropical species is proposed. The complexes were defined based on groups of characters. A key to separate species complexes is provided. A taxonomic review of Dorymyrmex flavescens complex is also given with redescriptions of the different castes (worker, male and female). Each description is accompanied with standard measurements and schemes of the main characters. New keys to species and data of geographical distribution to each species are provided. After this study, flavescens complex comprise 15 species distributed in Chile and Argentine. I consider D. alboniger as new synonym of D. ebeninus (new status), D. azulensis, and D. albipes were redescribed as good species (first available use); D. weiseri, D. patagon, D. mandibularis and D. jactans considered as good species were elevated to species range (new status). ectotypes and paralectotypes were designed when it was necessary. The other complexes felimited in the present contribution are currently being reviewed by the author and will be publish in the near future.

[0483] COLLEMBOLA (ARTHROPODA: HEXAPODA) BIODIVERSITY IN TROPICAL AGRICULTURAL ENVIRONMENTS OF ESPIRITO SANTO, BRAZIL

<u>M. P. Culik¹</u>, J. L. de Souza¹ & J. A. Ventura¹, ¹Empresa Capixaba de Pesquisa, Assistência Técnica e Extensão Rural, EMCAPER, Rua Afonso Sarlo, 160 - Bento Ferreira, CEP 29052-010, Vitoria, Espirito Santo, Brazil, E-mail: markculik@hotmail.com.

Collembola are among the most widespread and abundant arthropod inhabitants of terrestrial ecosystems, and by feeding on organic matter and microorganisms they have important influences on soil microbial ecology and fertility. However, despite their environmental importance, basic information on the biodiversity and ecology of Collembola is lacking. The Neotropical collembolan fauna is probably the most diverse but least known in the world and knowledge of the collembolan fauna of Espirito Santo, Brazil, which contains some of the most diverse tropical forests in the world, consists of only two records of nine species. Likewise, knowledge of the biology of Collembola in agroecosystems is also limited. The goal of this research is to increase basic knowledge of the biodiversity and ecology of Collembola in tropical agricultural environments. Specific objectives are to determine what Collembola species inhabit agricultural soils of Espirito Santo, obtain a record of the seasonal abundance of Collembola in this area, and determine effects of alternative agricultural practices on Collembola in this tropical environment. Field sites for the project are located at the EMCAPER Central Mountain Research Center, Domingos Martins (20° S latitude), and consist of three sites designated: A, Fertilizer site (the site contains two blocks (replications) with plots, $100m^2$, subjected to two fertilizer treatments, organic fertilizer (compost) and inorganic fertilizer application); B, Tillage sile (with treatments, organic fertilizer (compost) and inorganic fertilizer application); B, Tillage sile (with two blocks containing plots, 155m², subjected to two different (illage treatments, no-tillage and conventional tillage); and C, Mulch site (with two blocks containing plots, 150m², subjected to two different mulch treatments, mulch and uo mulch application). The same plots have received similar treatments annually since the sites were established in 1992 (site A) and 1991 (sites B and C, in an organic system) and a variety of vegetable crops are grown on the sites. Beginning in December 1999, two soil core samples (5cm diameter) are taken randomly from the surface 10cm of each plot each month. Collembola are extracted from the soil cores using Tullgren lunnels and identified as far as possible to species level. Fourteen taxa of Collembola have been identified from initial samples collected from site A including Hypogastrura sp., Brachystomella sp., Onychiurus sp., Tullbergia sp., Isotomodes sp., Heteromurus sp., Entomobrya sp., Pseudosinella sp., Sinella sp., and Oncopodura sp., Two genera, Isotomodes and Heteromurus, are new records for Brazil. These initial results indicate that a diverse variety of Collembola can inhabit agricultural soils in Espirito Santo. This research is continuing and additional information on collembolan diversity and effects of agricultural practices on collembolan populations will be presented. Additional studies such as this in other areas and environments in Espirito Santo are also likely to add greatly to knowledge of the biodiversity and ecology of Collembola. This research is supported in part by a grant from the National Geographic Society. hidex Terms: Neotropical, biogeography, soil biology, organic agriculture

[0484] *BIOTRACK:* CONCEPTUAL AND INFORMATION TECHNOLOGY SOLUTIONS FOR UNDERSTANDING MORE OF BIODIVERSITY

J.M. Dangerfield, <u>D.A. Briscoe</u>, A.J. Pik, I. Oliver & A.J. Beattie, Key Centre Biodiversity & Bioresources, Dept of Biological Sciences, Macquarie Univ., Sydney, NSW 2109, Australia.

Our current understanding of biodiversity is largely limited to information from vertebrates and plants. Sampling constraints, taxonomic impediments and the sheer volume of material have constrained our use of the organismal diversity in other taxa, yet invertebrates and microbes account for more than 99% of extant biodiversity. Here we describe *BioTrack*, a system that integrates para-taxonomy, sampling protocols, a powerful relational database, bar-code technology and the use of high-quality digital images into a complete solution for question driven assessment and monitoring of biodiversity. We demonstrate the use and advantages of *BioTrack* in a large-scale project to test the efficacy of land systems as surrogates for biodiversity, in which 178,000 invertebrate specimens from 1500 pitfall traps were sampled and sorted. We also briefly describe other applications. Our results show that conceptual shifts and information technology tools, such as *BioTrack*, Monitoring, Parataxonomy, Computers

[0486] SOCIEDAD MEXICANA DE ENTOMOLOGIA, A.C.

C. Delova & S. Ibáñez-Bernal, Sociedad Mexicana de Entomología & Instituto de Ecología, A.C., Apartado Postal 63, 91000 Xalapa, Veraeruz, MEXICO, E-mail: deloyac@ ecologia.edu.mx.

The Mexican Society of Entomology (Sociedad Mexicana de Entomología, A.C.) was founded on January 29, 1952 at Mexico City. This society publishes a newsletter, Boletin Informativo, and a scientific research journal, Folia Entomologica Mexicana. The latter began in 1961 and currently publishes 3 numbers per year. Through the end of 1999 there have been 34 National Congresses, and since 1975 these meetings have been an annual event. Beginning in 1984 the Memorias of the National Congress began to be published independently; before that year they were published in Folia Entomologica Mexicana. The number of papers presented at the Congress has grown from 50 in 1958 to 353 in 1991; a total of 5,513 have been presented through 1996. There are 8 session subjects: Acarology and Arachnology, Biology, Ecology and Behavior, Biological Control of Pests, Agricultural Entomology, Forest Entomology, Medical and Veterinary Entomology, Physiology and Toxicology, and Systematics and Morphology. In addition, a great many symposia have been organized on a wide variety of specific subjects, Folia Entomologica Mexicana is recognized by the Mexican National Council of Science and Technology as a journal of excellence and is well known internationaly. The Mexican Society of Entomology has at present nearly 1,000 members, not only from Mexico but from other countries of the world.

Index words: entomological societies, Latin America, Mexico.

[0485] THE INSECT PESTS OF MYRCIARIA DUBIA (MYRTACEAE) IN PERU: A REVIEW

C. Delgado¹ & <u>G. Couturier</u>², ¹Instituto de Investigaciones de la Amazonía Peruana, Progr.biodiversidad, C.P. 784, Iquitos, Peru, E-mail pbioinv@halcon.rail.org.pe ²Antenne IRD Entomologie, Mus. nat. d'Histoire naturelle, 45 rue Buffon 75005 Paris, France, E-mail couturie@mnhn.fr.

Myrciaria dubia (Myrtaceae), called camu camu in Peru, is a native shrub of the Amazon basin that grows naturally along the periodically flooded banks of rivers and lakes. Its fiuits are round shaped berries and have a very high content of ascorbic and deshydroascorbic acid (from 8.64 to 9.70 g/kg of pulp). The fruits are collected in the native stands and sold in local markets to process juice and sorbet. The fruits have been exported as frozen pulp for a few years. Due to the increasing demand of the foreign market, the plant is now cultivated in experimental and commercial plantations. The Peruvian Ministry of Agriculture promoted since 1997 a 5 years project to develop cultivated areas in agroforestry systems. In natural conditions, M. dubia is only slightly damaged by insects whereas domestication in very different ecological conditions permitted the colonization by numerous species of phytophagous insects. Since 1985 the entomological fauna of this fruit have been studied in natural conditions and cultivated orchards. In this work, 62 species are reported for Peruvian Amazonia (Iquitos, Pucallpa). The major pests in plantations are, *Ceroplastes flosculoides and Conotrachelus* dubiae, newly described species; Tuthillia cognata, only known on M. dubia; Aleurothrixus floccosus, Edessa sp.,Dysmicoccus brevipes and Xylosandrus compactus, that are common and polyphagous pests of various crops. Many other species of Coleoptera, Diptera, Hemiptera, Lepidoptera, Phasmoptera, and Thysanoptera are considered at the moment, as secondary pests. Biology and ecology of the new pests are now studied in order to develop the use of IPM strategies.

Index terms : Conotrachelus dubiae, Edessa sp., Tuthillia cognata, Xylosandrus compactus

[0487] THE VENEZUELAN SPECIES OF POEMENIINAE, LYCORININAE AND XORIDINAE (HYMENOPTERA:ICHNEUMONIDAE)

F. A. Díaz, Univ. Centroccidental Lisandro Alvarado, Decanato de Agronomía, Depto. Ciencias Biológicas, Tarabana 3023, Lara, Venezuela.

Ganodes wahli, Lycorina albomarginata and Xorides sondrae are described and illustrated. G. balteatus, L. apicalis and X. humos are recorded for the first time in Venezuela. Ganodes (Poemeninae) is a small Neotropical genus ranging from tropical Mexico to southern Brazil and comprising five rather similar species. Only two are described, G. balteatus from southern Brazil and G. matai from Costa Rica. Lycorina (Lycorininae) is a moderate sized genus that is represented in Venezuela by two species, the widespread tropical American species L. apicalis, whose known range extends from southern Mexico southward into Brazil, and the new one. Xorides (Xoridinae) is a large cosmopolitan genus that is represented in the Neotropics by fourteen described species, and ranges from Mexico to Argentina. Characteristics that allow to separate the Venezuelan species are given.

Index terms: Ganodes wahli, Lycorina, Xorides sondrae

Symposium and Poster Session

[0488] SPECIES OF OPHIONINAE (HYMENOPTERA: ICHNEUMONIDAE) FROM THE ANDEAN AND CENTRAL WESTERN REGIONS OF VENEZUELA

F. A. Díaz¹ & Y. Colmenárez¹, ¹Univ. Centroccidental Lisandro Alvarado, Decanato de Agronomía, Depto. de Ciencias Biológicas, Tarabana 3023, Lara, Venezuela. E-mail: dbfrancis@hotmail.com.

The venezuelan representatives of the ichneumonid subfamily Ophioninae present in the collection of insects at the Museo Dr. José M. Osorio (UCOB), Universidad Centroccidental Lisandro Alvarado, Tarabana, Lara state, are reviewed and a key is provided to the four genera occurring in the Andean and Central Western regions of Venezuela. One species of Alophophion, fifty species of Encospilus, four species of Ophion and one species of Thyreodon, are found. Two genera, Alophophion and Thyreodon, and twenty eight species, Enicospilus aktites, E. alvaroi, E. bima, E. brevis, E. cressoni, E. duckworthi, E. echeverri, E. forsithei, E. gallegosi, E. hallwachse, E. jesicae, E. lacsa, E. lebophagus, E. madrigalae, E. masoni, E. mexicanus, E. peigleri, E. persimilis, E, pescadori, E. simoni, E. tenuigena, E. xanthocarpus, E. xanthostigma, Ophion cacaoi, O. calliope, O. euterpe, O. flavidus and Thyreodon atriventris, are recorded for the first time in Venezuela. Alophophion is a moderately species-rich genus whose component taxa are restricted to the cooler southern part of South America, with 25° S as its previously stablished northern limit. Now, being recorded at 9° 7' N this limit spreads enormously. Alophophion gauldi is described and illustrated. Enicospilus chiriquensis, E. columbianus, E. cubensis, E. devriesi, E. dispilus, E. exoticus, E. fernaldi, E. flavoscutellatus, E. flavus, E. glabratus, E. guatemalensis, E. hemicrescellae, E. kelloggae, E. kleini, E. leoni, E. liesneri, E. maculipennis, E. major, E. marini, E. monticola, E. opleri, E. purgatus, E. randalli, E. sanchezi, E. scuintlei, E. trilineatus and E. ulfstrandi are the previously recorded species in Venezuela. Information about known distribution and hosts is briefly outlined.

Index terms: Alophophion, Enicospilus, Ophion, Thyreodon

[0489] BIODIVERSITY OF CYNIPOIDEA FROM BRAZIL (HYMENOPTERA)

N. Diaz¹, <u>F. Gallardo¹</u>, P. Ros-Farré² & J. Pujade-Villar², ¹Dept. Científico de Entomología, Museo de La Plata, Paseo del Bosque s/n, 1900 La Plata, Argentina,E-mail gallardo@museo.fcnym.unlp.edu.ar; ² Dept. de Biologia Animal, Facultat de Biologia, Universitat de Barcelona, Avda. Diagonal, 645, E-08028-Barcelona, Spain, E-mail pujade@porthos.bio.ub.es.

The fauna of microhymenoptera from the Neotropical region is poorly known biologically as well as taxonomically, and this is specially evident if we consider their high biodiversity, the great number of undescribed species housed in the different entomological collections and that many areas have been scarcely sampled or remain nearly unknown. In these aspects Brazil is not an exception, inventory works are necessary to provide information on the distribution and ecology of species, as well as specimens necessary to systematic studies. De Santis (1980), was who first listed the Hymenoptera from this country, including 91 species belonging to the superfamilia Cynipoidea. Recent studies made by several authors notably increased this number with the description of new genera and species; besides this news taxa, many new records of brazilian Cynipoidea have been found, and even Paleartic species introduced for the biological control of some pests. The main objective of the present catalogue is to update the state of the knowledge of the representatives of this taxon in Brazil and the organization of this work follows the guidelines of that published for De Santis (op.cit.). For each species, the synonymy, the geographical distribution in the country, hosts and first Brazilian references are given. It is also provided a table with the number of species for families and subfamilies, registered for each state and territories of Brazil, the used abbreviations are those adopted by the Department of Mail and Telegraphs of that country.

Index terms: Catalogue, cynipoid wasps, brazilian fauna

[0490] HISTORICAL BIOGEOGRAPHY OF THE SOUTH AMERICAN RHYTIRRHININI (COLEOPTERA; CURCULIONIDAE)

M. Donato¹, P. Posadas¹ & D. R. Miranda- Esquivel², ¹Departamento Científico de Entomología and Laboratorio de Sistemática y Biología Evolutiva (LASBE). Museo de La Plata. Paseo del Bosque S/ N, 1900 La Plata, Argentina. ²Universidad Industrial de Santander. AA 678, Bucaramanga, Colombia: E- mail: mdonato@museo.fenym.unlp.edu.ar

The weevil sutribe Listroderina belongs in the tribe Rhytirrhinini (subfamily Cyclominac), and has 25 genera and 300 species in the Americas. The historical biogeography of the subtribe was reconstructed applying dispersal- vicariance analysis (DIVA) using genera as terminals. The results at the ancestral node suggest that the subtribe has been originated within an area actually represented by the Central Chile, Paramo, Puna, Patagonia and Subantartic provinces of the Andean subregion and the Neotropic. At this time has suffered extintions and was confined in Central Chile, Paramo and Subantartic provinces. Posteriorly took place extintions and dispersions and the subtribe was restricted in the Paramo and Puna provinces, after that occurred a dispersal event to the Subantartic province from these areas. A vicariant event separates Puna and Paramo provinces in one hand, and the Subantartic province in the other. Macrostyphlus generic group was confined in Paramo and Puna provinces and from there dispersed to other areas. In the Subantartic province Antarctobius, Falklandius, Listronotus and Listroderes generic groups was diversified. This hypothesis is not coincident with that of Morrone, J. J. Glab. Ecol. Biogeog. Lett. 188- 194, 1994, who proposed an austral biota to the southern most part of the Andean subregion, meaning Central Chile and Subantartic provinces, which dispersed northward, using track compatibility analysis and parsimony analysis of endemicity. Nonetheless one of the optimal reconstruction from DIVA for the subtribe ancestral node is coincident with Morrone's hypothesis.

[0491] EVALUATION OF ECOLOGICAL NETWORK QUALITY FOR BUTTERFLY INDICATOR SPECIES BY COMPARISON OF OBSERVED POPULATION DENSITY AND PREDICTED DENSITY FROM BOTANICAL RELEVÉS

<u>M. Dufrêne^{1, 2} & J. Sawchik², 1. Centre de Recherche de la Nature, des Forêts et du Bois</u> (MRW), Avenue Maréchal Juin, 23 B-5030 Gembloux Belgium, 2. Unité d'Ecologie et de Biogéographie (UCL), Place Croix du Sud, 4 B-1348 Louvain-la-Neuve Belgium

Minimum viable site networks are crucial for many threatened species, although the design procedures for doing so are always problematic, especially for invertebrate species. The present study investigated methods to estimate the potential habitat quality of an ecological network for butterfly species of wel grassland, by measuring a small set of ecological parameters. We use this approach to evaluate fragmentation consequences, by comparing site potential and observed densities. It is expected that greater differences will be observed when sites are more isolated. Species assemblage analyses with the Indicator Value approach revealed five species (Brenthis ino, Clossiana selene, Lycaena hippothoe, Lycaena helle, Proclossiana eunomia), as indicators of the main wet grassland types. Density predictions are performed on the basis of botanical relevés as explanatory variables with classical autecological multiple regressions and a synecological approach that combines canonical correspondence analysis and multiple regressions for these five species. Models are defined with a reference site set and are evaluated with a test site set. The precision of autecological approach was better on the reference site test, however the ability to generalize with the test site set of the synecological approach was largely better. The coefficient of determination of regression models were very high for Brenthis ino (75.10%) Clossiana selene (85.82%), Lycaena helle (61.36%) and Proclossiana eunomia (66.62 %). For Lycaena hippothoe, the predictions were not reliable as a result of sampling and behavior problems. On the test site set, differences between predicted and observed abundance were largely correlated with site isolation ($r^2 = 51.10\%$, 79.96% and 79.48 % respectively for Clossiana selene, Lycaena helle and Proclossiana eunomia). The more the sites are isolated, the greater the chances that potentially good sites are empty-Reciprocally, when the sites are not isolated, observed abundance is always greater than predicted, seeming to confirm the role of metapopulation effects by the significance of interactions or true rescue effects between more closed populations. Index terms: Proclossiana eunomia, Brenthis ino, Clossiana selene

[0492] TERMITE DIVERSITY AND LAND USE CHANGES: LESSONS FOR FUTURE GENERAL BIODIVERSITY STUDIES

P. Eggleton¹, ¹Dept. of Entomology, The Natural History Museum, Cromwell Road, London SW7 5BD, UK, E-mail: pe@nhm.ac.uk.

Termites are not only the most important arthropod decomposers in tropical forests, they are also extremely sensitive to the effects of forest clearance. Complete degradation of forests will often lead to the almost total destruction of termite assemblages, with a potentially enormous concomitant loss of ecosystem services. Termites would therefore seem to be extremely good target organisms both as indicators and as direct mediators of ecological processes. In this talk I will critically evaluate the problems of using termites as indicators of land use change, especially those due to variation in sampling technique, analytical procedures and biogeographical history. Generalising to studies with a wider remit I conclude that many of the studies that assume simple disturbance responses in species richness are flawed, often by an overemphasis on catch-all parameters, especially species richness and diversity indices. Compositional (multivariate) approaches are likely to be much more informative and far more sensitive to the complex but subtle changes increasingly being observed in disturbed biotas.

Index terms: Isoptera, land use changes, species richness, analyses of assemblage composition

[0494] LATITUDINAL AND ALTITUDINAL VARIATION OF THE RICHNESS, DIVERSITY AND COMPOSITION OF THE BUTTERFLY COMMUNITY IN THE "CORDILLERA ORIENTAL" (COLOMBIA)

<u>G. Fagua</u>¹, ¹Laboratory of Entomology, Dept. of Biology, Pontificia Univ. Javeriana, Carrera 7 No. 43 – 82. (Edificio 52 – Piso 5). Santafé de Bogotá, D.C., COLOMBIA, Email fagua@javercol.javeriana.edu.co.

The altitudinal and latitudinal variation in richness, estimated richness, diversity, frequency and structure of butterfly communities along four altitudinal gradients on the eastern slope of the Cordillera Oriental were studied. The study gradients were located in the mountains along the following rivers: Margua (7º 45' N, 72º 28' W, Toledo, None de Santander), Gazaunta (4º 36' N, 73º 25' W; Medina, Cundinamarca), Pato (2º 43' N, 74º W, San Vicente, Caquetá) and Sibundoy-Rumiyacu (0° 25' N, 77° 16' W - 1° 5' N, 76" 42' W, Nariño and Putumayo). Samples were collected at 14 sites between 600 m and 2200 m elevation. The samples were made during the rainy season. I collected 565 butterfly species of the 780-850 possible species for the study area. I observed an inverse correlation between altitude and: richness, richness estimated, abundance and diversity, and a positive correlation between altitude and dominance. I also observed an inverse correlation between richness and latitude. The altitudinal variation patterns for each subfamily were variable, but richness generally declined with altitude. Only Satyrinae, Lycaenidae and Pieridae were independent of altitude, but not of latitude, and declined with the latitude. I propose priority areas for conservation and emphasize the importance of the region for the protecting Colombian biodiversity. The region has 30% of the butterfly species of the country in only the 8% of the total area.

Index terms: Colombian Andes, Biodiversity, Bioindicador, Conservation

[0493] WHITE FLIES FAUNA OF WILD PLANTS AND THEIR ABUNDANCE IN EGYPT

<u>S. Elnagar</u>¹, G. Sewify¹, S. Abd-Rabou² & N. Ahmed², ¹Department of Economic Entomology and Pesticides, Faculty of Agriculture, Cairo University, Egypt; ²Plant protection Research Institute, Agriculture Research Center, Cairo

Two years survey at different locations in Egypt revealed eleven species of white flies associated with 39 wild plant species. Most of the wild plant species are first recorded as hosts for the whiteflies *i.e.* 9 new host species for (*Bemesia tabaci*).6 Species for (*Trialeuroodes vaporariorum*) and 5 Species for (*Parabemisia myricae*). The seasonal abundance of five most prevalent whitefly species on both wild and economic host plants is discussed.

[0495] DIVERSITY OF DIURNAL INSECTS SPECIES IN PLANTS OF AN AGROFORESTRY SYSTEM IN ACRE

M. Fazolin¹ & J.L.V. Estrela², ¹Embrapa Acre, Caixa Postal, 392-CEP 69901-180, Rio Branco Acre, Brazil; E-mail murilo@cpafac.embrapa.br.; ² Dept. of Entomology, Universidade Federal de Viçosa Caixa Postal, 392-CEP 69901-180, Viçosa Minas Gerais, Brazil.

The agroforestry systems established in the Acre region are composed mainly of perennial plants such as peach palm (Bactris gasipaes), cupuaçu (Theobroma grandiflorum), coffee (Coffea arabica cv. Catuai), acai (Euterpe oleracea) and Brazil-nut (Bertholletia excelsa). In the first years of establishment of these systems, annual crops such as beans, rice and corn are intercropped between the lines of the perennial crops. This procedure increases the diversity of plant species in this agroescosystem, makes it possible to expect that an integration of some stable properties of natural communities takes place, particularly an increased diversity of insect species, resulting in a decrease of the level of infestation of pests. The experiment was conducted from January,1995 to December, 1998 in an area of 0.5 ha, consisting of 70 plants of peach palm, 53 of cupuacu, 36 of coffee, 20 of acai and 10 of Brazil-nut, all in the spacing of 6 x 6 m. The evaluations were done at weekly intervals using an entomological net to capture all insects present in a sample of 30% of the plants. In this agroecosistem, starting in 1995, growing values of the index of diversity of the insect species were observed, probably due to the increase in the leaf biomass of the perennial plant species, culminating in 1997 with the maximum value in the period (80.0). In 1998, there was a decrease in this value (55.1). Analyzing the average of all years jointly an index of 90.1 was obtained, value considered high and expected for diversified agroecossistems. The individual indexes obtained for each plant species were: Brazil-nut, 17.9; coffee, 25.7; acai, 37.6; cupuacu, 40.1 and peach palm, 41.0. Besides these diversity indexes, it was also verified that high populations of important pests of annual crops such as Cerotoma tingomarianus and Mormidea maculata were still present in the environment surrounding the plants of peach palm and acai, even two years the bean and rice crops were harvested. It can be concluded that these plants species, although important components for the diversification of the agroecosystem, are shelters or refuges for these pests. Therefore this fact should be taken in consideration when establishing new areas that have these plant species as initial components, especially because larger populations and larger levels of damages caused by the same pests were verified during this period. The study of the mechanism of association of these insects with these palm species may lead to the identification of the causes that make them possible give it origin, once it was not verified that these insects feed of these shelter plant species.

Index terms: Cerotoma tingomarianus, Mormidea maculata, insects diversity, plants diversity.

[0496] STRUCTURE AND DIVERSITY OF STREAM INSECT ASSEMBLAGES APPLIED TO ASSESSMENT: THE LULES RIVER (TUCUMAN, ARGENTINA)

H. R. Fernandez¹, V. F. Romero², E. Domínguez¹, S. A. Cohen¹ & <u>V. Manzo¹</u>, ¹Fac. Cs. Nat. Univ. Nac. Tucumán, Miguel Lillo 205, 4,000, Tucumán, Argentina. E-mail: Mayfly@unt.edu.ar; ²Fund. Miguel Lillo, Miguel Lillo 251, 4,000 Tucumán, Argentina.

The use of stream Insect Assemblages for water quality and anthropogenic impact assessment is becoming more and more important. Based on the previous knowledge of insect assessment as bioindicators established for the rivers of Tucumán Province, we started a study on a mountain river that is going to be dammed. These data obtained before the dam construction will be very valuable for the evaluation of the dam impact. Lules river and its affluents drain approximately 4,200 Km², with an annual flow of 6.07 m³/s. The studied segment of the river runs through rain mountain forest (Yungas province). The sampling was carried out in 4 stations, located from 490 to 880 m, using Suber sampler, with 3 replications in each station. The results of this study, obtained in the Lules drainage, showed that the water quality, using as biotic index a score-system and confirmed by physic-chemical analysis was good in all stations and seasons. Forty-five insect taxa were collected, but for the multivariate analysis only 27 were used (scarce and infrequent taxa were not included). Using the Canonical Correspondence Analysis (λ_1 =0.52; λ_2 =0.35), all the stations grouped together except the summer and fall samples of the first station (880 m). The taxa responsible for the separation of this station were Parargyractis sp. (Pyralidae) in summer and Thinobius sp. (Staphylinidae) in Fall. The results of this study show that the summer spates have a stronger impact on station 1, which persist through most of the fall season. For the damage on the riversides, the relation spate/normal flow is also bigger in station 1. These results are also important at the moment of water quality assessment through biotic index.

[0498] COMPOSITION AND RELATIVE ABUNDANCE OF DIPTERAN FAMILIES (EXCLUDING NEMATOCERA AND ACALYPTRATAE) COLLECTED BY MALAISE TRAPS, WITHIN AND OUTSIDE FOREST FRAGMENTS IN TWO DIFFERENT AREAS

J. C. R. Fontenelle¹, F. S. de Castro¹, E. L. Paschoalini¹, J. C. Almeida¹ & R. P. Martins¹, ¹Laboratório de Ecologia e Comportamento de Insetos. Dept. de Biologia Geral. Univ. Federal de Minas Gerais, Cx Postal 486 CEP: 31140-390 Belo Horizonte, M.G. Brasil. E-mail: juliocrf@mono.icb.ufmg.br.

The importance of study of forest fragmentation is growing, owing to the increase in the process itself, principally in urbanized regions. Flies occupy a large variety of niches, both created and modified by human activity. Two areas with fragments of forest, within the metropolitan region of Belo Horizonte, Minas Gerais, Brasil (one, the Ecological Station of the Universidade Federal de Minas Gerais, and the other an area preserved by the Zoobotanical Foundation of Belo Horizonte) were used for the present study. A total of 8 Malaise traps were placed, 2 within the forest fragment and 2 outside, in each of these areas. 8210 Diptera from 17 families were collected in two non-consecutive weeks of sampling, and the total number of flies was significantly greater in the second week of collection, 6078 versus 2132. There was also a greater number of flics collected in traps just outside of the forest versus within, 2164 and 1352, respectively, in the UFMG Ecological Station, and 2749 and 1945 in the preserve. The family with the greatest number of individuals collected was Phoridae, comprising roughly 28% of the total, with Stratiomyidae, Syrphidae, Tachinidae, and Sarcophagidae together making roughly 48%, and Dolichopodidae, Muscidae, Pipunculidae, and Calliphoridae accounting for another 21%. Several families were found in significantly greater numbers outside the fragments than inside, such as Syrphidae, Tachinidae, Sarcophagidae, Dolichopodidae. Phoridae, Stratiomyidae, and Conopidae, but no families were significantly more abundant within the fragments. Analysing the distributions of abundances in the different habitats, we note that within the fragments there was a tendency suggestive of a greater dominance of specific families in this habitat-

Index terms: Fly, Brachycera, Cyclorrhapha, Forest fragment, Community

[0497] GEOGRAPHIC RANGES AND PATTERNS OF DIVERSITY FOR PSEUDACTEON FLIES, PARASITOIDS OF SOLENOPSIS ANTS, FROM ARGENTINA AND BRAZIL

P. J. Folgarnit¹, O. A. Bruzzone¹, S. D. Porter², M. A. Pesquero & L. E. Gilbert³, ¹Centro de Estudios e Investigaciones, Universidad Nacional de Quilmes, Roque Saenz Peña 180, 1876 Bernal, Bs As, Argentina, E-mail: pfolgarait@unq.edu.ar; ²USDA-ARS, CMAVE, Gainsville, FL 32604, USA; ³Department of Zoology, University of Texas, Austin, TX 78712, USA.

More than 40 species have been described within the cosmopolitan genus Pseudacteon, which specializes in attacking Solenopsis ants and is being considered to be used as a biological control tool in USA. Information on Pseudacteon records and distribution is currently dispersed and hardly published. However, this type of data is very important as a source of information on phorids localities for future captures and to infer phorids climatic tolerances to rear and release them at proper places in the States. Using bibliographic information, data from brazilian nuseums, and collections made by the authors, we compiled a data base on Pseudacteon throughout the distribution range of the two exotic fire ant pests, Solenopsis invicta (red) and Solenopsis richteri (black). The whole area included the region between 10-40°S and 35-65"W encompassing Argentina and Brazil. We used the grid method to estimate richness per cell and per phytogeographical regions and calculated equiprobabilistic curves following Rapoport (1982). We also estimated geographical ranges and climatic correlates for each species and classify them as broadly or narrowly distributed species. Equiprobabilistic curves were calculated for each cell using as central points of observations four cells that span a latitudinal gradient. These cells were: Goiania-Brasilia (GB), Belo Horizonte-Sao Paulo (BHSP), Corrientes (CO), and Capital-Buenos Aires (CBA); the first two in Brazil and the latter two in Argentina. There was no clear latitudinal pattern in species richness but phytogeographical regions in Brazil had greater diversity. However, the pattern of species that were lost from the centers of observations towards other cells changed consistently if the center was calculated at lower latitudes or at higher ones. This means that most of the species found at CO and CBA represented assemblages of species found in GB and BHSP, and represented species with broad geographic ranges and climatic tolerances. These data suggest that the introduction of broadly distributed Pseudacteon species will be more successful because these species have been able to spread across different climatic and phytogeographical regions and may have greater physiological tolerances to abiotic variables. In fact, broadly distributed Pseudacteon flies represent species that currently find red and black fire ants throughout their geographic range of distribution. Index terms: biogeography, biological control, fire ants, Phorids, richness

[0499] COMPOSITION AND RELATIVE ABUNDANCE OF HYMENOPTERA FAMILIES IN TWO URBAN AREAS OF BELO HORIZONTE, MINAS GERAIS, BRAZIL

J. C. R. Fontenelle¹, **D. A.Yanega ²& L. R. S. Zanetle ³**, ^{1,3} Lab. of Insect Behaviour and Ecology, Biological Science Inst., Fed. Univ. of Minas Gerais, P. O. Box: 486, Belo Horizonte, Minas Gerais, Brazil, E-mail: ¹Julioerf@mono.icb.ufmg.br; ² Dep. Entomology, Univ. of California, Riverside, CA 92521, USA, E-mail: dyanega@pop.uer.edu.

Two areas in the UFMG's Campus, with forest fragments, (Prefeitura = 20 ha / 6 of forest and Estação = 68 ha / 16 of forest), within the metropolitan area of Belo Horizonte, Minas Gerais, Brazil, were sampled with Malaise traps during two different seasons (between May 1996 and May 1997). A total of 6 traps (3 per area) were set, only during the day (9 a.m. to 4 p.m.), in the forest fragment's borders. 4556 Hymenoptera from 45 families were collected. In both areas, a greatest number of individuals was collected during the wet season. In the "Prefeitura" area, during the dry season, 521 insects from 29 families (H'= 2,68) were collected, in the wet season 1488 insects from 42 families (H'= 2,68) were collected, in the wet season 1488 insects from 42 families (H'= 2,68) were collected in the wet season 1488 insects from 42 families (H'= 2,69) were collected in the wet season 1488 insects from 42 families (H'= 2,69) were collected during the dry season, 521 insects from 29 families (H'= 2,68) were collected, in the wet season 1488 insects from 42 families (H'= 2,69) were collected during the dry season and 1840 insects from 41 families (H'=2,91) in the wet season. The most abundant families (in decreasing order) were: Ichneumonidae, Formicidae, Scelionidae, Braconidae, Eulophidae and Chalcididae, together they represent almost 60% of all the collected individuals. In the two areas, in both seasons, Ichneumonidae. Formicidae, Scelionidae and Braconidae were among the most abundant families. Index terms: Malaise traps, community ecology, Hymenoptera parasitica

(0500) LANDSCAPE DIVERSITY AND THE DISTRIBUTION OF THE [0. BUTTERFLIES OF THE GENUS ACTINOTE (LEPIDOPTERA: NYMPHALIDAE) THE IN SERVICE ACTINITY AND THE DISTRIBUTION OF THE [0.]

<u>R.B.Francini</u>, Museu de História Natural, FAFIS, Univ. Católica de Santos, Rua Euclides da Cunha, 247, 11065-902, Santos, SP, Brasil, E-Mail francini@unisantos.com.br. Financial support: BIOTA-SP (FAPESP)

A study was undertaken of 21 species of butterflies of the genus Actinote (Lepidoptera: Nymphalidae) (Actinote alalia, A. brylla, A. canutia, A. carycina, A. conspicua, A. discrepans, A. genitrix, A. melanisans, A. mamita mitama, A. morio, A. parapheles, A. pellenea pellenea, A. quadra, A. rhodope, A. surima surima, A. thalia pyrrha, A. zikani, A. bonita, A. dalmeidai, Actinote ca, terpsinoe, Actinote sp.4), and 47 species of larval food plants in Asteraceae genera: Mikania, Eupatorium, Trichogonia, Symphyopappus, Erigeron, Senecio and Vernonia, in the region between 21°40'-24°00'S and 44°30'-47°00'W, about 65.000 km². Four species A. carycina, A. thalia pyrrha, A. parapheles, and A. melanisans had an wide distribution in the whole area, while five: A. quadra, Actinote ca. terpsinoe, A. morio, and Actinote sp. 4 occupied a very restricted area The Activitie ca. terpsinoe, A. morio, and Activities 5, 4.0ccupied a very contacted and the geographical distribution of each species of Activities was related with various environmental characteristics (geological terrain, altitude, relief, soils, mean yearly rainfall, hydric excess, vegetation types and anthropic influence). The richest areas were located between 500-1500 m. A PCA on the whole coincidence matrix showed that the variation in anthropic impacts accounted for 76% of the species distribution. In spite of this, the PCA on separate matrices showed that this distribution was 86% explained by influence of remnant environments of dense forests among vegetation types. The association between the species of Actinote of the area (coefficient of Jaccard) showed that 28 pairs are mutually exclusive. The species with largest association indices were A. carycina, A. thalia pyrrha, A. melanisans, and A. surima. The distribution of the 21 species of Actinote by squares of 5' showed that the richest areas were along a central diagonal, oriented SW-NE, in the highest points of the Serra da Mantiqueira. A. brylla is present on the coastal plain and lower Serra do Mar slopes, and Actinote ca. terpsinoe only in the NW of the study area. Grouping the data by squares of 30' showed that the richest area (17 spp.) is situated in the NE, corresponding to the Itatiaia mountains followed by Serra do Mar, near Paranapiacaba (Santo André, SP), with 14 species. The correlation between Actinote species richness and the environmental factors by squares of 30' showed a strongly association with rain forests and rainfall between 2000-4000 mm. Index terms: environmental analysis, Serra do Mar, Serra da Mantiqueira

[0501] MANAGING THE DIVERSITY OF CARABIDAE IN AGRICULTURAL LANDSCAPES

<u>B. W. French¹ & N. C. Elliott²</u>, ¹USDA, ARS, NGIRL 2923 Medary Ave., Brookings, SD 57006, E-mail wfrench@ngirl.ars.usda.gov; ²USDA, ARS, PSWCRL 1301 N. Western Road, Stillwater, OK 74075.

The family Carabidae is a highly diverse group of Coleoptera with approximately 40,000 species worldwide. These beetles occupy a variety of habitats including grasslands, forests, riparian zones, and agricultural fields. Their ecological role as polyphagous predators in these habitats makes them important participants in community dynamics. What once was a vast area of grasslands, the North American Great Plains is now a mosaic of highly fragmented landscapes. Dominating the landscapes are agricultural fields intermingled with grass pastures and riparian zones. We used pitfall traps to collect carabid beetles in several winter wheat fields adjacent to grasslands and riparian zones in north central Oklahoma. We placed traps in the edges and interiors of the wheat fields and adjacent natural habitats. We classified edges and interiors as distinct habitats, and focus this analysis on differences in species richness (S), Shannon diversity indices (H), and Shannon evenness indices (J) among the habitats throughout the winter wheat growing season (autumn through spring). Species richness measures the number of species present. Species richness was higher in the natural habitats than in the wheat habitats during autumn. During winter S was least in the wheat interiors adjacent to riparian zones, and showed no differences among the grassland-wheat habitats. Compared to autumn and winter, we captured more species during spring, and significant proportions were captured within the habitat edges. Species diversity accounts for both S and relative abundance. Species diversity was higher in the natural habitats than in the wheat habitats during autumn. During winter H showed no differences among the riparian-wheat habitats or the grassland-wheat habitats. During winter H was least in the wheat interiors adjacent to riparian zones and grasslands. Species evenness indicates the variation in relative abundances among species with values ranging from 0 to 1. Low values indicate that a few species dominate in total abundance in that particular location. During autumn and winter J showed no differences among the riparian-wheat habitats or during autumn for the grassland-wheat habitats. However, J was significantly less in the wheat interiors adjacent to grasslands during winter and in the wheat interiors adjacent to riparian zones during spring. We discuss the differences in S, H, and J among habitats in terms of managing agricultural landscapes to enhance carabid diversity and abundance.

Index terms: ground beetles, insect communities, predators, agroecosystems, biological control.

[0502] SYSTEMATICS AND BIOGEOGRAPHY OF THE CYCLOTELINE THEREVINAE (DIPTERA: THEREVIDAE)

S. D. Gaimari^{1, 2} & M. E. Irwin¹, ¹134 EASB, 1101 W Peabody Dr., Univ. Illinois, Urbana, IL 61801, USA; ² current address: Dept. Entomology, National Museum of Natural History, Smithsonian Inst., Washington, DC 20560-0169, USA.

The cyclotelines represent a Laurasian group of Therevinae (Diptera: Therevidae), members of which are compared using 65 adult morphological characters. Cladistic analysis using parsimony reveals several convincing synapomorphic characteristics in support of the monophyly of this group, which is currently an assemblage of 10 genera spanning the Americas and into Middle, Far East, and Southeast Asia. Methods of cladistic biogeography were used to compare patterns of cycloteline cladogenesis and vicariant events in geological history. Using the taxon-area cladogram, a resolved area cladogram was derived using component analysis. In assessing the probable ancestral area inhabited by early cyclotelines, several additional quantitative methods were employed. All of the latter analyses suggest Asia as their ancestral area, with subsequent movement into the New World. Two major vicariant events account for their current distribution. The first relates to the Beringian land bridge connecting western North America and eastern Asia in the Cretaceous. Second, New World cyclotelines were affected by the Early Eocene breakup of the bridge between North and South America, and their distributions support hypotheses favoring continental origins of the Greater Antilles. By the Late Cretaceous, 65-90 million years before present (Myr), high sea levels resulted in extensive epicontinental seas. Potentially important to cycloteline cladogenesis was the Mid-Continental Sea separating Euramerica (i.e., eastern North America + western Europe) from Westamerica which formed a single continent with eastern Asia via the Beringian land bridge. In the late Cretaceous and early Paleogene, these northern latitudes were characterized by subtropical climates. From the middle to late Paleogene (Eocene into Oligocene), the northern latitudes encountered a steady increase in humidity and precipitation, and a drop in temperatures, all of which could have acted as vicariant barriers separating the North American and Asian cycloteline fauna. Further south, North and South America were connected through the Cretaceous-Paleogene boundary. This proto-Antillean link was on the eastern edge of the Caribbean plate which migrated eastward in the early Eocene, to eventually become the present-day Greater Antilles. A second land mass followed on the western edge of the plate, becoming attached to southern North America. This Central American isthmus only reattached North and South America as recently as the Pliocene, less than 5 Myr. Index terms: Asiloidea, Cretaceous, Laurasia, Beringia, Proto-Antilles.

[0503] A RELATIONAL DATABASE MODEL TO INTEGRATE DISTRIBUTION DATA IN GEOGRAPHICAL INFORMATION SYSTEMS (G.I.S.)

A. Gayoso¹ & <u>]. Garrido²</u>, ¹Dept. of Animal Biology, Univ. of Santiago de Compostela. E-15701, Spain., E-mail bagayoso@usc.es; ²Dept. of Ecology and Animal Biology, Univ. of Vigo. E-36200, Spain, E-mail jgarrido@uvigo.es.

Relational databases are normally used to manage the distribution data of biological populations. They help us to make simple inventories of specific areas, but also to make complex ecological analyses, such as resource selection functions, to characterize the distribution of organisms. Their field of application in Ecology and Faunistics can be made wider if it in used in combination with Geographical Information Systems (GLS.) to generate quality distribution maps or to carry out detailed spatial analyses which aimed to identify any hidden patterns and to identify the environmental variables affecting of the organisms' distribution. In this work, we propose a design for relational databases oriented to record the results of field studies on freshwater arthropods (mainly Coleoptera) that makes possible integrate these results in a GLS. This integration enables the user to make quick and powerful spatial searches and analyses of the information contained in the database.

Index terms: database, G.I.S., Faunistics, distribution

[0504] ACOUSTIC METHODS IN BIODIVERSITY INVESTIGATIONS OF CICADAS IN TROPICAL RAIN FORESTS

<u>M. Gogala</u>, Prirodoslovni muzej Slovenije, (Slovenian Museum of Natural History) Presernova 20, SI-1001 Ljubljana, Slovenia, E-mail: matija.gogala@uni-ij.si.

One of the difficulties in the investigation of insect biodiversity in the tropical rain forests is the limited possibility for location and collection of animals, the high number of morphologically similar species, and in many cases a high number of undescribed taxa. In such insect groups as Cicadoidea that emit loud and species specific sound signals, the use of acoustic methods can be of great help. During our field work in Malaysia we had the chance of comparing our acoustic sound patterns ("acoustic species") with the results of other colleagues working in the same localities or even at the same time with classical collection methods. In many cases we were able to point out the possible existence of different species by differences in song patterns and in some cases we also confirmed the identity or the presence of certain species in the investigated region which could not be proven by other means. On the other hand, we were not able to detect in certain localities the same or a higher number of distinct species than our colleagues who used light trapping. This can be explained by different daily time windows or seasons in which single species are acoustically active, in unrecognized differential sound characteristics, or in unsuitable equipment for a detection and recording of sounds with unusual frequency ranges or propagation substrates (e.g. ultrasonic sounds and vibrational signals). Index terms: Homoptera, Cicadoidea, song, sound

[0506] COMPARISON OF CARYOCAR BRASILIENSE CATERPILLAR FAUNA IN TWO CERRADO AREAS OF THE DISTRITO FEDERAL, BRAZIL

E. G. S. Gondim'; <u>H. C. Morais</u>¹ & I. R. Diniz², 1. Department of Ecology; 2. Department of Zoology, University of Brasília, 770910 900 Brasília, DF, Brazil, morais@unb.br

Caryocar brasiliense (Caryocaceae) is a typical cerrado tree, having economic importance due to its fruits and wood. The objective of this study was to compare the caterpillar faunas, which utilize this tree as a host, in two cerrado areas of the Distrito Federal, Brazil. One of the areas belongs to EMBRAPA-Cerrado Research Center (CPAC) (15° 35' S 47° 42' W), and the other area, "Fazenda Água Limpa" (FAL), belongs to the University of Brasília. The two study areas are about 60 km apart. Collection were made between October, 1997 and December, 1998 at CPAC, and from May to December, 1999 at the FAL. Fifteen C. brasiliense individuals were visited weekly at each study area and all caterpillars were collected. Caterpillars were numbered as morphospecies and raised in the laboratory, in order to obtain adults, which were then identified and deposited into the Entomological Collection of the Department of Zoology of the University of Brasília. Twenty-nine species from 14 families of Lepidoptera (previous collections and this study) were recorded. A total of 810 visits were made at CPAC, and in 9.6% of these, caterpillars were found, totaling 147 specimens from 20 morphospecies. The most abundant were Rhodoneura intermedia (Thyrididae) and Inga sp. (Occophoridae). At the FAL, 395 visits were made, with 9.9% of the trees presenting caterpillars, registering 106 specimens from 15 morphospecies, with Phidotricha sp. (Pyralidade) and one Noctuiidae species being the most abundant. At both areas, most of the caterpillars were found in May and June, on old leaves, where at least 75% of them built some kind of shelter. Significant differences were not found for the frequency of plants with larvae ($\chi^2 = 0.018$ df = 1 p>0.05), and the caterpillar faunas of the two areas were highly similar (Sorensen index = 0.514). In spite of the difference between the most abundant species, the overall features of the caterpillars are extremely similar in relation to diet (old leaves), defense mechanisms (crypt coloration and shelters) and months of greater abundance. The low frequency of plants presenting caterpillars throughout the year, and a peak of abundance occuring at the beginning of the dry season (May-June) corroborate previous surveys made for other host plants of the cerrado in the Distrito Federal. Despite the paucity of caterpillars, C. brasiliense presents a rich fauna of Lepidoptera larvae, showing similar features in both areas here studied. Index terms: Inga, Phidotricha, Rhodoneura, Noctuidae, Lepidoptera.

[0505] BIODIVERSITY OF GALLING INSECTS: HISTORICAL, COMMUNITY AND HABITAT EFFECTS IN THE NEOTROPICAL SAVANNAS

S. J. Goncalves-Alvim & G. W. Fernandes, Lab. Ecologia Evolutiva de Herbívoros Tropicais, Univ. Federal de Minas Gerais/ICB, CP 486, 30161-970, Belo Horizonte, MG, Brazil, E-mail: silmary@icb.ufmg.br.

Five hypotheses were tested to explain the pattern of galling insect species richness in four neotropical savanna physiognomies, "canga", "campo sujo", "cerrado", and "cerradāo", that occur in Minas Gerais, southeastern Brazil. i) *The plant species richness hypothesis*: predicts that galling insect richness is positively correlated with plant species richness. The increase of plant species richness explained 35% of the variation in galling insect richness (r² = 0.35, p < 0.05). Galling insect richness also showed a positive relationship with species of herbs and trees (p < 0.05), corroborating the plant species richness hypothesis. ii) The plant structural complexity hypothesis: predicts a positive relationship between galling insect richness and structural complexity of plants. Most of the galling insect species occurred on trees, followed by shrubs and herbs. However, the difference in mean number of galls was only significant between herbs and trees (p < 0.05). Therefore, these results corroborate only partially the plant structural complexity hypothesis. iii) The resource concentration hypothesis: predicts a positive relationship between galling insect richness and density of plants. A significant relationship was observed between the number of galling insects and density of herbs ($r^2 = 0.38$, p < 0.05), and shrubs ($r^2 = 0.39$, p < 0.05), but not on trees, therefore corroborating partially the resource concentration hypothesis. iv) The harsh environment hypothesis: predicts that galling insect richness is positively correlated with nutrient stress in the soil. The number of galling insect species showed a negative correlation with content of magnesium, potassium and zinc, corroborating the harsh environment hypothesis. There was also an increase galling insect richness with increasing iron content. In addition, galling insect richness showed a negative relationship with the organic matter content, and total capacity of cation change [CTC(T)]. The content of magnesium, potassium, iron and CTC (T) explained 72% of the variation in galling insect richness in the four vegetation types. v) The plant family size hypothesis: predicts a positive relationship between galling insect richness and host plant family size. Galling insect richness was positively influenced by plant family size ($r^2 = 0.42$, p < 0.05), corroborating the plant family size hypothesis. Overall, the results corroborate the hypothesis that predicts that habitat nutritional stress might be the main factor generating the patterns of galling insect richness in Brazilian savannas. Other variables, such as the composition, density and species richness of plants (local factors), and family size of host plants (historical factor) also influenced the richness of galling insects in the studied neotropical savanna physiognomies.

Index terms: environmental stress; galling insect richness; insect-plant interactions

[0507] FUNCTIONAL BIODIVERSITY AMONGST DIFFERENT MICROSITES IN A PATAGONIAN STEPPE, SOUTHERN ARGENTINA

<u>Guerrieri F.I.</u>¹, Folgarait P.J.² & Sala O.E.³, UIIB-CEI Universidad Nacional de Quilmes, R. Sáenz Peña 180, 1876 Bernal, Buenos Aires, Argentina. E-mail: ¹mordi@bg.fcen.uba.ar; ²pfolgarait@unq.edu.ar; ³sala@ifeva.edu.ar;

Soil organisms are important for maintaining soil structure and function. Despite there being little information on soil biodiversity, soil-related processes seem to differ according to the soil fauna assemblage. Nothing is known about the composition of the soil fauna of the Western District Patagonian steppe (Southern Argentina; 45°41'S, 70°16'W). Nevertheless, the region's flora and its climate have been properly described. The vegetation comprises bushes and grasses, grouped in patches within a bare soil matrix which covers the 52% of the surface. This distribution defines 5 microsites differing in their contents of water and organic matter: amongst bushes, the main are Adesmia campestris and Mulinum spinosum, grasses can be found either as a ring around M. spinosum or as scattered tussocks, and, finally, bare soil. We analysed the nematodes and the mesofauna distribution and diversity amongst the mentioned microsites. 10 soil samples were taken from each microsite. Nematodes were extracted using Baermann's funnels and their abundance was quantified. Litter and soil mesofauna organisms were extracted using Berlese's funnels. Abundance and richness were compared across microsites and amongst zoological groups with non-parametric tests (Kruskall-Wallis test, Mann-Whitney test and \square^2 -test). The greatest nematodes abundance was observed at bushes. Litter mesofauna richness and abundance were greatest at M. spinosum (p<0.032) and A. campestris (p<0.005), respectively. Mites were the richest and the most abundant zoological group in the litter. Soil mesofauna richness was greatest at A. cumpestris (p<0.05) whereas the greatest abundance was found at tussocks (p<0.03). Amongst zoological groups, mites and dipterans were the richest and mites were also the most abundant. Using bibliographic information on diets, we assigned the organisms found to trophic groups. According to their relative abundance within each microsite, we inferred different interactions among trophic groups. We observed that soil foodwebs were more complex than litter ones. Soil foodwebs involve phytophagous organisms and organic matter was supplied both by living roots and decomposing litter; except at bare soil, where no litter was found. Amongst microsites, most complex foodwebs were found at bushes and the least complex occurred at the bare soil. These results show that different vegetation modules corresponded to different soil invertebrates assemblages. Index terms: soil fauna, diversity, Patagonia, nematodes, mesofauna, foodweb

[0508] EXPLORATION AND DIVERSITY OF INDIAN MITE FAUNA(ACARI) AND INDICATIONS OF UNEXPLORED AREAS FOR FUTURE STUDY

S.K. Gupta, 1C/10, Anandam Housing Complex, 7 K.B. Sarani, Calcutta- 700080, India.

Commensurating with the rich biodiversity of India due to I to luxuriant vegetation , varied climatic conditions and diverse ecological niches, the mite fauna of India is also varied and rich as appears from the fact that while little over 40% of the Indian geographical areas have been properly surveyed, the mite fauna known so far indicates adequate richness as uptil now 2350 species represented by 725 genera, 190 families and 4 orders are recorded from India, of which, over 70% shows endemism. The number of species / general families known under each order is :- Astigmata- 155 /75/35, Mesostigmata 475/ 125 /35, Prostigmata 1275 /340 /60 / and Cryptostigmata 435/190/60. This paper provides all these details and documents number of species known from different environs like :water vertebrate and invertebrate associates plant , nests,stored preducts, dusts, mushroom, aquatic weeds , lichens and soil dwelling prosignatid mesostigmatid and cryptostigmatid mites. Besides, a brief discussion is made regarding unexplored areas in India needing surveys, emphasizes the taxa needing intensive/revisionary studies, focuses the economically important groups needing priorities and indicates the groups where more work or very little has been done. All these will provide guidelines to the future workers in formulating research stratagies on Indian mites.

Index terms : Indian mite diversity, mite environs, Indian mite review, future strategies,

[0509] ENTOMOLOGICAL SOCIETIES IN LATIN AMERICA

<u>G. J. Hallman¹</u> & A. R. Panizzi², ¹United States Dept. Agriculture, Agric. Research Service, 2301 S. International Blvd., Weslaco, TX 78596. E-mail ghallman@weslaco.ars.usda.gov. ²Centro Nacional de Pesquisa de Soja, EMBRAPA, Caixa Postai 231, Londrina, PR 86001-970, Brasil, E-mail panizzi@enpso.embrapa.br.

The theme of the XXI International Congress of Entomology is "entomologists preserving biodiversity". The theme of this symposium concerns the role of entomological societies in Latin American in preserving biodiversity. Latin American entomological societies are ideally situated to the task of preserving biodiversity. Three of the four so-called "megabiodiversity" countries are in the region: Brazil, Colombia, and Peru. The Amazon basin and adjacent regions contain levels of biodiversity that can only be imagined. This poster unites information from existing entomological societies in the region, especially those that are not represented in other posters or talks of this symposium. Unfortunately, several societies can be considered in a state of prolonged "diapause", in that they have been inactive for years. It is a challenge for the entomologists of those countries to revive these sleeping societies and put them to work solving the entomological problems of the region, including the preservation of biodiversity.

[0510] BLACK FLIES (DIPTERA: SIMULIDAE) FROM THE GRAND SAVANNA REGION OF VENEZUELA

N. Hamada⁴ & M. E. Grillet², ¹Inst. Nacional de Pesquisas da Amazônia-INPA/CPEN; Caixa Postal 478; 69011-970 Manaus, AM, Brazil; E-mail ahamada@inpa.gov.br. ²Inst. de Zoología Tropical (IZT), Univ. Central de Venezuela (UCV); Ap. 47058, Caracas 1041-A,Venezuela.

Little work has been done on black flies from the Grand Savanna region (Bolivar state) of Venezuela. This region includes Canaima National Park, which is known for its endemic species. Seventeen species of Simuliidae have been previously reported for the Grand Savanna region. The present study provides distribution data on black fly species collected during our sampling period in the Grand Savanna region, Venezuela, providing information needed for ecological studies of aquatic insect communities in the region. The study was done in streams accessible by roads in Canaima National Park, Grand Savanna region, Venezuela. Since the Pacaraima mountain region (Roraima, Brazil) has a long border with this area we decided to include the black fly species collected there, since both regions can share species. The samples were collected in October 1996, February and October 1998. Voucher specimens of all species examined are deposited in the Invertebrate Collectiion of UCV, Caracas, Venezuela and at the Invertebrate Collection of INPA, Manaus, AM, Brazil. Twenty-one species of Simulium were collected in the study area. In Canaima National Park the following species were collected: S. iracouboense, S. spinibranchium, S. subpallidum, S. metallicum species complex, S. guianense, S. inaequale, S. incrustatum, S. quadrifidum, S. cauchense, S. goeldii, S. kabanayense, S. suarezi, S. maroniense, S. perflavum, S. ignacioi and S. lutzianum. In the Pacaraima mountains the following species were collected S covagarciai, S. metallicum species complex, S. lutzianum, S. rorotaense, S. maroniense, S. trombetense, S. perflavum, S. bipunctatum, S. rubrithorax and S. cauchense. This is the first record of S. covagarciai in Brazil, this species had previously only been reported from the Parima mountains, Venezuela, its type locality. This is also the first record of the S. metallicum species complex in Brazil and southern Venezuela; this species complex has been reported only in the northern portion of the Orinoco Basin. The S. mletallicum species complex has at least 12 cytotypes distributed in Central America and northern South America, in Venezuela, only cytotype E is associated with the onchocerciasis transmission. Cytological studies will be necessary to define the cytotype present in the study area, and collection of females in this area will be necessary to determine if they are anthropophilic, Index terms: aquatic insects, Simulium, species distribution, species richness

[0511] BLACK FLIES (DIPTERA: SIMULIIDAE) OF FRENCH GUIANA: A PRELIMINARY LIST OVER 50 YEARS AFTER FLOCH AND ABONNENC

N. Hamada¹ & F. Fouque², ¹Inst. Nacional de Pesquisas da Amazônia-INPA/CPEN; Caixa Postal 478; 69011-970 Manaus, AM, Brazil, E-mail nhamada@inpa.gov.br; ²Institute Pasteur, Cayenne, French Guiana, ffouque@pasteur.cayenne.fr.

The last black fly paper published from French Guiana was by Floch & Abonnenc in the 1940s. Until that time, six species were reported for this region: Simulium cauchense. Simulium rorotaense, Simulium maroniense, Simulium, iracoubocnse, Simulium oyapockense and Simulium guianense. The objective of the present study was to widen the black fly list for this region and to determine the geographical distribution of the species. The samples were collected in June 1999 around Cayenne, Saül, Vovony community (L'Approuage River), Maroni River (on the border with Suriname) and along the highway that connects Cayenne to Iracoubo. With only 16 samples, we double the number of species known in French Guiana; we add to the list presented above the following species: Simulium quadrifidum!1033, Simulium goeldit, Simulium trombetense, Simulium near incrustatum, Simulium metallicum species complex 1 and S. metallicum species complex 2. In the two large rivers sampled (Maroni and L'Approuage) the most abundant species was S. iracouboense; S. guianense also was collected in these places, but in lower abundance. Although S. guianense is involved with transmission of onchocerciasis in Brazil and Venezuela, in French Guiana this species appears not to be anthropophilic, since the indigenous people that live along these water courses did not complain about their biling, as in some places in Brazil and Venezuela where they can be very annoying. *Simulium oyapockense* is involved with onchocerciasis transmission in lowland areas in Brazil, but in French Guiana this species was collected in very low abundance in the large rivers; it also appears not be anthropophilic. Simulium cytotype E is involved with onchocerciasis transmission in metallicumng1033 mountainous areas of Venezuela, near the Atlantic Ocean. The two species in the S. metallicum species complex collected in French Guiana were collected in small mountain streams also, but they appear not to be anthropophilic, since the riverine population does not complain about biting females. It is clear that once we increase sample size in French Guyana we are going to find more black fly species, since this country has many types of geographical landscape and black flies are poorly studied

Index terms: aquatic insects, Simulium, species distribution, species richness, taxonomy
[0512] SPATIAL MAPPING OF TWO PEST POPULATIONS IN NEW JERSEY SWEET CORN

<u>G. C. Hamilton</u>¹, M. Hughes², K. Holmstrom¹ & S. Walker¹, ¹Dept. of Entomology, Rutgers – The State Univ. of New Jersey, 93 Lipman Drive, New Brunswick, NJ, 08901, USA, E-mail hamilton@aesop.rutgers.edu; ²Grant F. Walton Center for Remote Sensing and Spatial Analysis, Rutgers – The State Univ. of New Jersey, 14 College Farm Road, New Brunswick, NJ, 08901, USA.

In 1999 and 2000 the Rutgers Cooperative Extension Vegetable IPM Program operated a network of approximately 80 blacklight insect survey traps in New Jersey to monitor adult populations of corn earworm (*Helicoverpa zea*) and European corn borer (*Ostrinia nubilalis*). All trap sites were mapped using a Trimble GeoExplorer II Global Positioning System unit. Data collected from these sites were used by the Grant F. Walton Center for Remote Sensing and Spatial Analysis to map the spatial distribution of each species. Average daily population data were imported into ArcView software and linked to corresponding mapped locations throughout New Jersey. Weekly, throughout the growing season, statewide spatial distributions of both pests were produced and distributed to growers via extension newsletters and websites to augment the current IPM outreach program in pest management.

Index Terms: Helicoverpa zea, Ostrinia nubilalis, GPS mapping, information delivery

Symposium and Poster Session

[0514] THE INSECTS COLLECTED BY THE COMISIÓN CIENTÍFICA DEL PACÍFICO: STUDYING BIODIVERSITY THROUGH HISTORICAL COLLECTIONS

<u>I. Izquierdo</u>¹, C. Martín¹ & C. M. Santos¹, ¹Departamento de Colecciones y Documentación. Colección de Entomología, Museo Nacional de Ciencias Naturales, c/ José Gutiérrez Abascal, 2. 28006 Madrid, Spain. E-mail izquierdo@mncn.csic.es.

The Comisión Científica del Pacífico is one of the most representatives Spanish scientific expeditions. This expedition travelled across different countries of South America between 1862 and 1866, with the aim of studying its Fauna and Flora diversity, as well as multiple ethnological and social aspects of the visited places. The zoological collections gathered by this expedition, which have been the object of several research projects, are kept in the Museo Nacional de Ciencias Naturales of Madrid since then. They constitute one of the most esteemed funds of the Museum due to their historical relevance and their high interest as an inestimable resource for biodiversity studies. This paper exposes an analysis of the results of this expedition from the entomological point of view, considering the value of this material as representative of sites and ecosystems that could be nowadays very altered by the human influence. The current situation of the insect material that has reached us is evaluated by giving data of the localities, specimens and species of each group, as well as type specimens, etc. The objective is to attract toward these collections the attention of taxonomists and specialists on Neotropical fauna whom could be interested on its study, especially on the unpublished material. Information on the access to this material through an ongoing project Servidor World Wide Web de las colecciones documentales y científicas de la Comisión Científica del Pacífico (1862-1866) is also given. The project takes advantage of the new communication, information and multimedia technologies for the diffusion of the Comisión travel and its results, using an interactive information server where catalogs of the funds (zoological, textual and iconographic) will be offered, and a virtual trip with pictures and situations of the expedition itinerary will be recreated.

Index terms: biodiversity, Neotropical Fauna, scientific expedition, entomological collections, World Wide Web server

[0513] MANAGING THE BIODIVESITY OF NORTHERN AUSTRALIA'S SEMI-ARID RANGELANDS: CHANGES IN ANT SPECIES COMPOSITION AND COMMUNITY ORGANISATION TO GRAZING GRADIENTS AND FIRE REGIMES

B. D. Hoffmann, CSIRO Wildlife & Ecology, TERC, PMB 44 Winnellie NT 0822 Australia, and N. T. Univ. Casuarina NT 0909.

Northern Australia's savannas are used primarily for cattle production. Unlike most southern Australian rangelands, the native vegetation is still relatively intact and there is a great potential to conserve biodiversity whilst managing the region for cattle production. But while much is understood about the effects of stocking rates and fire on cattle production, little is known about how these management decisions affect biodiversity. In particular, ants play pivotal roles in ecosystem function within Australia's rangelands. Here I report the changes in ant species composition and community organization to grazing gradients and fire regimes within the semi-arid ranglands of the Victoria River District (VRD) of Australia's Northern Territory. Two grazing gradients were sampled ranging from beside a point water source to 10km from water. 5 fire regimes of varying burning frequency and seasonality were managed in 1 ha plots for 5 years and sampled in the latter two years. Species richness and total abundance did not change significantly with grazing intensity, however, multivariate analysis showed that species composition changed markedly. Despite large changes in species composition, only six of the 24 most common species correlated significantly with grazing intensity. Likewise, limited ant responses were found to fire regimes of different frequency, intensity, and seasonality. The greatest factor influencing ants was weather, particularly rain just prior to sampling. No species were found only in a grazing and fire exclosure. The conservation of ant diversity within the VRD appears achievable with current cattle management pracitices.

[0515] PHYLOGENY AND BIOGEOGRAPHY OF THE GENUS PROCALUS (COLEOPTERA: CHRYSOMELIDAE)

<u>V. Jerez</u>, Departamento de Zoología, Facultad de Ciencias Naturales y Oceanográficas, Universidad de Concepción, Casilla 160-C.Concepción, CHILE, e-mail: <u>vijerez@udec.el</u>. Grant: 96.113.036-1.2

The genus Procalus is a small genus of flea beetles represented by nine species: P. mutans , P. viridis, P. lenzi, P. reduplicatus, P. malaisei, P. silvai, P. artigasi, P. ortizi and P. vilosensis. This genus is endemic to Austral South America associated to the genera of Anacardiaceae, Lithrea and Schinus. The area of distribution of Procalus and its host plants, is included in the ecoregion named Mediterranean zone or Central Chile. This area is characterized by a high percentage of endemic fauna and flora. The objectives of this article, are to test the monophyly of Procalus, to identify characters shared by two or more species within the genus and to discuss biogeographic distribution. In this work, a phylogenetic analysis of *Procalus* was done by Hennig 86 (Farris,1988) using morphological and biological characters of adults, eggs and larvae stage of all species. The cladistic analysis resulted in a parsimonious tree of 114 steps. (CI: 0.56, RI: 0.42). This allows to establish the monophylly of Procalus, supported by eight synapomorphies: (1) association with Anacardiaceae, (2) mandibles of males with a tuberculate mola, (3) sternite VIII of males with a fosete, (4) metafemoral spring simplified, (5) egg shell constituted by a simple extrachorion (6) mycropyle indistinct, (7) larvae with the anterior margin of labrum emarginate and (8) egg bursters present in mesothorax. By means of PAE (Parsimonious analysis of endemicity), it was determined that some species present large distribution ranges, comprising all the Mesomorphic zone of Chile; on the other hand, other species have more restricted distribution areas constituting endemic areas. It is hypothesized that the diversification of Procalus, could be due to speciation mechanisms generated in the last glacial period and that the current distribution of the genus could reflect in part their evolutionary history.

Index terms: Procalus, Anacardiaceae, phylogeny, biogeography, Chile

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[0516] MÜLLERIAN MIMICRY: CAN POLYMORPHISM BE STABLE ?

<u>M. Joron, Génétique et Environnement</u>, cc065, Univ. de Montpellier 2, Place E. Bataillon, 34095 Montpellier cedex 5, France, E-mail joron@isem.univ-montp2.fr, and The Galton Laboratory, University College London, 4 Stephenson way, London NW1 2HE, U.K.

Positive frequency dependence in warningly coloured insects imposes a potentially strong selection against new/rare variants, hence theoretically precluding the existence of stable polymorphism in such insects. Most aposematic insects and their Müllerian mimics are indeed monomorphic, but there are a few exceptions. The Amazonian butterfly Heliconius numata (Nymphalidae, Heliconiinae) is polymorphic over most of its range, some populations bearing an amazing 10 different forms, each of which is an accurate mimic of a separate species in the genus Melinaea (Nymphalidae, Ithomiinae). We studied how such polymorphism could be maintained in the face of purifying selection, both empirically and theoretically. Crosses between the 8 different sympatric and parapatric forms of H. numata from a small area of eastern Peru confirmed the existence of very tight linkage between different colour-pattern genes (previously suggested from Brazilian forms), and showed that the different super-alleles formed an almost linear polymorphic series. However, crosses and progeny from wild-caught females revealed 1) that some mimetic forms are stable heterozygotes, and 2) that dominance is more complete between sympatric forms than between parapatric forms, indicating that selection for accurate mimicry is indeed acting. Tight linkage of colour genes is not expected in Müllerian mimics, and the evolution of supergenes is discussed. Field collections of H. numata and Melinaca spp. over three years suggested that the mimetic environment (the locally most common aposematic pattern) is very variable spatially, but apparently not temporally. Variability in selection pressure is therefore a likely cause of polymorphism in H. numata. Data are confronted to previous studies in H. numata and other systems. Although this study and data from the literature suggest that the selection against non-mimetic forms is indeed strong (ca. 10% in Heliconius erato in the same area of Peru), we propose that selection acts on numbers and not frequencies, and the analysis of a number-based selection model reveals that selection is rather small once a particular threshold is passed; this implies that polymorphism once evolved could be slow to remove.

Index terms: Heliconius numata, Melinaea spp., warning colour, supergene, spatiotemporal variability. [0518] AN APPROACH TO THE KNOWLEDGE OF THE BIOGEOGRAPHICAL HISTORY OF THE BEE GENUS *CALLONYCHIUM* (HYMENOPTERA: ANDRENIDAE) IN SOUTH AMERICA

L. Ruz ¹, ¹Laboratorio de Zoología, Sección Entomología, Universidad Católica de Valparaíso, Av. Brasil 2950, Valparaíso, CHILE, E- mail: lruz@ucv.cl.

Callonychium, a monophyletic group of solitary bees includes, up to now, 21 species. The range of distribution of this Neotropical genus goes from Ecuador to the Patagonia (Andean-Patagonian Domain), spreading out west to the Andes through desert areas of the northern regions and central Chile; east to the Andes into the whole Chaco (mostly Argentina) and in the Amazonian Domain (Paranense and Cerrado Provinces in Brazil. Distributional data has been obtained from collections of South and North American museums, which were recorded, mapped and analized, although information for several species is parcial and scarce. A previous cladistic analysis performed for the genus showed the relationships among the species and the diferenciation of two main clades. Relevant vicariant events such as the formation and uplift of the Andes, as well as geological factors and glaciations have apparently had an important effect on the biogeographic history of these organisms, among which some distributional patterns and endemisms have been recognized. It is interesting to notice that the greater species diversity of Callonychium is found in the xeric area of the Chaco Domain; only species of the subgenus *Paranychium* are present toward the west slope of the Andes occupying endemic areas, although several species of this subgenus also extend into the Chaco. On the other hand, the species of the sub genus Callonychium s, str. are distributed toward the east of the Andes ; only two Brazilian species have been recorded separately for the Paranense-Pampeana and Cerrado-Caatinga Provinces. Biogeographical studies on South American insects performed in the past have never considered bees in particular, except for some local studies in Brazil. Besides, most of the current biogeographical investigations on insects have been carried out in relation to Patagonian species, in cold places where most of bees are not present. This is the first attempt to study the distributional pattern of a group of Apoidea for a better understanding of its biogeographical history. Vicariant analysis, still in process, however, have not been conclusive yet, due to some polytomous relationships showed in the phylogenetic tree.

Index terms: Vicariance, distributional patterns, Neotropic, Apoidea

[0517] GEOGRAPHICAL VARIATIONS IN DELTOCEPHALINE LEAFHOPPERS (HOMOPTERA, CICADELLIDAE) IN EAST ASIA

<u>S. Kamitaui</u>, Entomological Laboratory, Faculty of Agriculture, Kyushu University, Fukuoka 812-8581, Japan, E-mail kamitani@agr.kyushu-u.ac.jp.

Geographical variations in two deltocephaline species complexes, Deltocephalus ogumae complex and Recilia heuksandoensis complex, were studied. These are very similar to each other in appearance, and both are distributed in East Asia including Southeast Asia. The host plants of both complexes are small undergrowth, Oplismenus undulatifolius and O. compositus (Poaceae), which are very common in East Asia. The semi-brachypterous wing form of deltocephaline species seems to indicate their less dispersal ability, hence susceptible to the influence of geographical isolation. The purpose of this study is to clarify the geographical variations in the deltocephaline species complexes in East Asia, especially in the Ryukyu Islands, and to analyze the evolutionary process with phylogeny. Materials were collected from the mainland of Japan, the Ryukyus, Taiwan, Java and Sulawesi. In D. ogumae complex, three morphological character states on aedeagus were observed, and two states on male subgenital plate were observed. The distributional pattern of these characters was not well consistent. In R. heuksandonensis, four states on aedeagus were observed, although this species complex was collected only from four restricted localities. Thus, these species complexes have unique geographical variations influenced by the global warming after the Wurm great ice-age. Index terms: geographical variation, Cicadellidae, East Asia

[0519] POPULATIONAL FLUCTUATION OF THE CITRUS LEAFMINER PHYLLOCNISTIS CITRELLA (LEPIDOPTERA: GRACILLARIDAE) IN THE PIEDMONT OF THE DEPARTMENT OF META

<u>G. A. León M.</u> & J. C. Campos P., Centro de Investigación La Lebertad, CORPOICA, A.A. 3129 Villavicencio, Colombia. E-mail: gleon@corpoica.org.co

From october 1996 to october 1998, it was carried out a study to determine the populational levels and the incidence times of the citrus leaf miner *Phyllocnistis citrella*, in two citric producers regions, belonging to Acacias and Restrepo municipalities, which are representatives of the Piedemonte of the Meta Department. Results shows a slightly bigger incidence of the pest in the locality of Acacias without statistical significal difference, then is concluded that a similar tendency in populational behavior at the two localities was founded. During july, august and november it was detected the biggest populational levels of the pest at the two localities. The smaller levels of population are presented during the months of january, february and march period that coincides with the time of smaller precipitation in the two areas. It was detected a direct relationship between populational levels and the percentages of natural parasitism of the pest only in Restrepo, but not in Acacias.

Index terms: Populational dynamics; citrus pest; pest-natural enemies relationship.

[0520] LEAF LITTER ANT AND TERMITE DIVERSITY IN IGUASSU AND RIO PILCOMAYO NATIONAL PARKS, ARGENTINA

<u>M. Leponce</u>¹, L. Theunis^{1,2} & Y. Roisin², ¹Royal Belgian Institute of Natural Sciences, Conservation Biology Section, rue Vautier 29, B-1000 Brussels, Belgium, E-mail Leponce@kbinirsnb.be, LTheunis@kbinirsnb.be; ²Université Libre de Bruxelles, CP 160/12, Dept. Animal Biology, 50 av. F.D. Roosevelt, B-1050 Brussels, Belgium, yroisin@ulb.ac.be.

Standardized methods of data collection are essential for large-scale comparisons of biodiversity distribution. We combined standardized protocols for collecting ground living ants and termites. Along 200m long transects, 3 samples were systematically taken every 10m: 1 leaf litter sample (1m² of leaf litter sifted and placed in a mini-Winkler extractor), I pitfall sample, and I soil sample (Agosti 1997). Additional termites and ants were collected in 20 contiguous 5 m x 2 m sections along the transects where every stump, log, or twig was investigated (wood samples) and where hand collection was performed (Eggleton et al. 1995). Our aim was to evaluate the efficacy of this inventory technique and the effect of habitat dryness on faunal organization in subtropical forests of Argentina. We collected in two contrasted habitats separated by 400 km along the 25th degree of latitude South : the semi-evergreen rainforest of Iguassu National Park and the xerophilous forest of Rio Pilcomayo National Park. Three transects separated by 2 - 10 kms were conducted at each site. Leaf litter samples yielded most of the ant species : 68 and 74 species were identified in Iguassu and Pilcomayo, respectively (23 species shared). Termites were also more abundant in Pilcomayo (16 species) than in Iguassu (8 species) (no species shared). The former site was especially richer in wood feeding species (9 vs. 2 species). The ant faunal similarity (Jaccard index) between transects and between samples within a transect suggests a greater heterogeneity of the ant fauna in Pilcomayo than in Iguassu. For termites, the faunal similarity between transects in both sites was generally I dow (average laccard index = 0.25). A good concordance was found between transects in the ranking of ant species according to their occurrences in the samples. These results indicate that the species richness patterns are markedly different between termite and ants. If the species accumulation curves (best fitted by the equilibrium model of island biogeography) show that 3 transects per habitat are unsufficient for reliably estimating the total species richness of both taxa in both sites, it appears however that one transect already gives a fair idea of the relative ranking of ant species.

Index terms: Formicidae, Isoptera, standard protocols, semi-evergreen forest, dry forest.

[0522] OCCURENCE OF LEAF-CUTTING ANTS IN DIFFERENT REGIONS OF RIO GRANDE DO SUL STATE

A. E. Locck¹, D. D. Grützmacher¹, A. H. Medeiros¹ & R. da S. Borba¹, ¹ Dept. of Fitossanidade, Univ. Federal of Pelotas, C.P. 354, Pelotas, RS CEP: 96.010-900, Brasil, E-mail alcienim@ufpel.tche.br

A survey in 282 counties among seven different regions in Rio Grande do Sul State was done to identify the occurrence of the leaf-cutting ants, to know the predominant species in each region and to verify their geographical distribution. Ants from 10,744 samples were identified, being observed 11 species: Atta sexdens piriventris Santschi, 1919; Acromyrmex laticeps (Emery, 1905); Acromyrmex crassispinus (Forel, 1909); Acromyrmex heyeri (Forel, 1899); Acromyrmex lundi (Guerin, 1838); Acromyrmex ambiguus (Emery, 1887); Acromyrmex striatus (Roger., 1863); Acromyrmex lobicornis (Emery, 1887); Acromytmex coronatus (Fabricius, 1804); Acromytmex landolti balzani Emery, 1890 and Acromyrmex aspersus (F. Smith, 1858). The most frequent species were Atta sexdens piriventris and A. laticeps, representing 62 % of the studied samples, and found in all regions. However, according to the region their distribution varied from very abundant to rare like Atta sexdens piriventris that occurred in almost every county in Planalto, Alto Uruguai, and Noroeste regions. In Sul and Campanha regions A. sexdens piriventris was found only in a few counties in a low frequency, while A. ambiguus, A. heyeri and A. lundi were found in a high frequency. A. crassispinus occurred in all studied regions, with frequency higher in the Serra region, while A. laticeps, predominated in Serra, Alto Uruguai, Planalto and Noroeste regions. The species, A. aspersus, A. coronatus and A. landolti balzani occurred rarely in isolated points. In Depressão Central region, considered as a transitional one for delimiting with east, south and north regions, the highest number of species was found, with various predominance. The variation in percentage of species found in different regions may be explained by soil type, crop system and existing vegetation, being necessary a more detailed regional study. In general, leaf-cutting ants are controlled in a similar way. However, considering the differences among the species in habit, nest, specificity of leaves cutting and geographic delimitation, some factors should be considered and they justify specific control techniques. This work cooperates in identification, regionalism and quantification of the important leaf-cutting ants species that occur in Rio Grande do Sul State. Index terms: Leaf-cutting ants, Acromyrmex, Atta, geographical distribution.

[0521] MONITORING REGIONAL AND GLOBAL CHANGES IN BIODIVERSITY: CHALLENGES FOR ENTOMOLOGISTS IN THE 21ST. CENTURY

T. M. Lewinsohu^{1,2}, ¹Lab. Interações Insetos-Plantas, Depto. Zoologia, Inst. Biologia, UNICAMP, C.P. 6109, CEP 13081-970, Campinas, SP, Brasil. E-mail: thomasl@unicamp.br; ²Conservation International do Brasil, Belo Horizonte, MG.

The last decade has seen a major shift in focus of conservation initiatives from the concern over the fate of a select group of endangered taxa or emblematic species, to an awareness of the necessity of conserving and managing entire communities within their regions and preserving ecosystem functions and services. Surprisingly - to politicians but certainly not to scientists - there are as yet no established procedures to assess unequivocally the current status or ongoing changes in the world's biodiversity. Following on the Rio-92 Convention on Biological Diversity, several initiatives are attempting to deal with this necessity. Here I will outline a recent enterprise spearheaded by the Center for Applied Biodiversity Science of Conservation International. After a brief presentation of the general goals and strategy of the project, I will concentrate on issues that are especially relevant to entomologists. The CABS/CI undertaking focuses on areas of high biodiversity value (species richness, endemism, at high risk), hence on recognized hotspots; primary targets are a set of tropical forests on different continents which should expand ultimately to a worldwide network. The main goal is to enable the assessment of quantitative, structural and functional changes in biodiversity and to ascribe these changes to major impact agents. Reliable measures of biodiversity change and dependable assignment to actual causes are necessary both as monitoring tools and as arguments to provoke political and economic action. Towards this end, it is necessary to make use of existing data, infrastructure and analytical tools, as well as choosing an efficient set of biological indicators for ongoing measurement. This entails the integration of intensive, site-specific monitoring and research with regional surveys and remote sensing, Entomologists have a particularly challenging task in this program and in other enterprises with similar purposes. In areas of high diversity, even the basic surveying and taxonomy is yet to be done; thus, fundamental work has to be carried out almost in parallel with its application. Since all encompossing taxonomic coverage is unfeasible, focal groups and field methods have to be selected carefully, based on issues of expediency such as ease of collecting, current state of the taxonomy, capacity etc; but also on the information content of the resulting data. Alternatives to taxonomic groups as standard units for surveying have to be appraised; for instance, assemblages with clear functional assignments (e.g. soil organisms) or readily identified links to particular resources or habitats (such as animal or plant hosts) may prove more informative than much larger but mass-collected sets of organisms.

[0523] DISTRIBUTION OF THE GENUS ADELPHA (LEPIDOPTERA: NYMPHALIDAE: LIMENITINAE) IN THE AMERICAN CONTINENT

R. A. Di Mare^{1,2}, J. A. Teston^{1,3} & E. Corseuil^{3,4}, ¹ PPG-Biociências PUCRS, Av-Ipiranga, 6681, Caixa Postal 1429, CEP 90619-900, Porto Alegre, RS, Brasil; ² Depto. Biologia, CCNE, UFSM, Camobi, Santa Maria, RS, Brasil, E-mail: ram13@zaz.combr, ⁴ E-mail: jateston@pucrs.br,⁴ E-mail: corseuil@pucrs.br

The Adelpha genus is distributed from USA to Uruguay and 50% of the species can be found in Brazil. So far few studies were performed with this group, although these butterflies are common. One reason is the difficulty of working with their small and sparse natural populations. The populations dynamic is not very well known either. It can be also related to the difficulty of settling down a phylogenetic pattern of these species. Coloration and venation patterns of wings, genitalia, or combination of these, were already tested, but the result were always conflicting and chaotic. In spite of the difficulties, they are suitable to studies with evolutionary interests, because of the conservatism of the pattern of coloration of the wings, similarity among species of distant distribution, and absence of this pattern among sympatric species. Mimetic relationships among species of this genus and others, like Doxocopa, are until now ignored, as well as studies related with the palatability. The species are opportunistic and polyphagous, since its use 5 orders, 16 families and about 56 plants species, registered until now, with a preference for Rubiaceae Some species like as A. cocala and A. iphiclus can use up to eight different host plants This work makes a revision of the host plants used and distribution by the species of the genus. The work is based in the following Adelpha species: abia, alala, anfidia, arete, aricia, attica, barnesia, basileia, basiloides, bocotia, boreas, bredowi, caliphiclea, calliphane, caphira, celerio, cestrus, cocala, collina, corcyra, coryneta, cytherea, deborah, delenita, delphicola, demialba, diocles, donysa, epione, epizygis, erotia, erymanthis, escalantei, ethelda, euboea, falcipennis, felderi, fessonia, gavina, gilletella. goyama, heraclea, herbita, hyas, incomposita, iphiclus, irma, irmina, isis, ixia. jacquelinae, jordani, justina, lapitha, lara, lerna, leuceria, leucerioides, leucophthalma. makkeda, massilia, melanthe, melona, mesentina, milleri, mincia, mythra, naxia, nea olynthia, paraëna, phliassa, phylaca, pithys, plesaure, poltius, pseudococala, rothschildi, salmoneus, saundersii, seriphia, serpa, sichaeus, stilesiana, syma, thesprotia, thessalia, thoasa, tracta, valentina, velia, ximena, zalmona, zea, zina and zunilaces. Index terms: Biogeography, Checklist, Host plants, Systematic.

Index terms: surveys; indicators; global change; biodiversity loss.

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[0524] PREDICTING SPECIES RICHNESS BY ASSESSING THE SAMPLING EFFORT: THE CASE OF THE IBERIAN DUNG BEETLES (COLEOPTERA SCARABAEINAE)

<u>F. Martín-Piera</u>^{1*} & J. M. Lobo^{1**}, ¹Dept. Biodiversidad y Biología Evolutiva (Entomología), Museo Nacional de Ciencias Naturales (C.S.I.C.), c/ José Gutiéπez Abascal, 2; 28006-MADRID (SPAIN), e-mail: ^{1*}fermin@mncn.csic.es; ^{1**}mcnj117@mncn.csic.es.

Recommendations for conservation of areas, based on predictions from species richness 'hot-spots', can be seriously biased if the effect of sampling effort is overlooked. Samplingeffort skewing can be reduced by using a defined sampling-effort unit, and, as proposed herein, by taking the number of database records per spatial unit as a measure of such effort. The geographic distribution of Iberian dung beetle species richness is predicted using several environmental variables as surrogates of biodiversity. Before elaborating a function to predict Iberian species richness, spatial variability of the sampling effort was assessed on a scale of 50 km UTM grid squares. For which firstly, physiographic subregions were defined by climatic variables (annual mean temperature, annual temperature variation, annual days of sun, total annual precipitation, total summer precipitation and annual precipitation variation) as well as mean elevation and altitudinal range. Secondly, to search for the well-prospected areas the asymptotic relationship between the added number of species at different levels of sampling effort were investigated. Then, the pool of well-surveyed UTM squares in each subregion was established by means of a ranking of the recording effort required for an arbitrary rate species increment. Eighty two squares (32.2%) were thus recognised as adequately sampled. Twenty four variables (two spatial, two geographic, four topographic, three geologic, eight climatic, and five land use) along with interaction terms, for this 82 squares, were used to generate the species richness geographic distribution model. Final model account for more than 65% of the species richness variability. Species richness 'hotspots' are concentrated mainly in Mountainous subregion, particularly in the Pyrenees and Iberian Central System, and in a few grid squares in the North and South Plateau of Central Spain.

[0525] FLIES AS A BIOINDICATOR FOR BIODIVERSITY LOSS IN AGRICULTURAL LANDING USE SYSTEMS

<u>M. Martins</u>, ¹, M. C. Esposito² & R. Santos², ¹Museu Paraense Emílio Goeldi, Dept. of Zoology, P. O. Box 399, Belém, Pará, Brazil 66040-170, E-mail marlucia@museugoeldi.br ²Univ. Federal do Pará, Box 479, Belém, Pará, Brazil 66075-900, BR, E-mail esposito@amazon.com/br rcos@ufpa.br.

The recent literature has been discussing about the validation to use bioindicator species in order to predict the biodiversity changes related to replacement of primary forest for landing use. Lawton et al (1998) show that no one groups serve as a good bioindicator taxon for changes in the species richness of other groups. In this project, we study some saprofagous flies families to understand the effect of substitution of primary forest liabitats by subsistence agricultural systems over this guild. We are looking for the changes in richness, composition and relative abundance of species. In terms of composition there are two kinds of changes expected: First, the disappearance of very sensitive species, characteristics of primary forest, and, second, the increasing number of invasor species, correlated to anthropic disturbation. Our collections were carried on Igarapé-Açú city, in secondary forests patches around small plantations. We used attractive traps, disposed in sorted points along sites with regrow ages from 2 to about 50 years old. The present data pointed to a fauna impoverishment of about 50 per cent for blow flies and 80% for fruit flies, when compared to inventories realized on the other studies areas, in primary forest habitats. Chrysomya putoria, C. albiceps, and Drosophila. malerkotliana were the invasor species observed in the area. All these species invaded the Amazon region in the 70's coming from Africa and the Malaysian region. The fly's species remnants of primary forestry were D. willistoni and D. sturtevanti (Drosephilidae), and Eumesembrinella quadrilineata and Mesembrinella bicolor (Calliphoridae). These species represented 32% of all individuals collected in the area. The other hand, the invasor species summed 59% of this collection. The rest of individuals belong to more generalist's native species, commonly present in forest and open areas. The similar responses observed for species of different genus and families, and the general diversity patterns and abundance distribution in these flies, indicate that the guild approach, like this saprofagous flies, could be useful in the biodiversity studies. However, the validation of these focused groups as a bioindicator needs more detailed investigation and depends on the consolidation of efficient evaluation protocols, which also has been tested in this project. Index terms: Drosophilidae, Calliphoridae, saprofagous guilds, invasor species

[0526] FACTORS AFFECTING TERMITE DISTRIBUTION AND DIVERSITY IN NATURAL AND MANAGED CENTRAL AMAZONIAN FOREST ECOSYSTEMS

C. Martius¹, ¹ Center for Development Research (ZEF Bonn), Walter-Flex-Strasse 3, D-53175 Bonn, Germany, E-mail: c.martius@uni-bonn.de

Termites are the most dominant group of decomposers organisms in soil arthropod assemblages in tropical rainforests. Litter and soil termites were collected in a primary forest site, a secondary forest site and two sites of a polyculture plantation system in central Amazonia. Termite genus diversity, abundance and biomass all were highest in the primary forest. The values in the secondary forest were half those of the primary forest, and they were lowest in the plantation systems, indicating that the latter sites may suffer from functional constraints concerning the process of organic residue decomposition. The average termite biomass of the sites was positively correlated to dead wood volume on the forest floor, but the termite biomass of the individual samples was not related to the wood in the litter layer of the sample. The possible correlation to other factors is discussed. In a second study, nest-building termite density was recorded in undisturbed primary forest site, and compared to the density in forest sites subject to selective logging. Only one genus, Nasutitermes, showed a (positive) correlation to increased logging impact, indicating that it is a group of species that follow forest disturbance. The implications of these findings for monitoring programs and for ecosystem management are discussed. Index terms: Isoptera, distribution, diversity, agroforestry, land use systems

[0527] A COMPARISON BETWEEN RECONCILIATED TREES, DISPERSE-VICARIANCE AND PARALOGY FREE BIOGEOGRAPHIC SCHEMES

D. R. Miranda-Esquivel¹, **M. Donato² & P. Posadas**², ¹ Escuela de Biología. Universidad Industrial de Santander. AA 678, Bucaramanga, Colombia. E-mail: dimiranda@uis.edu.co.² Laboratorio de Sistemática y Biología Evolutiva (LASBE), Museo de La Plata, Paseo del Bosque, 1900 La Plata, Argentina.

Proliferation of methodological schemes is a common place in present day biogeography. Many of those approaches have not been tested against the other approaches. The last comparison was conducted in 1994 by Carpenter & Morrone but new approaches as Disperse - Vicariance Analysis and Paralogy free sub- trees has been developed during the last 10 years. Our goal is to compare those approaches against reconcilied trees analysis, a common biogegraphic technique, using 12 biogeographic units of southern South America applying on 12 supraspecific taxa of arthropods and vascular plants for which phylogenetic analysis were available. The analyses show that dispersal could be a very common event, even more frecuent than vicariance. Dispersal could interfere with those reconstructions based on the premise that vicariance is the only or the more frecuent process. Paralogy free sub- tree analysis could be a solution to reconciliated trees but dispersal could also obscure this technique. To tackle the dispersal problem we propose to evaluate the dispersion events as depicted by the cladogram and to eliminate those event from the reconcilied trees analysis.

Index terms: Biogeography, Phylogeny, Southern South America

[0528] A CLADISTIC ANALYSIS OF NEOTROPICAL, ETHIOPIC AND AUSTRALIAN SUBGENERA OF THE GENUS SIMULIUM (DIPTERA:SIMULIIDAE)

D. R. Miranda-Esquivel¹ & S. Coscarón², ¹ Escuela de Biología. Universidad Industrial de Santander. AA 678, Bucaramanga, Colombia. E-mail: dmiranda@uis.edu.co. ² Museo de La Plata, Paseo del Bosque, 1900 La Plata, Argentina.

A phylogenetic analysis of Neotropical, Ethiopic and Australian subgenera of the genus *Simulium* was undertaken using 46 terminal taxa (ingroup = 42 taxa and 4 outgroups used simulitaneously) and 201 characters from larval, pupal and imago morphology, along with one ecological character. Multistate characters were coded as unordered. Two analyses were conducted: equal weights and implicit weights. To select the optimal concavity value we used the PC value. For the final cladogram the relative Bremer support was calculated. The cladogram shows that neotropical taxa are not a monophyletic taxon. There a monophyletic unit groping together *Xenosimulium*, *Freemaniellum*, *Anasolen*, *Hearlea*, *Hemicnetha*, *Thyrsopelma* and *Thrichodagmia*, this monophyletic unit is closed related to the other Neotropical taxa. The other Etiopic/Australian taxa form the other monophyletic unit.

Index terms: Phylogeny, Implicit weights, Monophyly

[0530] CICADA DIVERSITY IN BRASÍLIA, BRAZIL

P. C. Motta, Dept. of Zoology, Univ. of Brasília, 70910-900, Brasília, DF, Brazil. E-mail mottape@unb.br.

The annual appearance of cicadas (Hemiptera: Homoptera: Cicadidae), with their exuviae shed on tree trunks and their characteristic acoustic signals, from the middle of September until December, is so intense in Brasilia that it even becomes an obligatory subject in the local media. Despite their abundance and eloquence, there are no studies over them. Diversity and population dynamics studies of cicadas may be made by using their exuviae. The objectives of this study were to verify the differential emergence periods, abundance and the sex ratio of cicadas which occur in an urban area of Brasília. In all, 33 samplings were made, from September 10th, 1999, until January 5th, 2000, within a transect of 3.5 km by 16 m in an urban area of Brasilia (Asa Norte), where 292 trees were visited, and the exuviae were collected up to a height of 2.5 m on the trunk. A dichotomous key was prepared to identify species from their exuviae. The secure identification of species awaits confirmation. The exuviae began to emerge from the soil during mid-August, at the peak of the dry season. The number of individuals increased a great deal at the end of September and the beginning of October, coinciding with the first rains. In this period the intense and simultaneous vocalizations also begin. October is the month with the greatest number of exuviae. A total of 11800 exuviae were collected, representing 9 cicada species, the most abundant being Dorisiana viridis (57%), Quesada sp. (20%) and Quesada gigas (14%). The remaining species (9%), were Fidicina mannifera, Fidicina pronoe, Fidicina sp., Dorisiana drewseni, Dorisiana sp. 1 and Dorisiana sp. 2. Quesada gigas is most frequent from September until the middle of October, while all others being so in October. The proportion of males in the sex ratio is greater for *Dorisiana viridis*, while females are more abundant for Quesada gigas and Quesada sp. The number of exuviae on trees with rough bark is greater than on trees with smooth bark. It is estimated that eight hundred thousand to one million cicada individuals occur per year, between the months of September and November, in Brasília.

Index terms: Quesada, Dorisiana, Fidicinna, Cicadidae, exuviac

[0529] NEOTROPIC BIOGEOGRAPHY: A PERSPECTIVE FROM SIMULIIDAE TAXA

D. R. Miranda-Esquivel, Escuela de Biología. Universidad Industrial de Santander. AA 678, Bucaramanga, Colombia. E-mail: dmiranda@uis.edu.co.

Neotropic is a complex biogeographic area. Most of the biogeographic reconstructions are based in terrestrial organisms and the fresh water organisms have been not used extensively to test the relationship between the endemism areas. In This analysis a biogeographic study of the Neotropical Simuliidae endemism areas was conducted using nine phylogenies and 16 biogeographical units. The analysis was done in two steps, first a taxon biogeography approach to evaluate the ancestral area and the dispersal events for each supraspecific taxon using the dispersal-vicariance scheme. Second a cladistic biogeographic approach using reconciliated trees but eliminating those dispersal events evaluated during the first step. The results show a high level of dispersal between SE Brazil and Cerrado and between the Mountains of Mesoamerica and the Pacific region. Those dispersal events could interfere with previous reconstructions. The reconciliated tree shows the sequence (Neartic (Mountains of Mesoamerica (Pacific Caribean (Yunga, North Andes (Desert (Puna (Patagonia (Monte (Subantartic, Central Chile) (SE Brazil, Cerrado) (Guyana, Amazonia). This sequence is congruent with previous proposals using terrestrial organisms.

Index terms: Dispersion-vicariance, Reconciliated trees, Ancestral Area, Phylogeny.

[0531] THE ALL TAXA BIODIVERSITY INVENTORY IN GREAT SMOKY MOUNTAINS NATIONAL PARK

B. Nichols, United States Department of the Interior, National Park Service, Great Smoky Mountains National Park, 1314 Cherokee Orchard Road, Gatlinburg, Tennessee 37738, USA. becky_nichols@nps.gov

Great Smoky Mountains National Park, in Tennessee and North Carolina, USA, comprises more than half a million acres and contains some of the richest and most diverse floral and faunal communities in the temperate world. Past inventories of these communities have not been comprehensive, and fewer than 10,000 (10%) of an estimated 100,000 species in the Park are known. Existing and impending threats to this area include invasion by exotic species, air pollution, and forest diseases. Protection of natural resources from these threats requires management methods that could be enhanced by information on the identity and status of resident species. The need for such information led to the inception of an All Taxa Biodiversity Inventory (ATBI) in the Smokies. This comprehensive inventory will involve all life forms and is expected to take 10-15 years. The project will be funded through Discover Life in America (DLIA), a non-profit, volunteer, science and education organization which will direct the operation and secure funding." The Park and DLIA will form a cooperative agreement to conduct the inventory. The first pilot field season (1999) has been successful, and it inspired considerable public interest and press exposure, both regional and national. Among the taxonomic groups that were studied are flies, ants, fungi, crustaceans, diatoms, slime-molds, and small mammals. Additional funding has been acquired for work to begin on other groups, including worms, spiders, crayfish, ectoparasites, moths, plants, and remaining vertebrates. The project already has discovered previously unidentified species and many new distributional records. This type of scientific survey has never been undertaken on such a scale anywhere in the world, and it will serve as a model for future projects in other national parks and protected areas. Gaining a better understanding of natural communities, species distributions, and interactions will allow for better management and provide a critical knowledge base for responding to threats.

Key words: diversity, taxonomy, education

[0532] INSECT INDUCED GALL DIVERSITY IN COIBA NATIONAL PARK (PANAMA)

J. L. <u>Nieves-Aldrey</u> ¹& A. Ibañez², ¹Museo Nacional de Ciencias Naturales (CSIC), Dpto Biodiversidad. C/José Gutiérrez Abascal 2, 28006 Madrid (España), E-mail aldrey@mncn.csic.es; ²Real Jardín Botánico (CSIC), Plaza de Murillo,2. 28014 Madrid (España), E-mail alicia@mundivia.es.

The Coiba National Park, in the Pacific Ocean, is located in Veraguas province at the SW of Panama Republic. The terrestrial habitats of the National Park, mostly mangrove and rainforest ecosystems, are well preserved because of the existence since 1920 of a Penal Colony in Coiba, the park largest island. Since 1993 scientists from Panama and Spain are carrying out a Flora and Fauna inventory research project, and preliminary results have been compiled in a book published in 1997. Here we present the results of the inventory of the galls induced by insects and acari on flower plants in the National Park. Field data come from irregular sampling between August 1997 and September 1999 with three (twoweeks long) more intensive samplings in August 1997, July 1998 and August 1999. Seventeen sites, representing the main terrestrial habitats of the National Park were surveyed with intensive sampling in 7 localities. The preliminary list of galls from Coiba comprises 59 different galls from 43 plant genera and 29 botanical families. Bignoniaceae demostrated to be the most galled plant family with seven galls, accounting for about 12 per cent of total. In decreasing order others most galled plant families were: Myrtaceae, Euphorbiaceae, Guttiferae, Fabaceae, Melastomataceae and Moraceae. Leaf galls accounted for about 90% of the collected galls. Most leaf galls were pit/blister galls followed by covering and pouch galls. The identification of the gall-inducing taxa found mite galls (Acari: Eriophyidae) and among insect galls, gall midges (Diptera: Cecidomyiidae) and Psylloidea and Coccoidea galls (Homoptera). A first identification indicates that an important number of the Coiba gallicolous species can be undescribed. The gall richness per collecting site was between 3 and 12 species, showing, at the richest places, to be higher than predicted for such mesic-tropical-island habitats. Coiba gall diversity is discussed related to available data from other tropical and temperate sites. Index terms: Galls, Cecidomyiidae, Psyllidae, Eriophyidae, richness

[0533] HYMENOPTERA FROM "EL VENTORRILLO" (CENTRAL SPAIN): AN EXAMPLE OF HIGH ABUNDANCE AND RICHNESS AT THE LOCAL GEOGRAPHIC SCALE

J. L. <u>Nieves-Aldrey</u>, Museo Nacional de Ciencias Naturales (CSIC), Dpto Biodiversidad. C/José Gutiérrez Abascal 2, 28006 Madrid (España), E-mail aldrey@mnen.csic.es.

The Biological Research Station of "El Ventorrillo" is located at an altitude of 1500 m, on the south slope of the Sierra de Guadarrama (central Spain), about 60 km far from Madrid. Between 1988 and 1991 an insect biodiversity inventory was carried out using Malaise and yellow pan traps. Out of the near 1,000,000 insects trapped, the Hymenoptera represented more than 70,000 individuals. The abundance of Hymenoptera, as measured by Malaise trap catches, was very high, reaching a peak of 916 individuals per trap day at the most productive trap and sampling period. Until now eighteen hymenopteran families have been identified to species level accounting for 1071 species. Among the identified families, the more speciose at the study area were in decreasing order: Pteromalidae, Ichneumonidae, Eulophidae and Tenthredinidae, all of them surpassing 100 species. The richness of the 29 remaining families at the area of study was estimated extrapolating regional richness data from some countries in Europe. The global Hymenoptera richness at El Ventorrillo is estimated in 1700 species, representing 18% of the overall Iberian Hymenoptera richness, expected to be near 10,000 species. The hymenopteran numbers at the study area are compared with other local richness data from Spain and other sites in Europe and America. The comparatively high abundance and richness figures at El Ventorrillo, from an area less than 0.5 square kilometres, could be explained by its central geographic position in Iberia, the relative high altitude, favourable orientation and its rich floristic composition.

Index terms: Biodiversity, Malaise traps, local richness, inventory

[0534] DISTRIBUTION PATTERNS OF ANTS IN EAST ASIA (HYMENOPTERA: FORMICIDAE)

K. Ogata, Institute of Tropical Agriculture, Kyushu University, Fukuoka 812-8581 JAPAN

Recent taxonomic studies of ants in East Asia have clarified the biodiversity and suggested the utilization them as bioindicators. The purpose of the present study is to review a biogeographical attribute of ants in East Asia and to give basic information in comparing and assessing the local ant communities. There are about 200 species distributed in Japan excluding the Ryukyus and Korean Peninsula. The present study analyzes their distributions and classifies the patterns based on 2 factors: geographical range and temperature. According to the geographical, the ants are grouped into 3 major categories: 1) endemic to Japan and/or Korea (N: narrow); 2) East Asia (I: intermediate); 3) over the range of East Asia (W: wide). To see the aspect of temperature factor affecting the distribution, Warmth Index (WI) is used representing a kind of accumulative temperature calculated by a sum of average temperature of months over 5 °C. According to WI, the distributed area of ants is divided into 3 categories: 1) WI less than 85 °C (c: cold); 2) WI between 85 °C and 110 °C (t: temperate); 3) WI more than 110 °C (w: warm). Thus the distribution patterns can be presented in a 3 x 3 matrix table (N/I/W x c/l/w). In terms of thermal range of distribution, 6 patterns can be distinguished: 1) c zone; 2) t zone; 3) w zone; 4) cooler zone (n: c + t zones); 5) warmer zone (s: w + t zones) and 6) all zones (a). Based on this classification, the distributions of ants are divided into 18 patterns. Among them, the species having narrow distribution range are most abundant occupying about 40 %. The number of species in WI categorization shows temperature gradient (c zone=12 spp., t zone=16 spp., w zone =47 spp.). It should be noted that the species having wide range of geographical distribution tend to introduce new environment easily. The local study on ants in old and new urban parks shows that the species of the categories Ws and Ww will enlarge their distribution.

Index terms: Ants, Japan, Korea, temperature

[0535] BUTTERFLY DIVERSITY IN SERRA DO CIPÓ, BRAZIL: A RELIMINARY SURVEY

<u>E. G. Oliveira</u>¹ & G. W. Fernandes¹, ¹Departamento de Biologia Geral, Instituto de Ciências Biológicas, Universidade Federal de Minas Gerais, 30161-970, Belo Horizonte, MG, Brazil, E-mail evandro@mono.icb.ufmg.br.

Serra do Cipó is located in the southernmost portion of the Espinhaço Mountains, a high altitude mountain range in southeastern Brazil. It harbors one of the most diverse ecosystems in the world with high degree of floral endemism and morphological convergence. Low soil fertility, prolonged dry season, strong winds, and other harsh environmental conditions, which strongly influence its flora and fauna, characterize the region. In this scenario, we would expect to find a relatively poor butterfly fauna. On the other hand, due to its speciose flora and because the region has never been properly surveyed, we would also expect to find rare and new species. In an attempt to address these questions, for the first time we have sampled the butterflies in the region by (i) direct netting and (ii) trapping using rotting fruits as bait. During the first three months of this study, we have collected butterflies belonging to all common subfamilies, and the preliminary list of species suggests that its diversity may be higher than previously postulated. We have also recorded migration (i.e., unidirectional flight) events, which had not been previously studied in the region. Migration of Pieridae was observed in several occasions indicating that this is a common phenomenon in the region.

Index terms: Lepidoptera, species composition, mountain habitat, migration

Symposium and Poster Session

[0536] SAFETY OF PROTECTIVE CLOTHING AND SEMI-CABIN FOR TRACTOR DRIVER APPLYING INSECTICIDES AND ACARICIDES BY TRACTOR-TRAILED AIR-CARRIED SPRAYER IN CITRUS (CITRUS SINENSIS)

M. L. Oliveira¹ & J. G. Machado Neto¹, ¹Dept. de Fitossanidade, FCAV/UNESP – Câmpus de Jaboticabal, 14.870-000, Jaboticabal, SP, Brazil, E-mails: oliveiraml@hotmail.com; joaquim@fcav.unesp.br.

Safety of the tractor driver applying pesticides to citrus by tractor-trailed air-carried sprayer was evaluated calculating the margin of safety (MOS) from data of NOEL of pesticides and the occupational exposure in a 6 hours workday. Working condition of tractor driver was classified as safe (if MOS \geq 1), or unsafe (if MOS <1). Demoal exposure of tractor driver (DE) was evaluated using or not protective clothing and semi-cabin. Protective clothing was composed by AZR clothing (hood, long sleeved jacket, pants and acetate face visor) completed by nitrila gloves, rubber boots and charcoal treated disposable respirator. Evaluations on tractor driver were carried out in applications using Arbus 2000 Valência tractor-trailed air-carried sprayer in citrus orchard of the Cambuhy Agricola Farm, Matão-SP, Brazil during february/99. Cu⁺² of a cupric fungicide was used as tracer of spray. DE of tractor driver was quantified directly on white overall with long sleeve and hood and on cotton gloves. Exposure of face was evaluated on female sanitary pads attached on disposable face masks and exposure of feet was on same type of pads attached on upper part of rubber boots. DE of tractor driver in three working conditions were evaluated in ten replications for each activity during 30 to 40 minutes. After the exposure overalls were divided into parts and were immersed in solution of HCl (0.1 N) for extraction of the tracer. Same procedure was carried out on pads. Quantification of Cu⁺² was by atomic absorption spectrophotometer. The values of Cu⁺² recovered in spray collectors and concentration of the tracer in the spray solution were used to estimate the DE. Dermal exposure to 135 recommended pesticides were estimated using DE to spray and the dose of pesticides. These data were used to calculate MOS with the following equation: MOS = [NOEL x 70] / [1.1 DE]. The DE to spray driving the tractor without semi-cabin and clothing was of 217.3 mL/day. Wearing protective clothing it was 7.2 mL/day and with semi-cabin, 145.1 mL/day with 96.7% and 33.2% efficiencies respectively. Among 135 insecticides and acaricides recommended for citrus 56.4% were classified as safe (MOS \geq 1) for the tractor driver working without protective clothing and semi-cabin, 91.1% when the tractor driver used the protective clothing and 57.4% when the semi-cabin was used.

Index terms: citrus, pesticides, protective clothing, semi-cabin

[0537] GEOGRAPHIC DISTRIBUTION AND PHENOLOGY OF FIEL PLANTS AS PARAMETERS OF TROPHIC RESOURCES IN NEOTROPICAL ENTOMOTAXOCENOSES

<u>S. G. Oliveira</u>¹, A. Caldas² & J. R. Almeida³, ¹ Univ. do Est. Rio de Janeiro, Departamento de Biologia Animal e Vegetal, Setor de Ecologia, Rua São Francisco Xavier, 524, Maracanã – 20559-900, E-mail: sigomes@uerj.br; ² Univ. Fed. do Rio de Janeiro, Escola de Engenharia, Departamento de Hidráulica e Saneamento, CT – COPPE, bloco C, sala 211 Ilha do Fundão, 21941-590, E-mails: claudio@pcc.coppe.ulfj.br;

If a population for a certain hostplant species becomes abundant and concentrated along a certain part of the habitat, the phytophagous community tends to respond with a specielized diet strategy(monopaghy). If, on the other hand, a variety of food resources are present in low frequency, and if some factors such as predation and competition affect negatively the chance of these phytophagous organisms find and actually exploit the host plants, the resulting strategy is usually a generalized diet. The adaptation of a specialist insect to the foodplant it uses goes further beyond simple tolerance to the plant's defense substances. There are behavioral barriers that prevent specialized insects from using other plant species. The ecological advantage of specialization allows, for instance, a specialized insect to develop a synchronism with the phenology of its hostplant. In this work, we studied the geographic distribution and the phenology of field plants as parameters for trophic resources in neotroppical entomotaxocenoses. Large-scale collect areas throughout Brazil were previously selected based on the protential dispersion and the diestribuion of the plants. These areas were established random transects that covered six of the Braziulian morphoclimatic and phytogeographic domains: Tropical Atlantic, Cerrado, Caatinga, Tropical Amazonian, Pantanal and Araucaria Pine Forest. Most hostplants were herbaceous with relatively low biomass concentration in the reproductive structures. Another point to be considered is the dynamic of the availability of the resouces. These characteristics together suggest that, at least quantitatively, the availability of some specific food resources in some of the plants is low when compared with the consumption volume. Field observations confirm the use of other resources. In geographic distribution na abundance of the hostplants the fields did not present a uniform aspect troughout the year, varying according to the composition and structure of the soil, precipitation, and especially agrazing schedule. Depending on the degree of variation of these factors, some especies might be more or less conspicuous. The phenology of the hostplants and exploitation of available resources by the entomotaxocenoses were the vast majority of field plants was herbaceous. The relative amount of nutrients and minerals in these plants displayed some variation.

Index terms: hostplants, diet strategy, generilized diet, ecology

[0538] THE DIVERSITY OF COCCINELLIDAE IN SOUTHEN CHINA

II. Pang, State Key Laboratory for Biocontrol, Zhongshan University, Guangzhou 510275, P.R. China; E-mail: 1s40@zsu.edu.cn.

The present paper summarized developmental history of systematic of Coccinellidae over 200 years, discussed effect of development of integrated insect taxonomy and molecular systematic to Coccinellids. It deals with the analysis of diversity of Coccinellidae in Southern China, based on the land formation and climate condition on the evolution of plants, as well as the coevolution of insects and plants. A list of Coccinellidae in Southern China with 9 subfamilies, 76 genera and 547 species is constructed. We referred to document from abroad, improved methods of DNA extract in the present condition. The genomic DNA was extracted separately from fresh samples, alcohol steep samples, dry samples. Fragment of about 500 bp of the mitochondria 16S ribosomal RNA gene was amplified by polymerize chain reaction (PCR) from the DNA using primers CPE264-01: 5'-GCCTGTTTATCAAAAACAT-3', CPD264-02: 5'-CCGGTCTGAACTCAGATCA-3' and primers CPE418-01:5'-CGCCTGTTTATCAAAAACAT-3', CPE418-02:5'-CCGGTCTGAACTCAGATCACGT-3', Fragment of about 2000 bp of the 18S ribosomat RNA gene was amplified by PCR from the DNA using primers 18N1: 5'-TCTATCTGGTTGATCCTGCCAG-3', 18N11R: 5'-TCGATCCTTCCGCAGGTTCACC3'. The study results can be proved new data for phylogenetic reconstruction of the family relatiouships within coccinellids based on DNA sequences of rDNAgene.

[0539] DEVELOPMENT OF PHYTOPHAGOUS HETEROPTERANS ON DRY ARTIFICIAL DIETS

A.R. Panizzi¹, J.R.P. Parra² & <u>D.R. Carvalho</u>², ¹Centro Nacional de Pesquisa de Soja (CNPSo), Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), Caixa Postal 231, Londrina, PR, 86001-970, Brasil. E-mail: panizzi@cnpso.embrapa br. ²Departamento de Entomologia, Escola Superior de Agricultura Luis de Queiróz (ESALQ), Caixa Postal 9, Piracicaba, SP, 13418-900, Brasil. E-mail: jrpparra@carpa.ciagri.usp.br, deccarvalho@hotmail.com.

Laboratory studies were conducted in Londrina and Piracicaba to develop an artificial dry diet for phytophagous heteropterans. The diet components were: soybean protein (15g); potato starch (7.5g); dextrose (7.5g); sacarose (2.5g); cellulosc (12.5g); vitamin solution (5.0ml); soybean oil (20.0ml); wheat germ (17.9 gr); and water (30.0ml). Six different diets with slight variations in their components were rested: 1) Basic diet with rough texture cellulose: 2) Basic diet with rough texture cellulose plus anticontaminant (nipagin) (0.44g); 3) Basic diet with fine texture cellulose plus anticontaminant (nipagin) (0.44g); 4) Basic diet, with half soybean oil and half olive oil, with rough texture cellulose; 5) Basic diet, with haif soybean oil and half clive oil, with rough texture cellulose plus anticontaminant (nipagin) (0.44g); and 6) Basic diet, with half soybean oil and half olive oil, with fine texture cellulose plus anticontaminant (nipagin) (0.44g). All diets were oven dried for 4 hours at 75 °C. Diets were wrapped in aluminum foil and kept in the refrigerator. Small cubs of 5x5x5mm were offered to 2nd instars (n = 30) of Nezara viridula (L.), Piezodorus guildinii (Westwood), and Dichelops melacanthus (Dallas) (Pentatomidae) at 25 °C, RH 60 ± 10% and 14hL:10hD photoperiod. Diets 1,2 and 3 allowed N. viridula nymph survivorship of ca. 70%. With diet 1 all adults obtained were normal. Survivorship of P. guildinii and D. melacanthus were smaller (range of 12.5 to 50.0%, and 20.0 to 30.0%, respectively, fed on diets 1 to 3). Additional studies with N. viridula using the basic dict with soybean protein (7.5g) plus lyophilized soybean pods immature (7.5g), yielded the best results, with > 80% nymph survivorship and adult reproduction.

Index terms: Pentatomidae, stink bugs, rearing, artificial media.

[0540] SOCIEDAD ENTOMOLÓGICA DE PUERTO RICO

A. Pantoja & E. Abreu, University of Puerto Rico-Mayaguez Campus, Department of Crop Protection, P.O. Box 9030, Mayaguez, Puerto Rico 00681, E-mail Pantoja: a_pantoja@rumac.upr.clu.edu; Abreu: eabreu@prtc.net.

The first Puerto Rican Entomological Conference was on May 25, 1912. The organization of this first Conference was largely due to the enthusiastic support of D. L. Van Dine, at that time in charge of the Sugar Producers Experiment Station of Puerto Rico. The first publications of the Society were published in summary in the Journal of Economic Entomology, February 1931. The Society ceased activities until March 1932 when the third meeting of the Society was held in conjunction with the Fourth Congress of the International Society of Sugar Cane Technologists at San Juan, Puerto Rico. Papers presented at that meetings were printed in the House of Representatives of Puerto Rico, and reports of the meetings were printed in the Journal of Economic Entomology and in Entomological News. Additional activities by Society members were held in April and July 1933. A more formal organization Sociedad Entomológica de Puerto Rico (SEPR) or Entomological Society of Puerto Rico, was founded December 4, 1976 at the Puerto Rico Agricultural Experiment Station in Rio Piedras. The SEPR defined its constitution and by laws by April 25, 1981. The SEPR published a bulletin Contribuciones de la Sociedad Entomológica de Puerto Rico starting in 1981, but it was published sporadically. The last volume was published in 1985. The Society was inactive for many years and was reactivated in early 1999. Currently the society has 40 members. The SEPR is the only current entomological society in Puerto Rico. During 1999, the SEPR held a joint meeting with the Florida Entomological Society in Puerto Rico. The SEPR is concerned with critical issues of economic entomology, biodiversity, and insect ecology. Index terms: entomological societies, Latin America

[0541] REVISION AND PHYLOGENY OF THE GENERA OF LITHININI OF AUSTRAL SOUTH AMERICA (LEPIDOPTERA: GEOMETRIDAE)

E. Parra, Departamento de Zoología, Facultad de Ciencias Naturales y Oceanográficas, Universidad de Concepción, Casilla 160-C, Concepción, CHILE. e-mail luparra@udec.cl; http://www.udec.cl/entomologia/

The tribe Lithinini (Forbes, 1948) is amply distributed throughout the world. Its diagnosis is supported by the combination of various characters, although the deciding character seems to be the presence of a long, thin anellus processes. Rindge (1986) separates the American genera into two sections, a Holartic and South American, with a distribution restricted to the austral zone. The genera of this region are characterized by having high levels of endemism. This revision contains numerous taxonomic changes, the proposition of a new genus and species, and a systematic list of the valid taxa. The phylogenetic analyzis was done with Hennig86 (Farris, 1988), where all groups, except Catophoenissa, formed a monophyletic group supported by the following synapomorphies: (1) absence of metathorasic tuft; (2) absence of abdominal tuft; (3) cristae present; and (4) anellus processes not spiniform. The 20 austral South American genera show the following hypothesized relationships: (Franciscoia (gen. nov. (Proteopharmacis (Maendragonaria (Odontothera ((Martindoelloia (Callemo, Guara))) (Calta (Laneco (Psilaspilates (Lacaria, Nucara) (Euclidiodes (Acauro (Siopla, Duraglia) (Yapoma (Incalvertia, Rinoligia))))))))). Aspects of the Natural History and distribution, which are found to be associated to the temperate and sclerophyllous forest of austral America, are discussed.

Index terms: Ennominae, Taxonomy, Distribution, Phylogeny, Chile, Argentina

(0542) THE SOCIEDADCHILENA DE ENTOMOLOGIA

L. E. Parra, V. Jerez, T. Zaviezo, A. Cammouseight & D. Lanfranco, Casilla 21132, Santiago 2, Chile Fono: +56 2 6814095; Fax: +56 2 6817182; e-mail luparra@udec.cl; http://abulafia.ciencias.uchile.cl/sche.

The Sociedad Chilena de Entomología (SChE) was founded on June 4, 1922 in Santiago with the name Sociedad Entomológica de Chile; in March 30, 1933 it was changed to its current name. There are currently 100 members who are mostly university researchers and teachers with some members from public institutions and graduate students. The SChE meets for its annual congress in different institutions and universities in Chile. The SchE traditionally unites investigators from different countries, such as Argentina, Brasil, and Perú, and stimulates undergraduate and graduate student participation. The Revista Chilena de Entomología is published periodically once a year since 1951. Volumes 1-9 were financed by the University of Chile. It contains mostly papers on taxonomy and biology, with special reference to Chile or the Neotropics. Approximately 10 articles are published each year in Spanish or English. The publication of the journal is possible thanks to a donation by the late United States dipterologist Charles P. Alexander. The members of this society work principally in systematics, ecology, biogeography, veterinary medicine, economic entomology (agricultural and forest) and arachnology. The SChE organizes monthly meetings with oral presentations of advanced research of the members and incorporates new investigators and students with presentations of their regults

Index terms: entomological societies, Latin America, Chile

[0543] THYSANOPTERA DIVERSITY AT PARQUE ESTADUAL DE ITAPUÃ, VIAMÃO, RS, BRAZIL

S. M. J. Pinent¹, H. P. Romanowski¹ & L. R. Redaelli², ¹Dept. of Zoology, Inst. de S. M. J. Filterit, R. F. Kolminowski & L. Miv, Federal do Rio Grande do Sul, Ave. Biociências, Pós-Graduação Biologia Animal, Univ. Federal do Rio Grande do Sul, Ave. Paulo Gama P. 12.105, CEP 90040-060, Porto Alegre, Brazil, E-mail silviapi@portoweb.com.br; ²Dept. de Fitossanidade, Fac. de Agronomia, Univ. Federal do Rio Grande do Sul, Ave. Bento Gonçalves 7712, CEP 91540-000, Porto Alegre, Brazil.

There are huge gaps on our knowledge about the biology and diversity of wild thysanopterans of neotropical regions. This work aims to help filling this lacuna, by surveying these insects at Parque Estadual de Itapuã, RS, Brazil (30°22'S and 51º02'WGr), throughout the year. Four 500 m long transections, embracing different vegetation types, were established, in which a survey of thysanoptera species is being carried out and information on their natural history is recorded. In each transection, five points, 100 m apart from one another, were marked, and at each of these points two stations were set: one by the transection and another 1,5 m away from it. At these stations, flowers, branches, grasses and litter are sampled. Up to now, a total of 4,289 thrips was recorded; amongst those specimens identified so far, 49 belong to the Phlacothripidae family, 93 to the Thripidae and 3 to the Heterothripidae. The microhabitat with the highest thrip abundance was flowers (n=2689), followed by branches (n=765), litter (n=654) and grasses (n=181). Species richness, diversity and similarity will be estimated, for the different habitats, to evaluate the occurrence and distribution of thysanopterans in the area. Index terms: Thysanoptera, diversity, wild thysanopterans, neotropical fauna.

[0544] LITTER MICROARTHROPOD COMMUNITY IN AN URBAN FOREST STAND OF SÃO JOSÉ DO RIO PRETO, STATE OF SÃO PAULO, BRAZIL

D. Prieto¹, A. R. Oliveira² & <u>I.C. Bonfanti-Almeida³</u>, ¹Depto. de Biología Animal y Humana, Facultad de Biología, Universidad de La Habana, CP 10400 La Habana, Cuba. E-mail dania@fbio.oc.uh.cu, ²Setor de Zoologia, ESALQ/USP, CP 9, CEP 13418-900, Piracicaba, SP, Brasil, E-mail arolivei@carpa.ciagri.usp.br, ³Depto. de Biologia, UNIRP, CP 593, CEP 15025-400, São José do Rio Preto, SP, Brasil, E-mail bonfanti@unirpnet.com.br.

Despite the obvious importance of the microarthropods inhabiting the litter, relatively little is known about their community structure and dynamics in forest stands of urban areas subject to human interference. On this basis, a research was conducted in a seasonal semideciduous forest located at Bosque Municipal from São José do Rio Preto, State of São Paulo, Brazil. Litter samples were taken on 10 occasions with approximately 2-week intervals between late November 1998 and late April 1999. Microarthropods were extracted by means of Berlese-Tullgren funnels. The community appears to be dominated by Acari (55.0%), followed closely by Collembola (43.0%). Polyxenida, Pscoptera and Protura comprised only 2.0% of the total fauna. The mean density of all taxa for the whole period was 9,801±832 individuals m². Acari and Collembola resembled each other in the pattern of temporal fluctuation, but the variations in density were particularly significant for Collembola. Oribatida comprised 67.0% of total Acari collected. Oribatids were classified into 41 species belonging to 30 genera and 25 families. Among these, 4 species and 12 genera are new records for the State and 4 species and 2 genera for the country. Dominant and frequent oribatid species included Rostrozetes foveolatus, Scheloribates praeincisus and Galumna glabra. The aggregated pattern of horizontal distribution and abundance of the microarthropod community is related to the presence of a mosaic of microsites of varying amounts of litter and to the moisture content. Tha degree of environmental disturbance on the community structure is examined. Index terms: Acari, Collembola, mesofauna, Oribatida.

[0546] TRADITIONAL AND MOLECULAR APPROACHES TO GLOBAL HYMENOPTERA TAXONOMY

D.L.J. Quicke¹, ¹Center for Population Biology, Imperial College at Silwood Park, Ascot, Berkshire, SL5 7PY, UK; Unit of Parasitoid Systematics, CABI Bioscience UK Centre (Ascot), Department of Biology, Imperial College at Silwood Park, Ascot, Berkshire, SL5 7PY, and Department of Entomology, The Natural History Museum, London SW7 SBD, UK, E-mail d.quicke@ic.ac.uk.

Without doubt one of the three largest orders of insects and proportionately one of the least studied taxonomically, the Hymenoptera pose a major challenge for future taxonomists. While new species are being discovered every year in the United Kingdom (an unusual occurrence for many insect orders), it is possible to catch undescribed hymenopterans with ease. But kowing for sure that they are undescribed is a different matter. Thus using conventional taxonomy might not be the best way forward, as there is an undeniable shortage of morphotaxonomists relative to the task in hand. I propose that the way forward is to collect and process specimens with the intention that the material should be accessible equally both to DNA sequence analysis and to morphological investigation. Indeed, given the simple way that computers can now compare DNA sequences means that this methodology could largely replace morphological investigation in the first instance. Knowledge of the hierarchical way in which genes typically vary means that it ought to be easy to identify gene fragments that not only will uniquely place each sampled / sequenced entity in a putative species, but also in its more or less correct systematic position - surely no worse than the present situation. As it is unlikely that we will fully describe and illustrate all Hymenoptera within the next century using traditional processes, using new molecular techniques offers many advantages that will be discussed Index terms: Wasps, biodiversity, systematics, taxonomy, description, cryptic species, DNA.

[0545] MEASURING DIVERSITY OF CLOUD FOREST BUTTERFLIES ALONG ELEVATIONAL TRANSECTS - THE NEOTROPICAL TRIBE PRONOPHILINI (LEPIDOPTERA, NYMPHALIDAE, SATYRINAE)

T. W. Pyrczł, ¹Zoological Museum, Inst. of Zoology, Jagiellonian Univ., R. Ingardena 6, 30-060 Kraków, Poland. E-mail: pyrcz@zuk.iz.uj.edu.pl.

When evaluating diversity of montane butterfly faunas one may encounter difficulties which arise during estimation of an area related index (alpha or gamma). These indices are especially easy to distort. Therefore, a method combining within-area and betweenarea beta indices is proposed and termed the Potential Vertical Transect (PVT). PVT is the measure of the total number of species of an indicator group along an ecological gradient, where altitude is an exponent of habitat change. PVT data are extrapolated from samplings taken by the author in most discussed localities, mainly from 1500 to 3500 m by means of altitudinal transects based on a series of baited traps set every 25 -50 m. Additional data are obtained from literature and from museum specimens. In the cloud forests of the Neotropical realm, the tribe Pronophilini with over 500 species, is the best model group for measuring diversity. Butterflies of this group occur in well defined and usually narrow altitudinal bands with a noticeable percentage of endemic taxa. Adults show little vertical or horizontal vagility, they are numerous and show little variation. The results show invariant proportions of each genus or group of Pronophilini in each PVT especially in the group of "large Pronophilini" composed of 12 genera and in the genus Pedaliodes (sensu stricto). When a correlation analysis betwen latitude and 10 east Andean PVTs is applied, a strong correlation is obtained. Peripheral PVTs as those for Tucuman and for some northern areas where low species richness is a clear-cut effect of narrower altitudinal extension, are not included. The local diversity hotspot in southern Ecuador at 4° South can be explained as an effect of local topographic conditions leading to the overlapping of the west and east Andean faunal pools in that area. The gradient obtained in this study culminates at latitudes 13°-16° which is closer to the Tropic of Capricorn than to the Equator, and is obviously related to climatic factors nor to the habitat area which for long were thought to be responsible for geographic differenciation of species richness,

Index terms: distribution patterns, biodiversity gradients, vertical transects

[0547] HABITAT CONSTRAINTS AND PATTERNS OF DIVERSITY

<u>I. Ribera</u>¹, G. N. Foster² & A. P. Vogler¹, ¹Department of Entomology, The Natural History Museum, Cromwell Road, London SW7 5BD, UK, and Department of Biology. Imperial College at Silwood Park, Ascot SL5 7B, UK, E-mail ignr@nhm.ac.uk: ²Environmental Division, The Scottish Agricultural College, Auchineruive, Ayr KA6 SHW, Scotland, UK.

Certain large-scale patterns in species richness (e.g. latitudinal gradients, species-area relationships) are well known and robust ecological regularities. Most of the many explanations that have been proposed depend on geographical variables correlated, ultimately, with area and latitude. However, these explanations typically fail to identify underlying causal mechanisms and, equally, to demonstrate a connection between the scale at which diversity is varying with the scale at which the supposed processes affecting the diversity operate. In Europe, two contrasting types of freshwater habitat can be identified, with markedly different persistence values. Rivers and streams persist over relatively long periods, and are semi-permanent features of the landscape. In contrast, small to medium-sized stagnant water bodies are short-lived, and discontinuous in time and space. Most water beetles inhabit only one of these two habitat types, with a minority able to live in both (in western Europe the overall proportions are: 43% of species in running water, 38% in stagnant, and 19% in both). Running water species have smaller range sizes than stagnant water specialists, and this is explicable on habitat persistence as a constraint on the evolution and ecology of these insects. A model for water beetles in 15 areas in western Europe, based solely on total area, minimum latitude and a measure of mainland "connectivity", predicts with great accuracy the total number of species per area. However, when this beetle pool is divided into running water and stagnant water specialists, the results are very different. For running water species within each area, minimum latitude (seen as a surrogate for proximity to glacial refugia) is the variable with the highest correlation. For stagnant water species, the main explanatory variable is connectivity. These differences remain essentially the same when the data are divided amongst the four main phylogenetic groups represented (Hydradephaga, Hydrophiloidea, Hydraenidae, Dryopoidea). Thus, when species are separated according to a biologically significant variable (e.g. habitat persistence), their differing requirements and responses can be inferred to be the very processes that generate the observed overall patterns of diversity. An improved ability to understand these underlying causal mechanisms will enable us to make much better predictions about the extent and distribution of diversity, especially in poorly known or under-worked areas.

[0548] THE SPIDER FAUNA FROM SUGAR CANE CROP, SÃO PAULO STATE, BRAZIL

<u>I.M. P. Rinaldi</u>¹ & B. P. Mendes¹, ¹Depto. de Zoologia, Instituto de Biociências, Universidade Estadual Paulista,18618-000, Botucatu, SP, Brasil, E mail rinaldi@ibb.unesp.br.

The spider fauna (Araneae) from sugar cane crop was monthly surveyed by handling and beating in an extensive crop area of Botucatu, State of São Paulo, Brazil. Composition and richness (families and species), microhabitats preferences, diversity and eveness indexes of their fauna were analysed. A total number of 1,295 spiders belonging to 83 species and 20 families were collected. The most diverse families were Theridiidae, Salticidae, and Araneidae, and the most abundant ones were Theridiidae, Salticidae, Anyphaenidae and Titanoecidae. Seven species represented 58.6% of the total fauna, whereas *Crysso pulcherrima* weaver, alone, made up to 28.2%. About 56.6% of the spiders occupied the stratum 20 cm from the soil. Spiders were always present throughout the development of the crop. Along with the supression of the previous burning of the sugar cane crop, the importance of knowing these natural enemies increases.

Index terms: Araneae, sugar cane crop, spider diversity, natural enemies

[0550] AN UNEXPLORED STORE OF THE EQUATOGUINEAN BIODIVERSITY IN THE MUSEO NACIONAL DE CIENCIAS NATURALES

A. Sánchez¹, C. M. Santos¹ & <u>I. Izquierdo</u>¹, ¹Departamento de Colecciones y Documentación. Colección de Entomología, Museo Nacional de Ciencias Naturales, c/ José Gutiérrez Abascal, 2. 28006 Madrid, Spain. E-mail izquierdo@mnen.csic.es.

The Museo Nacional de Ciencias Naturales houses a great amount of specimens from Equatorial Guinea, which were collected during the first half of the 20th Century, when this country was a Spanish colony. The information on this material is being retrieved by the ongoing project *Inventario y Catálogo de las colecciones de fauna de Guinea Ecuatorial en el Museo Nacional de Ciencias Naturales.* The highest percentage of specimens are insects. In this paper, the information related to four superfamilies of Coleoptera -Chrysomeloidea, Elateroidea, Scarabacoidea and Tenebrionoidea-of this material is provided. Information regarding collecting data (more significative localities and collectors), as well as taxonomic data (type specimens, percentage of identified material, which can be very useful for the specialists on Afrotropical Coleoptera interested in the study of the biodiversity of this area. The way to access to this biodiversity resource through the Museo Nacional de Ciencias Naturales web site and by loan request to the Entomology Curators of the Collections Department is included.

Index terms: Coleoptera biodiversity, Afrotropical fauna, entomological collections, web site

[0549] ZOOGEOGRAPHICAL ANALYSIS OF THE FAUNA OF TERRESTRIAL HETEROPTERA FROM ROMANIA

I. Rosca¹ & <u>C. Popoy²</u>, ¹ Univ. Agricultural Sciences and Veterinary Medicine, Ave. Marasti 59, Bucharest, Romania; ² Research Inst. for Cereals and Industrial Crops, 8264 Fundulea, N. Titulescu Str., 1, Calarasi District, Romania, Email:fundulea@cons.incerc.ro

Romania is situated in Europe, at the crossroads towards Asia, and Africa, and its fauna including terrestrial heteroptera fauna, has faunistical elements proceed from these three continents, showing a large diversity which has to be knowed and preserved. Methodology. On the basis of literature and personal researches it was done world areal (spreading in the whole world) of each heteroptera species and they were enframed like zoogeogrphical elements. The whole fauna of terrestrial Heteroptera of Romania was zoogeographical compared to that from Egypt, Israel, Turkey and Central Asia (Tien Shan). It was calculated, on the species, differentiation and correlation index. Results. The 693 species of terrestrial Heteroptera recorded till the present time in Romania, which belong to 25 families, were from 9 zoogeographical elements (Cosmopolitan, Holarctic, Palearctic, Euro-Siberian, European, Mediterranean, Ponto-Mediterranean, Turanic and Endemic) which are unanimously agreed on by the various authors interested in this subject. Among the 693 species of terrestrial Heteroptera recorded in Romania, 6 are Cosmopolitan, 53 Holarctic, 61 Palearctic, 12 Euro-Siberian, 169 European, 191 Mediterranean, 53 Ponto-Mediterranean, 23 Turanian and 9 are endemic species. It can be seen that fauna of terrestrial Heteroptera of Romania contains less endenuic species than the other areas surveyed (i.e. 1.3%), this being due to the fact that Romania is not separated from the surrounding countries by effective geographic barriers, and that similar environmental conditions occur in a wide area. Taking into account relationship of terrestrial *Heteroptera* from 9 geographical zones of Europe, Asia and Africa, accordingly differentiation and correlation indexes, differentiation don't exceed value of +0.53 between Germany and North-East Africa, and correlation is highest between Romania and Ukraine (-0.61). There is not any strong differentiation or correlation between lower and higher zones of Romania, from point of faunistical species index (+0.024). Conclusions. Terrestrial Heteropteran fauna is well represented in Romania, having a large diversity. The comparison and mathematical analysis of the data on the Heteroptera fauna of Romania to that of Egypt, Israel, Turkey and Central Asia shows that the similitudes and differences are related particularly to the geographic position and the climate conditions. Key words. Heteroptera, differentiation, correlation, faunistical species index.

[0551] PATTERNS OF ANIMAL DISPERSAL, VICARIANCE AND DIVERSIFICATON IN THE HOLARCTIC

<u>I. Saumartín</u>¹, F. Ronquist¹ & H. Enghoff², ¹Dept. of Systematic Zoology, Evolutionary Biology Center, Univ. of Uppsala, Norbyvägen 18D, SE-75236, Uppsala, Sweden. E-mail: isa@mnen.csic.es; ²Universitetets Zoologisk Museum, Universitetsparken 15, DK-2100 Copenhagen, Denmark.

We analysed patterns of animal dispersal, vicariance and diversification in the Holarctic based on phylogenies of 57 nonmarine taxa, comprising 770 extant species connected by 713 speciation events. The selected phylogenies included a complete or almost complete sample of the species in each group. Age estimates suggest that the biogeographic events documented by the phylogenies span from the Late Mesozoic to the present. Four major areas were used in the analyses: eastern Nearctic (EN), western Nearctic (WN), eastern Palaearctic (EP) and western Palaearctic (WP); each area corresponding to a historically persistent land mass according to palaeogeological reconstructions. Parsimony-based tree litting shows that there is no hierarchical vicariance pattern, that is, there is no general area cladogram that can adequately describe the historical biogeography of the Holarctic. Yet, distributions are strongly phylogenetically conserved, as revealed by dispersal-vicariance analysis (DIVA). Permutation tests were used in conjunction with DIVA to pinpoint phylogenetically determined dispersal patterns. Continental dispersals (EP \leftrightarrow WP and EN \leftrightarrow WN) are significantly more common than palaeocontinental dispersals (EP \leftrightarrow WN and WP \leftrightarrow EN), which in turn are more common than disjunct dispersals (EP \leftrightarrow EN and WN \leftrightarrow WP). Within the Nearctic, (WN \rightarrow EN) dispersals are significantly more common than (EN \rightarrow WN) dispersals; within the Palaearctic, (EP \rightarrow WP) dispersals are more common than (WP \rightarrow EP) dispersals. Cross-Beringian faunal connections have traditionally been emphasized but they are not more important than cross-Atlantic connections in our data set. To analyse biogeographic patterns in more detail, we dated all nodes in each cladogram and then sorted the frequency of biogeographic events into time-intervals. Independent evidence (e.g., fossil record) or Holarctic biogeographic events were used to date the oldest and some interior nodes in each cladogram, and then the age of all other nodes was determined using a "branching clock". Trans-Atlantic distributions (WP-EN) were most common in the Early-Mid Tertiary time-class (70-20 mya), whereas trans-Beringian distributions (EP-WN) were least frequent in that period. The disjunct distribution EP-EN was most frequent in the Early Tertiary (70-50 mya). Diversification patterns differed among areas: the species richness of WN and WP increased during the Quaternary (< 3 mya), whereas the species richness of EP and EN increased during the Tertiary (70-20 mya).

Index terms: Historical biogeography, trans-Atlantic, trans-Beringian, disjunct distributions.

[0552] CHANGE OF INSECT DIVERSITY AS A GREAT MYTH

V. B. Sapunov, Scientific Res Center of Ecol Safety, Korpusnaya, 18, St. Petersburg, 197110, Russia, E-mail sapunov@VF4493, spb.edu

The important task of global ecology is essay of species diversity within taxon, ecological system and biosphere. This task has relation to a big number of international programs of variability and diversity safety. Theoretical basis of such a programs is not sufficient firm because the following questions are unclear: 1. How much species exists? 2. What is biological variability of main classes of animals andplants? 3. What is tempo of extinction? 4. What is temp of new species appearance (and does this process take place)? The first scientist who proposed approach for this problem was V.Vernadsky, which theory of biosphere is needful for deciding of the question. The present work is synthesis of this theory with empirical data gotten at field insect population. Modern ecology has no methods appropriate for general check of biological diversity of the biosphere. The real approach toward resolve of this question is use of insects as numerical well studied and representative group and any representative region of the Earth. This local data may become base for works toward study of general diversity and pattern of distribution of the species within taxons and ecological niches. The present work consider insects of natural landscape "Veppsky les"(North-West of Russia) as material for modeling of general species diversity. Insect species may be distributed into three groups - dominant, rare and hidden. Quantitative relations between them may be described by mathematical model. Majority of species are hidden, that is undetectable by methods of field ecology. The number of them may be between 30 000 000 and 1 billion, and the last mean is more real. During evolution of ecological systems pattern of distribution of insects within three groups may change. Sometimes extinction of insects is not real but means that population got state of hidden. Decrease of insect population doesn't make any ecological niche free They occupied by other species of animals. Because of great resistance of ecological systems, artificial control of insects has no sense. The number of insect species, biological mass of them and distribution within ecological niches are fundamental constants of biosphere.

Index terms: biosphere, insects, species diversity

[0554] BIO-DIVERSITY OF MOSQUITOES IN THE RIVER CAUVERY BASIN, KARNATAKA STATE INDIA

N. J. Shetty, Centre for Applied Genetics, Bangalore Univ., J. B. Campus, Bangalore 560056, Karnataka, India. E-mail: bnguni@kar.nic.in

The river Cauvery originates in the Western Ghats in the Coorg district and lies in Karnataka India to an extent of 42.2% of its total area of 81,155 sq km and flows for a length of 320 km out of its total length of 804 km in the state. Its major tributaries in the state are Hemavathi, Lakshmantheertha, Harangi, Kabini, Suvarnavathi, Lokapavani, Shimsha and Arkavathi. The area of basin in Karnataka comprises seven districts namely Coorg, Hassan, Mysore, Mandya, Chikamagalur, Tumkur and Bangalore rural totaling 34,273 sq km and an average annual flow of 11,000 M Cum, finally flowing into the Bay of Bengal in Tamil Nadu. This paper summarizes the diverse mosquito fauna at 27 different sites of river Cauvery basin (from Thalakaveri to Makedatu) for one calendar year in different seasons i.e., summer, autumn and winter. Mosquitoes were collected in the form of larvae, pupae and adults and were identified and classified. These included primary malarial vectors such as Anopheles stephensi, An. fluviatilis, An. subpictus, An. culicifacies and An. maculatus; secondary vectors like An. aconitus, An. annularis, An.varuna and other species like An. jamesi, An. karwari, An. majidi, An. vagus, An. splendidus. An. hyrcanus, An. barbirostris, An. tessellatus, An. pallidus, An. leucosphyrus, An. ramsi, An. gigas and An. jeyporiensis. An. dthali recorded in the present study is a very rare species and for the first time the said species is being reported from South India. Different species of culicine mosquitoes were also collected. These included primary vectors such as Culex quinquefasciatus, Mansonia uniformis (filarial vectors), and Cx. tritaeniorhynchus (vector for Japanese Encephalitis). In addition to this, other species like Cx. gelidus, Cx. vishnui, Cx. mimmulus, Cx. armigeres, and Cx. bitaeniorhyncus were also collected. Insecticide susceptibility tests were carried out on different species of mosquitoes of the basin area by using larvicides and adulticides supplied by W.H.O. These included organochlorines (DDT and Dieldrin) organophosphates (Parathion, Fenthion and Malathion), synthetic pyrethroids (Permithrin) and carbamate (Propoxur), Vector incrimination studies for malaria and filaria parasites have also been carried out from the field collected adult females.

Index terms: Anopheles, Culex, malaria, filaria, vector incrimination.

[0553] MUSEUM COLLECTIONS FOR ASSESSING INSECT BIODIVERSITY IN THE 21ST CENTURY: NEW METHODS AND TRADITIONAL ANALYSIS

M.J. Scoble¹, ¹Dept. of Entomology, The Natural History Museum, Cromwell Road, London SW7 SBD, UK, E-mail m.scoble@nhm.ac.uk.

The millennium coincides with a major social change, with the explosive development of information technology creating the potential to bring about the democratization of information. But while the "information age" is expected to have an impact on society similar in magnitude to the Industrial Revolution, it is still in its infancy: its patterns of behaviour are semi-chaotic and as yet largely unstructured. Even so, electronic access to data opens up whole new possibilities and ways of working. Especially notable is the potential for access to images, not only just to see what an organism looks like, but also as a means to key into information held in databases. Indeed, through digitization, civilization seems to be rediscovering the value of images, which have provided the dominant, non-oral form of communication for most of its history. For insects, not only do the world's museums held collectively the best sample of the known biodiversity, but also specimens and associated art-work are also excellent sources of digital images. However, the value of access to all this information depends on the quality of the data, including a deep knowledge of what those individual specimens and the images derived from them actually mean. We still need analysis, or what in descriptive taxonomy is often called revision. Taxonomists need to emphasize the highly analytical component in revisionary work: it tends to be overlooked, and is not helped by a parochial (noncontextual) approach still to be seen in too many descriptive papers. But new approaches are also required in the form of a sharper focus on key taxa and special geographical areas-albeit with revisionary work placed in a global context. The new technology has eased global networking for taxonomists, notably by means of e-mail. Moreover, interoperability across databases and interworking across different domains are likely to provide a greatly increased capacity for us to broaden the scope and social impact of our work. Although this means much more than just adopting new techniques of electronic communication, the potential for synergy within digital space will provide us with the means to reach a much wider, if diffuse, user community than has been possible hitherto. Index terms: taxonomic data, revisionary taxonomy, information technology.

[0555] DIVERSITY OF HYMENOPTERA IN AREAS OF PRIMARY FOREST FRAGMENT, REGENERATION FOREST AND PASTURE AT THE SOUTHEAST OF ACRE, BRAZIL

M. A. Silva¹, <u>A. P. B. W. Thomazini</u>¹, M. J. Thomazini¹ & E. S. Albuquerque¹, ¹Embrapa Acre, P. O. Box 392, Rio Branco, AC 69901-180, Brazil, E-mail ariane@epafac.embrapa.br

Insects of the Hymenoptera order carry out ecological functions of prominence, because, many of them are important for the pollination processes and dispersion of plant species, besides they act as predators and parasits of several agricultural and forest pests. The objective of this work was to evaluate the diversity of the hymenoptera fauna in a large forest fragment (800 ha) and adjacent areas, through surveys at fragmented primary forest, secondary forest (regeneration) and pasture. Eight samples (april to november/99) were taken in each area, using light traps of "Luiz de Queiroz" model, wich remained turned on during one night, monthly. The captured insects were taken to the Entomology Laboratory of Embrapa Acre, where specimens were separated, mounted and identified at the level of families and morphospecies. After that, a faunistic analysis was made, calculating the diversity index (α) of each area and the similarity quotient (QS) among areas. The indexes of abundance, frequency, constancy and dominance were also calculated for each morphospecies. It was obtained a total of 1943 individuals, of 486 morphospecies. Hymenoptera diversity was higher inside the fragment (a=33.1), that in adjacent areas of regeneration (α =26.9) and pasture (α =15.2). According to the obtained abundance indexes, most of the species collected in the fragmented forest (66.2%), regeneration forest (64.9%) and pasture (46.1%) were considered rare. In the pasture, occured the greatest proportion (79.4%) of not very frequent species. There were not constant species in the sampled areas and, in all of them, more than 74% were considered as of accidental occurrence. Three morphospecies in the fragmented forest (two of Vespidae and one of Halictidae), two in the secondary forest (one of Formicidae and one of Halictidae) and three in the pasture (two of Formicidae and one of Vespidae) stood out as predominant. There was a higher similarity between the areas of primary forest and regeneration (20.8%) than between regeneration and pasture (15.2%), being 13.5% the similarity between primary forest and pasture, and just 7.4% the similarity among the three sampled areas. It was concluded that deforestation and forest fragmentation processes on the southeast of Acre cause changes in the Hymenoptera community, besides they contribute to the reduction of richness and diversity of the local species.

Index terms: Faunistic analysis, tropical rainforest, Occidental Amazonia.

[0556] PRELIMINARY CHECK LIST OF ISOPODA (ARTHROPODA: CRUSTACEA) IN RÍA DE VIGO (NO ESPAÑA)

S. Soto, J. Garrido & F. Ramil, Departamento de Ecología y Biología Animal, Facultad de Ciencias, Universidad de Vigo, 36200 Vigo, Spain, E-mail: soto@uvigo.es.

The monographic studies about isopods in the NW of Spain come down to one only work refered to "Ría de Ferrol", while there are only internitent mentions of some species in the rest of the coast, and they are always included in general studies of the marine benthos. This study of rocky shores isopods in "Ría de Vigo" covers eight areas distributed along the ría. The samples were taken in UTL, MTL and LTL till 30 meters deep. These samples were carried out following a perpendicular transect to the coast line and with quarterly interval. In MTL the material was collected during spring tide every month. In LTL the samples were take diving, at different barometric levels according to the different communities or "facies" found in the area of study. In this communication are presented the results obtained for the samples which were carried out during the first quarterly in 1998. Up to now 2699 samples have been studied, which belong to 24 species in 18 genus, 8 families and 5 suborders.

Index terms: isopods, crustaceans, marine benthos

[0558] WHY DOES SPECIES RICHNESS INCREASE WITH FRAGMENT SIZE? PASSIVE SAMPLING IN ATLANTIC FOREST CRICKETS

C. F. Sperber¹ & A. Mesa², ¹ Unid, de Estud, em Ecol. de Comunid., Dep. Biologia Geral, Univ. Fed. Viçosa, CEP 36571-000, Viçosa, BRAZIL / Graduate program, Dep. Biologia, Inst. Biociências, UNESP, E-mail sperber@mail.ufv.br² Dep. Biologia, Inst. Biociências, UNESP, Av. 24A, nº 1515, CEP 13506-900, Rio Claro, SP

One of the few ecological "laws" is that species richness increases with habitat area. The explanations for this pattern range from island biogeography theory to sampling artefact. In this study I tested this "law" and two alternative explanations for it: (1) larger forest fragments presented greater habitat diversity for the crickets, and (2) larger forest fragments represented larger samples of the regional species pool, with no other effect on species composition but sample size. I sampled litter crickets in 18 forest fragments of semi-deciduous forest (Viçosa, MG, Brazil, 20°45'S, 42°50'W), ranging from three to 300 ha. Sampling was done with pitfall traps, located in 36 randomly located sites, in the rainy season of three consecutive years. 3765 adult crickets were sampled, belonging to 22 species, most of them new to Science. Cricket species richness increased linearly with the logarithm of forest fragment area. Data were analysed with generalised linear models, with fragments as replicates. If habitat diversity explained this relation, species similarity within fragments should decrease with increasing area. This was evaluated in two hierarchically nested spatial scales, within each fragment. If passive sampling explained the species-area relationship, (1) similarity should be independent of fragment size, (2) species richness and composition per sample should be independent of area, (3) observed species richness in the fragments should not differ from that expected by passive sampling simulation, and (4) distribution of cricket species between fragments should conform nested subsets. Similarity was independent of area in both spatial scales. Species richness and composition per sample were independent of area. Species richness in the fragments did not differ from that expected for the passive sampling simulation in 83% of the fragments. Species distribution was more nested than expected for random allocation simulation. I concluded that the species-area relation was due to passive sampling. Forest fragment size did not affect cricket species composition nor local richness. Cricket species location was homogenous throughout the forest habitat, and was independent of area. Where the cricket species not affected by forest fragmentation? I infer that either habitat loss in the studied region was still small for these insects, or cricket species that are sensitive to forest fragmentation were already extinct.

Index terms: species-area, Orthoptera, Grylloidea, diversity, habitat fragmentation

[0557] OWLET MOTH DIVERSITY (LEPIDOPTERA: NOCTUIDAE) COLLECTED WITH BLACK-LIGHT TRAP, IN SALVADOR DO SUL, RS, BRAZIL

A. Specht^{1,2} & E. Corseuil², ¹ Curso de Agronomia, UNISUL, Av. José Acácio Moreira, 787, CEP 88704-900, Tubarão, SC, Brasil, E-mail spechta@pucrs.br; ² PPG Biociências, PUCRS Av. Ipiranga, 6681, C. Postal 1429, CEP 90619-900, Porto Alegre, RS, Brasil, Email corseuil@pucrs.br.

The lepidoptera group forms one of the largest orders of insects and is referred as particularly appropriate for biodiversity studies and detection of environmental changes. The moths are relatively easy to sample because most species can be collected by using simple light traps in great number of species and individuals. This makes them particularly adapted for biodiversity approaches. The Noctuidae constitutes the largest macrolepidopteran family, large represented in Neotropical Region. The objective of this work is to evaluate the abundance and diversity of species, esteemed through the more frequently used indexes. The experiment was carried out in Salvador do Sul, RS; placed on 29°27' S, 51°30' O, altitude 610 meters, presenting subtropical climate. Fifty weekly collections were made, beginning on August 07, 1994, using two Pennsylvania black-light traps with lamps F15 T8 LN. The estimates of abundance of species and diversity indexes were generated though the EstimateS Richness Estimator Program version 5.0.1. One hundred randomization's and 10 abundance classes were used in the analyses. Of the total 3,974 noctuids belonging to 108 species and distributed in 14 subfamilys was captured. It was verified the richness of species per month of capture and observed that spring months (October to December) had the highest values. In these months 88,9% of all registered species were captured, although they were not the main months for abundance. Whatever richness 19 species are singletons 9 doubletons which could be considered rare or infrequent. The diversity indexes obtained with respective standard deviations in parentheses are Fisher Alpha 20.48 (0.88), Shannon-Wiener 3.37 (>=0.01) and Simpson 15.4 (0.46). The prediction of the total richness was 215 species for 1st-order Jackknife's method, 320 species for the 2nd-order Jackknife's and 148 for the Bootstrap's. Index terms: Ecology, Biodiversity, Inventory.

[0559] A VIEWPOINT ON PATAGONIAN BIOGEOGRAPHY FROM THE CERATOPOGONIDAE CASE (DIPTERA: NEMATOCERA)

G. R. Spinelli¹ & J. Muzón¹, ¹Departamento Científico de Entomología, Museo de La Plata, Paseo del Bosque s/n. 1900 La Plata, Argentina, E-mail spinelli@museo.fcnym.unlp.edu.ar

One of the most conspicuous areas of the austral landmasses is Patagonia, which is as well one of the largest areas located in the southern cone of South America. It is composed by two main biomas, strongly influenced by rainfall patterns: temperate forest ans steppe. Forest, located at both slopes of the Andes, are dominated by about ten species of southern beeches of the genus Nothofagus, being the biota characterized by a high degree of endemicity, showing a close relationship with fauna and flora of Australia, New Zealand and neighboring islands. On the other hand, the steppe, a large zone located east of the forest, is dominated by scattered low shrubs and bunch grasses, and its biota is currently accepted to be composed by depauperate guyano-brazilic components. Despite the different names, ranges and/or categories given to the Patagonian biomas within the published biogeographical schemes, it is widely accepted that their biotas are represented by taxa with remarkably distinct biogreographical significance, and therefore from a different origin. In this comunication, some of the currently accepted ideas about the origin and settlement of the taxa inhabiting the patagonian steppe are discussed from data on recent collections of small-sized migdes of the family Ceratopogonidae. The findings in the Valcheta stream basin (40° 59' S, 66° 40' W, altitude 630 m, in the northern slope of the Somuncurá plateau), Sierra Cuadrada plateau (44º 37' S, 67º 59' W, altitude 520 m) and valley of the river Pinturas (47º 09'S, 70° 39' W, altitude 520 m) of species belonging to genera of indubitable transantarctic origin (Paradasyhelea and Macrurohelea) suggest that current biogeographic schemes highly simplify the Natural History of Patagonia, postulating a clear distinction between the two main biomas. As it is known, during Pliocene and Pleistocene periods climate and vegetation drastically changed in Paragonia, becoming the area progressively cooler and drier. The steppe localities where species of Macrurohelea and Paradasyhelea were found during our field work, could represent areas with persistent favourable environmental conditions due to the permanent water supplies mainly by small springs. Thus, the manteinance of healthy vicariant populations of species belonging to ancestral genera could have been possible, being the desertification the herein postulated vicariant event. Finally a closer relationship between the above mentioned biomas is suggested considering records gathered from taxa inhabiting aquatic ecosystems in the steppe, which were scarcely considered previously. Index terms: Paradasyhelea, Macrurohelea, Patagonia, forest, steppe

[0560] SPECIES DIVERSITY AND FUNCTIONAL DIVERSITY OF TERMITES IN EASTERN ASIA

<u>Y. Takematsu¹</u>, **T. Abe²**, **F. Hyodo²**, **A. Sugimoto² & N. Kirtiburt³**, 1 Lab. of Chemical Ecology, Kyoto Institute of Technology, Kyoto, Japan, E-mail: takematu@ipc.kit.ac.jp, 2 Center for Ecological Research, Kyoto University, Kyoto, Japan, 3 Faculty of Agriculture, Kasetsart University, Bangkok, Thailand

Termites are widely distributed over temperate zones to the tropics, and play a crucial role in forest ecosystems as a decomposition agent. The purpose of this study is to examine how the species diversity of termites and their decomposition ability vary in the different types of forests. Eastern Asia is particularly an ideal model for this study because along its coasts there lay various types of forests from temperate forest to tropical rain forests. In this study we present the species diversity as well as functional diversity of termites in the following types of forests along the Eastern Asia coasts: tropical rain forest, dry evergreen and dry deciduous forests, and subtropical rain forest. In each type of forest, species richness of termites was assessed using the standard sampling method described by Eggleton et al. (1997). Decomposition ability was evaluated by a "comparative biomass" defined by (encounter frequency of each species)(its wet weight) instead of actual biomass, which is very difficult to measure. Then, termites were classified into the following three functional groups according to their decomposition activities: Non fungusgrowing wood feeder: Termites feeding on cellulose materials Fungus-growing wood feeder: Termites growing fungus, feeding on cellulose and lignin Soil feeder: Termites distributed in the soil, not feeding on cellulose and lignin. It was found that the species composition and functional group composition are different among forest types. The Macrotermitinae, which belongs to the fungus-growing wood feeder, was a dominant group in dry evergreen and dry deciduous forests. Soil feeding termites showed the highest diversity in tropical rain forest and decrease the species richness with increase in latitude. Non fungus-growing wood feeder was dominant in subtropical rain forest and tropical rain forest. Wood-feeder fauna of subtropical rain forest comprised Kalotermitidae and Rhinotermitidae (the lower termites), while that of tropical rainforest mainly comprised Termitidae. "Comparative biomass" was an effective index to define the tendencies of functional group diversity. It makes remarkable the dominance of fungus-feeding termites in dry areas and wood-feeding termites in subtropical rain forest. The results were related to the differences in climates and vegetations of forest.

Key words: Isoptera, species diversity, functional group, comparative biomass

[0561] DIVERSITY OF COLEOPTERA IN A FOREST FRAGMENT, SECONDARY FOREST AND PASTURE IN THE SOUTHEAST OF ACRE, BRAZIL

A. P. B. W. Thomazini¹, M. J. Thomazini¹, M. A. Silva¹ & E. S. Albuquerque¹, ¹Embrapa Acre, P.O.Box 392, 69908-970. Rio Branco, AC., Brazil, E-mail ariane@cpafac.embrapa.br

Agricultural activities involving deforestation, in the State of Acre, Brazil, were responsible for the formation of different types of ecosystems such as pastures in several degradation levels and fallows with different regeneration ages. This research had the objective to evaluate the effect of ecological succession on the diversity of Coleoptera. Samples were collected, monthly, by light traps ("Luiz de Queiroz" model) in a fragment of primary forest with 800ha and adjacent areas of secondary forest (12 years) and pasture. from April to November of 1999. The coleopterous collected were identified at family level and separated into morphospecies. Data were analyzed using the faunistic indices of abundance, frequency, constancy, dominance, diversity and similarity quotient. Species richness was greater in the area of primary forest (502), followed by the secondary forest (429) and at last by the pasture (256). However, more individuals were collected in pasture (4126) than in the areas of secondary (1750) and primary (1734) forests. Consequently, a higher diversity index was found for the primary forest (67.16) than for the secondary forest (57.30), and for the pasture (30.61). In the three areas, most of the species was classified as rare and of accidental occurance. Five species of the primary forest were considered predominant (higher values of constancy, dominance, frequency and abundance), belonging to Lycidae (2) to Scolytidae (2) and Platypodidae (1). Only three predominant species were found in the secondary forest, belonging to Byrridae, Scarabaeidae and Scolytidae. The greatest number of predominant species was observed in the pasture (8) belonging to Scarabaeidae (Ataenius sp1, sp2, Aphodius sp., Digitonthophagus gazella and Onthophagus sp.) Chrysomelidae (Maecolaspis sp.), Scolytidae and Staphylinidae. A similarity quotient of 19.5% was recorded comparing primary and secondary forest areas. Comparing secondary forest with pasture the similarity quotient was only 9.3%. The lowest similarity was obtained by comparing primary forest and pasture (6.6%). Just thirteen species, belonging to Scarabaeidae (4), Scolytidae (4), Staphylinidae (3) and Curculionidae (2) were common to the three sampled areas. It was concluded that the community of Coleoptera is different at each stage of ecological succession, with observed alterations in its composition and reduction in its diversity, mainly in the pasture area.

Index terms: faunistic analysis, tropical forest, Occidental Amazonia

[0562] RHOPALOCEROS FROM IGUAZU NATIONAL PARK (MISIONES, ARGENTINA)

A.E. Tricio¹, H.A. Chaves² & C.I. Fernandez Diaz¹, ¹ Misiones Entomological Survey Project (PREM). Fac. of Exact, Chemical and Life Sciences. Universidad Nacional de Misiones. Félix de Azara 1552. (3300) Posadas - Misiones. Tel: 0054-3752-422186. Fax: 0054-3752-425414. E-mail: atricio@rector.unam.edu.ar. ² Delegación Técnica Regional Nordeste Argentino. Iguazu National Park E-mail: hugux@latinmail.com

This report presents a Rhopalocero's list including 13 months work, from october 1995 to november 1996. The observing and capture notes were taken at Iguazu Falls area, San Martin island, Palo Rosa's jungle, including some footpaths, paths inside the vegetation and occasionally any transects between the forest. Once a month, the work was made from 3 to 5 days depending on climate conditions. The butterflies were captured using net, with fruit traps, over flowers by hand, over excrement or near water's pond. During field work species were identified by direct observation. The identification in laboratory was made by comparing chromatic patterns with identified specimens from "Misiones Entomological Survey Project - PREM"'s collection and the identifications and taxonomic statements of Dr. Mielke (Parana Federal University, Brazil). This research is the result of a great effort from the participant team and the engagement between both institutions. The pictures and list can be found at Iguazú National Park. The list includes 11 families (Pieridae, Lycaenidae, Papilionidae, Nymbphalidae, Heliconiidae, Morphidae, Ithomiidae. Riodinidae, Brassolidae, Hesperidae and Satyridae), 70 genera and 130 species. The butterflies can be found at PREM collection. Index term: Rophalocera, butterflies, Iguazú.

[0563] DISTRIBUTION OF SOME SWALLOWTAIL BUTTERFLIES OF POSADAS, MISIONES, ARGENTINA

A. Tricio, S. Najle, C. I. Fernández Díaz & P. Morawicki, Misiones Entomological Survey Project (PREM). Fac. of Exact, Chemical and Life Sciences. Universidad Nacional de Misiones. Félix de Azara 1552. (3300) Posadas - Misiones. Tel: 0054-3752-422186, Fax: 0054-3752-425414. E-mail: atricio@rector.unam.edu.ar.

The study of the wealth of species of a certain area have a great importance, not only for its historical knowledge, but also for the global comprehension of its biodiversity. Among the animals, the butterflies and the birds constitute groups of easy visualization and identification, consequently they are good indicators. The intense human activity in Posadas city, given by the urban growth and the location of Yacyretá Dam, made a deep modification to the Fluvial and Fields District of vegetation. A great part of vegetation was lost by the increassing in the amount of water in the dam iake; the new flooded land would take place, reestablishing its dynamics allowing the reappearance of the different vegetable covering in the bank of the Paraná river, where the past expression was the jungle in gallery and the grassland. Therefore, the changes in the dispersion and reproduction of the plants will be able to affect the populational structure of the butterflies. In this instance, we want to show which are the species of Papilionidae Family present in the area that will be modified. The resulting data came from the sampling methods using net and recognition during flight of the well known species during a period of time including 14 months, from August of 1997 to October of 1998. The capture places have been: Arroyo Apepú, Barrio El Laurel, Toma de Agua, Jardín Botánico and Center of the city. The Swallowtail butterflies found were Mimoides Lysithous ssp. (Graphiini); Heraclides anchisiades capys, H. astyalus astyalus, H. hectorides hectorides, H. thous brasiliensis (Papilionini); Battus polydamas polydamas, Parides agavus, P. anchises nephalion (Troidini). The greatest diversity observed was at Barrio el Laurel through the months of April, September, and December. At Center and Toma de Agua points there was no record of this family. The fragile balance among plants and animals which inhabited the Earth has survived several episodes of massive extinction after millions of years of evolution. Now once again, but this time by the human influence with destruction of their habitats, the introduction of exotic species and the intensive and not sustained use of the biological resources. In the scientific forums and of political deliberation, the process of erosion of the natural resources comes being boasted as one from the most serious problems to be faced by the human population at the end of this century Index Term: Lepidoptera, Papilinionidae, Argentina

[0564] PRESENCE OF *DIURAPHIS NOXIA* (*HOMOPTERA: APHIDIDAE*) COLONIZING BARLEY CROPS IN THE CENTRAL AREA OF THE PROVINCE OF CÓRDOBA (ARGENTINA)

<u>G. A. Truol</u>¹; P. S. Herrera² & J. D. Arneodo³, 1. INTA; 2. CONICOR; 3. CONICET, IFFIVE - Instituto Nacional de Tecnología Agropecuaria (INTA). Camino a 60 cuadras km. 5½ (5119) Córdoba, Argentina. gratruol@cordoba.com.ar

Studies conducted on barley crops near Alta Gracia (Province of Córdoba, Argentina) showed aphid colonies of the Diuraphis noxia species, commonly known as "Russian Aphid' or "Wheat Russian Aphid", for the first time. This aphid had already been mentioned in this province in Manfredi but only occasionally were winged individuals captured in Moericke-type yellow traps. Colonized plants displayed sheathed leaves containing aphids in their basal section and featuring pale green longitudinal stripes which usually amounted to three and had different sizes. Samples for serological tests were obtained in order to determine whether symptoms were caused by either the insect itself or barley stripe mosaic virus (BSMV) and/or barley yellow dwarf virus (BYDV) infection, which symptoms are similar to the ones described above. Indirect ELISA was performed for BSMV and DAS ELISA for BYDV (PAV variant) but the assays failed to show any of these virus diseases. Moreover, samples for transmission electron microscopy were processed and no virions could be observed. Yet, severe alterations were noticed in chloroplasts concurrently with the results of visual observation. Aphid colonies could be reared in wheat (Prointa Federal cultivar) under greenhouse conditions and the same symptoms mentioned earlier appeared again. It is believed that such symptoms are due to vector action and attention should be thus paid to both the adaptation of the vector and its ensuing spreading into the cereal growing area in the province of Córdoba not only on account of the direct damage it causes but also on account of its ability to transmit, among other diseases, BYDV (widely spread in Argentinian grasses) with brome mosaic virus (BMV) as a helper.

Index terms: Russian aphid - barley - syptoms

[0565] RELATION BETWEEN THE DIVERSITY OF CARABID BEETLES AND DEER, MICE, AND DWARF BAMBOO IN A DECLINING ALPINE FOREST

<u>A. Ueda</u>, T. Hino, T. Shimada, H. Ito, Y. Takahata & II. Furusawa, Kansai Res. Ctr., Forestry and Forest Products Res. Inst., Kyoto 612-0855, Japan, E-mail akira@fsm.affrc.go.jp

Fragmented alpine forests in western Japan are at a crisis in their existence because of remarkable high density of deer that feeds seedlings and bark of trees, resulting in an impediment to the natural regeneration of trees and the death of adult trees. However, not only deer affect the natural regeneration of trees, but also mice, dwarf bamboo, herbivorous insects and their predators, infectious or mycotrophic fungi, and so on. Thus, to restore these forests while maintaining biological diversity, we need to understand the network of interactions between these organisms. By artificially controlling populations of deer, mice, birds, and dwarf bamboo, we are investigating how these four kinds of organisms individually or additionally affect the survival of seedlings, the occurrence of mycotrophy, the nature of the soil, populations of herbivorous insects, and the diversities of carabid beetles, creeping spiders and medium size soil animals. Our goals are to establish a simulation model for the dynamics of these organisms in relation to the natural regeneration of trees by clarifying their inter-relationships, and to develop technology for adequate management in order to restore these forests while maintaining biological diversity. The project was begun to management in 1997 at a fragmented alpine forest. Since carabid beetles are at the top of the food chain of small animals residing in the soil and understory, the diversity of carabid beetles is strongly related to the diversity of these small animals. Thus, 320 pitfall traps were set to investigate how deer, mice and a species of dwarf bamboo relate to the diversity of carabid beetles. The beetles were collected for 3 or 4 days in June, August and September in 1999. Beetle species present greatly differed between collection times. However, slashing of dwarf bamboo induced an increase in the average diversity (H') of the beetles at all collection times. On the contrary, the average diversity of the beetles was significantly correlated with the biomass of the dwarf bamboo in September at plots in which dwarf bamboo was not slashed. Moreover, although the absence of deer increased the biomass of the dwarf bamboo, the average diversity of the beetles was higher in plots without deer than with deer. An enclosure to exclude mice (also preventing entry by carabid beetles, except for those flying or tunneling) reduced the average diversity of the beetles. These results suggests that deer, mice and dwarf bamboo somehow affect the diversity of carabid beetles. These results are contradictory. Only continuous observations in the future will improve our knowledge from its present incomplete state to a more integrated perspective of these inter-relationships.

[0566] ESTIMATING INSECT DIVERSITY IN CENTRAL ARGENTINA: A COMPARISON AMONG TAXA AND HABITATS

<u>G. Valladares</u>¹, A. Mangeaud¹, S. A. Salvo¹, W. Almirón¹, M. A. Delfino¹ & S. I. Molina¹, ¹Centro de Investigaciones Entomológicas, FCEFYN, Univ. Nac. Córdoba, Av. Vélez Sársfield 299, 5000-Córdoba, Argentina. E-mail: grv@onenet.com.ar.

Natural habitats in Central Argentina are rapidly disappearing while their biodiversity remains poorly known. Fast and reliable estimations of such diversity are therefore needed. This contribution aims to provide comparable estimates of punctual (space / time) diversity and to evaluate the distinctness of local species assemblages, for 5 insect groups (from different trophic and environmental niches) in 4 of those habitats. Comparisons with further collections in space and time were also made in order to assess the accuracy of the former estimations. Leaf-mining Agromyzidae (Diptera), their parasitoids (Hymenoptera) and Aphididae (Homoptera) were collected along 5 transects (100m x 1m each), while Culicidae (Diptera) and Trichoptera were sampled by using 5 specific light traps for each group, Samples were taken in 4 localities representing different phytogeografic units (Chaco Hill Forest, Chaco Dry Forest, Espinal, Pampa). Observed and estimated (using Estimates 5.0) species richness at the studied localities were compared among taxa by Spearman Correlation analysis. Multivariate (cluster) analysis was performed to analyse distinctness of local assemblages regarding their specific composition. A total of 35 Agromyzidae, 19 Aphididae, 11 Culicidae, 37 parasitoids and 22 Trichoptera species were recorded in the punctual collections. Species richness distribution patterns were independent among taxa, though both phytophagous groups were richer in the Hill Forest while both aquatic groups were more diverse in the Chaco Dry Forest area. At the best studied habitat (Chaco Hill Forest), observed values of local species richness for each taxa ranged between 1/5 and 1/2 of the corresponding number of species known to occur throughout the area. Values noticeably closer to the latter were obtained by adding one sample, particularly for leaf miners (70% of the total number of species known in the area, and as many as those recorded after 30 monthly samples in a comparable locality). Proportion of singletons (0 - 0.75 for each group, 0.12 - 0.32 for each habitat), was also considered as an indicator of inventory completeness for each locality. Although each habitat accounted for less than half of the total species recorded in the region, the species assemblages found in the pampean locality showed the strongest and most consistent differences regarding taxonomic composition. The marked similarity of assemblages in the three other habitats could be expected from their closer phytogeographic affinity. Index terms: Agromyzidae, Aphididade, Culicidae, Parasitoids, Trichoptera

[0567] AQUATIC COLEOPTERA ASSEMBLAGES FROM SHALLOW LAKES ASSOCIATED TO THE CANAL DE CASTILLA (CENTRAL SPAIN)

L. F. Valladares¹, <u>J. Garrido² & F. García-Criado¹</u>, ¹Departamento de Biología Animal, Facultad de Ciencias Biológicas y Ambientales, Universidad de León, 24071 León, Spain, E-mail: dbalvd@unileon.es; ²Departamento de Ecología y Biología Animal, Facultad de Ciencias, Universidad de Vigo, 36200 Vigo, Spain, E-mail: jgarrido@uvigo.es.

Aquatic Coleoptera was seasonally sampled during an annual cycle (spring 1998 - winter 1999) in shallow lakes associated to the Canal de Castilla (Palencia province, Spain). These waterbodies are typical plateau wetland ponds with dense vegetation, varying in water permanence (from short-lasting temporary to permanent ponds) and surface (from 3.3 ha to 29.35 ha). Several physico-chemical variables were recorded at the time of sampling: oxygen concentration, conductivity and pH. Pond surface, depth, water permanence and type of vegetation were also taken into account, 92 species (44 Hydradephaga, 48 Polyphaga) belonging to 12 families were collected. Richness was higher than other studies carried out in other wetlands from the Northern Iberian mescta, such as the Laguna de la Nava (50 Coleoptera species collected) and the Lagunas de Villafáfila, where 31 Hydradephaga species were recorded. The assemblage structure was assessed by three parameters: richnes, abundance and diversity (Shannon index). Their relation with the environmental variables was explored by using correlation coefficients. The richness values for each pond ranged from 22 to 43 species. The highest richness and abundance values were recorded in spring (1,406 specimens, 74 species) and winter (1,049 specimens, 72 species). The assemblage composition was analysed by an ordination multivariate technique: Detrended Correspondence Analysis (DCA). Correlation coefficients between the environmental variables and the DCA axes were used as an aid to interpreting the ordination diagram. Both richness and the first DCA axis were significantly correlated with water permanence and conductivity, but they were not with any of the remaining parameters. Conductivity, is not too high in the study area and is significantly inter-correlated with permanence. Therefore, permanence seems the main factor influencing water beetle assemblages.

Index terms: aquatic Coleoptera, community structure, shallow lakes, Iberian plateau, Spain.

[0568] BEETLE DIVERSITY AND FOREST CHARACTERISTICS IN FLANDERS (BELGIUM)

<u>V. Versteirt</u>¹, K. Desender⁴, K. Smets¹, G. Geudens¹, D. Drugmand¹, D. De Bakker¹, P. Grootaert¹, P. Verdyck¹, D. Van Den Meersschaut², K. Vandekerkhove² & B. De Vos², ¹ Dept. Entomology, RBINSc, Vautierstr. 29, B-1000 Brussels, Belgium, E-mail: kdesender@kbinirshbe; ² Inst. Forestry and Game Management, AMINAL, Gaverstraat 4, B-9500 Geraardsbergen.

This study on beetle diversity and forest characteristics in the region of Flanders (Belgium) is part of a larger investigation on the use of terrestrial arthropods as ecological indicators in site assessment studies and forest evaluation. The aims of this study are manifold: (1) gather basic information on the occurrence and recent distribution of these organisms, (2) evaluate and understand species richness and species quality within the framework of nature conservation values and (3) examine how far the studied organisms can be used as indicators for the evaluation of forest site quality and woodland management, by analysis of relationships between relative abundance (habitat and/or microhabitat preference) and environmental parameters. With exception of the ground beetles (Carabidae), data on the occurrence and diversity of Coleoptera in Flemish forests are until now very incomplete. During a one year period (1997-1998), a large scale sampling was performed in 56 forest plots from 40 different forests in Flanders. The sampling techniques involved were three pitfall traps, three while and three yellow pan traps in each studied forest plot. Extensive data were available for most important abiotic and biotic descriptive variables, including vegetation, forest structure, forest soil and forest floor characteristics, and for a number of landscape ecological variables such as area, isolation and distance of study plots to nearest woodland edges. Because of the huge amount of invertebrate material gathered, data presented in this contribution are restricted to the months of April till July and to several beetle families, including Elateridae, Scolytidae, Cerambycidae, Silphidae, Scarabaeidae, Chrysomelidae and Staphylinidae. On the whole about 200 species were caught, belonging to more than 50 beetle families. Results are presented with emphasis on faunal interest, diversity and bio-indication. This study will contribute to the necessary baseline knowledge for future studies on the impact of forest management and within the context of nature development.

Index terms: woodland, Coleoptera, forest management, ecological indicators.

[0570] BIODIVERSITY OF AN'T SPECIES IN NATURAL AND CREATED WETLANDS

D.A. Waller, Biology Dept., Old Dominion Univ., Norfolk, VA, USA 23529.

Wetland habitats have been lost in the United States through development or conversion to agriculture. Recent appreciation of the value of ecosystem services provided by wetlands has resulted in the current policy of no net wetland loss. Now development of wetlands must be mitigated in other sites by either the preservation of pristine wetlands, the restoration of degraded wetlands or the creation of new wetland habitats. However, it is unknown whether created or restored wetlands ever attain the structure and function or provide the ecosystem services of natural wetlands. Most mitigation efforts have focused on vegetation establishment in created wetlands and ignored the invertebrate inhabitants, which are essential in many ecosystem processes. The assumption has been that invertebrates will follow once wetland vegetation is in place. However, invertebrates may be constrained from colonizing created wetland sites by such factors as 1) the distance of the created site from natural source areas, 2) the land area and vegetation structure of the created site, and 3) the dispersal abilities of different invertebrate species. The present study compared the ant faunas of created and natural wetlands in southeastern Virginia, an area that has suffered extensive wetland losses. Ants play vital roles in ecosystems and the presence of some ant species may be critical to the establishment of ecosystem function in created sites. Numerous ant species can occupy a given habitat where different species may serve as herbivores, predators, scavengers, seed dispersal agents, soil modifiers and food for other organisms. Ants were sampled from the soil, litter layer and herbaceous and shrubby vegetation in three created wetland sites and in three natural wetland sites. Collection methods included ant baits of peanut butter and jelly, litter extractions using Berlese funnels, pitfall traps consisting of testtubes filled with soapy water and insect net sweep samples taken along transects established in each site. Ants were returned to the laboratory and identified to species. Shannon's diversity index was calculated to compare the ant fauna at these sites. Diversity values were significantly lower for the ant species inhabiting the created wetland sites than for ants from the natural wetland sites. The few ant species collected from the created sites included widespread species such as Tapinoma sessile (subfamily Dolichoderinae) and Prenolepis imparis (subfamily Formicinae); these species nest in a variety of microhabitats and they can tolerate a large range of environmental conditions. In contrast, dozens of ant species were collected from the natural wetland sites, including many specialized species that are confined to the litter layer and have poor dispersal abilities. These sites will be followed to determine whether created sites ever reach the levels of ant diversity characteristic of natural wetlands. Index terms: Formicidae, Prenolepis imparis, Tapinoma sessile

[0569] AQUATIC HETEROPTERA (GERROMORPHA & NEPOMORPHA) FROM RETIRO DAS PEDRAS, A LOCALITY NEARBY BELO HORIZONTE, MINAS GERAIS, BRAZIL

G. J. C. Vianna¹ & A. L. Melo¹, ¹Dept. of Parasitology, Federal University of Minas Gerais, P.O. Box 486, Belo Horizonte, 30161-970, MG, Brazil, E-mail: guze@icb.ufmg.br

Aquatic insects are important and conspicuous members of freshwater habitats, mainly concerning aquatic Heteroptera. There is some information on the Heteroptera species composition from Minas Gerais, but studies about the fauna of the Belo Horizonte boundaries, which comprise part of the city water supply, are scarce. Aiming to contribute to the current knowledge of the aquatic Heteroptera in M.G., focusing the water bodies from the vicinities of Belo Horizonte, a list of the Heteroptera species collected is presented as well as community structure in different habitats. Samples were taken from January to December 1999, at three sampling stations representing different habitat types (4th order stream, artificial pond and temporary pools), with a hand net, sweeping the edges, water column and bottom. The insects were sampled in order to define faunal affinities between the three habitat types. Cluster Analysis (UPGA) and Principal Component Analysis (PCA) were performed and presence/absence data were used. A total of 24 species, distributed in 11 families were collected, two of which seems to be the first record for M.G. The composition of the community from the three habitat types is clearly distinct from each other. The first axis of PCA analysis (which was defined by artificial pond site at its positive end and by stream site at the negative end) separates lentic from lotic habitats. The second axis (which was defined by temporary pool site at its positive end and by artificial pond site at its negative end) separates species characteristic of temporary habitats from permanent habitats. The cluster analysis, in turn, showed greater similarity between artificial pond and temporary pool, probably due to the lentic characteristic of these two habitats. The nature of habitat preferences remains unknown, but could reflect the physical patterns of the three habitat types and differential colonization abilities and physiological tolerance.

Index terms: Aquatic insects, community structure, habitat preference.

[0571] INSECT HERBIVORES AS PREDICTORS OF PLANT PHYLOGENY: EXAMPLES FROM NEW GUINEA FICUS

G. D. Weiblen¹, V. Novotny², Y. Basset ³ & S. Miller⁴, ¹Dept. of Zoology, 203 Natural Sciences Bldg., Michigan State University, East Lansing, MI 48824, USA, E-mail gweiblen@pilot.msu.edu. ²Institute of Entomology CAS and Faculty of Biological Sciences, University of South Bohemia, Branisovska 31, 370 05 Ceske Budejovice, Czech Republic, E-mail binatangi@datec.com.pg. ³Smithsonian Tropical Research Institute, Apartado 2072, Balboa, Ancon, Panama City, Republic of Panama, E-mail bassety@tivoli.si.edu. ⁴Department of Entomology, National Museum of Natural History, Smithsonian Institution, Washington, DC 20560-0105, E-mail miller.scott@nnnh.si.edu.

The associations between figs (*Ficus* spp., Moraceae) and insect herbivores in several feeding guilds were examined using comparative methods. Feeding records for leafchewing, sap-sucking and infloresence-feeding insects from New Guinea were compared with host plant phylogeny using two approaches. First, the ancestral associations of herbivores were reconstructed on host phylogeny to examine patterns in homoplasy. Colonization of multiple *Ficus* lineages was common in all herbivore guilds and only the associations of larval Lepidoptera feeding on leaves and fig wasps (Agaonidae: Hymenoptera) showed less homoplasy than expected by chance. Second, the faunal similarity of host species was inferred from cluster analysis and compared with host phylogeny. Fig wasp associations of less specialized herbivores. Most *Ficus* herbivores in New Guinea were oligophagous and their patterns of association were not simply explained by host phylogeny, suggesting the importance of ecological factors in the evolution of plant/insect interactions.

Index terms: Agaonidae, Ficus, fig wasps, herbivores, phylogeny

Session 03 – BIOGEOGRAPHY AND BIODIVERSITY

[0572] BIODIVERSITY IN THE SOFT SCALE INSECTS OF CENTRAL AMERICA

M. L. Williams, Dept. of Entomology & Plant Pathology, 301 Funchess Hall, Auburn Univ., Auburn University, AL 36849-5413, USA.

The soft scale insect family Coccidae contains 1088 species in 144 genera, making it the third largest family of the Coccoidea in terms of species. A total of 51 genera and 298 species of Coccidae are known from the Neotropical Region. The soft scale insect fauna of the Neotropics tends to be specialized and rich, with 20 endemic genera and 247 endemic species. The fact that almost all of these records are from a relatively small area of Brazil indicates a pressing need for collecting the entire Neotropical Region. Central America, makes up only a small part of the Neotropical Region, in land area being only about the size of the state of Texas in the United States. However, Central America has provided a continuous land bridge for the mixing of the floras and faunas of North and South America for millions of years. Due to their complex geological and climatic histories, the countries of Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama have experienced repeated invasion and establishment of flora and fauna from both North and South America and have served as centers of speciation and biotic diversification. Today this area boasts one of the highest diversities of insect species on earth yet little is known about the scale insects of these countries. Information on the soft scale insects of Central America is scattered throughout the literature and generally includes information and/or descriptions of only a few species. There has not been a comprehensive study of the scale intect fauna for any of the seven countries of Central America. Information presented in this paper represents our current knowledge of the biodiversity of the soft scale insects of Central America, with the exception of two undescribed genera and approximately five undescribed species known to the author. The family Coccidae is represented in Central America by 20 genera and 56 species, discounting the undescribed taxa mentioned above. Taxonomic diversity by country is as follows: Belize - 5 genera, 7 species; Costa Rica - 15 g., 21 spp.; El Salvador - 12 g., 15 spp.; Guatemala - 18 g., 27 spp.; Honduras - 13 g., 24 spp.; Nicaragua - 13 g., 18 spp.; and Panama - 18 g., 36 spp.. Mexico, Central America's neighboring country to the north, is represented by 24 genera and 62 species of soft scales. When comparing soft scale diversity between Central America and Mexico, which is much larger in land area than Central America, one can get an appreciation for the importance in studying this area of the Neotropics before habitat destruction eliminates much of the biodiversity in the scale insect fauna before we can collect, study, identify and catalog them

Index terms: Homoptera, Coccidae, Neotropical Region.

[0573] SOCIEDAD ENTOMOLOGICA ECUATORIANA

N. Zabala, Executive Director, Universidad San Francisco de Quito, Apto 17-12-841, Quito Ecuador, E-mail nelson@mail.usfq.edu.ec.

The Sociedad Entomológica Ecuatoriana (SEE) was founded in 1982 and since then has been actively involved in studies of the entomological biodiversity of neotropical Ecuador and applied entomology. Currently there are more than 150 members of the SEE with some from other countries such as Brazil, Colombia, Peru, Venezuela, and the USA. Most members work in universities and research centers of applied entomology, especially in agricultural, medical, or veterinary areas. The main research centers are in Quito: Museo Ecuatoriano de Ciencias Naturales (MECN), Univ. San Francisco de Quito (USFQ), Univ. Catolica del Ecuador (PUCE), Escuela Politecnica Nacional (EPN), Univ. Central del Ecuador (UC) and Instituto Nacional de Investigaciones Agropecuarias (INIAP). In Guayaquil: Univ. de Guayaquil and Instituto de Medicina Tropical. In Cuenca: Univ. de Cuenca. And in the Galapagos Islands: Charles Darwin Research Station (CDRS). These centers are the principal focus for training entomologists and where most of members are. The most important in number and diversity neotropical entomological collections are in Museo Ecuatoriano de Ciencias Naturales, Univ. Catolica del Ecuador, Escuela Politecnica Nacional, Instituto de Medicina Tropical and Charles Darwin Research Station of the Galapagos Islands. The Ecuador National Congress of Entomology takes place every 4 years since 1982 in Quito; the next one will be in 2003. Ecuadorian scientific activity in entomology is reflected in these events with topics such as biodiversity, biological control, medical and veterinary entomology, ethology and ecology. Since 1988 the SEE has edited the Boletin de la Sociedad Entomológica Ecuatoriana. In 1998 the SEE in collaboration with the Univ. San Francisco de Quito published the book Butterflies of Ecuador. The same year Univ. Catolica de Ecuador published the book families of Ecuadorian Butterflies. Our members also contribute to understanding neotropical biodiversity taking part in national and international meetings and publishing papers and books. The Society has a special library located at the Museo de Ciencias Naturales del Ecuador and maintains relationships with a number of similar institutions in the world, which exchange publications and obtains funding.

Index terms: Entomological Societies, Latin America, Ecuador.

[0574] BIONOMICS OF PEPPERTREE PSYLLID CALOPHYA RUBRA (HOMOPTERA: PSYLLIDAE) IN MEXICO

R. Alvarez-Zagova¹ & D. Cibrián-Tovar², ¹ Instituto Politécnico Nacional, CIIDIR Unidad Durango, Lab. Entom., Sigma s/n, Apdo. Postal 57, Fracc. 20 de Noviembre II, Durango 34220, Dgo., México. Becario/COFAA-IPN, E-mail: raz_ciidir@yahoo.com² Universidad Autónoma Chapingo, Div. Cien. For., Lab. Entom. For., Apdo. Postal 37, Chapingo 56230, Edo. de Méx., México. E-mail: dcibrian@taurus1.chapingo.mx

Peppertree psyllid, Calophya rubra, is an insect highly associated to peppertree, Schinus molle L., which has been dispersed in South America along with its native host. In the last decade, C. rubra has become the cause of the reduction of aestethic quality on introduced peppertree in central México and California, USA, where it has been used as an ornamental species. Field and laboratory-reared observations were carried out in 1997 and 1998, at Chapingo, Texcoco, Mexico State. In this work, the aims were to describe the psyllid life cycle, mating, ovipositing and feeding behaviour, nymphal instars description, damage, distribution, natural enemies of the psyllid and peppertree phenology. Life cycle variation depends on temperature having 48 to 68 days from egg to adult; females live two days more than males do. Each female deposits a mean of 50 eggs, even though they can oviposite 110 eggs. Long and width measurements on 523 exuvies and nymphs showed that exist five nymphal instars. Long mean in milimeters from nymphal instars N1 to N5 were: 0.23, 0.34, 0.50, 0.68 and 1.07 mm; mean width for N1 to N5 were: 0.17, 0.28, 0.40, 0.58 and 0.99 mm, respectively. Nymphal instars separation were statistically analized with y2-test and principal component analysis. C. rubra was similar in field and laboratory. Disc gall forming is the damage derived from feeding behavior on the leaves, giving them a cinder green color. There are seven potential predator species and a new parasitoid species, *Tamarixia schina* Zuparko. This Eulophid wasp is an outstanding natural control species of C. rubra population. Its life cycle lasts 20 days from egg to adult and 96% of adults emerged were females. Parasitism percentage was from 10 to 28% on psyllid nymphs N3 to N5 with a 1:1 rate, without hyperparasitism.

Index terms: Insecta, Calophya rubra, psyllids, biological control, Tamarixia schina Z., Schinus molle L.

[0575] CHEMISTRY OF OLFACTORY LANDSCAPES; ODOR SIGNAL COMPLEXITY, EVOLUTIONARY CONVERGENCE AND DECEPTION

R. A. Raguso, Dept. of Biol. Sci., Univ. of S. Carolina, Coker Life Sci. Bldg., 701 Sumter St., Columbia, SC 29208, USA, E-mail Raguso@biol.sc.edu

One critical challenge to the evolution of sex-related chemical communication is the need to effectively attract the desired party from a distance without attracting an unwanted third party. In floral pollination systems, the third party often consists of non-pollinating florivores or seed predators, whereas in pheromone-driven insect mating systems, either predators or related species (inappropriate mates) constitute the unwanted third party. In these examples, reproductive fitness is decreased or abolished by third party exploitation of a chemical signal, through mortality or hybrid infertility. Ideally, sex pheromones should provide their users with a private channel of communication. Given the staggering chemical complexity of natural odorants, and the versatility of most insect olfactory abilities, chemical specificity of sexual signals should not be difficult to achieve. Furthermore, the pheromone detection and processing cauabilities of most insects generally have evolved such that the olfactory "noise" provided by complex background odors does not seriously impact the salience of pheromone signals. However, the biosynthetic pathways that generate volatile compounds are ancient and shared among biological kingdoms, providing opportunities for semiochemical convergent evolution, mimicry and deception between insects, plants and fungi. For example, orchids with floral fragrances that mimic hymenopteran sex pheromones have evolved independently in Mediterranean Europe/N. Africa and in Australia, exploiting the sexual behaviors of male wasps for pollination services. Certain chemical classes of insect pheromones may be more vulnerable to exploitation by plants than others, and the combination of biochemical and phylogenetic analyses are needed to better discern the constraints under which pheromones evolve in different insect lineages.

Index terms: fragrance, mimicry, pheromone, pseudocopulation, semiochemistry

Symposium and Poster Session

[0577] THE MOLECULAR BIOLOGY OF *DROSOPHILA* ODORANT RECEPTORS

L. B. Vosshall, H. Amrein, P.S. Morozov, A. Rzhetsky & R. Axel, Center for Neurobiology and Behavior, Columbia Univ., 701 West 168th St., Box134, New York, NY 10032 USA. Email: LV25@columbia.edu

Drosophila fruit flies display robust olfactory-driven behaviors with an olfactory system far simpler than that of vertebrates. Endowed with approximately 1500 olfactory receptor neurons, these insects are able to recognize and discriminate among a large number of distinct odorants. Candidate odorant receptor molecules responsible for this specificity were identified by complimentary approaches of differential cloning and genome analysis The Drosophila odorant receptor (DOR) genes encode a novel family of proteins with seven predicted membrane-spanning domains, unrelated to vertebrate or nematode chemosensory receptors. There are approximately 60 members of this gene family in the Drosophila genome, far fewer than the hundreds to thousands of receptors found in vertebrates or nematodes. DOR genes are selectively expressed in small subsets of olfactory neurons, in expression domains that are spatially conserved between individuals, bilaterally symmetric, and not sexually dimorphic. Double in situ RNA hybridization with a number of pairwise combinations of DOR genes fails to reveal any overlap in gene expression, suggesting that each olfactory neuron expresses one or a small number of receptor genes and is therefore functionally distinct. How is activation of such a subpopulation of olfactory receptor neurons in the periphery sensed by the brain? In the mouse, all neurons expressing a given receptor project with precision to 2 of 1800 olfactory bulb glomeruli, creating a spatial map of odor quality in the brain. We have employed DOR promoter transgene that recapitulate expression of endogenous receptors visualize the projections of individual populations of olfactory receptor neurons to subsets of the 43 glomeruli in the Drosophila antennal lobe. The results suggest functional conservation in the logic of olfactory discrimination from insects to manunals.

Index terms: Drosophila melanogaster, antennal lobe, glomeruli, olfactory receptor genes

[0576] AIR FLOW THROUGH PECTINATE INSECT ANTENNAE AND ODORANT INTERCEPTION RATES

C. Loudon¹ & M.A.R. Koehl², ¹Dept of Entomology, Univ. of Kansas, Lawrence, KS 66045, USA, E-mail loudon@ukans.edu; ²Dept. of Integrative Biology, Univ. of California, Berkeley CA 94720-3140.

Many organisms increase the air or water flow adjacent to olfactory surfaces when exposed to appropriate chemical stimuli; such "sniffing" samples fluid from a specific region and can increase the rate of odorant molecule interception. We used hot wire anemometry, high-speed videography and flow visualization to study air flow near the pectinate antennae of male silkworm moths (Bombyx mori). When exposed to conspecific female sex pheromone, male B. mori flap their wings through a stroke angle of 90 to 110° at about 40 Hz without flying. This behavior generates an unsteady flow of air (mean speed 0.3 to 0. 4 m/s) towards the antennae from the front of the male. A pulse of peak air speed occurs at each wing upstroke. The Womersley number (characterizing the damping of pulsatile flow through the gaps between the sensory hairs on the antennae) is <1, hence pulses of faster air (at 40 Hz) should move between sensory hairs. Calculation of flow through arrays of cylinders and random walk simulations suggest that this wing fanning can increase the rate of pheromone interception by the sensory hairs on the antennae by at least an order of magnitude beyond that in still air. Although wing fanning produces air flow relative to the antennae that is about fifteen times faster than that generated by walking at top speed (0.023 n/s), air flow through the gaps between the sensory hairs is about 560 times faster because a dramatic increase in the leakiness of the feathery antennae to air flow occurs at the air velocities produced by fanning. The pressure drop across single antennae was measured for both male and female antennae mounted over orifices such that air was forced to pass through the antennae. Resistance to flow of both male and female antennae (PaAs/m) was approximately independent of air speed and was higher for male antennae. Drag forces were measured on both male and female antennae using a novel terminal velocity assay. By combining the measured resistance and the drag forces, the proportion of approaching air that passes through the antenna was estimated as about 15% for both male and female antennae. This approximate "bluff body" behavior is likely to be exhibited by pectinate antennae from a variety of insect taxa in ambient air speeds of 1 m/s or less.

Index terms: biomechanics, diffusion, chemosensory, Bombyx mori.

[0578] DIVERSITY, PHYLOGENY, AND FUNCTIONS OF ODOR RECEPTION PROTEINS: OBP, ODE AND SNMP

<u>R.G. Vogt</u>¹ & M.E. Rogers^{1,2}, ¹Dept. of Biological Sciences, Univ. of South Carolina, Columbia SC 29208, USA, E-mail vogt@biol.sc.edu; ²Dept of Biological Sciences, 922 Fairchild, Columbia Univ., New York NY 10027, USA, E-mail mt959@columbia.edu. Support: NIH-NICDC DC00588; NSF-IBN9731005; USDA-CGRP94373020615.

Three classes of antennal specific proteins have been identified, in the course of our studies; Odorant Binding Proteins (OBPs) and Odorant Degrading Enzymes (ODEs), and the neuronal membrane protein SNMP (sensory neuron membrane protein). prevailing models of odor reception suggest odors are solubilized into the sensillum lymph by interaction with OBPs, and so transported to receptor proteins in the neuronal membranes, and subsequently inactivated and degraded by ODEs. OF these proteins, OBPs have received the most attention, and are recognized in part by their homologous relationships to the Pheromone Binding Proteins (PBPs) of lepidoptera or the OS-E/OS-F proteins of *Drosophila melanogaster*. OBPs are present in individual species as a multigene family, with members differentially expressing in morphologically distinct sensilla, or in various combinatorial patterns. These OBPs have been identified from a wide range of insect species, but to date appear restricted to the holometabolous and hemipteran lineages which together are thought to form a single clade distinct from other Neopteran insects. A distinctly different family of protein, recognized by its homology with the Drosophila protein OS-D, is widely distributed throughout the Neoptera, and may represent a second type of OBP-like protein. ODEs, have been less studied, and are known primarily from the sensilla esterase of Antheraca polyphemus and the aldehyde oxidases of several lepidoptera. ODEs are also present as body surface enzymes, and recently as potentially dual purpose detoxification / odor termination enzymes of the olfactory support cells, such as GSTolf from Manduca sexta. SNMP is an antennal specific protein uniquely expressing in olfactory neurons and abundantly distributed in the receptive membranes of olfactory neurons. SNMP homologues have been identified from A. polyphemus, Heliothis virescens and Bombyx mori, as well as from M. sexta where two were identified. SNMP is homologous with a pan-phyletic family of dual-transmembrane domain receptors, recognized in part by their similarity to the vertebrate CD36 protein; this family typically interacts with proteinaceous ligands. SNMP is incorporated into the model of odor reception in several possible sites, including interactions with OBP-odor complexes to induce off loading of odors in proximity to odor-receptor proteins, and We interacting with odor-receptor proteins to enhance or support receptor function. suggest sensillar class odor specificities are strongly influenced by combinatorial expression of these proteins.

Index terms: pheromone binding protein, olfaction, receptors, odor

[0579] THE NITRIC OXIDE – SOLUBLE GUANYLYL CYCLASE SIGNALING SYSTEM IS INVOLVED IN THE PROCESSING OF OLFACTORY INFORMATION IN THE HAWKMOTH, MANDUCA SEXTA

A. Nighorn & T. Christensen, ARL Division of neurobiology, University of Arizona, Tucson, AZ 85721 USA, E-mail: nighorn@neurobio.arizona.edu

We are examining the role of the NO/sGC pathway in the processing of olfactory information in the hawkmoth, Manduca sexta. The role of this pathway was first examined in the antennae where this signaling system was hypothesized to play a role in the adaptation of the olfactory receptor neurons. Examining the expression of the candidate proteins however, we found that nitric oxide synthase (NOS), the enzyme that generates nitric oxide (NO), is expressed in the axons, but not cell bodies or dendrites of apparently all olfactory receptor neurons. The best characterized target of NO, soluble guanylyl cyclase (sGC), is not present in olfactory receptor neurons at all, strongly suggesting that this pathway does not play a role in olfactory adaptation in the antenna. In the antenna lobe however, we found that NOS continued to be highly expressed in the axons of apparently all olfactory receptor neurons. Moreover, sGC was found to be expressed in a subset of antennal lobe neurons. These expression patterns suggest the possibility that odorant stimulation of olfactory receptor neurons causes the release of NO in the antennal lobe and that this phenomenon plays an important role in the subsequent processing of that odor signal. We are testing this hypothesis in two ways. First, we are using the NOsensitive dye Daf-2DA to visualize NO in the antennal lobes. Second, we are recording from antennal lobe neurons using both single and multi-unit recording methods before and after treatment with agonists and antagonists of NO pathways. Using Daf-2DA, we have found labeling antennal lobe glomeruli in response to odorant stimulation. This staining was eliminated by preincubation with the NOS inhibitor, L-NAME. Direct electrical stimulation of the antennal nerve also resulted in an increase in fluorescence in the caps of some glomeruli. Using single-unit responses of antennal lobe neurons, we found that agents that interfered with NO signaling, including L-NAME and Carboxy-PTIO, caused a dramatic and reversible change in response latency and a desynchronization of the response to repeated stimulation. SNP, an NO donor, caused a dose-dependent depolarization of antennal lobe neurons. The phosphodiesterase inhibitor IBMX, an agent that should potentiate the NO/sGC response, caused depolarization of the cells and also blocked spiking. These data point to an important role for the NO/sGC signaling system in maintaining synaptic efficacy in the olfactory pathway. Index terms: Daf-2, nitric oxide, olfaction, antennal lobe

[0580] PHEROMONE BINDING PROTEINS: STRUCTURAL, FUNCTIONAL AND GENETIC IMPERATIVES IN TORTRICID MOTHS

D.R. Greenwood¹, R.D. Newcomb¹, M. Rasam¹, T. Sirey¹, C. Baldock^{1, 2}, H.M. Baker² & E.N. Baker², ¹ Plant Health and Development Group, The Horticulture and Food Research Institute of New Zealand Ltd., Mt Albert Research Centre, Private Bag 92-169, Auckland, New Zealand; ² Structural Biology Group, School of Biological Sciences, University of Auckland, Private Bag 92-019, Auckland, New Zealand.

Pheromone binding proteins (PBPs) are involved in the perireceptor events surrounding the highly sensitive and specific semiochemical detection system used by insects to detect potential mates. In most male moths, specialised sensory organs (sensilla) residing on their antennae are tuned to respond to components of the sex pheromone blend produced by females. Volatile pheromone molecules diffuse through wax-filled pores into the aqueous lumen of these sensilla, where they are bound to PBPs. These proteins are thought to facilitate the transport of pheromone molecules to membrane-bound receptors. We are examining in detail the PBPs from the light brown apple moth, Epiphyas postvittana, a horticultural pest in both Australia and New Zealand. These PBPs have been compared with those from a number of other New Zealand indigenous species of leafroller moths (Tortricidae) that use different pheromone blends, in addition to comparisons with PBPs from other more distant species. There are principally two E. postvittana PBPs; we have expressed both of these in baculovirus-infected SF9 cells and purified them to homogeneity for 3-D structural studies by X-ray crystallography. This paper will describe our studies into the structural attributes of this novel family of small (15-18 kDa) proteins that are essentially α -helical and globular in nature with a hydrophobic pheromone binding pocket. This contrasts to the lipocalin family of ligand carriers that perform a similar function in the vertebrate olfactory system but possess a Bbarrel structure. Analysis of the structure will help us determine what role PBPs have in pheromone specificity and assist in resolving the molecular events occurring at the receptor surface, resulting in triggering of the signal transduction process via the G protein-linked seven transmembrane domain pheromone receptor, and ultimately in the guiding of a pheromone-directed flight response.

Index terms: *Epiphyas postvittana*, light brown apple moth, purification, characterisation, structural analysis

[0581] INSECT PHEROMONE BINDING PROTEINS FORM DIMER IN SOLUTION

W. S. Leal, Dept. Entomology, University of California, Davis CA 95616, USA, Email: wsleal@ucdavis.edu

Insects primarily rely on their olfactory system to detect chemical cues from the environment and initiate the transduction of these chemical signals into neuronal activities, which ultimately lead to the appropriate behavioral responses, such as mating, the location of food and oviposition sites, etc. There is growing evidence in the literature that the inordinate sensitivity and selectivity of the insect olfactory system is achieved by a combination of various olfactory-specific proteins, namely, odorant-binding proteins (OBPs), odorant receptors, and odorant-degrading enzymes. It is widely believed that OBPs play a part in the selectivity of the olfactory system by "filtering" chemical signals during the carly olfactory processing (perireceptor events). Nevertheless, the function(s) of these proteins is(are) still a matter of considerable debate, with postulated functions, altering their conformation and oligomeric state in pH-dependent ways. Using a comprehensive approach (Western immunobloting experiments, mass spectral analysis, gel filtration estimation of molecular masses, and cross-linking reactions), it was clarified that the pheromone-binding protein of *Bombyx mori* is a monomer at acid pH and a dimer at basic, neutral, and slightly acidic pH. The relevance of the duality monomer-dimer for binding and release of the pheromone ligand will be discussed.

Index terms: Bombyx mori, electrospray ionization mass spectrometry, Western blotting, cross-linking reactions

[0582] MATE RECOGNITION IN NEZARA VIRIDULA (HETEROPTERA, PENTATOMIDAE): A MATTER OF SONGS AND PHEROMONES

N. Miklas¹, <u>M. Renou¹</u>, A. Cokl² & M. Virant Doberlet², ¹ INRA, Unité de Phytopharmacie et Médiateurs Chimiques, Route de Saint Cyr, 78026 Versailles Cedex, France. E-mail : renou@versailles.inra.fr; ² NIB, Laboratory for Neurobiology Laboratory, Veena Pot 111, P.O.B. 141, 1001 Ljubljana, Slovenia.

Premating behavior in the southern green stink bug, Nezara viridula, involves vibratory and chemical communication. Males produce a volatile pheromone. The song repertoire of male and female Nezara is composed of a variety of substrate-transmitted signals. It was first postulated that the sex pheromone is mediating long range mate finding whereas vibratory signals modulate close range attraction. However, recent investigations suggest that both sensory modalities interplay during courtship behavior. A conjunction of techniques including olfactory stimulation, volatile collection, song recording and playback of acoustic signals, was used to determine the precise temporal and spatial pattern of the interactions between olfactory and vibratory communication. Males start to produce pheromone at age 8-10 days. We did not observe any conspicuous calling behavior and pheromone production does not follow a circadian rhythm. Stimulation of males with female calling song (FCS) failed to trigger the pheromone production and isolated males emit as well. Virgin females rarely emit the FCS spontaneously, but they respond with FCS emission to the presentation of male volatiles or of synthetic pheromone. When put on a new plant, males spontaneously emit male courtship song (MCrS) and when a couple of bugs was observed on a loudspeaker, it was usually the male who started singing first. On a plant, males alternate with the pre-precorded FCS by emitting MCrS and they increase their locomotion. Male bugs are able to locate the source of the female song on a plant. The ratios of terpenoid pheromone components and the temporal parameters of the songs show variability between geographicaly isolated populations. The specificity of the responses of male and female to signals of their own population or other population was investigated. Signals of both modalities interact to improve mate finding and recognition.

[0583] SENSORY AND BEHAVIOURAL RESPONSES OF TRIATOMINE BUGS TO ODOURS OF VERTEBRATE HOSTS AND TO CONSPECIFIC SEMIOCHEMICALS

P. M. Guerin, P. Guerenstein, M. Vlimant & S. Wicky, Inst. of Zoology, University of Neuchâtel, Rue Emile-Argand 11, 2007 Neuchâtel, Switzerland, E-mail patrick.guerin@unine.zool.ch.

Triatomine bugs search for vertebrate hosts to procure a blood meal and host odours mediate this behaviour. Perception of vertebrate odours occurs via an array of olfactory receptors in wall-pore and grooved-peg olfactory sensilla on the antennal flagellum. Electrophysiological recordings show that three of these receptors respond selectively to the host odour components nonanal, ammonia and isobutyric acid. Whereas nonanal causes increased displacement by the bugs, both anunonia and isobutyric acid attract triatomines walking on a servosphere. There is evidence for parsimony in the use of these semiochemicals in triatomines. As isobutyric acid occurs in the headspace of both *Rhodnius prolixus* and *Triatoma infestans* it may have an additional function as an aggregation stimulus in triatomines. Refuges occupied by triatomines are marked with their own faeces and are attractive to triatomines. Ammonia released from fresh faeces contributes to this attractivity. The bugs also perceive uric acid, a major constituent of their faeces, via receptors in a set of terminal pore gustatory sensilla on the distal flagellum of the antenna.

Index terms: Triatoma, Rhodnius, olfaction, gustation, behaviour

[9585] IDENTIFICATION OF SEX PHEROMONES OF ECONOMICALLY IMPORTANT STINK BUG PESTS OF AGRICULTURE

J. G. Millar¹, **H. L. McBrien¹**, **H.-Y. Ho¹ & R. E. Rice²**, ¹Dept. of Entomology, Univ. of California, Riverside CA 92521, USA, ²Dept. of Entomology, Univ. of California, Davis CA 95616, USA.

Phytophagous stink bugs (Heteroptera: Pentatomidae) are occasional to chronic pests in all types of cropping systems, including annual crops such as grains, alfalfa, beans, and tomatoes, and perennial crops such as tree fruits and nuts. Damage is caused by both immatures and adults, but only adults are winged and capable of long-distance movement. Injury to young seeds, fruits, or nuts produces necrotic lesions and often results in premature abortion, while attacked leaves may will and die. Stink bugs are also known or implicated as vectors of plant pathogens such as yeast, fungi, and bacteria. Many stink bug species are polyphagous and the adults are highly mobile, which exacerbates problems with their monitoring and control. Bugs migrate into crops in response to natural events such as the senescence of native vegetation in the habitat, or in response to mowing or harvesting of nearby crops harboring large bug populations. Effective bug control hinges on the rapid detection of these invasions so that appropriate control measures can be implemented before serious crop damage occurs. However, sampling methods for most bug species are still relatively primitive, consisting mainly of sweep-net or beating tray sampling, or visual inspection of fruits for feeding damage or excrement. Monitoring methods based on pheromones or other attractants, have not yet been developed for the major pest bug species. We report here identification, synthesis, and bioassay results for five phytophagous pest species, Thyanta pallidovirens, Acrosternum hilare, Chlorochroa ligata, C. uhleri, and C. sayi. Pheromones produced by sexually mature male bugs were collected by aeration and identified by bioassay-driven fractionation, and reconstructed blends were optimized in both laboratory and field bioassays. Furthermore, the pheromone of T. pallidovirens also attracted a predatory wasp which specializes on stink bugs. Problems encountered during identification and bioassay of the pheromones, and ongoing research on the development of practical applications for the pheromones will be discussed.

Index terms: Thyanta pallidovirens, Acrosternum hilare, Chlorochroa ligata, Chlorochroa uhleri, Chlorochroa sayi, pheromone

[0584] SEMIOCHEMICALLY-MEDIATED HOMO- AND HETEROSEXUAL BEHAVIOR IN TRUE BUGS

<u>W. S. Leal,</u> Dept. Entomology, University of California, Davis CA 95616, USA, Email: wslcal@ucdavis.edu

Chemical communication requires the release of specific chemicals from a producer, the transmission of these chemicals to a receiver, and the processing of these chemical signals leading to the appropriate behavioral responses in the receiver. To date, male-released pheromones of true bugs have been identified from a number of species and they are captured in pheromone-baited traps. However, our observation that *Piezodorus hybneri* (Heteroptera: Pentatomidae) males responded to the male-released pheromones and that by referring to the seniochemicals that attract both sexes as aggregation pheromones may be misleading. In this presentation, I will discuss previous and some ongoing projects for the identification of pheromones in true bugs.

Index terms:Riptortus clavatus, R. lineolaris, Leptocorisa chinensis, Piozodorus hybneri, Tynacantha marginata

[0586] PHEROMONE BIOLOGY OF A PENTATOMID PEST OF AUSTRALIAN CITRUS AND A REDUVILD PREDATOR

D.G. James, Irrigated Agriculture Research and Extension Center, Washington State University, 24106 North Bunn Road, Prosser, WA 99350, USA. Email: diames@tricity.wsu.edu.

Reproductive males of the Australian stink bug citrus pest, Biprorulus bibax, possess large dorsal abdominal glands (DAG's) containing an aggregation pheromone ((3R,4S,1'E)-3,4-bis(1'-butenyl)tetrahydro-2-furanol, linalool, farnesol and nerolidol). Glasshouse and orchard studies showed post-diapause (pre-reproductive), reproductive and early diapause (migrating) B. bibax were significantly attracted to sites (bunches of citrus foliage/fruit or citrus trees) baited with the major component or a synthetic blend of the pheromone. Reproductive, but not reproductively inactive bugs, were also attracted to citrus trees baited with (E)-2-hexenal. B. bibax did not enter pheromone-baited cylinder or funnel traps. Pheromone-baited baffle/funnel traps positioned on posts 2m above ground level around a citrus block captured five bugs during a six week period during spring. Pristhesancus plagipennis is a large reduviid predator of B. bibax in northern areas of the citrus pest's range. Adults of *P. plagipennis* have three median DAG's with the anterior and posterior much larger in males than females. In Laboratory olfactometer and outdoor flight cage bioassays, female P. plagipennis were significantly attracted to calling males, male posterior DAG extracts and the (2R) enantiomer of the major component of the secretion, (Z)-3-hexenyl 2-hydroxy-3-methylbutyrate. The male secretion also includes 3methylbutanol, 2-phenylethanol, (Z)-3-hexenol, decanal, (E)-2-hexenoic acid and three minor hexenyl esters. Males were also attracted to the major ester. Females appear to produce a pheromone from their anterior DAG that attracts males at close range and may facilitate mating. The potential and prospects for developing synthetic aggregation pheromones of B. bibax and P. plagipennis as tools in a single or separate integrated pest management systems, are discussed.

Index terms: Biprorulus bibax, Pristhesancus plagipennis, baits, traps, integrated pest management

[0587] EFFECTS OF PHEROMONES IN ARTIFICIAL DIETS FOR PREDATORY BUGS

J. C. Zanuncio¹, J. B. Torres², E. F. Vilela¹ & M. D. A. Coracini¹, ¹ Dep. de Biologia Animal, Univ. Federal de Viçosa. 36.571-000 Viçosa, Minas Gerais, Brasil. E-mail: zanuncio@mail.ufv.br; ², Univ. Federal Rural de Pernambuco. Recife, Pernambuco, Brasil.

Predatory bugs can present satisfactory results with alternative prey but rearing them represents an additional cost. For this reason artificial diets are been used but development and reproduction of these bugs with them are inferior than with natural or alternative prey because these predators feed on diet for short periods of time than with prey. Two studies were developed aiming to increase attractiveness of an artificial diet to Podisus nigrispinus and Supputius cincticeps. The first evaluated possible attractant and feeding stimulant effects of extracts of dorsal abdominal glands of these predators in the diet of their nymphs compared to those fed factitious prey. The extract spread over the diet attracted 88% of the nymphs of P. nigrispinus. Nymphs feeding on diet with extract (spread over and added-84%) or M. domestica larvae showed similar results. Nymphs of S. cincticeps feeding on the same diet showed maximum value of 60 and 56% but lower than that achieved on the factitious prey Tenebrio molitor (92%). Second instar nymphs of P. nigrispinus and S. cincticeps showed similar lower weights when reared on the artificial diet (2.7 mg and 1.2 mg), diet with extract (2.8 and 1.6 mg), extract spread over the diet (2.1. and 1.0 mg), or spread over and added to the diet (2.4 and 1.3 mg) than that on the factitious prey (3.1 and 3.0 mg). Effect of the synthetic sexual pheromone of P. nigrispinus on the localization and acceptance of an artificial diet and also on nymphal development and female fecundity of P. nigrispinus were evaluated. The complete synthetic sexual pheromone or its components were applied to the diet at 0.05 µg/µg concentration. The artificial diet with pheromone promoted an weight gain similar to that with M. domestica larvae, but did not improve the development of this predator over several generations compared to those fed only pure diet. Nymphal development period was longer for nymphae with pure diet, diet with pheromone, with a-terpinol or with (E)-2-hexenal; and it was shorter in the treatments: diet with linalool, M. domestica larvae, diet with the three major components, with trans-piperitol or with benzyl alcohol. During three generations nymph survival was generally lower when fed M. domestica larvae than with pure diet or diet containing complete pheromone. Females fed M. domestica larvae presented shorter longevity and greater egg production than those fed pure diet or diet containing complete pheromone. Extracts of dorsal abdominal glands or sexual pheromone of P. nigrispinus or S. cincticeps added to artificial diet can increase performance of these predators in such diets

Index terms: Podisus nigrispinus, Supputius cincticeps, olfactory responses

[0588] A PHEROMONE COMPONENT OF THE BEAN BUG, *RIPTORTUS CLAVATUS*, ATTRACTS AN EGG PARASITOID, *OOENCYRTUS NEZARAE*

N. Mizntani¹, T. Wada¹, H. Higuchi², M. Ono³ & W. S. Leal⁴, ¹Kyushu Natl. Agr. Expt. Stn., Suya 2421, Nishigoshi, Kumannoto 861-1192, Japan, E-mail nobuo@knaes.affrc.go.jp; ²Hokuriku Natl. Agr. Expt. Stn., Inada 1-2-1, Joetsu, Niigata 943-0193, Japan; ³Fuji Flavor Co., Ltd., Midorigaoka 3-5-8, Hanura, Tokyo 205-8503, Japan; ⁴Natl. Inst. Seric. Entomol. Sci. Owashi 1-2, Tsukuba 305-8634, Japan.

The egg parasitoid, Ocencyrtus nezarae, is a predominant natural enemy of the bean bug, Riptortus clavatus, which is one of the economic important soybean pests in south Japan. Parasitic females of O. nezarae are attracted by the synthetic aggregation pheromone of R. clavatus. The female parasitoids utilize the host pheromone as a chemical cue to locate their hosts. The synthetic pheromone comprises three chemical components. In this study, we first checked the attractiveness of each component for O. nezarae and R. clavatus, using sticky traps baited with the component. Then, we investigated the effect of the field application of the pheromone and its component upon the density and the parasitic activity of O. nezarae. The trap experiment indicated that one of the three components, (E)-2 hexenyl (Z)-3-hexenoate (E2HZ3H) attracted females of O. nezarae as the pheromone did. However, E2HZ3H did not attract R. clavatus. Therefore, we applied E2HZ3H in experimental soybean fields. The parasitoids attracted by E2HZ3H immigrated into the field earlier than the invasion of R. clavatus. High densities of the parasitoid were observed in E2HZ3H-treated field compare to untreated field. E2HZ3H did not increase the density of R. clavatus as we had expected. High parasitism rates of R. clavatus eggs artificially set on soybean plants in E2HZ3H-teated field were observed when compare to untreated field. The difference in parasitism rate was only observed in autumn when O. nezarae densities were high. However, this was not the case when the parasitoid density around the soybean fields was low in summer.

Index terms: synthetic aggregation pheromone, (E)-2-hexenyl (Z)-3-hexenoate, natural enemy, parasitism, soybean

[0589] SEMIOCHEMICAL COEVOLUTION BETWEEN HETEROPTERA AND THEIR TACHINID FLY PARASITOIDS: GAS CHROMATOGRAPHY-ELECTROANTENNOGRAM DETECTION AND BEHAVIOR

J. R. Aldrich & A. Zhang, USDA-ARS Insect Chemical Ecology Laboratory, Agricultural Research Center-West, B-007, Beltsville, MD 20705, USA, E-mail: jaldrich@asrr.arsusda.gov.

Many, if not most, of the known heteropteran pheromones also attract certain tachinids which exploit the bug pheromones as host-finding kairomones. The system we will describe involves the sympatric predaceous stink bugs, Podisus maculiventris and P. neglectus (Pentatomidae: Asopinae). Male-produced pheromones and the nymphal defensive secretions of these Podisus spp. are usurped as kairomones principally by two tachinid species: Euclytia flava (a generalist pentatomid parasitoid) and Hemyda aurata (a specialist asopine parasitoid). The pheromone of P. maculiventris consists mainly of (E)-2-hexenal and D-terpineol, while that of P. neglectus is predominantly (E)-2-hexenal with linalool. Curiously, the nymphal secretion of P. maculiventris contains linalool, along with (E)-4 oxo-2-hexenal and tridecane; whereas nymphs of P. neglectus secrete linalool and \Box -terpineol, plus (E)-4-oxo-2-hexenal and tridecane. GC-EAD experiments with P. maculiventris, E. flava and H. aurata revealed that the tachinids are much more electrophysiologically sensitive to the pheromone of the bug than are the bugs themselves. Furthermore, the antennae of E. flava are more responsive to D-terpineol than linalool, but H. aurata antennae respond to D-terpineol and linalool more equally. In addition, the antennae of both tachinids respond strongly to minute amounts of (E)-2-octenal and (E)-2decenal, alkenals that are characteristic defensive compounds of stink bug adults. Captures of E. flava and H. aurata individuals in traps baited with blends containing either Dterpineol or linalool were positively correlated with the respective antennal sensitivities of the tachinids toward these monoterpenoids. Field tests in which some pheromone-baited traps also contained a high dose of (E)-2-octenal showed that the addition of (E)-2-octenal tended to repel the bugs. However, (E)-2-octenal significantly increased attraction of E. flava females to the pheromone of P. neglectus, whereas attraction of E. flava individuals to P. maculiventris pheromone was either unaffected (female flies) or sometimes reduced (male flies) by the presence of (E)-2-octenal. Our working hypothesis to explain these results is that the intensity of a tachinid's antennal response toward particular host volatiles is directly proportional to host suitability. This interpretation is substantiated by GC-EAD showing that methyl (E,E)-2,4-decadienoate-the main pheromone component of Euschistus spp., acceptable but not preferred stink bug hosts of E. flava-elicited significantly weaker responses from the antennae of E. flava females than seen for Dterpineol and linalool.

[0590] SUBSTRATE-BORNE HOST KAIROMONE FOR THE EGG PARASITOID TRISSOLCUS BASALIS: BEHAVIORAL AND CHEMICAL ECOLOGY ASPECTS

<u>S. Colarza</u>, Inst. of Agricultural Entomology, Univ. of Palermo, viale delle Scienze13, Palermo, 90128, Italy, E-mail colazza@unipa.it.

Behaviors leading to the host location by the egg parasitoid Trissolcus basalis are trigged by the perception of host cues during various phases of the foraging process. The eggs of Nezara viridula, one of the main hosts of T. basalis, are immobile, do not interact with the plants and do not emit odours. Therefore T. basalis female might have to rely mainly on cues that do not directly originated from the altacked host stage. Laboratory investigations have demonstrated the importance in the short-range host finding process of the traces deposited on substrate by both the immature $(3^{sd}, 4^{sh} \text{ and } 5^{sh} \text{ instar larvae})$ and the adult stages of N. viridula. These chemicals play a role as contact cues since T. basalis female must contact the contaminated area with its antennae before it can perceive it. Then the wasps are flight inhibited for a certain amount of time, and, throughout the entire time, they are stimulated to an ambulatory-searching behavior. Because the host's traces seems to serve as a general kairomone to the possible presence of host eggs, an increment in the amount of time which a wasps allocate to the contaminated area with kairomones left by host stages more correlated with the host egg presence is predicted. Then, the actual encounters with host eggs in the presence of the kairomone should provide more reliable estimation for parasitoids than would the contact with the kairomone alone do. Our data agreed with these predictions. When wasps encounter a patch contaminated by immature stages and adults of N. viridula their resident time was longer and their walking pattern was different compared to uncontaminated areas. However, the longest wasp's resident was recorded only when in contact with the trace left by N. viridula mated females in a pre-ovipositional condition. The different in the resident time in the host-contaminated area for naive versus experienced females (those that have oviposit in the presence of the contact kairomone) indicates the importance of experiences with the host eggs. Observations were also done with both potential and non-host pentatomid bugs in which results should aim at defining predictability of T. basalis's host specificity. Solid-phase microextraction (SPME) fibers, subsequently analyzed by gas chromatography/mass spectrometry (GC/MS), were used to detect the compounds from the headspace of sample filter papers treated with males or females of N. viridula. Also selectively solvent extractions confirmed a different chemical composition on the cues left by male or mated female. These broader understanding of host-parasitoid interactions can enhance the possibility to improve the efficacy of this world wide used parasitoid in biological control programs

Index terms: Nezara viridula, host location, arrestment, foraging behavior.

[0591] MULTIPLE MATINGS AND EFFECTS ON FECUNDITY AND ATTRACTION IN LYGOCORIS PABULINUS

A.T. Groot¹ & H.M. Smid², ¹Plant Research International, Wageningen UR, P.O. Box 16, 6700 AA Wageningen, The Netherlands. e-mail: a.t.groot@plant.wag-ur.nl; ²Lab. of Entomology, Wageningen Univ., P.O. Box 8031, 6700 EH Wageningen, The Netherlands.

Lygocoris pabulinus (emales are polyandrous under laboratory conditions. Before determining effects of multiple matings, we studied the female reproductive tract and the process of sperm transfer and storage in detail, as in mirids female genitalia have only been studied partially so far. The bursa copulatrix consists of 4 plates, wich are dorsally enclosed by a circular-shaped plate of the median oviduct, posteriorly and ventrally by a membrane. A spermatheca is connected anteriorly to the bursa. At copulation a spermatophore is formed in the spermatheca. The spermatophore is compartmentalized, consisting of a sperm-containing portion, a large sperm-free portion and a mating plug. After 24 h the spermatophore is partially disintegrated, the mating plug is still intact but reduced, and sperm is found throughout the spermatheca and in the median and lateral oviducts, where most likely fertilization takes place. We conducted two oviposition experiments to determine effects of multiple matings on fecundity and longevity. Neither factor seemed to be influenced by multiple matings. We also determined sexual attraction of mated females at long range and at close range. At long range females were unattractive for only 1-2 h after mating, while they remained attractive at close range. Mated males did not respond to virgin females for 2 h after mating, and only 23 % of the tested males mated again within 24 h. Hence, females may not cease to attract males, but males may be unresponsive to females after mating.

Index terms: Heteroptera, Miridae, female reproductive tract, spermatophore, mating effort, fecundity, longevity, sexual attraction, sexual communication



[0592] PROSPECTING WITH INSECT CHEMOSENSORS FOR BIOACTIVES IN PLANT AND ANIMAL STRESS

J. A. Pickett, Biological & Ecological Chemistry Department, IACR-Rothamsted, Harpenden, Hertfordshire, ALS 2JQ, United Kingdom, E-mail john.pickett@bbsrc.ac.uk.

Plants and higher animals under stress from predation and disease, and also undergoing normal physiological changes such as hormone cycling, produce compounds released externally which have signalling roles with other organisms and within their own species. Plant receptors involved in these interactions are little understood, and such systems are difficult to exploit within higher animals because of welfare considerations and the disturbance caused to these organisms by invasive techniques. However, where such signals interact with insects, the highly developed techniques of electrophysiology used traditionally in identification of insect semiochemicals can be employed. Furthermore, relatively robust monitoring devices can be made using organ or whole organism preparations for exploiting the external signalling compounds in diagnostic systems. With the prospect of further exploitation by means of molecular genetics, in which overexpressed molecular recognition proteins will be used directly in biosensors, these aspects of insect chemical ecology are likely to have considerable bearing on areas as diverse as agricultural crop plant nutrition and human health and forensic science.

[0593] REPELLENTS: NATURE'S FIRST LINE OF CHEMICAL DEFENSE

D. M. Norris, Univ. of Wisconsin, Madison, WI 53706, U.S.A., E-mail: dalekim@msn.com

Chemical defenses of plants, against especially insects, involve a continuum of compounds ranging from volatile repellents: through relatively non-volatile feeding and oviposition deterrents and inhibitors; to inhibitors and disrupters of most, if not all, aspects of the insect's nutrition and physiology of growth, development including metamorphosis, sexual maturation and reproduction, and aging and longevity. The evolved, natural wild (i. e., not genetically altered by humans) survivor plant thus is usually chemically able to affect most insects in the plant's environment adversely at a multitude of critical target sites. The first tier, or order, in such plants' chemical defenses thus involves volatiles (c. g., allomones). Volatile repellents have the supreme ability to prevent, or to discourage significantly, the insect from even arriving at the source plant. This first-order chemical defense thus may yield the plant protection not only from herbivory, but also against ovipositional and pathogen (including toxin)-transmission ill effects. This paramount chemical defense involves a mixture of volatile phytochemicals per plant and variety. It thus provides a relatively stable protection as compared to the single-chemical defense so frequently applied to a cultivated plant by humans. A plant's bouquet of volatiles, of course, is not repellent to all herbivores; however, plants have coevolved with parasites and predators of herbivores that attack them so some of their volatiles are kairomones for the pertinent biological-control agent. Thus, the plant, even before, but especially when experiencing herbivorous attack, extrinsically emits kairomones for its ally parasites and predators of the attacking herbivore. Through volatiles, plants therefore practice both intrinsic (direct) and extrinsic (indirect) chemical defenses against their herbivores. In situations where a parasite or predator is highly selective, or specific, in attacking a given species of herbivore, plants attacked by that herbivore cause the attacker to ingest precursor(s) which metabolically force the herbivore to release in its feces kairomones for the specific parasite or predator. These quite marvelous chemical-communication happenings in nature are surely not random events, but in fact both the chemical releases and perceptions are biophysically regulated as information by a unifying sulfhydryl disulfide dependent redox protein electrochemistry. Details of this unifying informationcoding electrochemistry will be discussed further in the lecture. Index terms: plant, defense, chemical.

[0594] PHYTOCHEMICAL PROSPECTING FOR INSECTICIDES: IMPROVING THE ODDS OF DISCOVERY

<u>M.B. Isman</u>, Faculty of Agricultural Sciences, Univ. of British Columbia Vancouver, BC, Canada V6T 1Z4, Email: murray.isman@ubc.ca

Many investigators have screened plant material in search of natural products possessing insecticidal or antifeedant properties against pest insects. Some of these efforts have identified useful lead chemistries for the subsequent development of synthetic insecticides, while others suggest potential direct utility of extracts as botanical pesticides. In our investigations, we have focussed on tropical plants in the families Annonaceae, Meliaceae and Olacaceae. Crude methanolic extracts are evaluated via incorporation into artificial media on which neonate tobacco cutworms, Spodoptera litura are allowed to feed and grow for 10 days at 26°C. Initial screening takes place with dietary concentrations of 1000 ppm (0.1% fwt); extracts reducing growth by more than 75%, relative to controls, are subjected to further bioassay at a range of concentrations to establish the the EC₅₀ (dietary concentration reducing growth by 50%). Extracts with EC50 values below 100 ppm then proceed to bioassay-driven fractionation in an effort to isolate and identify the active principle(s). From over a decade of experience utilizing this approach, it has become apparent that the probability of finding natural insecticides in plants can be improved by: 1. Collecting as many individuals from each plant species as is practical, rather than just one; 2. Screening different tissues from each plant species; 3. Focussing on particular genera where bioactivity has previously been documented. Results from our recent investigations of *Trichilia* species from Costa Rica and *Annona* species from Indonesia show considerable intraspecific variability (temporal, geographical and among plant tissues) in bioactivity against the tobacco cutworm. In concentrating on taxa in the genera Aglaia and Trichilia (both Meliaceae), our 'hit' rate for bioactivity was approximately 35% and 50% respectively. In contrast, random screening of the family Olacaceae had a hit rate of 22%, and a random screening of tropical timber species of Indonesia and Malaysia led to a single hit among 20 species examined. Given the extremely limited success in the development of new botanical insecticides in recent years, and the difficulties in production and registration of botanicals for use in industrialized countries, academic and industrial researchers would do best to focus their efforts on plants already identified as being bioactive, or at least limiting their search to closely related taxa (e.g. congeneric species).

Index terms: bioprospecting, natural products, Meliaceae, Annona, Trichilia

[0595] CHALLENGES IN IDENTIFYING AND EXPLOITING PLANT-DERIVED INSECTICIDES

<u>B. P. S. Khambay</u>

ABSTRACT NOT RECEIVED

[0597] MOLECULAR MECHANISM OF SEX PHEROMONE PRODUCTION IN THE SILK WORM, BOMBYX MORI

S. Matsumoto¹, N. Yokoyama^{1, 2}, T. Yoshiga^{1, 3}, K. Okano⁴ & A. Fonagy⁵, ¹Molecular Entomology and Baculovirology, RIKEN, Wako-shi, 351-0198, JAPAN, E-mail smatsu@postman.riken.go.jp; ²Dept. of Agricultural & Life Sciences, Univ. of Tokyo, Tokyo 113-8657, JAPAN; ³Lab of Nematology, Saga Univ., Saga 840-8502, JAPAN; ⁴Lab of Cell Biology, Akita Pref. Univ., Akita 010-0195, JAPAN; ⁵Plant Protection Inst. Hungarian Acad. of Sciences, Budapest, II. 1525, P. O. Box 102, HUNGARY.

Female moths attract conspecific males by producing and releasing species-specific pheromone blends. Biosynthesis of pheromone components takes place specifically in the pheromone gland generally associated with the intersegmental membrane between the 8th and 9th abdominal segments. Production of sex pheromones in many Lepidoptera is (PBAN), which has been identified as a 33-34 amino acid peptide with a C-terminal FSPRLamide sequence responsible for pheromonotropic activity. In order to understand the molecular as well as cellular mechanisms of pheromone production regulated by PBAN, we have isolated functional clusters of viable pheromone producing cells of B. mori. One of the prominent morphological features of the pheromone producing cells is the abundance of large refractile granules in the cytoplasm at adult eclosion. Precise analysis on these granules revealed that the large granules at adult eclosion dramatically reduced their size and increased the number of small granules by 28 hrs after eclosion, and then reduced both number and size. These changes were prevented by decapitation and proceeded by PBAN injection. Nile Red staining and chemical characterization using FAB-MS indicated that these granules were triacylglycerols mainly composed of pheromone precursor fatty acids. Therefore, it is likely that the granules work as storage or carriers of sex pheromone precursors. Present results also suggest that the isolated cell preparation can be used for quantitative visualization of the cellular dynamics during pheromone production in B. mori. We will also discuss the expression of functional proteins and their genes involved in the process of pheromone production in B. mori. Index terms: PBAN, cellular dynamics, pheromone biosynthesis, hormonal control, triacylglycerol.

[0596] PHEROMONE BIOSYNTHESIS: UNIQUE DESATURASE GENES

W. L. Roelofs & W. Liu, Dept. of Entomology, Cornell Univ., Geneva, NY 14456, USA. E-mail: WLR1@cornell.edu

Research on biosynthetic pathways of sex pheromones in moths has revealed that the majority of known pheromone components are produced by various combinations of two unique enzyme systems, desaturases and chain-shortening enzymes, that produce an array of unsaturated long-chain fatty acetates, aldehydes and alcohols. The unusual desaturases discovered in moth pheromone glands are of interest because they function to produce different unsaturated products than the normal metabolic Z9-desaturases found in the rest of the insect body. Not only do they produce various Z11 fatty acids, but some generate mixtures of Z and E geometrical isomers, which are rare in nature. The evolution of these desaturases has played a key role in the generation of the diversity of chemical blends used as species-specific mating signals by many moth species, and, thus, is significantly involved in the speciation process. Full-length cDNA that encodes a Z11 desaturase from sex pheromone gland of the cabbage looper moth, Trichoplusia ni, and another that encodes a Z9 desaturase from the fat body of this species was characterized. A functional assay was developed for these desaturases based on a previous report that the unsaturated fatty acid auxotrophy of a desaturase-deficient ole1 strain of the yeast saccharomyces cerevisiae can be complemented genetically with plasmid encoding a rat stearoyl-CoA Z9desaturase cDNA. Genetic transformation of this mutant yeast with expression plasmids encoding either the T. $ni \triangle 11$ or $\triangle 9$ desaturase resulted in complementation of the strain's fatty acid auxotrophy and the production of Z11- or Z9- unsaturated fatty acids, respectively. cDNA that encodes the metabolic Z9 desaturase from redbanded leafroller moth, Argyrotaenia velutinana, fat body was characterized and functionally defined using the mutant yeast assay. However, cDNA that encodes desaturases in the sex pheromone gland of this species could not assayed with the mutant yeast assay. The ole1 strain's unsaturated fatty acid auxotrophy cannot be rescued by supplementation of the growth medium with Z11- or E11-14: Acid, which are the acids produced by desaturases in this sex pheromone gland. Therefore, other functional assays were researched, including the use of a pYES2 yeast system, an insect select system, and injection of xenopus eggs. The successful assay will be used as genes are characterized for other unique desaturases in some New Zealand leafroller species.

Index terms: Trichoplusia ni, Argyrotaenia velutinana, functional assay, cDNA

[0598] REGULATION OF PHEROMONE BIOSYNTHETIC PATHWAYS IN MOTHS

<u>R. A. Jurenka</u>, Dept. of Entomology, Iowa State University, 411 Science II, Ames, IA 50011-3222, USA, e-mail rjurenka@iastate.edu.

Pheromone biosynthesis in female moths will be discussed especially with regard to the regulation of biosynthetic pathways. Most moth pheromones utilize a hydrocarbon chain with a functional oxygen group (acetate ester, aldehyde, alcohol, or epoxide) or the absence of any oxygenated functional group (hydrocarbon). The biosynthesis of these molecules is determined by the type and specificity of the enzymes involved in the biosynthetic pathway. The production of the oxygenated molecules is usually under the control of the peptide hormone PBAN (Pheromone Biosynthesis Regulating Neuropeptide). Background information will be presented on the biosynthesis of the regulation of hydrocarbon pheromones is not clearly understood but may not require the presence of PBAN. Hydrocarbons are produced by oenocyte cells and then transferred to other cells for use. The biosynthesis and regulation. Index Terms: Helicoverpa zea, Lymantria dispar, Scoliopteryx libatrix, PBAN

[0599] ENDOCRINE REGULATION AND MECHANISM OF HYDROCARBON PHEROMONE PRODUCTION IN THE HOUSEFLY, MUSCA DOMESTICA

<u>G. J. Blomquist</u>¹, A. G. Bagneres², C. Schal³, M. Kuenzli¹, X. Shen¹ & C. Tittiger¹, ¹Dept. Biochem, Univ. Nevada, Reno, NV 89557, USA E-mail: blomquis@unr.edu; ²Lab. de Neurobiolgie, CNRS-UPR, Comm. Chimique, Marseille, Cedex 20, France; ³Dept. Entomol., Univ. North Carolina, Raleigh, NC 27695.

The major pheromone component, (Z)-9-tricosene, of the female housefly, Musca domestica, is produced about two days after emergence to the adult. Ovarian-produced ecdysteroids induce a change in the chain length of the cuticular alkenes from producing primarily (Z)-9-heptacosene to produce (Z)-9-tricosene (muscalure) by altering the chain length specificity of fatty acyl-CoA elongases. (Z)-9-Tricosene appears in the hemolymph, associated with lipophorin, about one day prior to similar amounts appearing on the surface of the insect. Other pheromone components include epoxide and ketone derivatives of (Z)-9-tricosene. The C23 epoxide and ketone pheromone components are not present in the hemolymph, suggesting that (Z)-9-tricosene is converted to the epoxide and ketone in the cells that transport hydrocarbon from the hemolymph to the surface of the insect. Cytochrome P450s are involved in both converting a C24 aldehyde to (Z)-9-tricosene and subsequently converting (Z)-9-tricosene to the epoxide and ketone. Three integument enriched cytochrome P450s have been cloned and sequenced and are in the process of being expressed and assayed.

[0601] MICROSOMAL REACTIONS INVOLVED IN THE FORMATION OF HYDROCARBONS AND THE CONTACT SEX PHEROMONE IN *BLATELLA GERMANICA* INTEGUMENT

<u>M.P. Juárez</u>¹ & G. J. Blomquist², ¹Inst. Investig. Bioquím. La Plata, Fac. Cs. Méd. UNLP, calles 60 y 120, La Plata 1900, Argentina. ²Dept. Biochem., Univ. Nevada, Reno, NV 89557, USA. E-mail: mjuarez@isis.unlp.edu.ar.

The major cuticular hydrocarbon component of the german cockroach Blatella germanica, 3.11-dimethylnonacosane, and the major female contact sex pheromone, 3.11-dimethyl-2nonacosanone, are metabolically linked through hydroxylation and oxidation steps. We report that the integument is the site of pheromone synthesis. Integumental fatty acid synthetases (FASs) were shown to produce the methylbranched fatty acid precursors. Elongation of fatty acyl-CoAs to very long chain fatty acids, and the final step in the synthesis of the major component of the sex pheromone, the conversion of 3,11-dimethyl [11,12 ³H]nonacosane to 3,11-dimethyl [11,12 ³H]-2-nonacosanone, were studied in integumental microsomes. Incubation of [1-¹⁴C]palmitoyl-CoA, malonyl-CoA and NADPH resulted largely in the production of [¹⁴C]C18-CoA with minor amounts of C20, C22, C24, C30 and C32 acyl moieties. Similar experiments with [1-14C]stearoyl-CoA rendered C20-CoA as the major product, minor peaks of C22 and C24-CoAs were also detected. After solubilization of the microsomal FAS, kinetic parameters were determined radiochemically or measuring NADPH consumption by spectrophotometry. The reaction velocity was linear up to 10 min incubation time, and with protein concentration up to 0.025 Dg/Dl. The effect of the chain length on the reaction velocity was compared for block light in the effect of the end frequencies of the relation velocity was compared to palmitoyl-CoA, stearoyl-CoA and eicosanoyl-CoA, the optimal sustrate concentration was 12 \square M for C16-CoA, 9 \square M for for C18-CoA, and 4 \square M for C20-CoA. Studies were performed to examine in vitro the last steps in the synthesis of the contact sex pheromone after incubation of microsomal preparations with [11, 12-3H]3,11-dimethylnonacosane or [11,12-3H]3,11-dimethyl-2-nonacosanol. After 30 min at pH 7.8, in O2 atmosphere, the alkane was converted into methylketone and the corresponding alcohol. When the sustrate was the C29-ol, almost 90% was metabolized into the sex pheromone. Index terms: elongases, acyl-CoA, hydrocarbons, german cockroach

[0600] SYNTHESIS OF HYDROCARBONS AND SEX PHEROMONES AND THEIR TRANSPORT THROUGH THE HEMOLYMPH IN INSECTS

C. Schal & Y. Fan, Department of Entomology, North Carolina State Univ., Raleigh NC, 27695, USA

The outer surface of insects is covered with a lipid layer that provides water-proofing and protection against environmental stresses. Hydrocarbons are major constituents of this epicuticular wax and in some insects they are also exploited as biosynthetic precursors for contact pheromones. In the German cockroach hydrocarbons and pheromones are synthesized by oenocytes which are situated in the integument. Synthesis of hydrocarbons is dependent to a large extent on food availability, but its sex-specific conversion to pheromone in the adult female is regulated by juvenile hormone. An important site for deposition of hydrocarbons in females is the ovary. Shuttling of hydrocarbons from the abdominal integument to the epicuticle, fat body, and gonads uses a versatile lipoprotein, lipophorin, which carries both hydrocarbons and the contact sex pheromone, and also serves as a juvenile hormone-binding protein. In several tiger moth species and in the housefly, short- and medium-chain hydrocarbons sex pheromones are also transported by lipophorin from integumental biosynthetic sites to sex pheromone glands or the epicuticle. In Holomelina tiger moths pheromone is synthesized by tissues associated with the abdominal integument. Lipophorin transports the pheromone to an abdominal gland that stores and releases the pheromone only during active calling behavior. We suggest that such transport pathways are common not only among insects that emit hydrocarbon pheromones, but also among insects that sequester hydrophobic plant-derived metabolites.

[0602] MOLECULAR STUDIES ON THE ENDOCRINE REGULATION AND TISSUE LOCALIZATION OF *DE NOVO* MONOTERPENOID PHEROMONE COMPONENT BIOSYNTHESIS IN PINE BARK BEETLES

C. Tittiger¹, J. A. Tillman¹, G. Hall¹, C. S. Bengoa¹, C. O'Keeffe¹, F. Lu¹, L. S. Barkawi², G. J. Blomquist¹ & S. J. Seybold², ¹ Dept. Biochem., Univ. Nevada, Reno, Reno, NV 89557 USA, E-mail: crt@unr.edu.² Dept. Entomol., Univ. Minnesota, St. Paul, MN 55108 USA

Male pine engraver beetles, Ips spp., produce the isoprenoid pheromone components ipsdienol and ipsenol while feeding on pine phloem. The de novo, mevalonate-derived synthesis of monoterpenoids in these beetles is an unusual biochemical system with great potential for targeted insect control strategies. Since pheromone production is controlled by juvenile hormone III (JH III), we studied the effects of JH III on the two most likely regulators of the mevalonate pathway: HMG-CoA reductase and HMG-CoA synthase (HMG-R and HMG-S, respectively). JH III raises HMG-R transcript levels in male and female *1. pini* and *I. paraconfusus* in a dose- and time-dependent manner, with males responding more strongly than females. HMG-R activity levels also respond to JH III in male I. pini, but not in I. paraconfusus. Post-transcriptional control of HMG-R in male I. paraconfusus requires an additional, unidentified factor. Similarly, male Jeffrey pine beetles (Dendroctonus jeffreyi) produce the bicyclic acetal frontalin following topical JH III treatment. Both HMG-R and HMG-S transcript levels respond to JH III in male D. *jeffreyi*. The time course for mRNA induction precedes the appearance of frontalin by approximately four hours, suggesting this semiochemical is a monoterpenoid synthesized de novo via the mevalonate pathway. A combination of northern blotting and in situ hybridization localizes the site of HMG-R gene expression to the ventriculus in male l. pini and D. jeffreyi. Biochemical studies confirm that this is also the site of pheromone Thus, pheromones are synthesized by insect tissues, and likely not by biosynthesis. symbiotic bacteria. A genomics-based approach to identify additional targets for control is underway.

Index terms: Ips pini, Ips paraconfusus, Dendroctonus jeffreyi, juvenile hormone, isoprenoid

[0603] SEX PHEROMONE BIOSYNTHESIS IN SCARAB BEETLES

<u>W. S. Leal,</u> Dept. Entomology, University of California, Davis CA 95616, USA, Email: wsleal@ucdavis.edu

In scarab beetles, chemical communication is achieved using a wide variety of pheromone structures ranging from ubiquitous anisole to a unique medicinal alkaloid. A typical structure of the sex pheromone of rutelines is the five-member gamma-lactones having a long unsaturated hydrocarbon chain, such as (R,Z)-5-(--)-(oct-1-enyl)oxacyclopentan-2one (buibuilactone) and (R,Z)-5-(--)-(dec-1-enyl)oxacyclopentan-2-one (japonilure), which are pheromones for a number of species. Using deuterated precursors, it has been demonstrated that the biosynthesis of these compounds starts from saturated fatty acids (palmitic and stearicacid), involves their desaturation followed by stereospecific 8hydroxylation, chain shortening and cyclization. Various scarab species have developed pathways to produce unique pheromone molecules by changing either storeospecificity or regiospecificity of the hydroxylation step. Anomala cuprea and Popillia japonica utilize the (R)-8-hydroxylase, whereas the hydroxyylase of A. osakana is specific to the (S)substrate. It seems that A. rufocupren is devoid of the enzyme so it makes the methyl Z-(5)-tetradecenoate. The pheromone biosynthesis in scarabs is regulated by a PBAN-like factor. The pheromone liter in the glands of decapitated females dramatically decreased 24 hr after surgery, but it resumed after the injection of the brain extracts of virgin females. The activity of the brain extracts is lost after treatment with proteinase K. Because BmPBAN is also active, characterization of the gene encoding the peptide was pursued by library screening and PCR. Hitherto, none of the molecular approaches' have led to the identification of the PBAN gene in scarab beetles. On the other hand, a bioassayoriented strategy lead to isolation of the active peaks by reversed phase HPLC and ionexchange chromatography. The small amount of the isolated peptide prevented any further characterization.

Index terms: hydroxylase, PBAN, PCR, Anomala cuprea, Popillia japonica

[0604] HORMONAL REGULATION OF OLFACTORY DEVELOPMENT: DIAPAUSE ACCOMODATION?

<u>R.G. Vopt</u>¹ & M.-D. Franco^{1,2}, 1Dept. of Biological Sciences, Univ. of South Carolina, Columbia SC 29208, USA, E-mail vogt@biol.sc.edu; ² Dept. of Molecular and Cellular Biology, Univ. of Arizona, Tucson, AZ, 85721, USA E-mail franco@U.Arizona.edu. Support: NIH-NICDC DC00588; NSF-IBN9731005; USDA-CGRP94373020615.

Olfactory sensilla include 3 support cells (trichogen, tormogen, thecogen) and 2-3 odor receptor neurons; in adult holometabolous insects, these cells derive from proliferative processes occurring early in antennal development. Adult antennae of the hawkmoth Manduca sexta derive from imaginal discs which grow primarily during the final larval instar, everting about 2 days before pupation. At pupation, the antenna is laid along the body surface as a tubular structure with a monolayer epithelium which secretes the pupal antennal cuticle with the sensory epithelium facing outward. Mitoses yielding sensilla cells were previously reported between 20 and 60 hrs after pupation (S-phase, Sanes and Hildebrand, 1976). Antennal epidermis detaches from the pupal cuticle around 72 hrs (apolysis), and sensillar cells begin acquiring morphologically recognizable phenotypes by We have re-evaluated mitotic activity in the M. sexta antenna using BrdU 96 hrs. incorporation (S-phase, accumulative) or immuno-detection of the phosphorylated state of the H3 histone (M-phase, momentary). Mitotic activity was both temporally and spatially dynamic. No mitotic activity was observed during the first 24 hrs a.p., a low level of activity occurred during the second 24 hrs a.p., and a dramatically high level of activity occurred during the third 24 hrs a.p., culminating around the time (shortly after) apolysis at 72 hrs. Mitotic activity initiated along the presumptive proximal and distal borders of each annulus, restricted to the sensory epithelium. Over the course of the third 24 hr period, these peripheral zones broadened, meeting in the middle of each annulus shortly after apolysis. The homeobox gene distal-less (Dll) showed an overlapping temporalspatial pattern of expression. Both mitotic activity and Dll expression were enhanced by culture in the presence of either ecdysone (500 ng/ml) or 20-hydroxy ecdysone (20-HE, 200 ng/ml). Tissue from animals entering pupal diapause showed no mitotic activity, while animals induced to break diapause by injection of 20-HE initiated and completed proliferation during the initial 36 hrs after injection (non-injected controls resembled tissue entering diapause). We suggest the temporally asymmetric pattern of proliferation and its hormone sensitivity is a developmentally plastic accommodation to the decision of diapause. Under continuous development, high mitotic activity occurs only after a 48 hr check point is past which would otherwise be the entry point for diapause. Since development of central olfactory pathway requires sensory afferents, peripheral hormone sensitivity may coordinate diapause decisions for much of this pathway. Index terms: pheromone binding protein, olfaction, receptors, odor

Symposium and Poster Session

[0605] MOLECULAR, PHYSIOLOGICAL AND ETHOLOGICAL PERSPECTIVES ON INSECT OLFACTION

<u>B.H. Smith.</u> Department of Entomology, 1735 Neil Ave., Ohio State University, Columbus, OH 43210-1220, USA Email: smith.210@osu.edu

Research on insect olfaction has made significant progress on a number of fronts. Recent advances highlight the molecular and biochemical bases for transduction of chemical information into signals projected to the CNS. Further work has revealed the bases for processing those signals and integrating them with motor systems. Finally, work under both laboratory and field conditions have revealed behavioral mechanisms that insects use to approach or avoid important odors. Even in the case of pheromonal systems, these behavioral mechanisms always involve reasonably stereotypical responses to odors that can be modified by one or another learning process. In many cases important correlations have been established across molecular, physiological and behavioral levels of analysis. For example, odor stimulation activates defined spatial and temporal activity patterns that are characteristic for different odorants. More recently, several lines of evidence have revealed synaptic plasticity in the antennal lobes, which are the first-order processing centers for olfactory information in the brain. This plasticity is correlated to learned recognition of the association of odors to food reinforcement. Yet there have only been a few attempts to establish a causal link between any these neural events and behavior, and these attempts have met with limited success. Thus causal relationships are bound to be complex. The seminar will briefly review what has been done to link olfactory processing across different levels of analysis and highlight the need for these kinds of studies in the near future.

[0606] CHEMICAL VOCABULARY OF THE COLORADO POTATO BEETLE

J. C. Dickens, U. S. Department of Agriculture, Agricultural Research Service, Beltsville Agricultural Research Center, Plant Sciences Institute, Vegetable Laboratory, Beltsville, MD 20705, USA, E-mail jdickens@asrr.arsusda.gov.

The chemical vocabulary of an insect requires specialized receptors that are exquisitely tuned and uniquely sensitive to chemical signals emitted by conspecifics and their hosts. Communication within a species is extremely important for resource utilization and reproduction; especially for specialized feeders such as the Colorado potato beetle (CPB) in which both immature and adult forms exist on the same host plant. Investigations into chemical communication by CPB have yielded little until recently when blends of chemicals emitted by potato plants were identified that were attractive to CPB and some of its predators (Dickens 1999; Dickens 2000a, b). However, the question of whether immature and adult CPB might communicate by way of chemical signals and the nature of this vocabulary remained unknown. Now we have determined textual differences among chemical signals emitted during larval and adult feeding on potato plants. These differences are detected by antennal chemoreceptors in adult CPB and their detection may result in attraction or avoidance of occupied host plants, as well as other behaviors. The messages are comprised of at least nine chemicals emitted as different blends during insect feeding. Behavior elicited by the chemical messages may be modified by previous experience. Thus, intraspecific communication occurs in CPB and is likely to be present in other species where larval and adult forms compete for the same resource. The expanded vocabulary inherent in these intraspecific "chemical conversations" demands a corresponding enhancement of receptor types, plasticity of the central nervous system, and a diversity of behaviors in response to overlapping syntax of the blends.

[0607] PLASTICITY OF OLFACTORY AND BEHAVIORAL RESPONSES OF HAWKMOTHS TO FLORAL FRAGRANCE

R. A. Raguso, Dept. of Biol. Sci., Univ. of S. Carolina, Coker Life Sci. Bldg., 701 Sumter St., Columbia, SC 29208, USA, E-mail Raguso@biol.sc.edu

The reproductive fitness of adult hawkmoths (Lepidoptera: Sphingidae) depends to a large extent on detecting and tracking relevant odors. Neuroethological studies have shown that male Manduca sexta detect, process and respond to female sex pheromone in reproducible and stereotypical ways. Recent work has documented similar responses of female M. sexta and other hawkmoths to hostplant odors. Both sexes of M. sexta and other nocturnal hawkmoths also use olfactory cues, in combination with visual inputs, to forage for floral nectar, a critical source of energy for long-distance dispersal and hovering flight. However, studies of M. sexta foraging behavior reveal that adult feeding is much less predictable than odor-driven sexual behaviors, such as mate finding and oviposition. Although EAG responses to floral odors remain keen throughout adult life, behavioral responses to fragrance may be modified by larval diet, stored fat reserves, mating status, photoperiod, temperature and experience (associative learning). Such flexibility raises questions as to how floral odorants, particularly those with some similarity or overlap with hostplant odors, are processed by the hawkmoth brain. The specific effects of larval dietary components on adult feeding behavior will be discussed.

Index terms: floral scent, Lepidoptera, Manduca sexta, pollination, Sphingidae

[0609] ATTRACTION OF PLUM CURCULIOS TO INTERACTING, HOST ODOR, PHEROMONAL AND VISUAL STIMULI

R.J. Prokopy¹ & T.C. Leskey¹, ¹Dept. of Entomology, Univ. of Massachusetts, Amherst, MA 01003, USA, E-mail prokopy@ent.umass.edu

Plum curculios overwinter in woods near orchards. They move into orchards around blossoming of trees and commence to feed upon and oviposit in developing fruit, causing severe injury. In laboratory assays in large still-air arenas, males were not attracted to odor of females alone or males alone but were attracted to odor of plums alone and females feeding on plums (a native host fruit). Females were attracted to odor of males alone, but attraction disappeared in presence of plum odor. Combined findings suggest greater response of each sex to host odor than to pheromone released by conspecifics. Sixty compounds have been identified from host plum or apple fruit at the stage most susceptible to plum curculios (2 weeks after bloom). Thirty of these (each at 3 release rates) were evaluated in field tests. The following were attractive to adults: E-2-hexenal, limonene, decanal, benzyl alcohol, benzaldehyde, hexyl acetate, geranyl propionate and ethyl isovalerate. Synthetic male pheromone (grandisoic acid) did not enhance attractiveness of compounds but release vehicle (rubber septum) may have been inappropriate. Attractive odor may be developed effectively when in combination with a visual trap, such as clear or colored panel near woods to intercept immigrating adults, a trunk-mimicking black pyramid next to an orchard tree to attract adults entering trees by crawling, or a branch-mimicking black cylinder in a tree canopy to attract adults foraging for branches with fruit. Prospects for using odor-baited visual traps for monitoring and controlling plum curculios will be discussed.

Index terms: Conotrachelus nenuphar, host odor, pheromone, vision, attraction.

[0608] SENSORY INPUTS GOVERNING UPWIND FLIGHT OF MALE MOTHS ALONG PHEROMONE PLUMES

R.T. Cardé¹, K. Justus¹ & J. Murlis², ¹Dept. of Entomology, Univ. of California, Riverside, CA 92521, USA, E-mail ring.carde@ucr.edu; ²Inst. for Environmental Policy, University College London, 29/30 Tavistock Square, London WC1H 9EZ, UK

Mate-location in most moths is mediated by a plume of female-emitted pheromone that induces flight by males along that plume. In wind, the principal mechanism governing the direction of flight along pheromone plumes is optomotor anemotaxis in which the upwind heading is gauged by transverse image flow. Maintenance of forward progress appears contingent on the rate of encountering individual filaments of odor within the plume. If the rate of filament encounter falls below about 10 Hz, moths head more toward the crosswind. If contact with odor is lost for a large fraction of a second, casting or zigzagging flight without upwind progress ensues. Rapid and often nearly straight flight toward upwind is prompted by rates of filament encounter > 10 Hz. Some intermittency of the odor signal appeared requisite for upwind movement, because two moth species have been found not fly upwind when they are in a homogenous plume. We have explored in a wind tunnel how the fine-scale structure of the pheromone plume dictates flight along the plume in the almond moth, Cadra cautella. To verify the plume's structure we have used a tracer gas and monitored the concentration of a variety of plume types at 330 Hz. Plumes which were pulsed from 10 to 25 Hz produced many rapid flights upwind and no arrestment of upwind progress. Homogeneous plumes also produced rapid upwind flights over a wide range of concentrations. Together these findings suggest that a rapidly flickering pheromonal signal is not requisite for upwind flight in Cadra. Index terms: optomotor, anemotaxis, pheromone, attraction, moths

[0610] MASS TRAPPING OF RHYNCHOPHORUS PALMARUM USING PHEROMONE IN COCONUT PLANTATION, IN BRAZIL

J. L L. Moura¹, E. F. Vilela¹, G. H. Brasil³ & R. Canguçu³, ¹ Estação Experimental 'Lemos Maia', CEPLAC/CEPET, Una, BA, 45600-00; ² Dept. de Biologia Animal, Universidade Federal de Viçosa, MG, Brazil, 36571-000. e-mail: evilela@mail.ufv.br; Fazenda Novo Horizonte, Porto Seguro, BA, Brazil.

The weevil *Rhynchophorus palmarum* is one of the most serious pest of coconut and palm oil plantations in Central and South America, not only because of the damage they can cause to trunk trees, but also because of the transmission of a nematode to plants, which causes the 'red ring disease'. Food attractants have been used since a long time for trapping the pest. More recently, the species aggregation pheromone {2(E)-6-methyl-2-hepten-4-ol} became commercially available in Brazil. Using this pheromone associated with a food attractant (sugar cane), we tested the mass trapping technique in the 'Novo Horizonte' Area, in Porto Seguro (BA), Brazil. From May 1997 to September 1999, we captured 97,835 insects, in an area of 54 hectares (4634 plants). The disease reduction in the area, due to the decrease in the insect pest population was significantly high, from 206 attacked trees in May 1997 to only three trees in September 1999. Pheromone traps seem to be a very interesting tool for the control of *R. palmarum*.

Index terms: semiochemicals, integrated pest management, pheromone trap

[0611] THE USE OF ATTRACT AND CONTROL TECHNOLOGIES IN THE CONTROL, PREVENTION, SUPPRESSION AND ERADICATION OF THE COTTON BOLL WEEVIL

T.A. Plato, J.C. Plato, J.S. Plato & S.E. Plato, Plato Industries, Inc., 2020 Holmes Road, Houston, Texas 77045, USA, E-mail: plato@nol.net

The use of attract and control technologies in boll weevil (Anthonomus grandis Boh.) control, prevention, suppression and eradication is making substantial progress in area wide programs in Argentina, Bolivia, Brazil, Colombia, Paraguay and the USA. Discoveries by early workers as reported in the literature and a USDA-ARS monograph (Agriculture Handbook Number 259, Ridgeway et al. 1983) led to the isolation, identification and synthesis of the boll weevil pheromone and the subsequent design and production of effective boll weevil traps. In the 1980s, the traps as designed by Dr. Dick Hardee and Dr. Bill Dickerson evolved into commercial production for use in early IPM and early boll weevil eradication programs (BWEPs) in the Southeast USA. The traps were more effective as detection devices than as control devices and this lead to research and development of the boll weevil bait stick at the USDA-ARS-Boll Weevil Research Laboratory. Technology surrounding the bait stick was patented by the USDA and transferred as an exclusive license to Plato Industries, Inc. under the US Government's Technology Transfer Act. During the years of 1990, the bait stick was modified, improved, commercialized and evaluated as the Boll Weevil Attract and Control Tube (BWACT) in more than 200 IPM tests in the USA. The use of the BWACT (Tubo Mata Picudo or Tubo Mata Bicudo) in Central and South America was heavily influenced by the outstanding results of a two-year area wide program in Nicaragua. Through collaboration with the USDA-ARS, State Extension Agencies and Latin America cooperators the BWACT technology was implemented as a "preventative" approach against the boll weevil, the number one cotton pest in the Americas. It has been adopted by Paraguay (210,000 ha.) and Colombia (100,000 ha.) as a strategic component in their National Cotton Reactivation Programs and as a key component in the IPM programs of Brazil (150,000 ha.). Argentina (50,000 ha.) and Bolivia (20,000 ha.) have implemented the use of the BWACT and traps to detect and prevent the establishment of the boll weevil in their major cotton zones. BWACT results from an area wide program in Paraguay are exemplary of the potential for using the attract & control technology; cotton yields have been increased an average of 400 kgs. per ha., insecticide usage for boll weevil control has been reduced from 6 - 8 applications per crop to less than 1. As a consequence, the incidence of secondary pests and damage to beneficial insects has been drastically reduced. Results from the aforementioned programs will be presented. Index terms: Anthonomus grandis, BWACT, Grandlure.

[0612] PHEROMONE-BASED MASS TRAPPING OF THE BANANA WEEVIL, COSMOPOLITES SORDIDUS & THE WEST INDIAN SUGARCANE WEEVIL, METAMASIUS HEMIPTERUS IN BANANA & PLANTAIN

A.C.Ochlschlager,¹ D. Alpizar,² M.Fallas,² L.M. Gonzalez¹ & S. Jayaraman³ ¹ChemiTica Int., S. A., Apdo. 159-2150 San José, Costa Rica, E-Mail chemitica@sol.racsa.co.cr; ²Min. de Agric., Guapiles, Costa Rica; ³Dept. of Chem., Simon Fraser Univ., Burnaby, B.C., V5A 156, Canada

Cosmopolites sordidus is the most important insect pest of banana & plantain. Surveys in the Atlantic region of Costa Rica revealed that larvae & adults of both C. sordidus & Metamasius hemipterus (West Indian sugarcane weevil) were present in corm of both banana & plantain. C. sordidus predominated in banana & M. hemipterus in plantain. Larval feeding causes corm damage that is assessed by inspection of crosscut sections of corms of recently harvested plants. In plantations that routinely used nematicideinsecticide applications (e.g. Counter, Furadan) to combat root damage by Radopholus spp. nematodes surveys determined C. sordidus associated corm damage of 15-35%. In 1995 we demonstrated that the male-produced aggregation pheromone of C. sordidus was attractive in the field. Since 1996 we have conducted studies to determine the extent to which pheromone-based mass trapping reduces corm damage due to C. sordidus & increases fruit bunch weight. Trapping of C. sordidus revealed that initial capture rates in pheromone-baited traps correlated well with banana corm damage & capture rates of M. hemipterus correlated well with plantain corm damage. Mass trapping C. sordidus using a pheromone-baited pitfall trap (soapy water as killing agent) & M. hemipterus using a pheromone-sugarcane-baited open gallon trap were conducted in commercial banana & plantain. Four traps for each insect per ha were placed in each of three 1 ha plots of plantain & two 5 ha plots of banana during 10-17 months. Capture rates of C. sordidus & M. hemipterus in both plantain & banana declined by > 75% over 10-12 months. Corm damage decreased by 61-64% over the same period. Fruit bunch weights increased by 27% in plantain & 23% in bananas relative to control plots after 11-12 months of trapping. Trapping only for C. sordidus in several large plantations (>200 Ha each) reduced corm damage by 62-86% relative to pre-trapping levels after 4-5 months. In all plantations in which trapping was conducted for more than 5 months corm damage was reduced to less than 10%. After completion of these trials a new above ground ramp trap was developed for C. sordidus that is 25-40% more effective than the pitfall trap. The cost of year round trapping is less than a single insecticide application & is recovered by a 1-2% increase in vield.

Symposium and Poster Session

[0613] FIELD EVALUATION OF FEMALE-TARGETED TRAPPING SYSTEMS FOR DETECTION AND USE IN POPULATION SUPPRESSION/ERADICATION OF CERATITIS CAPITATA (DIPTERA: TEPHRITIDAE)

<u>R. R. Heath¹</u>, N.D. Epsky², B. I. Katsoyannos³ & J. Hendrichs⁴, ¹United States Department of Agriculture, Agricultural Research Service, South Atlantic Area, Subtropical Horticulture Research Station, 13601 Old Cutler Road, Miami, FL 33158-1334 USA, E-mail mianh@ars-grin.gov. ²USDA/ARS, CMAVE, P.O. Box 14565, Gainesville, FL, USA, ³32604 University of Thessaloniki, Department of Agriculture, Laboratory of Applied Zoology and Parasitology, 540 06 Thessaloniki, Greece, ⁴ International Atomic Energy Agency, Insect & Pest Control Section, Wagraumer Strasse 5, P.O. Box 100, A-1400 Vienna Austria.

Field trials were conducted in Argentina, Guatemala, Greece, Costa Rica, Honduras, Israel, Mauritius, Mexico, Morocco, Portugal, South Africa, Spain and Turkey to compare captures of the Mediterranean fruit fly, Ceratitis capitata (Wiedemann), among several types of traps baited with female-targeted attractants. Female-targeted trapping systems were baited with a new food-based three component synthetic attractant composed of ammonium acetate, putrescine and trimethylamine lures or with liquid protein bait. The synthetic attractants were tested in either wet traps (with water) or dry traps (with pesticide or sticky insert) and compared to capture of flies with McPhail-type traps baited with an aqueous solution of NuLure and borax. Traps baited with the three component attractant captured equal or greater numbers of flies than the McPhail-type traps baited with NuLure/borax. In trials with low C. capitata population levels, traps baited with the three component attractant captured more flies than the trimedlure (TML)-baited Jackson traps or NuLure/borax baited traps. Females accounted for 48 - 90% of the total capture in the female-targeted trapping systems. Traps baited with the three component attractant were more C. capitata specific than the other female-targeted trapping systems. In high density trapping (15 pairs/Ha) synthetic lures captured flies 4 weeks earlier than TML-baited Jackson traps. In low density trapping (1 pair/Ha + 1 TML/Ha), 3 weeks earlier than TML-baited Jackson traps. Results from these experiments has afforded the development of control strategies using mass trapping and bait stations. Index terms: Ceratitis capitata; Mediterranean Fruit Fly; Trapping; Suppression

[0614] PHEROMONE TECHNOLOGIES FOR MANAGING DOUGLAS-FIR TUSSOCK MOTH IN WESTERN NORTH AMERICA

G. E. Daterman¹, J. M. Wenz² & K. A. Sheehan³, ¹U. S. Forest Serv., Pacific NW Research Station, 3200 Jefferson Way, Corvallis, OR 97331, USA, E-mail gdaterman@fs.fcd.us; ²U.S. Forest Serv., Stanislaus National Forest, 19777 Greenley Rd., Sonora, CA 95370, USA; ³U. S. Forest Serv., Pacific NW Region, P. O. Box 3623, Portland, OR, 97208, USA.

The Douglas-fir tussock moth (DFTM)), Orgyia pseudotsugata, is a severe defoliator of conifer forests in western North America. Populations of DFTM are cyclic, with outbreaks that develop suddenly and with little warning. When a sex attractant pheromone, (Z)6-heneicosen-11-one, was identified in 1975, a trapping system was developed for early detection of outbreaks. The focus was to calibrate a trap lure that would result in minimal moth captures in low-density populations, while providing a quantitative measure of increasing population densities in areas where an outbreak might be developing. The system emphasizes low cost and simplicity to encourage use. Trapping was implemented in 1980 when several hundred five-trap plots were placed in Oregon, Washington, Idaho, and California forests. For the past 20-years at least 750 trapping plots have been maintained in susceptible forests in those states. Eleven DFTM outbreaks of varying size and intensity have occurred during that time period. Seven of those were predicted by the trapping system. Trapping also helped detect the remaining four outbreaks, but in those cases too few traps were located in the vicinity of the high populations for effective early detection. Effectiveness of the system depended on number of trap plots and their proximity to areas with high populations. Interpretation of trapping records, and sampling of other life stages of DFTM in the vicinity of high trap counts, also influenced system effectiveness. Pheromones also have been successfully tested in the USA and Canada to demonstrate mating disruption as a method to control DFTM. If a pheromone product were registered it would likely be used in DFTM management, particularly in the early phases of an outbreak. The (Z)6-heneicosen-11-one monoene is effective for mating disruption. However, the addition of a new pheromone compound, the dienone (Z)6,(E)8heneicosadiene-11-one, reported in 1997, would likely improve effectiveness if a dispenser system could be formulated to maintain isomeric stability. Use of pheromone plus an insecticide as an "attract-and-kill" method of control has not been evaluated for DFTM. This may be a useful approach to manage DFTM, but it would almost certainly require use of both pheromone components, because the monoene by itself is ineffective inducing male contact with pheromone dispensers. Index terms: Orgyia for pseudotsugata, monitoring, mating disruption, forest insects.

Index terms: corm damage, aggregation pheromone, banana yield, plantain yield

[0615] MATING DISRUPTION OF LEPIDOPTERA IN AUSTRALIA – TRIALS, TRIBULATIONS AND TOMORROW

R. A. Vickers, Commonwealth Scientific & Industrial Research Organisation, Entomology, PB 3 Indooroopilly, QLD Australia 4068

The chemical identification of the silkworm moth's sex pheromone by Butendandt et al in 1959 was the first of many hundreds of identifications made over subsequent decades. Entomologists were quick to recognise the potential of sex pheromones as tools in insect pest management and chemists soon began to focus their attention on insects of economic importance. In 1969 the major component of the oriental fruit moth (OFM), Grapholita molesta, was identified and in the following year CSIRO Entomology commenced trials in Australia to evaluate its potential as a mating disruptant. Fortuitously, the compound contained in approximately the right amount a contaminant that subsequently proved to be a minor pheromone component. From the very beginning of the trials, and despite the rather crude dispensing system used, it became clear that mating disruption offered real prospects for controlling this key pest of Australia's stone fruit industry. Minimum pheromone release rates were established, effective dispenser distribution patterns determined and protocols for establishing and assessing mating disruption trials developed. Successful area-wide trials followed and a mating disruption system that is now used by more than 90% of Australia's commercial pome fruit producers became commercially available soon after. Codling moth, Cydia pomonella, was our next target but, in contrast to OFM, proved to be a much more difficult candidate. Within the chemical ecology community there was considerable debate about the identity and behavioural role of the minor components and their influence on mating disruption, the major component was inherently unstable and, despite almost total suppression of catches at monitoring traps, there were many occasions when damage levels far exceeded thresholds tolerated by growers. After numerous trials and tribulations we (and others) eventually recognised that the larger the area treated and the lower the initial pest density the more likely it was that mating disruption would succeed. This scenario is of course not confined to codling moth. A commercial mating disruption product became available in Australia in 1993 and is currently used by about 20% of Australian commercial producers. A mating disruptant has also been identified for the two heliothine pests of cotton in Australia. But fears of physical contamination of the crop and labour costs has made our cotton industry unwilling to consider mating disruption in anything other than a sprayable formulation and further trials have been put on hold. However an effective sprayable formulation is believed close to market. If so, it will revolutionise mating disruption, making it an attractive option in broad-acre crops, very tall tree crops and forests. Index terms: Grapholita molesta, Cydia pomonella, heliothine moths, pheromone

[0616] MATING DISRUPTION TO MANAGE ORCHARD PESTS IN THE PACIFIC NORTHWEST OF NORTH AMERICA: PAST, PRESENT AND FUTURE

D.R. Thomson¹ & O. Knutson², ¹DJS Consulting, 3015 SW 109 Street, Seattle, WA 98146, USA, E-mail dthomso@pacifier.com, ²Alamo Orchards, Mattawa, WA 99349, USA.

There are 100,000 hectares of pome fruit grown in the Pacific Northwest of North America. The first pheromone-mediated mating disruption product for control of an orchard pest, codling moth, Cydia pomonella was registered in 1991. In 1997, the first leafroller mating disruption product was registered for control of 2 orchard pests, Choristoneura rosacena and Pandemis pyrusana. Currently, there are 6 and 4 products registered for codling moth and leafrollers, respectively. Commercially available delivery systems include microdispersible sprayable formulations, and reservoir-type dispensers. In 1999, codling moth and leafroller mating disruption technologies were used on approximately 25,000 and 1,500 hectares, respectively. Pheromone-based IPM programs based on the deployment of mating disruption technologies in conjunction with the judicious use of insecticides can be as or more cost-effective than the use of insecticides alone. Other benefits include reduced environmental residues of broad spectrum insecticides, decreased costs associated with worker protection and labour management, higher populations of natural enemies, and decreased potential for the development of insecticide resistance. Grower concerns include the high initial costs of transition to pheromone-based IPM programs, the often unpredictable impacts of insect population density, micro climate, canopy structure and topography on efficacy, the need for intensive monitoring and the potential for outbreaks of secondary pests. A case study will be presented to illustrate the economics, and problems associated with pheromone-based IPM practices in organic and conventional orchards. Research is still needed to improve the efficacy and reliability of pheromone-based IPM programs. There are extensive research efforts by industry into modifying and developing new delivery systems. Recent registrations include new formulations of microdispersibles and novel large aerosol dispensers. By identifying effective blends, measuring the spatial and temporal distribution of pheromones and then correlating those measurements with pheromone-mediated behaviours, the mechanisms of mating disruption will be better understood. The development of improved monitoring techniques in conjunction with the use of economic thresholds to determine the need for and timing of supplemental controls is essential. The continued adoption of pheromone-based IPM will depend on how well such programs meet grower concerns about risk, efficacy and cost.

Index Terms: Cydia pomonella, pome fruit, pheromones, mating disruption

Symposium and Poster Session

[0617] WIDELY SPACED, HIGH-EMISSION-RATE PHEROMONE SOURCES FOR MATING DISRUPTION OF LEPIDOPTEROUS PESTS

T. C. Baker & D. L. Mahr¹, Dept. of Entomology, Iowa State Univ., Ames, Iowa USA 50011; ¹ Dept. of Entomology, Univ. of Wisconsin, Madison WI USA 53706

Widely spaced, high-emission-rate pheromone dispensers are being explored as a possible effective way to deploy pheromone disruptants on large contiguous acreages of crops such as corn and cranberries. One of these systems, called Metered Semiochemical Timed Release System, or MSTRSTM, consists of a bottle containing pheromone that is placed in a machine that, on a timed basis (e.g., every 15 min) delivers an aerosol spray of pheromone to a pad. Pheromone is then emitted from the pad at extremely high rates, ca. 20 times higher than most existing disruptant dispensers. Fewer dispensers are therefore needed for effective disruption, and pheromone is not wasted by being passively emitted from the reservoir during periods of the day when the insects are inactive. Only 4 or 5 machines are needed per treated hectare, and they are retrievable. A second, newer system has also been explored that uses 20 to 25 dispensers per hectare, and these are also retrievable. In the past few years we have conducted pheromone disruption experiments using MSTRSTM technology against the most distructive pest of corn in the midwest United States, the European corn borer, Ostrinia nubilalis, in Iowa cornfields containing significant proportions of grassy borders and waterways in the fields' interiors that serve as mating aggregation sites. We have also conducted $MSTRS^{TM}$ disruption experiments against the blackheaded fireworm, Rhopobota naevana, and Sparganothis sulfureana, two pests of cranberry, in Wisconsin cranberry marshes. These experiments have shown much promise in disrupting males' ability to locate synthetic pheromone sources or calling females up to 99% for an entire flight period. We have also been able to assess the ability of the disruptant systems to suppress mating by freely flying females. For instance, during the first flight of the European corn borer, we have been able to reduce the percentage of feral females mating in grassy aggregation areas by up to 50% early in the flight. As the flight period progresses, all the females become mated, but the $MSTRS^{TM}$ treatment suppresses the number of matings that females achieve by 30-50% compared with the untreated check plots. These levels of mating disruption are similar to those achieved in plots treated with Shin-Etsu/Mitsubishi "ropes" using higher levels of pheromone per hectare. The mating disruption results in cranberry marshes against the blackheaded fireworm also showed significant reduction of mating by free-flying females of that species. Recent results have shown the new MSTRSTM formulation to be equivalent in disruption efficacy to both the old MSTRSTM formulation as well as a commercially available sprayable pheromone formulation for us against the blackheaded fireworm and S. sulfureana.

Key Words: Ostrinia nubilalis, Rhopobota naevana, Sparganothis sulfureana, sex pheromones, mating disruption

[0618] REGULATORY ISSUES IN THE COMMERCIAL DEVELOPMENT OF PHEROMONES AND OTHER SEMIOCHEMICALS – GLOBAL ASPECTS

I. Weatherston¹ & <u>R. R. Stewart²</u>, Technology Sciences Group Inc., 4061 North 156th Drive, Goodyear, AZ 85338, USA¹; 110 17th Street, N.W., Suite 500, Washington, D.C. 20036, USA E-mail rstewart@tsgusa.com²

The commercialization of pheromones and semiochemicals requires regulatory approval in most countries. Applications for approval must be accompanied by a variety of data. In the United States, regulatory officials have developed an abbreviated set of data requirements in recognition of the natural occurrence and low toxicity of these compounds. Additional regulatory relief has been granted for well understood groups of chemicals. In other countries, especially Europe, pheromones and semiochemicals are initially subject to the same data requirements as all chemical pesticides. While some of these requirements may be waived, the uncertainties surrounding the data requirements and cost of developing these data appear to have had a chilling effect on the pheromone and semiochemical industry. As a result there are far fewer approved products and the value of the resulting markets is much less. The specificity of pheromones places practical limits on the size of the potential market. In addition, the costs for user education and competition from the more traditional chemical pesticides place financial burdens in the marketplace. In the face of business pressures, overly burdensome data requirements to support registration can easily deter companies from pursuing the development and registration of pheromones and other semiochemicals.

[0619] OVIPOSITION ATTRACTANTS AND OVIPOSITION STIMULANTS FOR CULEX MOSQUITOES

J. G. Millar, Dept. of Entomology, Univ. of California, Riverside CA 92521, USA

Culer mosquito ovinosition is mediated by chemical and physical cues that are associated with typical oviposition sites such as ponds and other bodies of stagnant water that contain decomposing plant debris. We have identified a number of volatile chemical cues that influence mosquito oviposition from aqueous infusions of decaying plant materials mimicking natural oviposition waters. Compounds were identified both by traditional bioassay-driven fractionation of solvent extracts of infusions, and by collection of headspace volatiles, followed by analysis by coupled gas chromatography-electroantennogram detection. Behaviorally and physiologically active compounds included indole and 3-methylindole, phenols, aldehydes, and sulfur compounds. We also investigated the development of bioassays to determine which steps in the oviposition sequence (attraction or oviposition stimulation) were influenced by various chemical cues. Several general conclusions could be drawn from experiments with Culex First, concentration was critically important; quinquefasciatus and Cx. tarsalis. compounds which were attractive or stimulatory at parts per billion levels in water became repellent at higher concentrations, particularly to Cx. tarsalis. Second, oviposition stimulation (treatment vs. control frequently > 10:1) appeared to be more strongly mediated by chemical cues than attraction (treatment vs. control, ~3:1). Third, blends of compounds were more biologically active than individual compounds, with the increase in activity being approximately additive rather than synergistic. Fourth, correct formulation of blends was important because the release rates of compounds from aqueous solutions was dependent on their hydrophobicity and hydrogen bonding abilities. Thus, if the relative proportions of compounds in the headspace volatiles from infusions were used to formulate synthetic blends, hydrophobic compounds were overrepresented, and hydrophilic compounds were underrepresented. Once blends had been adjusted to compensate for these effects, the corrected blends were more biologically active than the unadjusted blends. Overall, considerable progress has been made in identification of compounds that mediate Culex mosquito oviposition, but even the best synthetic blends are not yet as active as crude infusions of decaying plant material, indicating that further compounds remain to be discovered.

Index terms: Culex tarsalis, Culex quinquesfasciatus, oviposition stimulant, oviposition attractant

[0620] CHEMICAL ECOLOGY OF TRIATOMINAE

<u>M. G. Lorenzo</u>, Laboratório de Triatomíneos e Epidemiologia da Doença de Chagas-CPqRR-FIOCRUZ. Brazil. Supported by Capes-SeTCIP, FIOCRUZ, PRONEX, PAPES, UNDP/World Bank/WHO(TDR), UBA and CONICET.

Triatominae is a subfamily of the Heteroptera-Reduviidae, that represent a total of 126 species of haematophagous insects. They include all vector species of the flagellate parasite *Trypanosoma cruzi*, the etiological agent that causes Chagas disease. This health burden affects approximately 17 million people in Latin America. Triatomine bugs obtain their blood meals mostly from endothermic vertebrate hosts. For this task they use CO2 and other host odours, probably short chain aldehydes, amines and carboxylic acids, as orientation cues. In the close range, warmth is the most powerful attractant. We have shown that odours released by yeast cultures are attractive for several species, probably because of their intense liberation of CO2 and, perhaps, for some other volatiles they emit. These cultures have been successfully tested in our laboratory as baits in traps for capturing Triatoma infestans, T. sordida, Rhodnius prolixus and Panstrongylus megistus, all important vectors of the disease. These traps exploit a characteristic behaviour exhibited by triatomines during host search, i.e., falling down from walls or ceilings in the presence of host-related stimuli. Besides, chemical communication has been reported in many species of this group in different contexts. Two kinds of aggregation pheromones have been described, a volatile and a contact one (footprints), for several species of triatomines, and in all cases studied, interspecific aggregation responses to these signals have been found. In addition, sexual and alarm pheromones have been reported to exist in triatomines. Since some time ago, we are dealing with the isolation and chemical characterization of these substances. Recently, we have studied the chemical composition of the alarm pheromone of T. infestans by means of SPME and GC-MS techniques. We were able to find three substances in the blend, that had not been previously described in the literature. These are: 3-Pentanone, 2-methyl-butyl alcohol and 2-methyl-butyric acid. The complete mixture we found was: 3-pentanone, isobutyl alcohol, isobutyl isobutyrate, 2-methyl-butyl alcohol, acetic acid, propionic acid, isobutyric acid, butyric acid, 2-methyl-butyric acid, and phenylethyl alcohol. Isobutyric acid was the major component of the mixture, as already described in the literature. Thus, we have found a blend that is more complex than those reported by previous authors. SPME sampling showed to be highly effective for this analysis, as it allowed to detect previously described compounds as well new components in the volatile blend liberated by triatomines. These studies with vectors of Chagas disease may assist control strategies providing new tools for their detection or capture.

Index terms: triatomine, chemical baits, aggregation, alarm pheromone, contact pheromone.

[0621] EFFICACY OF NEW ATTRACTANTS AND TRAPS FOR MOSQUITO SURVEILLANCE AND CONTROL

D.L. Kline, USDA, ARS, CMAVE, P.O. Box 14565, Gainesville, FL, 32604, USA; Email: dkline@gainesville.usda.ufl.edu

New mosquito management strategies that reduce reliance on chemical insecticides by utilizing combinations of attractants and traps have been developed. This presentation will focus on laboratory and field evaluation techniques used to determine the efficacy of these combinations. Volatile chemicals, primarily those which emanated from human skin, were initially evaluated in a triple cage, dual port olfactometer to assess the attraction of 6 8 day old laboratory reared nulliparous female *Aedes aegypti*. Over 125 chemicals have been screened for activity. Many of these compounds produce attraction at high chemical emission rates. Blends of multiple compounds have been eveloped that provide collection efficiencies, measured by percent attraction, equal to or greater than that of the human hand. Some of these blends have also been evaluated against laboratory reared mosquitoes in a large outdoor screened cage and against natural populations by means of Counter Flow Geometry traps. Data will be presented that show the importance of species-specific attractant blends, trap type, and trap spacing in obtaining meaningful population reduction. The future prospects of removal trapping for control of nuisance and vector mosquito species will also be discussed.

Index terms: Mosquitoes, human emanations, kairomones, traps, targets, olfactometer

[0622] THE ROLE OF GRASS INFUSIONS AS OVIPOSITION ATTRACTANTS AND OVIPOSITION STIMULANTS FOR *AEDES AEGYPTI* MOSQUITOES

<u>Á. E. Eiras</u>, Dept. of Parasitology, Universidade Federal de Minas Gerais, Brazil (alvaro@icb.ufmg.br). Supported by CNPq, FAPEMIG, FUNASA, IFS (Sweden)

The mosquito A. aegypti is the main urban vector of dengue and yellow fever, arboviral diseases that can spread rapidly in explosive epidemics in South America. Oviposition traps (ovitrap) provide a very sensitive and economical method for detecting Aedes mosquitoes") when the population density is low, whereas general larval surveys and adult collections produce unsatisfactory results. The addition of grass infusion in the ovitrap enhances significantly the number of eggs collected, thus increasing the trap efficacy. We evaluated grass infusions aiming to identify the volatiles that attract gravid Ae. aegypti female mosquitoes to ovitraps. We screened infusions of four grasses (Pennisetum purpureum; Panicum maximum; Cynadon plectosa chyus and Cynadon dactylon) and the results showed that P. maximum associated traps collected a significantly higher number of eggs than the control. Infusions of fresh and dried leaves of P. maximum were also evaluated and showed that the egg detection of ovitraps baited with fresh leaves infusions was significantly higher than other treatments. The volatiles from grass infusions are likely to be produced by microorganisms, as ovitraps baited with aerobic fermentation collected significantly more eggs than those with anaerobic and sterilized infusions. The fermentation period and concentration of infusions are also important to produce a blend of active compounds. The identification of the volatiles released from grass infusions that attract gravid Ae. aegypti female mosquitoes to ovitraps has being carried out in order to use specific synthetic chemicals to eliminate the need to create infusions. We also evaluated in laboratory and field, larval holding water as oviposition attractant and in combination with grass infusions. The highest? concentration of larval holding water increased significantly the number of eggs collected and a synergistic effect was observed when both stimuli were presented in combination. Video recordings of the oviposition behavior of gravid A. aegypti females showed that there is a pattern of behavioral sequences during the pre-oviposition and oviposition period. Discrimination between oviposition attractants and stimulants, and how gravid female mosquitoes exploit baited ovitraps will be discussed.

Index terms: Aedes aegypti, infusions, oviposition stimulants.

Symposium and Poster Session

[0623] UTILIZATION OF PCR FOR DETECTION OF WUCHERERIA BANCROFTI IN BARRA DE GUABIRABA - PE, NON-EDEMIC CONSIDERED AREA

A. L. Albuquerque¹, <u>R. M. R. Barbosa²</u>, L. N. Regis¹& A. F. Furtado¹, ¹Dept. de Entomologia, Centro de Pesquisas Aggeu Magalhães/HOCRUZ, Av. Moraes Rego, CEP-50670-420, Brazil, E-mail ale@epqam.fiocruz.br.² Mest. em Biologia Animal, Dept. de Zoologia, Univ. Fed. de Pernambuco, Av. Moraes Rego, CEP-50670-420, Recife, PE, Brazil. Supported by CNpQ/HOCRUZ

Lymphatic filariasis is caused by Wuchereria bancrofti and is transmitted by the insect Culex quinquefasciatus. PCR technique has been used in molecular diagnosis by the amplification of a repeated fragment of 188bp from W. Bancrofti, utilizing two species-specific oligonucleotides (NV1 and NV2). In the evaluation of PCR viability in epidemiologic surveys of non-endemic considered areas, we run our experiments in the municipality of Barra de Guabiraba-PE. 775 mosquitoes were collected and subdivided into 31 pools of 25 mosquitoes each, as well as 114 blood samples from the inhabitants. DNA extraction, PCR and electrophoresis were the techniques used. We also proceed the purification of DNA from the agarose gel, southern-blot, hybridization and markage with SspI cold probes in the insect pools. The blood samples were filtered in membranes. Bands of 188bp and 1050bp were amplified in 74,19% of the pools 19,35% presented only the band of 1050bp and 6,45% were negative. The bigger fragment was investigated by purification and amplification and besides the band of 1050bp the one of 188bp was equally present, suggesting that the fragment of 1050bp contains the 188bp. SspI-DIG (188bp) probe hybridizes with the 1050bp fragment. From the 114 blood samples, 8 (7,02%) showed to be positive by PCR. The PCR technique confirmed the presence of W. Bancrofti in the city of Barra de Guabiraba-PE. We suggest that the 1050bp may also be used for the diagnosis of filarial infection in the vector, improving the efficiency an efficacy of control programs.

Index terms: Wuchereria bancrofti, Culex quinquefasciatus, PCR, diagnosis.

[0624] IDENTIFICATION OF CHEMICAL DEFENSE SECRETION OF A DUNG BEETLE

<u>A. Aliabadi</u>¹, R. J. Bartelt² & D. W. Whitman³, ¹4160 Chemistry, Illinois Sta. Univ., Normal, IL 61790, USA, E-mail aaliab@ilstu.edu; ²USDA, ARS National Center for Agricultural Utilization Research, Bioactive Agents Research Unit, Peoria, IL 61604, USA, E-mail bartelrj@mail.ncaur.usda.gov; ³4120 Biological Sciences, Illinois Sta. Univ., Normal, IL 61790, USA, E-mail dwwhitm@ilstu.edu.

Dung beetles are not generally known to be chemically defended; however, some species in the genus *Canthon* (fam.: Scarabaeidae; subfam.: Scarabaeinae) emit tiny droplets of a fetid-smelling liquid from two small glands on the posterior margins of the elytra when disturbed. We analyzed this secretion via GC/MS and found the chemical components of this foul-smelling emission included indole, *m*-cresol, phenol, and creosol. The beetles discharged their odorous secretion when attacked; bird, mammal, and reptile predators, refused to eat them.

Index terms: Canthon, Scarabaeidae, Scarabaeinae, allomone.

[0625] CHEMOSENSORY PROTEINS IN SCHISTOCERCA GREGARIA

<u>S. Angeli^{1, 2}</u>, ¹Scuola Superiore di Studi Universitari e Perfezionamento "S. Anna", 56100 Pisa, Italy; ²Dipart. di Chimica e Biotecnologie Agrarie, University of Pisa, 56100 Pisa, Italy, e-mail: angeli@sssup.it

The desert locust Schistocerca gregaria is one of the major crop pests in Africa and the Middle East. Recently, chemoreception of the species has been investigated with regard to ecological, behavioural and physiological aspects. An aggregation-maturation pheromone and an egg-pod attraction pheromone have been isolated and characterized and the finestructure of antennal sensilla was studied. Here we describe the biochemical characterization and the immunocytochemical localization of the first family of chemosensory proteins (CSP) expressed in Orthoptera. Three acidic and soluble proteins of 14 kDa were purified, each from distinct chemosensory organs (antennae, tarsi and labrum) of crowd-reared locusts. The N-terminal sequences were obtained and were found to be similar to each other. They exhibit significant homology with a subclass of putative chemoperception proteins, expressed from Phasmids to Diptera. A large quantity of the tarsi-specific protein was purified from females and used for chemical characterization, polyclonal antibody preparation and binding assays. In TEM-immunocytochemical of chemosensory organs, the antibody labelled specifically the receptor lymph of contact, terminal-pore sensilla. Therefore we designed degenerate primers from the N-sequence and were able to amplify, by RT-PCR, the nucleotide sequences from mRNA isolated from the tarsi of one female. After cloning and sequencing, the sequence analysis showed five isoforms, all encoding for proteins 109 amino acids long. Comparison of peaks of the mass-spectrometry analysis of the native protein with the theoretically calculated molecular mass from the five cDNAs, shows a complete overlap, suggesting that these isoforms are all expressed in single animals without any post-translational modifications. Therefore, we decided to express an isoform in E. coli. The chemical analysis of soluble recombinant protein showed no differences with the native protein in terms of PAGE analysis, mass-spectrometry, disulfide bridges dispositions and circular dichroism. Crystallization experiments and ligand-binding assays of the recombinant form are now in progress. Although the specific function of these proteins is still unknown, their high degree of homology with the 4 conserved cysteines, and their expression in chemosensory organs of large number of species have suggested a role in chemoreception. Recently a member of this family was found to bind the Drosophila pheromone vaccenyl acetate. In Orthoptera, our experimental data suggest a role for these proteins in contact chemoreception, for instance in response to chemicals on surfaces like cuticular hydrocarbons. No binding of radioactively labelled glucose or bicarbonate was detected. Index terms: Schistocerca gregaria, chemoperception, chemosensory proteins.

[0626] DIVERSITY OF DUNG BEETLES (COLEOPTERA: SCARABAEIDAE) IN BORDER-INNER TRANSECTS IN A FOREST OF THE COLOMBIAN ANDES

<u>**J. M. Ardila¹**</u> & G. Fagua¹, ¹Laboratory of Entomology, Dept. of Biology, Pontificia Univ. Javeriana, Carrera 7 No. 43 – 82. (Edificio 52 – Piso 5). Santalé de Bogotá, D.C., COLOMBIA, E-mail elitros@yahoo.com

The variation in the composition, abundance, richness and structure of dung communities beetles (Coleoptera: Scarabacinae and Aphodiinae) was determined in a submountain rain forest in the "Farallones de Medina" (Colombia). Samples were collected between June 1999 and January 2000 along six transects each with eight sampling stations; five in the interior of the forest, one along the border and two outside of the forest. At each station six pitfall traps were set up with a distance of 20 m between each one and a bait of human feces. A total of 1,606 beetles were captured, distributed in two subfamilies and 22 species, during 13,824 trap - hours. Species richness was greater than reported in previous studies. Grouping analysis using the program Syntax was undertaken. Syntax reported differences between the composition of forest zones species and open zones. For each transect, species composition varied depending upon the vegetation present during the sampling. The results showed the difficulty that forest species have when moving into open areas. The highest abundance index was observed at the border stations. Index terms: Abundance, Aphodinae, Scarabacinae, Similarity, Richness

[0627] IDENTIFICATION OF FEMALE AND MALE SEX PHEROMONES IN THE SOLITARY BEE OSMIA RUFA (HYMENOPTERA: MEGACHILIDAE)

<u>M. Ayasse¹</u>, G. Dutzler¹, F. Schiestl¹, F. Ibarra² & W. Francke², ¹Inst. of Zoology, Althanstrasse 14, 1090 Vienna, Austria, E-mail Manfred.Ayasse@univie.ac.at; ²Inst. of Organic Chemistry and Biochemistry, University of Hamburg, D-20146 Hamburg, Germany. Supported by a grant of the FWF Austria (P09773-BIO).

The reproductive biology of the solitary bee Osmia rufa has been well studied, in order to investigate this species' potential for crop pollination. Almost no data exist so far on the chemical communication involved in the mating biology. Males search for receptive females at feeding areas and nests. Most females of this monandrous species mate immediately after having emerged. Therefore, it should be an advantage for males to distinguish between receptive and unreceptive females. Males show a characteristic postcopulatory behaviour of rubbing the female wing surfaces with their sternites, which leads to the hypothesis that they mark the females with an antiaphrodisiac. In behavioural experiments, combined gas chromatography - electroantennography recordings (GC-EAD) and chemical analyses, we studied the function of female and male pheromones in mating biology. Bioassays with different samples obtained from attractive females showed extracts of the cuticular surface to be most attractive, indicating that the female sex pheromone is evidently located there. In GC-EAD analyses of surface extracts, we found that fatty acids, ethyl esters, hydrocarbons and aldehydes triggered receptor potentials in the antennae of males. Odourless dummy bees impregnated with synthetic compounds mixed according to the proportions found on the cuticular surface of unmated females were significantly more attractive to males than dummies impregnated with solvent only. In bioassays, O. rufa males clearly distinguished between newly emerged females and those that mated one or two days prior to a dual-choice experiment. Chemical analyses showed different odour bouquets of unmated and mated females and the total amount of odour decreased within three days after mating. The assumption that males mark females during copulation with an antiaphrodisiac, that is produced in the sternal glands, was confirmed by means of behavioural experiments, GC-EAD analyses and chemical analyses. Solvent extracts of wings obtained from just mated females yielded an increase of the total amount of odour as compared to that of unmated females and many of the main chemical compounds identified in the male sternal glands contributed to this increase. In dual-choice experiments, unmated females impregnated with sternal gland extracts proved significantly less attractive than females impregnated with solvent only. In a further bioassay we identified Ethyl (Z)-7-hexadecenoate as a male antiaphrodisiac. Index terms: Osmia rufa, mating biology, chemical communication

[0628] EFFECTS OF SQUASH GENOTYPES ON BIOLOGY AND FEEDING PREFERENCE OF LEPTOGLOSSUS GONAGRA

E. L. L. Baldin¹, A. C. Caetano² & F. M. Lara², ¹Dept^o de Biologia, Univ. de São Paulo, Avenida Bandeirantes, 3900, Ribeirão Preto, SP, 14040-901, Brasil, E-mail elbaldin@usp.br; ² Dept^o de Fitossanidade, Univ. Estadual Paulista, Via de Acesso Prof. Paulo Donato Castellane, Jaboticabal, SP, 14884-900, Brasil, E-mail fmlara@fcav.unesp.br.

Among the bugs of Coreidae family, the most is considered agricultural pests, and Leptoglossus gonagra (Fabr., 1775) is one of them. In Brazil, this insect is known as a polyphagous pest, damaging the squash, orange, watermelon and passion fruit. The adults and nymphs of this species suck floral-buttons, flowers, small fruits, branches and leaves, leaving characteristic points and harming the yield and physiologic development of the plants. Due to occurrence of these damages and wishing to investigate the existence of squash genotypes resistant to this bug, feeding preference and biological assays were accomplished under laboratory conditions. For the feeding preference assay were used seedlings (15-20 days after emergence) of thirty three squash genotypes of Cucurbita moschata and one commercial genotype of C. maxima (used as standard). These plants were placed inside of cages with five adults of L. gonagra, in four replications. The preference index (attractivity) at 45, 60, 90 and 120 minutes after the releasing was calculated. After analysis of the obtained results in this assay, twelve genotypes were selected, being three very attractive (BRA 015024, BRA 003531 and BRA 003603), two intermediary attractive (BRA 014737, Exposição) and six few attractive (BRA 015113, BRA 014664, BRA 014711, BRA 014770, BRA 014788, BRA 014869) to study some biological parameters. Seedlings of the different genotypes (15-20 days after emergence) were placed inside of glass cages, with 50 nymphs recently-hatched (each one corresponding to one replication). These insects were observed daily, evaluating the duration and mortality per instar. The results showed that seedlings of all genotypes caused 100% of mortality in the second instar, except BRA 003531 that allowed that 6% of the nymphs reached to the third instar. These results indicate the presence of antibiotic components in the seedlings and also suggest that the nymphs of second instar of L. gonagra need other structures of the squash, such as branches, floral-buttons, flowers and fruits to complete its biological development.

Index terms: Coreidae, host plant resistance, antibiosis, antixenosis

[0629] RESISTANCE OF FRUITS OF PASSION FRUIT GENOTYPES TO ANISOSCELES FOLIACEA MARGINELLA

E. L. L. Baldin¹, A. C. Caetano², A. L. Boiça Júnior² & F. M. Lara², ¹Dept^o de Biologia, Univ. de São Paulo, Avenida Bandeirantes, 3900, Ribeirão Preto, SP, 14040-901, Brasil, E-mail elbaldin@usp.br; ² Dept^o de Fitossanidade, Univ. Estadual Paulista, Via de Acesso Prof. Paulo Donato Castellane, Jaboticabal, SP, 14884-900, Brasil, E-mail fmlara@fcav.unesp.br; aboicajr@fcav.unesp.br.

Some species of the Coreidae family are the main pest bugs of passion fruit. These insects, associated with the caterpilars and phytopatogenic agents are responsible for the low productivity of this crop in Brazil. The bug Anisosceles foliacea marginella (Dallas, 1852) is big, generally with yellow-orange coloration, similar to Diactor bilineatus. These bugs are harmful for the crop, once, both youngest and adult forms attack the fruits, floral buttons and branches. The attacked fruits fall down and when stay on the plant, they show twisted forms, making disable its consumption. Due the need of new control methods, the objective of this research was to identify the resistance of passion fruit genotypes to A. foliacea marginella and to verify the mechanisms involved. Attractivity and consumption (in free choice and no choice) tests were evaluated, using Passiflora alata, P. edulis f. flavicarpa, P. cincinata and P. giberti fruits, releasing one adult bug/fruit/genotype, in a completely ramdonized design. Ten replications were made, evaluating the number of attracted insects at 1, 3, 5, 15, 30, 45, 60, 90, 120 and 180 minutes after the releasing, the total number of pricks, the total time of feeding (min.) and the mean time of feeding per prick (min.). To evaluate antibiosis, 24 nymphs recently-hatched per genotype (each one corresponding to one replication) were daily accomplished in glass cages, evaluating the duration and mortality per instar. The results showed that in free choice test, the *P. edulis* f. flavicarpa and P. giberti fruits revealed to be less attractive than P. cincinnata and P. alata, although there was not statistical differences; in antibiosis tests, all genotypes caused 100% of nymphs' mortality on the second instar (except P. cincinata), indicating the presence of antibiotic components in its fruits and showing to be inadequate to development of nymphs of A. foliacea marginella,

Index terms: Coreidae, Passiflora spp., host plant resistance, antixenosis, antibiosis

[0630] ATTRACTIVITY OF PASSION FRUIT GENOTYPES TO HOLHYMENIA HISTRIO AND FEEDING PREFERENCE

E. L. L. Baldin¹, A. C. Caetano², F. M. Lara² & A. L. Boiça Júnior², ¹Depl^o de Biologia, Univ. de São Paulo, Avenida Bandeirantes, 3900, Ribeirão Preto, SP, 14040-901, Brasil, E-mail elbaldin@usp.br; ² Dept^o de Fitossanidade, Univ. Estadual Paulista, Via de Acesso Prof. Paulo Donato Castellane, Jaboticabal, SP, 14884-900, Brasil, E-mail fmlara@fcav.unesp.br; aboicajr@fcav.unesp.br.

The brazilian yield of passion fruit is sensibly reduced by the attack of insects on this crop. Among the main responsible pests are the bugs and caterpilars; the first ones for the direct attack to the branches, floral buttons and fruits, reducing the productivity and the second ones for the significant leaf area reduction of the plants, harming its development. The bugs Holhymenia histrio (Fahr., 1803) are characterized by the fast flight and high colors, similar to wasps, with which are frequently confused. In this work was evaluated the adult bugs feeding preference for fruits of the following passion fruit genotypes: Passiflora edulis t, flavicarpa, P. coccinea, P. giberti, P. cincinata and P. setacea. Free choice attractivity and consumption tests were accomplished, with 15 replications in a completely randomized design, releasing one adult/fruit/genotype. The number of attracted insects at 1, 3, 5, 15, 30, 45, 60, 90, 120 and 180 minutes after the release; the total number of pricks; the total time of feeding (min.) and the mean time of feeding per prick (min.) were evaluated. The results showed that in free choice test, the P. giberti and P. coccinea fruits were the least favorite ones, suggesting to be resistant. P. edulis f. flavicarpa, P. setacea and P. cincinata, unlike the first ones, were more preferred for feeding, indicating to be susceptible to the attack of this insect.

Index terms: Passiflora spp., host plant resistance, antixenosis

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[0631] RESISTANCE OF BEAN GENOTYPES TO THE BEAN WEEVIL ACANTHOSCELIDES OBTECTUS

E. L. L. Baldin¹ & F. M. Lara², ¹Dept^o de Biologia, Univ. de São Paulo, Avenida Bandeirantes, 3900, Ribeirão Preto, SP, 14040-901, Brasil, E-mail elbaldin@usp.br; ² Dept^o de Fitossanidade, Univ. Estadual Paulista, Via de Acesso Prof. Paulo Donato Castellane, Jaboticabal, SP, 14870-000, Brasil, E-mail fmlara@fcav.unesp.br.

During the grain storage of Phaseolus vulgaris bean there usually appear some problems caused by bruchids. This insects' attack may destroy the embryo, affecting plant germination, and also giving an unpleasant taste to the product, which affects its marketing. The bean grains are severely attacked by bruchids all over the world and one of the most frequent species in Brazil is Acanthoscelides obtectus (Say, 1831). Due to these damages and to the need of developing more efficient control techniques against these pests, tests were done, aiming to detect under lab conditions, genotypes that are resistant or susceptible to this pest's attack. Eighteen different genotypes were submitted to no choice tests in plastic recipients containing 10g/genotype, together with 6 adult insects (48 hours age) for a period of 7 days, in a completely randomized design with four replications. These recipients were maintained in B.O.D. (T= 25 \pm 2 °C, RH= 70 \pm 10 % and L/D = 12/12 h). From the 26th day of storage the recipients were observed daily and the number of emerged insects was counted. After counting, these insects were put into glass vials and immediately conducted to a freezer. By the end of emergences the vials with insects were maintained in a stove (T=50°C) for two days and thereafter the dry weight/replication/genotype was evaluated. The life cycle of the insects/genotype was also calculated. The results showed that the material containing arceline, mainly Arc. 1 and Arc.2, presented antibiosis as resistance mechanism to the bean weevil, making its cycle longer and differing significantly from the other genotypes. Differences towards the number of emerged insects and adults' weight were not observed among the genotypes. Index terms: Acanthoscelides obtectus, host plant resistance, antibiosis

[0633] EVALUATION OF FEEDING PREFERENCE OF *EPICAUTA ATOMARIA* FOR PASSION FRUIT GENOTYPES

<u>E. L. L. Baldin¹ & F. M. Lara²</u>, ¹Dept^o de Biologia, Univ. de São Paulo, Avenida Bandeirantes, 3900, Ribeirão Preto, SP, 14040-901, Brasil, E-mail elbaldin@usp.br; ² Dept^o de Fitossanidade, Univ. Estadual Paulista, Via de Acesso Prof. Paulo Donato Castellane, Jaboticabal, SP, 14884-900, Brasil, E-mail fmlara@fcav.unesp.br.

The passion fruit crop counts a rich fauna of insects, being some of them extremely useful and other ones highly harmful (caterpilars, bugs and beetles). Epicauta atomaria (Germar, 1821) is a polyphagous pest and in great populations it can destroy totally the leaves of the passion fruit, leaving just the veins, affecting the yield. The use of resistant genotypes in pest control is increasing once do not harm the environment and to reduce sensibly the yield costs. The feeding nonprefernce of E. atomaria adults for leaf disks and leaf extracts of five passion fruit genotypes (Passiflora alata, P. edulis f. flavicarpa, P. nitida, P. setacea and P. giberti) were evaluated under laboratory conditions. The consumption (free and no choice) and attractivity tests were evaluated with 2 leaf disks per genotype (2,54 cm of diameter), being an used as treatment and another as standard. In free choice tests, leaf disks were placed inside Petri dishes, releasing one adult per genotype in ten replications, in a ramdomized block desing. The attractivity was evaluated at 15, 30, 60, 90, 120, and 180 minutes after the releasing and the consumption evaluated through diference of fresh weight. In consumption no choice test, the same methodology was proceeded, however one disk/dish/genotype was placed with 2 adults in a completely ramdomized design. In attractivity test with olfactometer, it was used cotton with 1ml of leaf extract (1g of leaves + 5 drops of H2O2) per genotype, placed inside of the olfactometer, releasing 2 insects per genotype. The number of attracted adults at 1, 5, 15, 30, 45 and 60 minutes after the releasing was counted in 10 replications in a randomized block design. The results showed that in attractivity tests accomplished in Petri dishes and olfactometer, the leaf disks and leaf extracts of *P. setacea* and *P. edulis* f. *flavicarpa* were the most preferred by adults of E. atomaria, while P. giberti, P. nitida and P. alata were the least preferred in the two kinds of recipients. In consumption tests (free and no choice), using leaf disks, P. setacea was the most consumed, confirming to be susceptible; P. giberti, P. nitida, P. alata and P. edulis f. flavicarpa were not very consumed by the insect, presenting feeding nonpreference as resistance mechanism. Index terms: Meloidae, Passiflora spp., host plant resistance, leaves

[0632] FEEDING PREFERENCE OF *DIABROTICA SPECIOSA* FOR SQUASH GENOTYPES

E. L. L. Baldin¹, F. M. Lara² & M. F. Batista³, ¹Dept^o de Biologia, Univ. de São Paulo, Avenida Bandeirantes, 3900, Ribeirão Preto, SP, 14040-901, Brasil, E-mail elbaldin@usp.br; ² Dept^o de Fitossanidade, Univ. Estadual Paulista, Via de Acesso Prof. Paulo Donato Castellane, Jaboticabal, SP, 14884-900, Brasil, E-mail fmlara@fcav.unesp.br; ³Embrapa/Cenargen, E-mail fatima@cenargen.embrapa.br.

The Cucurbitaceae are very affected by the insects and among these are the beetles of Chrysomelidae family. Diabrotica speciosa (Germar, 1824) attacks the squash from the germination to the crop, destroying the leaves, causing characteristic damages. Beside these direct damages they can also transmit virus of great importance. Several control methods exist for this pest, and among them the use of resistant genotypes appears as an alternative and efficient method. In this aspect, was tried to select squash genotypes less preferred for feeding by adults of D. speciosa, in assays with seedlings and leaf disks. Initially, attractivity tests were accomplished in cages, being used seedlings (15-20 days after emergence) of thirty three squash genotypes of Cucurbita moschata and one commercial genotype of C. maxima (used as standard). Five insects per genotype were released in a completely randomized design, with four replications, being evaluated the number of attracted insects at 30, 75 and 120 minutes after the releasing. To observe the consumption in seedlings, free and no choice tests (10 and 5 replications, respectively) were accomplished with eight selected genotypes from the attractivity test. Eight insects per genotype were released in a completely ramdomized design and the damages caused were evaluated using a visual scale. The attractivity and consumption tests (free and no choice) in Petri dishes, using leaf disks (2.54 cm of diameter) of those eight genotypes also were accomplished, releasing two insects per disk, with 10 replications in a ramdomized block design. Feeding nonpreference was measured through leaf area consumption. The results showed that in free and no choice tests with seedlings and leaf disks, the BRA 015024 and BRA 015059 genotypes were less preferred for feeding by adults of D. speciosa, while BRA 014958, BRA 014869 and BRA 014737 were the most preferred. In the Exposição (commercial), BRA 014745 and BRA 003531 genotypes the adults showed intermediary behaviour.

Index terms: Chrysomelidae, host plant resistance, leaf disks, seedlings, antixenosis

[0634] RESPONSE OF GRAVID FEMALE CULEX QUINQUEFASCIATUS (DIPTERA - CULICIDAE) TO NATURAL PHEROMONE IN THE CHOICE OF AN OVIPOSITION SITE

R. M. R Barbosa¹ & L. N. Regis², ¹Mestrado em Biologia Animal, Dept. de Zoologia. Universidade Federal de Pernambuco, Av. Moraes Rego, CEP50670-420 Recife, PE, Brazil. ²Dept. de Entomologia, Centro de Pesquisa Aggeu Magalhães/FIOCRUZ, Cx. Postal 7472, CEP50670-420, Brazil. E-mail leda@cpqam.fioeruz.br. Supported by FACEPE and FIOCRUZ

The choice of an oviposition site by gravid females is the principal factor responsible for the distribution of the mosquitoes in breeding sites and it is of great relevance for the dispersion of the species in the nature. Therefore, accurate monitoring of *Culex* abundance is critical in forecasting the risk of disease outbreaks. Previous studies have demonstrated the atractiveness of natural oviposition pheromone in some Culex. quinquefasciatus, strains. Our objective is to determine the effects of natural pheromone as oviposition attractants for C. quinquefasciatus from in endemic area of lymphatic filarioses in Recife, Brazil. To examine the effects on mosquito oviposition behaviour, six cages (30x22x20cm) were used; two glass cups (200ml) were placed inside the cage, with one containing 10 egg-rafts and the other containing tap water as a control. The positions of treatment and control cups were alternated between replicates. Twelve replicates of 20 gravid females per cage were used. The egg-rafts were counted 24:00h after the beginning of the experiment. The results of this oviposition bioassay have shown that 76% females oviposite in the test site and 24% in the control site. These bioassays demonstrated that natural pheromone strongly attracted oviposition by C. quinquefasciatus gravid female. These data are of great usefulness to improve the atractiveness of an oviposition traps model under development.

Index terms: Culex quinquefasciatus, oviposition attraction, vectors control, pheromone.

[0635] CASSAVA HORNWORM, *ERINNYIS ELLO*, CONSUMPTION RATES AND PERFORMANCE ON FOUR CASSAVA VARIETIES

J. A. F. Barrigossi¹, ¹National Rice and Bean Research Center (Embrapa Arroz e Feijão), Caixa Postal 179, Santo Antônio de Goiás, GO, Brazil, 75375-000. E-mail: alex@cnpaf.embrapa.br.

Cassava hornworm, Erinnyis ello, is one of the most important defoliators of cassava in South America. Information about damage potential to cassava is necessary before economic injury levels are established. We conducted laboratory experiment to determine the consumption rates of cassava and characterize the injury potential by E. ello. First instar E. ello larvae (<3 h old), that hatched from field collected eggs, were individually reared on excised cassava leaves of four varieties, at 27 °C. A randomized block design with 9 replications was used. Leaves and larvae were kept in plastic containers. Leaves were maintained with petiole placed in water picks to prevent wilting. Fresh leaves were provided to the larvae daily beginning from the 3rd day of the experiment. Leaf areas were determined for each leaf using a leaf area meter (Model 3100, LI-COR, Lincoln NE, USA) before the leaves were provided to the larvae. After every molt, leaves were removed from the containers and leaf areas were determined. Then, leaves were either replaced or returned to the plastic containers. Foliage consumption per instar, developmental time and weight of larvae and pupae were recorded. Total leaf area consumption (square cm) for the varieties were: 1030.45 ± 63.2 (Fio de Ouro), 971.45 ± 34.24 (Aipim Bravo), 968.57 ± 75.73 (Urubu), and 956.08 \pm 37.3 (Jaburu). There were no significant differences in the larval consumption on the four varieties at p < 0.05. About 85% of the feeding occurred during the last two larval stages. Varieties also had no effect on larval development. Mean larval weight (g) were: 4.92 ± 0.35 (Jaburu), 4.82 ± 0.23 (Fio de Ouro), 4.73 ± 0.18 (Urubu), and 4.61 ± 0.24 (Aipim Bravo). These data indicate that the varieties tested in this study had similar impact on the fitness and biology of E. ello. In addition, because the consumption rates of E. ello is the same economic injury levels can be used to manage E. ello on these varieties.

Index terms: leaf consumption, EIL

[0636] INTENSITY OF LOSSES IN MAIZE CULTIVATED UNDER MINERAL AND ORGANIC FERTILIZATION SYSTEMS

C.S. Bastos¹, M. Picanço², J.C.C. Galvão¹, A.H.R. Gonring² & A.R.R. Tavares¹, ¹Dept. de Fitotecnia, ²Dept. de Biol. Animal, Univ. Fed. Viçosa, CEP: 36571-000, Viçosa, MG, Brasil. E-mail: csbastos@alunos.ufv.br.

This research was accomplished in the Experimental Station of the Federal University of Vicosa at Coimbra, State of Minas Gerais, Brazil, during the agricultural year 1996/7 and it aimed to study the losses that occur in the production components of maize cultivated under mineral and organic fertilization systems, using the possible life table of the cultures. The treatments were represented by the possible combinations of three doses of mineral fertilization (zero, 250 Kg of 4-14-8/ha + 100 Kg of ammonium sulfate (AS)/ha and 500 Kg of 4-14-8/ha + 200 Kg of AS/ha) and two doses of organic fertilization (zero and 40 m³ of organic matter/ha). The losses were evaluated in the production components: plants, ears of corn, ovule and grains. Maize's productivity and cultivation losses were estimated. This data was made the basis for life table of the culture. The production component with major losses was ovule, and the main cause of it was the absence of ovule fecundation (responsible for 97.42% of the losses in the component and 80.02% of the total losses). These losses were correlated positively with Dalbulus maidis (Homoptera: Cicadellidae) attack to the plants (r = 0.31, n = 24 and p = 0.068). Another factor associated to the losses in ovule the *Helicoverpa zea* (Lepidoptera: Noctuidae) attack (causing 2.58% of losses). The attack of Spodoptera frugiperda (Lepidoptera: Noctuidae) to the plants caused 20.21% of losses while seeds perforation by immature Coleoptera: Elateridae caused 10.49% of losses. The losses in the component ears were due to occurrence of maize's ears without ovule or grains. Twenty point ten percent (20.10%) of the losses in grains were caused by H. zea attack and 31.04% by Sitophilus zeamais (Coleoptera: Curculionidae) attack. The largest losses happened due to absence of ovule fecundation in the treatments that received organic fertilization (about 4,660 Kg/ha of losses). Index Terms: Life table, Dalbulus maidis, Helicoverpa zea, Sitophilus zeamais,

Index Terms: Life table, Dalbulus maidis, Helicoverpa zea, Sitophilus zeamais, Spodoptera frugiperda.

[0637] SELECTION OF TROPICAL STEM BORERS FOR RESISTANCE TO CRYLAB IN MAIZE

D.J. Bergvinson¹, S. García-Lara¹ & S. McLean¹, ¹Int. Maize and Wheat Improvement Center, Apdo Postal 6-641, Col. Juárez, CP 06600 México, D.F., México, E-mail d.bergvinson@cgiar.org.

Transgenic maize expressing CryIAb toxins derived from Bacillus thuringiensis Berlinger have been commercially grown since 1996. Insect resistant management programs based on high-dose and refugia have been implemented in maize to reduce the probability of resistance development in target pests. The impact this technology will have on secondary pests of maize will be an important consideration as Bt-maize moves into more topical ecologies. The objective of this study was to document population changes in Diatraea saccharalis (sugar cane borer, tropical) and Diatraea grandiosella (Southwestern corn borer, subtropical) when selected using maize plants expressing CryIAb toxin. Neonate larvae (ca.400) were placed onto maize at the 6-leaf stage of development for 48h, with surviving larvae transferred to artificial diet to complete development, with a subsample of 300 larvae returning to Bt-maize to monitor survivorship. Survivorship, pupal weight, days to pupation, egg production and fertility were recorded for each cycle of selection After 14 and 18 cycles of selection for *Diatraca sacchardis and Diatraca grandiosella*, respectively, significant increases were observed for pupal weight and survivorship. Survivorship increased at a rate of 1.8 and 1.7%/cycle while pupal weight increased at a rate of 2.2 and 1.5mg/cycle for Diatraea saccharalis and Diatraea grandiosella, respectively. Significantly more larvae from the latest cycle of selection survived to 6d on Bt-maize than unselected populations; however, no larvae survived beyond 8d. Monitoring pupal weight and duration of larval survival when exposed to Bt-maize under controlled conditions my serve as practical tools for monitoring insect resistance in areas grown to Bt-maize.

Index terms: Maize, stem borer, Bacillus thuringiensis, selection

[0638] BIOCHEMICAL BASIS FOR STORAGE PEST RESISTANCE IN MAIZE

D.J. Bergvinson¹, S. García-Lara¹ & A. Savidan¹, ¹Int. Maize and Wheat Improvement Center, Apdo Postal 6-641, Col. Juárez, CP 06600 México, D.F., México, E-mail d.bergvinson@egiar.org.

Storage pests are a major constraint to resource poor farmers in developing countries. Developing maize grain with improved resistance to storage pests is one component of storage pest management that has been lacking in modern variety development. The International Maize and Wheat Improvement Center has screened maize germplasm bank accessions for resistance to storage pests. Caribbean accessions with elevated levels of resistance have been used a recurrent selection scheme under artificial infestation to improve resistance levels. This germplasm has enabled the development of surrogate screening technologies, identification of biochemical traits correlated with resistance and to study the interaction between kernel resistance and biological controls. The rapid screening technique involves measuring the break force of equilibrated kernels which correlates well with resistance for both Prostephansu truncatus (r=0.88) and Sitophilus zeamais (r=0.85). Using a peril mill, enriched tissue fractions were isolated for the pericarp, germ and endosperm for biochemical characterization. Four forms of diferulie acid located within the pericarp cell wall correlated with *Sitophilus zeanais* resistance (>0.85) and kernel hardness (r>0.82). Diferulic acids within the endosperm cell wall showed similar results while no significant correlation was observed for germ tissue. This resistance mechanism does not appear to alter the nutritional quality of the grain as measured by nitrogen content. Resistance to both pests is negatively correlated with grain moisture content. Breakdown of kernel resistance occurred at 14% moisture for Sitophilus zeamais and 16% moisture for Prostephanus truncatus. Kernel resistance did not affect the performance of the parasitoid Anisopteromalus calandrae when Sitophilus zeamais densities were calibrated. The importance of kernel resistance within the context of other management techniques will be discussed.

Index terms: maize, storage pests, resistance, selection

[0639] DEVELOPMENT AND CHARACTERIZATION OF MAIZE POPULATIONS RESISTANT TO TROPICAL STEM BORERS AND ARMYWORM

<u>D.J. Bergvinson</u>¹ & S. García-Lara¹, ¹Int. Maize and Wheat Improvement Center, Apdo Postal 6-641, Col. Juárez, CP 06600 México, D.F., México, E-mail d.bergvinson@cgiar.org.

Maize production in tropical ecologies can be severely reduced by stem borers and armyworm. Moreover, grain quality can be reduced further by ear rots associated with borer attack. Host plant resistance has traditionally been considered the cornerstone of integrated pest management. At the International Maize and Wheat Improvement Center, tropical and subtropical maize has been improved for insect resistance by artificial infestation of Diatraea grandiosella, Diatraea saccharalis and Spodoptera frugiperda. After five cycles of S3 recurrent selection, good levels of resistance to both artificial and natural infestation have been achieved. The basis of resistance appears to involve both increased epidermal cell wall toughness and reduced nitrogen content in the leaf. Since reduced leaf nitrogen content adversely affect yield, germplasm development efforts have focused on increasing leaf toughness. Using a force displacement meter fitted with a 1mm dia. probe, epidermal cell wall toughness is measured between the primary veins. Leaf feeding damage and leaf toughness are correlated (r=-0.8), with advanced cycles of selection having significantly tougher leaves. The biochemical basis for increased leaf toughness appears to be increased levels of phenolic acids that cross-link the hemicellulose of the epidermis. Mapping of insect resistance and leaf toughness has identified chromosomes 1, 5, 7 8, 9 to contain important quantitative trait loci, with both traits mapping to the same regions. On-farm testing of resistant germplasm has shown good yield stability under natural infestation and improved grain quality due to reduced incidence of Stenocarpella maydis. Leaf nitrogen content is currently being investigated within the context of fertilizer management to exploit low leaf nitrogen during the early stages of crop development and higher nitrogen levels before flowering for incorporation into the grain. Future research in maize resistance research will be discussed within the context conventional breeding.

Index terms: maize, stem borer, armyworm, resistance, breeding

[0641] TRIALS OF CONTROLLING LEPIDOPTERAN PESTS WITH SEX PHEROMONES IN KOREAN APPLE AND PEAR ORCHARDS

K. S. Boo¹, S.W. Lee², K.S. Hau¹, J.K. Jung¹, K. Choi¹ & C.Y. Yang², ¹Seoul Natl. Univ., Graduate School of Agric. Biotechnol., Suwon 441-744, Korea; ²Natl. Hort. Res. Inst., RDA, Suwon 440-310, Korea

History of research on application of insect sex pheromones are quite young in Korea. We have been investigating sex pheromone composition of lepidopteran pest insects damaging apple tree and fruit for last 5 years and pear for 3 years or so. In Korean apple orchards major pest insects are the Oriental fruit moth (Grapholita molesta) and the peach fruit moth (Carposina sasakii) on fruits, two leafminers of the apple leafminer (Phyllonorycter ringiniella) and the apple lyonetid (Lyonetia prunifoliella), and two leafrollers of the smaller tea tortrix (Adoxophyes orana) and the asiatic leafroller (Archippus breviplicanus). Their sex pheromones were found to be composed of Z-8-dodecenyl acetate : E-8dodecenyl acetate : Z-8-dodecenol (95:5:1) for G. molesta, Z-7-eicosen-11-one for C. dodecenyl acetate : Z-8-dodecenol (93:3:1) for *G. motesta*, Z-7-etcosen-11-one for *C. sasakii*, Z-10-tetradecenyl acetate : E4,Z10-tetradecedienyl acetate (4:6) for *P. ringiniella*, Z-9-tetradecenyl acetate : Z-11-tetradecenyl acetate (95:5) for *A. orana* and *E*-11tetradecenyl acetate : Z-11-tetradecenyl acetate (7:3) for A. breviplicanus. The sex pheromone of L. prunifoliella are under investigation for their stereochemistry, after finding of three different components including the major component of 10.14dimethyloctadec-1-ene(Gries et al., 1997). During last two years we deployed polyethylene tubes containing sex pheromones premixed at the rate of 100-150g/ha for C. sasakii, G. molesta and P. ringiniella. The preliminary results were not comparable to those by insecticide treatments yet, partly due to small size of orchards, but promising, Beginning this year we are going to work at a larger scale at farmers' orchards. Korean apple growers are still spraying insecticides 7.5 times and acaricides 3.5 times in a year, which were reduced from previous 10.3 and 4.5 times thanks to sex pheromone monitoring. We are also working on controlling of G. molesta in pear orchrads. Besides G. molesta and A. orana, we have Adoxophyes sp. in pear orchards. Adoxophyes sp. was found using Z-9-tetradecenyl acetate : Z-11-tetradecenyl acetate (7:3) as their sex pheromone in Korea. We will go after the control of lepidopteran pest insects in apple and pear orchards with sex pheromones and mites and aphids with their natural enemies. Index terms: apple insects. Pear insects. Sex pheromone, mating disruption

[0640] NO PLEIOTROPIC EFFECT OF INSECTIDE RESISTANCE ON SEXUAL COMMUNICATION IN CYDIA POMOMELLA

D. Beslay¹, B. Frérot², C. Malosse², M. Renou², J.C. Bouvier¹ & <u>B. Sauphanor¹</u>, ¹Unité de Zoologie-Apidologie - INRA, Agroparc, F 84914 AVIGNON Cedex, E-mail sauphano@avignon.inra.fr; ²Unité de Phytopharmacie et médiateurs chimiques, INRA - Route de St-Cyr- F 78026 VERSAILLES Cedex.

Monitoring codling moth, Cydia pomonella, by sex trapping is an important part of integrated pest management in apple and pear orchards. Discrepancy between C, pomonella catches in traps and level of infestations was observed in a number of orchards in Southern France. Insecticide in Insecticide resistance is widespread in these areas and as a consequence, it was hypothesised that the specific mate recognition system (SMRS) was modified in resistant populations. Both pheromone production and perception were compared on a susceptible and two laboratory strains resistant to diflubenzuron or deltamethrin respectively. GC and GC-MS analyses showed that females of resistant strains (ou resistant females) produced the same pheromone blend as sensitive females. In wind tunnel females of both strains induced the same levels of behavioural responses wether males are sensitive or resitant. EAG studies showed the same response spectra to minor components within the three strains. Finally, EAG and wind tunnel studies revealed identical dose-response curves to codlemone in both resistant and sensitive strains. Captures in traps baited with virgin females belonging either to the susceptible strain or both resistant strains were similar all over the season in field situation., Traps baited with synthetic pheromone captured the same rate of susceptible? and resistant males released in the orchard. Thus, the hypothesis of pleiotropic modifications in the SMRS of C. pomonella was rejected. The study allowed to assert that resistance mechanisms did not affect the flight capacity of the male moths, and that the sex pheromone can be used for monitoring or for direct control of resistant populations.

Index terms: codling moth, sex pheromone, codlemone, wind tunnel, electrophysiology.

[0642] RESPONSE SPECTRA OF SENSILLA TRICHODEA (A2-TYPE) OF FEMALE AEDES AEGYPTI TO HUMAN VOLATILES

O. J. Bosch¹ & J. Boeckh¹, ¹Inst. für Zoologie, Univ. Regensburg, Universitätsstr. 31, D-93040 Regensburg, Germany, E-mail oliver.bosch@biologie.uni-regensburg.de

Recent behavioral findings in female yellow fever mosquito *Aedes aegypti* (L.) (Diptera: Culicidae) led us to investigate the electrophysiological response spectra of sensilla trichodea A2-type in more detail. This sensillum type houses two receptor cells which can be distinguished by their different spike-amplitudes in single-sensillum recordings. We have classified these receptor cells based on their odor-evoked response spectra to volatiles emitted from humans. These stimuli included the natural multicomponent odors breath and body odor as well as different concentrations of following single compounds, which have been found in human sweat: (1) L-(+)-lactic acid, the indispensable synergist for other attractive components in behavioral studies, (2) ammonia, and (3) n-aliphatic carboxylic acids with chain length from C_1 to C_6 . Our results show several functional classes of receptor cells with distinct overlapping response spectra. These classes are mingled within the A2-type sensillum in varying pairs.

Index terms: Mosquito, olfaction, host odor, single-sensillum recording, sensillum trichodea.

[0643] BIOPROSPECTING FOR NOVEL PEST MANAGEMENT CHEMISTRY

W. S. Bowers, Laboratory of Chemical Ecology, Dept. of Entomology. The University of Arizona, Tucson, AZ 85721 USA. Email: wbowers@ag.arizona.edu

The application of chemistry to the control of insect pests of agriculture and public health provided an abundance of high quality food and a health status heretofore unimagined. Nevertheless, the residues of a few indifferent toxicants, poisonous to the basic and shared biochemistry of eukaroytic organisms, continues to threaten planetary ecology. Unable to return to the pastoral deficits of yesteryear we must adopt revolutionary research priorities seeking environmentally pacific methods for future pest management strategies. Bioprospecting among insect and plant chemistry yields novel chemistry leads for the development of biorational pest management strategies. Although vertebrates and invertebrates continue to share a similar physiology, biochemistry and genome we recognize certain mechanisms regulating these shared life processes have undergone significant evolutionary divergence. Thus, hormones regulating growth, development and reproduction in insects have no counterpart in vertebrates. Similarly, infochemicals lacking any complement in higher animals are employed by invertebrates for communication. Clearly, manipulation of these unique biological regulators represents a biorational approach to pest management. Bioprospecting among insect and plant chemistry has provided an abundance of natural products that have been optimized into insect growth and behavior regulator products for pest management with outstanding efficacy and environmental safety. We have focused our efforts on searching among insects and plants for hormonal and behavior regulators with potential for application. Utilizing novel biological assays capable to detecting activities previously unrecorded we have isolated and identified insect hormones and anti- hormones, pheromones, repellents, fungicides and antibiotics. We have also shown that plants respond to stress and certain signaling chemistry by deploying their defenses against insects and nematodes.

[0644] POSSIBLE ROLE OF AMMONIA IN HOST-SEEKING BEHAVIOR OF BLOOD-FEEDING INSECTS

<u>M.A.H. Braks</u>^{1,2}, J. Meijerink^{1,3} & W. Takken¹, ¹ Wageningen Univ. & Research Center, PO Box 8031, Wageningen, NI, E-mail marietabraks@hotmail.com, ² Florida Med. Entomol. Lab. 200 9th Str. Vero Beach, FL 32962 USA, ³ Dept. of Ecology Lund Univ., Ecology Building SE-22362 Lund, Sw.

Since the beginning of the century it has been recognized that malaria mosquitoes use host odors for host-seeking. It is vital for any blood-feeding insect to discriminate volatiles emanating from a living host from residues on materials in absence of the host. Carbon dioxide present in expired air is considered to be reliable 'life sign' of a living host and is a proven kairomone for many blood-feeding insects, including mosquitoes. However, in addition to expired air, olfactory stimuli may also originate from the skin. Studies on the anthropophilic Afrotropical malaria mosquito, Anopheles gambiae, showed that volatiles from the human skin, specifically sweat, play an important role in host-finding. Behavioral responses of An. gambiae to freshly collected sweat samples were variable; the females were attracted to some fresh sweat samples but not to others. However, responses to sweat samples that had been incubated for two days at body temperature were stable; mosquitoes were attracted to every incubated sweat sample. The pH of the sweat samples changed from acidic (pH 5-6) when fresh to alkaline (pH 8-9) after incubation. During incubation microbes in the sweat proliferated exponentially. The pH shift was caused by the production of animonia from urea and other nitrogen-rich components by the action of cutaneous microbes. In bioassays, An. gambiae was highly attracted to a wide range of ammonia concentrations. This is the first report of An. gambiae being attracted to a single compound other than carbon dioxide. As ammonia is continuously produced on the skin of a living host but evaporates quickly from non-living material, it may function as a reliable 'life sign', in addition to carbon dioxide, for blood-feeding insects.

Index terms: Anopheles gambiae, sweat, body odor

[0645] SIRENE® 6.0 GS: ATTRACT AND KILL, A NOVEL WAY TO CONTROL CODLING MOTH WITH AN AGE OLD VICE

J.A. Brits, H.J. Weideman & C.F. van Eeden, Novartis South Africa (Pty) Ltd., Crop Protection Sector, P.O. Box 92, Isando, 1600, South Africa, E-mail johann.brits@cp.novartis.com.

Codling moth, (Cydia pomonella) a cosmopolitan pest of pome fruit has been notoriously difficult to control owing to the prerequisite of residue free fruit demanded by the consumers world wide. Currently, codling moth in South Africa is being controlled chemically or by means of mating disruption. Both these avenues poses certain disadvantages. With chemical control there is always the risk of residues, while for mating disruption the treated orchards have to meet specific geographic requirements. SIRENE is a combination of both these control methods without the disadvantages. SIRENE comprises of a grease carrier containing female codling moth pheromone and an insecticide, which is applied as droplets on the branches of the trees. Male moths are lured to the droplets by the pheromone and when trying to mate with the droplets, they are killed by the insecticide. SIRENE has been extensively tested against Codling moth in South Africa.

Index terms: Pheromone, SIRENE, codling moth

[0646] BARK BEETLE RESPONSE TO AGGREGATION PHEROMONE INHIBITED BY MONOTERPENES RELEASED BY A PIEZOELECTRIC SPRAYER

J. A. Byers¹ & A. M El-Sayed², ¹Dept. Plant Protection, Swedish Univ. Agricul., SE 230 53 Alnarp, Sweden; ²Southern Crop Protection & Food Research Centre, Agricul. & Agri-Food Canada, Vineland Station, Ontario L0R 2E0, Canada.

A piezoelectric sprayer for dispensing semiochemicals was developed and used for a field test of bark beetle semiochemicals. The sprayer consists of a geared pump that pushes a syringe slowly to dispense semiochemicals in solvents through a micro-tube to a glass micropipette fixed to a piezoelectric high-frequency vibrator. The frequency is adjusted via a function generator to about 120 KHz until the harmonic properties of the glass micropipette, drawn by an electrophysiological pipette puller, cause vibrations that atomize the solvent from the micropipette tip. The sprayer, syringe, pump, function generator, and power supply were hung on one arm of a rotating trap pair (traps 6 m apart) that was slowly rotated at 2 rph to even out the position effects on trap catches. The aggregation pheromone components of Pityogenes bidentatus (Hbst.) (Coleoptera: Scolytidae), grandisol and cis-verbenol, were released by standard tube dispensers in one trap and compared to the release of similar amounts by the sprayer in the other trap. No significant differences in catch were observed. No effect of the solvent hexane on aggregation could be observed. The trap pair also caught approximately equal numbers of bark beetles when the baits were identical. The release of (+)- and (-)- α -pinene, (+)-3carene, and terpinolene, monoterpenes of host Scotch pine Pinus sylvestris L., at increasing rates from 0.01 to 10 log-equivalents in decadic steps (each at 0.1 to 100 µg/min) resulted in decreasing responses to aggregation pheromone (only 9% at highest rate). Inhibition by the individual monoterpenes tested at the 100 µg/min rate was significant for (+)- and (-)- α -pinene and terpinolene (12, 13, and 15% of control, respectively). The inhibition by the host Scotch pine monoterpenes may allow P. bidentatus to avoid resistant trees that release large amounts of toxic monoterpenes in their resin and instead colonize dying and diseased limbs or slash, the usual host substrate. The piezoelectric sprayer should prove generally useful to dispense precise amounts of semiochemicals in field and laboratory experiments.

Index terms: Pityogenes bidentatus, Pinus sylvestris, host selection, dispenser, release rates, Coleoptera, Scolytidae, Scotch pine, conifers

[0647] THE HARMFUL INSECTS ON PINUS BRUTIA TEN

<u>P.Can.</u> Ege Ormancılık Araştırma Müdünlüğü Karşıyaka/İZMİR- 35530 TÜRKİYE, E-mail: Peymancan@yahoo.com.

Pinus brutia Ten. forests cover on area of more than 3 million hectares in Turkiye being the most extensive of the forest tree species in this country. In the Mediterranean basin, the largest pure and the largest natural stands of *P.brutia* are found in Turkiye. There are different harmful insects on different parts of this species. Defoliators are *Thaumetopoea pityocampa* Schiff (*Lep., Thaumetopoeidae*), *Diprion pini* L. (*Lep., Diprionidae*), pests of cones and seeds are *Dioryctria mendacella* Stgr (*Lep., Pyralidae*), *D. pinea* Stgr (*Lep., Pyralidae*), bark beetles are Orthotomicus .erosus (Wall) (Col., Scolytidae), *Ips sexdentatus* (Boerner), Blastophagus piniperda L. (Col., Scolytidae), Bminor (Hartig) (Col., Scolytidae); one of borers is Dioryctria splendiella H.S. (*Lep., Pyralidae*) such as these insects cause significant economic losses. While using different treatments against these insects, studies have been carried out about IPM.

Index terms: Defoliators, sucking insects, borers, bark beetles, P.brutia

[0649] INSECTICIDE ACTIVITY OF COTTON CRUDE OIL ON ADULTS OF CYDIA POMONELLA (LEPIDOPTERA:TORTRICIDAE)

M. Cariac¹, A. Ferrero¹, T. Stadler² & <u>A.A. Suarez</u>³, ¹ Dept. Biología, Bioquímica y Farmacia, Univ. Nac. Del Sur, San Juan 670, (8000) Bahía Blanca, Argentina, e-mail: mjcariac@criba.edu.ar. ²Museo Cs. Nat. Bernardino Rivadavia, Av. A. Gallardo 470, (1405) Buenos Aires, Argentina. ³E.E.A.INTA Anguil, Ruta Nac. N°5 Km 580, C.C. 11, (6326) Anguil, La Pampa, Argentina.

Cydia pomonella is the most important pest that affects apple, pear, quince and walnut production in Argentina. Due to increasing number of insecticide resistant pest populations, it is neccessary to look for alternative control methods such as oil applications. Compared to syntethic insecticides, oils are cheaper and less toxic to mammals. In laboratory experiments, we determined the contact insecticide activity of crude cotton oil on C. pomonella adults. Insects were immobilized with CO2 and 1µl of crude oil was applied on the abdomen ventral part. Adult insects without oil treatment were used as checks. After treatment, insects were transfered to plastic containers and kept in rearing conditions. Mortality was determined at 24 h intervals. A nested design was used, and the data obtained were analized using ANOVA. Insects treated with cotton oil suffered a longevity reduction of 39% (n < 0.01) compared to untreated ones. In treated females and treated males longevity reduction was 27% (p<0.01) and 55% (p<0.01), respectively. These results suggest that determining subletal effects of cotton oil applications, such as fecundity and egg viability, should be neccesary to further evaluate the effectiveness of this technique.

Index terms: Cydia pomonella, longevity, cotton oil.

[0648] LOCAL DETERRENCE OF MULTIPLE ATTACKS BY THE COFFEE BERRY BORER

F. Cantor, O. DeSouza, E. F. Vilela, C. A. Faria & F. G. Costa, Depto. Biologia Animal, Univ. Fed. Viçosa, 36571-000 Viçosa MG, Brazil, Email: fcantor@alunos.ufv.br

Coffee berries (Coffea arabica) attacked by the borer Hypothenemus hampei (Coleoptera: Scolytidae) are known to be infested by a single individual, which builds its gallery into one of the fruit's seed, rarely attacking the second seed. Such a pattern of infestation differs markedly from other Scolytidae, which normally aggregate when attacking their hosts. We explore such a phenomenon, checking whether females seeking new oviposition sites are deterred by some clue produced by a female already attacking a berry. To do so, we carried out an experiment in which females of the coffee berry borer were allowed to choose between naturally infested berries and berries in which a borer attack was simulated. The attack by the borer was simulated by introducing a pin into the berry, thereby producing a hole and gallery of the same diameter as a borer would do. We arbitrarily call "resident" the borers already in the berry and "invaders" the borers to which the choice was presented. Three different tests were performed using the set up described above (natural x simulated infestations). Firstly, natural infested berries containing its borer were offered as an alternative to simulated infested berries. The second test ran similarly, with the exception that the resident borer was previously removed from the naturally infested berries. In the third test, the resident borer was killed and left inside the berry. Naturally infested berries were consistently more attacked by invading borers than berries on which the attack has been simulated (P<0.05). In lab conditions, when invading borers attacked infested berries, they avoided the fruit's end which had been already perforated, choosing instead the opposite end to build their galery. It seems, therefore, that either (i) our simulation of an attack actually deterred attacks by the invading borer, or (ii) the natural infestation acted as a clue for new borers, which are deterred only locally by some mark deposited by the female on its gallery. In natural conditions, the newcomers would then by able to depart to a nearby, noninfested, berry. This would allow borers to locate suitable hosts, without enhancing the risk of interindividual conflicts among their offspring.

Index terms: Hypothenemus hampei, aggregation, oviposition marks

[0650] SEX ATTRACTION OF MALES OF *COPITARSIA CONSUETA* (LEPIDOPTERA: NOCTUIDAE) UNDER CONDITIONS OF LABORATORY

V. R. Castreión¹, J. Cibrián², R. Osorio² & M. Camino¹, ¹ Centro de Desarrollo de Productos Bióticos del I.P.N. Carretera Yautepec-Jojutla km. 8.5, Yautepec, Morelos, México. C.P. 62730. A.P. 24. Tel. (739) 4-18-96. e-mail: vcastrej@hotmail.com.² Instituto de Fitosanidad, Colegio de Posgraduados. 56230 Montecillo, Estado de México, México. This research was supported by I.P.N. grant (CGPI 980052).

All laboratory studies were conducted between the 7-8 hr of the scotophase that coincided with the peak period of pheromone release by females. Test were conducted in a 1.8 X 0.7 X 0.7 m plexiglass flight tunnel housed in a room with the same photoperiod, temperatures and humidity maintained in rooms used to house adults. Air was pulled through the tunnel at 0.2 m/sec and expelled outside the building. For testing, a release cage with the male was placed on a cage older at the downwind end of the tunnel. Males were used once and those that were not activated within 120 sec of placing in the tunnel were discarded. The behavioral repertoire of males responding to calling females or abdominal glandular extracts included activation behaviors, random flight, guided flight, stopping on the wall, landing, reorientation and attempted copulation. Activation behaviors were identified by random walk before flying (orientation toward the stimulus), wing fanning and antennal grooming. Random flight involved upward and descending movements in any direction and crashes on the walls of the flight tunnel. The guided flight consisted of movements on zig-zag to the half height of the flight tunnel and the same level of the objective, these movements diminished in according width the insect came closer to the target, it was also observed the insect to be suspended in the air during some seconds and to fly short tracts. The landing was considered when the insect stopped in the wire cage and later walked vertical and horizontally looking for the female, besides shaking the wings vigorously. In the reorientation the insect flew against the wind toward the target after having oriented previously. Attempted copulation was a lateral curving of the abdomen to either left or right, besides touching the cage with the antennae.

[0651] FLOWER PREFERENCE AND FORAGING BEHAVIOR OF CENTRIS RODOPHTHALMA (HYMENOPTERA:ANTHOPHORIDAE)¹

<u>E. Chiappa</u>² & S. Rodríguez³, 1 Supported by FONDECYT Grant 1971141; 2 Fac. of Sciences. Univ. of Playa Ancha, 34-V, Valparaíso, Chile. 3 Lab. of Zoology, Catholic Univ., Valparaíso. boxmail 4059, Valpso., Chile. E-mail srodrigu@ucv.cl.

In 3 places of the IV Region of Chile (Varillar, Andacollito and Hurtado), a study was angle in Geoffroea decorticans, 3 species of Adesmia (Fabaceae) and Stachys albicaulis (Lamiaceae). In A. gluinosa and A. pedicellat the angle was 160° , making easy the access to the nectar of the tongue of C. rodophthalma, and did not for those plants with a smaller angle, 2.- To determine the foraging behavior of C. rodophthalma, the influence of 2 flower characters of 3 species of Adesmia, (a) the number of open flowers and (b) the nectar volume, was recorded and related on behavioral aspects of the bee: visitation frequency, the time spent at flowers and searching time (refers to the time spent outside of the bushes). To examine relations between those parameters, an analysis of multiple regression was performed. Results of the analysis shawn that in Varillar, the visitation frequency and the time spent at flowers are determined by nectar volume, through high quality and/or concentration of nectar in A. glutinosa. In Hurtado, distinctjy, is the number of flowers that are leading the foraging behavior of the bee, probably because this locality was in the peack of flowering. In the 3 places, the nectar volume and number of flowers did have not influence on searching time, supposedly, also used in other funtions like nesting, mating, resting, etc. The bee had foraging behavior alike in Varillar and Andacollito, probably because this localities have similar enviromental and geographical parameters and, with the strengthener of human disturbance of the habitat. Hurtado remain unchanged, is a natural habitat, there the foraging behavior of C. rodophthalma had greater values for each variable considered. This results suggest behavior variability of C. rodophthalma at populations level in this last locality.

index terms: Insecta, bee, insect-plant interaction, Adesmia, Fabaceae, Chile

[0653] CONTACT CHEMICAL CUES RELEASED BY ADULTS OF NEZARA VIRIDULA HAVE A KAROMONAL EFFECT ON THE EGG PARASITOID TRISSOLCUS BASALIS: A CHROMATOGRAPHIC INVESTIGATION

S. Colazza¹, E. Peri¹, G. Salerno², F. Saiano³, S. Ramirez³ & G. Alonzo³, ¹Inst. of Agricultural Entomology, Univ. of Palermo, Viale delle Scienze 13, 90128 Palermo, Italy, E-mail colazza@unipa.it; ²Dept. of Arboriculture and Plant Protection, Univ. of Perugia, Borgo XX Giugno, 06121 Perugia, Italy; ³ Dept. ITAF, Chemistry section, Viale delle Scienze 13, 90128 Palermo, Italy.

The host foraging behavior of insect parasitoids is generally mediated by chemical cues which may be detected both at long distance, where cues from the host-plant complex often play a major role, or at short distance, where host cues are frequently important for orientation. For insect parasitoids attacking the egg stage, short-range cues usually arise from sources associated with the adult host rather than from the egg stage itself, as for Trissolcus basalis, whose female shows an arrestment response when contacting traces left by adults of its host, Nezara viridula. Filter paper contaminated by males or females of N. viridula was extracted with solvents of increasing polarity: hexane, dichloromethane and acetone. The subsequent analysis by GC/MS revealed the presence of different contributing compounds in the various extracts (chemical identifications are currently underway). Laboratory bioassays were designed to determine the response of T. basalis females to the different extracts. The responses were scored as positive when the females, upon contacting the contaminated area, arrest locomotion and remain motionless for about 4-10 s, tapping the substrate intensively. Acetone filter paper extracts contaminated by Negara males or females were the most active; similar activity was also found in dichloromethane filter paper extracts contaminated by Nezara males alone. No activity was recorded with either hexane or dichloromethane extracts from Nezara females. Further analysis of the acetone extract has been done by HPLC producing five fractions of which only one shows evidence of some activity (chemical identifications in progress). Although the effectiveness of this kairomone for large-scale control has not been determined, the identification of the active compounds could provide an important tool to increase the biocontrol efficacy of T. basalis by stimulating host-seeking. Index terms: gas chromatography/mass spectrometry, solvent extracts, host location.

[0652] THE SOUTHERN PINE BEETLE INTERNET CONTROL CENTER: AN INTERACTIVE INTEGRATED PEST MANAGEMENT WEB-SITE

S. R. Clarke¹, S. M. Salon², N. D. Stone², B. R. Ward². & Q. C. McClellan², ¹Forest Health Protection, USDA Forest Service, 701 N. 1st St., Lufkin, TX 75901, USA, E-mail sclarke/r8_tx@fs.fed.us; ²Dept. of Entomology, Virginia Tech, Blacksburg, VA 24061-0319, USA.

The Southern Pine Beetle Internet Control Center is designed as an interactive web-site that provides current and historical information on the southern pine beetle (SPB), Dendroctonus frontalis, the most destructive forest insect pest in the southeastern United States. The SPBICC substantially increases the accessibility and utility of the vast amount of information available on SPB, and includes a searchable bibliographic database and a personnel directory of expertise. The search engines built into the site utilize state-of-theart technology developed at Virginia Tech, allowing experts and data collectors throughout the region to either access or update critical databases embedded in or linked to the site, minimizing the cost and effort that generally goes into site maintenance. Prediction models, decision keys, an IPM program, and training modules for SPB suppression techniques built into the site provide foresters or private landowners with a one-stop source for information on managing SPB on their lands. Maps illustrating the location of SPB infestations are presented, and users can point and click on individual spots to obtain spot data. Oracle 8 was selected as the database management system, with Livelink as the current search engine. A new, customizable Java servlet called StoneFission was created to link the databases to the web. Web-based, interactive training utilities are integrated into the site to provide opportunities for self-instruction. Currently, the front page and framework for the site are complete. The entity relationship diagram has been designed and the database built. SPB experts have been recruited to draft informative pages on SPB biological control, fungal associations, population dynamics, and IPM. The online bibliography is almost complete, and an integrated pest management program for SPB has been developed. A program demonstration will be run.

Index terms: Dendroctonus frontalis, website development, interactive training modules.

(0654) SEX PHEROMONE OF THE BRAZILIAN APPLE LEAFROLLER, BONAGOTACRANAODES (LEPIDOPTERA: TORTRICIDAE): EFFECT OF GEOMETRICISOMERS ON MALE ATTRACTION TO (E,Z)-3,5-DODECADIENYL ACETATE

M.D.A.Coracini¹, M.Bengtsson¹, J.L-fqvist¹, A.E. Eiras², E.F. Vilela³, A.Reckziegel⁴ & P.Witzgall¹, ¹Dept. of Plant Protection Sciences, Swedish Univ. ofAgricultural Sciences, P. O. Box 44, S-230 53 Alnarp, Sweden, E-mail:miryan.coracini@vsv.slu.se; ²UFMG, ICB, Dept.Parasitologia, Entomologia, Bloco L3, Campus da Pampulha,Belo Horizonte, MG, 31270-901, Brasil; ³UFV, DBA, Av. P.H.Holfs s/n, Vicosa, MG,36571-000, Brasil; ⁴Institut f.Organische Chemie & Biochemie der Universit"t Hamburg,Martin-Luther-King-Platz 6, D-20146 Hamburg 13, Germany.

The behavioural response of maleBrazilian apple leafroller, *Bonagota cranaodes*, to the main sexpheromone compound (E,Z)-3,5-dodecadienyl acetate (E3,Z5-12Ac) and tofemale extracts was studied in a wind tunnel. A field trapping test showedthat contamination of the main compound with the non-pheromonal isomersE,E; Z,E and Z,Z does not account for the discrepancy in male attraction toE3,Z5-12Ac and female extracts. Index terms: *Bonagotacranaodes*, geometric isomer, behavior, flighttunnel.
Symposium and Poster Session

[0655] DAMAGE-INDUCED CHANGES ON LEAF QUALITY OF BAUHINIA BREVIPES (LEGUMINOSAE) AND INSECT HERBIVORE ATTACK

T.G. Cornelissen¹ & G.W. Fernandes¹, ¹Univ. Federal de Minas Gerais, Lab. Ecologia Evolutiva de Herbívoros Tropicais, ICB, CP 486, 30161-970, Belo Horizonte, MG, Brazil, E-mail: tatiana@icb.ufmg.br.

Induced defenses to herbivory are physical, nutritional, and allelochemical traits that change in plants following damage or stress, and that reduce the performance and/or preference of herbivores. The aim of this study was to verify the occurrence and effect of induced responses in B. brevipes against herbivores through the manipulation of its leaves and its consequences to herbivore foraging behavior. We selected 15 planis, and 3 shoots per plant were designed for one of the three treatments: damaged shoots (simulation of the main types of foliar herbivory and insect exclusion), damaged control shoots (insect exclusion), and control shoots (not manipulated). Water and nitrogen content, tannin concentration, levels of herbivory, and shoot growth rates were compared among treatments through ANOVA. Leaf quality differed among treatments. Damaged leaves presented higher tannin concentration (df=2.0; F=8.57; P<0.05), and lower water (df=2.0; F=7.64; P<0.05) and nitrogen content (df=2.0; F=18.60; P<0.0001), but experienced higher rates of herbivory (df=2.0; F=12.82; P<0.0001) than leaves on control shoots. Moreover, shoots that were experimentally induced showed higher increment in final shoot length, a parameter that estimates fitness. These results suggest that simulated herbivory on B. brevipes reduced the nutritional quality of its leaves and increased the amount of secondary compounds, altering insect herbivore attack and increasing shoot performance.

Index terms: Induced defenses, plant quality, herbivory

[0656] CHEMICAL CONTROL OF THE "LEAF MINER", LEUCOPTERA COFFEELLA (LEPIDOPTERA: LYONETHDAE), WITH FURY 400 CE AND MARSHAL 400 SC IN COFFEE CROP, COFFEA ARABICA

L. E. A. Correa¹, A. C. Silva², L. O. Salgado² & R. S. de Mendonça³, ¹FMC do Brazil, Campinas, SP, Brazil, E-mail: luis_correa@fmc.com; ²Agroteste-Pesquisa e Consultoria, P.O.Box 201, Lavras, MG, Brazil, Zip Code 37.200-000, E-mail: agrotest@ufla.br, Instituto de Ciências Agrárias, Universidade de Alfenas/UNIFENAS, P.O. Box 23, Alfenas, MG, Brazil, Zip Code 37.130-000, E-mail: fileni@artefinal.com.br.

Leucoptera coffeella is responsible for a great damage on production and longevity of coffee plants in Brazil, being the chemical control the principal methods against this pest. The objective of the present work was to evaluate the efficiency of the commercial products Fury 400 CE (Zetacypermethrin) and Marshal 400 SC (Carbosulfan) to control the "leaf miner", *L. coffeella* In coffee crop. The treat was set up at the area Araguari, Minas Gerais State, Brazil, during December 1999 up to January 2000. The experimental design was the randomized blocks with 6 treatments and 4 replications. Each plot had 19.60 m² with seven plants. The efficiency of the treatment was evaluated according to the number of alive *L. coffeella* in damage leafs. It was used the Abbott formula as a measure of efficiency and means were separated by Ttukey test (p<0.05). As a whole of six evaluation were done during the observation period and the results are presents on the

According to the results the insecticides Fury 400 CE in all doses utilized and Marshal 400 were efficiency to control *L. coffeella* in coffee crop up to 30 days after application, reaching the top of 92,86 % of efficiency.

Index terms: Lepidoptera, Lyonetiidae, insecticides, coffee crop

[0657] ANTIFEEDANT EFFECTS OF ARGENTINE *MELIA AZEDARACH* FRUIT EXTRACT AND ITS ACTIVE COMPOUND MELIARTENIN

M. T. Defagó¹, <u>G. Valladares¹</u>, M. C. Carpinella², S. Palacios² & E. Banchio¹, ¹Centro de Investigaciones Entomológicas, F.C.E.F.Y.N., Univ. Nac, Córdoba, Av. Vélez Sársfield 299, (5000)-Córdoba, Argentina. ² CEPROCOR, Av. Arenales 230, (5000)-Córdoba, Argentina. E-mail: grv@onenet.com.ar.

Insect damage to plants results mainly from feeding, particularly in the case of chewing herbivores, therefore pest injury can be reduced by rendering plants unattractive or unpalatable. Antifeedants are chemicals which reduce or prevent insect feeding, and can be an important tool for pest management. One of the weak points of investigations into the occurrence of antifeedant substances is that in most cases only one test insect species is used. The objective of this study was to evaluate the antifeedant effects of Melia azedarach crude fruit extracts against a wide array of insects. Also, antifeedant and insecticide effects of Meliartenin (the extract's active compound) were assessed and compared with those of Azadirachtin. Insects from 17 mandibulate species (3 Orders, 8 Families), mostly folivores and seed eaters, were subject to laboratory Choice tests in order to evaluate the antifeedant properties of the extracts. A Feeding Inhibition Index was calculated which reflects the relative reduction in food consumption due to the extract being applied to the insect diet. Three extract concentrations were used (2%, 5%, 10%). Moreover, Choice and No-Choice tests were carried out to evaluate the antifeedant and lethal effects of Meliartenin and Azadirachtin (0.25, 0.5, 1, 4µg/cm²) using Epilachna paenulata (Coleoptera, Coccinellidae) larvae as insect test and Cucurbita sp. leaf disks as substrate. Data were analysed by Wilcoxon signed rank test, T test and ANOVA. All the species tested significantly preferred non treated food, at least for some extract concentrations. The extracts were strongly deterrent (reducing food consumption in more than 75% compared to non treated food) for 13 of those species. For 3 of the species, the extracts were tested on adults and larvae, being effective against both stages. Meliartenin completely inhibited feeding by E. paenulata at a concentration of 1µg/cm². When the insects were fed only on treated leaves, mortality rates of 80% or higher were reached after 4 to 8 days of treatment, depending on the concentration used. In both aspects, Meliartenin effects were similar or even slightly higher than those of Azadirachtin.

Index terms: Botanical pesticides, Epilachna paenulata, Meliaceae, Phytochemicals, Deterrents

[0658] PHYSIOLOGICAL REGULATION OF PHEROMONE PRODUCTION AND ITS INHIBITION FOLLOWING MATING IN *CHORISTONEURA FUMIFERANA AND C. ROSACEANA* (LEPIDOPTERA: TORTRICIDAE)

<u>J. Delisle¹</u>, J.-F. Picimbon² & J. Simard¹, ¹Natural Resources Canada, CFS, Laurentian Forestry Centre, P.O. Box 3800, 1055 du P.E.P.S., Sainte-Foy, QC G1V4C7, CA. E-mail: jdelisle@cfl.forestry.ca ²Inst. of Physiology, Hohenheim Univ., 70593 Stuttgart, GE. Email: jfp@uni-hohenheim.de.

In both *Choristoneura* species, the periodicity of calling and pheromone production is well synchronized, with maximal activity occurring during the early scotophase. Newlyemerged females decapitated prior to the onset of the scotophase produced no or very little pheromone, but the injection of PBAN or Br-SEG extracts restored normal pheromone production. Transection of the ventral nerve cord (VNC) did not affect pheromone production in controls females or in decapitated females injected with PBAN or Br-SEG extracts. These results clearly indicate that the regulation of pheromone production is not neurally mediated in either Choristoneura species. Furthermore, there was no evidence of PBAN-like factors in hemolymph collected during the calling period. However, while the presence of the bursa copulatrix (BC) was essential to produce pheromone, an extract of the BC injected into decapitated females did not elicit pheromone production. In both species, mating significantly depressed the pheromone titre 24 h later. However, on subsequent days, pheromone production increased in C. fumiferana but not in C. rosaceana. Male accessory gland extracts or hemolymph taken from mated females did not have pheromonostatic activity. However, pheromone production in mated females was not inhibited when the VNC was transected prior to mating, indicating that the integrity of the central nervous system is required to permanently switch off pheromone production. As suggested for other species, the presence of sperm in the spermatheca probably triggers the release of a signal, via the VNC, to inhibit pheromone production. Therefore, we speculate that in mated C. fumiferana females, the neural signal declines following the depletion of sperm in the spermatheca, and as it is less effective in preventing the release of PBAN there is a resumption of pheromone production. Mating induces a significant rise in the JH tire of both female moths, suggesting that the post-mating pheromone suppression may also be under hormonal regulation. Following injection of JH pheromone titres only declined in C. rosaceana virgins. This suggests that the significant post-mating rise in the hemolymph JH titre in this species plays a role in keeping the pheromone consistently low throughout reproductive life. These findings will be discussed in relation with the different life histories exhibited by the two Choristoneura species.

Index term: Choristoneura fumiferana, Choristoneura rosaceana, PBAN, bursa, JH

[0659] WHY METABOLITES PRESENT ON THE PLANT SURFACE HAVE TO BE CONSIDERED IN HOST SELECTION : APPLICATION TO TWO LEPIDOPTERA OVIPOSITION

<u>S. Derridi</u> & N. Lombarkin, INRA, Unité de phytopharmacie, Route de St Cyr, 78026 Versailles, France, E-mail derridj@versailles.inra.fr.

Till now the theory for dealing the factors determining insect-plant relationships and the strategies developed by plant and insect to evolve together remain obscure. The last step behaviour before feeding or ovipositing is the acceptation of the plant when the insect is in contact with the plant surface. There, there are metabolites which constitute a finger print and give also informations on plant state physiology. The plant cuticle which select the passing through of molecules from the tissue to the surface has a major role in the expression given by the surface. The balance between the expression of plant surface and the possibilities of insect to detect some of them is probably one of the alternative explanation for co-evolution. With rather few components for example five to six free amino acids, plant species can be discriminated. Furthermore a single component can give both informations on the plant specificity and the plant site nutritive value. Studies on the generalist Ostrinia nubilalis and the specialist Cydia pomonella oviposition showed clearly the incidence of the metabolites present on the plant surface (leaves, fruit) on the insect oviposition. Soluble carbohydrates (glucose, fructose, sucrose) have an influence for both insects on the site preference and the number of eggs laid per female. Fructose in both cases is highly involved. C. pomonella oviposition is also influenced by sugaralcohols which characterise its host plants (Rosaceae). In a combination of three sugars and three sugar-alcohols, sorbitol is as stimulant as fructose. On C. pomonella it was observed that according to time the influence of substances could be different. Both sugars and sugar-alcohols induced a rapid response of the females after 3 mn dark. After 25 mn of dark the oviposition stimulation was diminished only by the suppression of sugaralcohols by combinations of two. A deterrent effect of combinations of three sugars and three sugar-alcohols could be attributed to the concentration and was loss when diluted 100 times. Fructose and sucrose which elicit oviposition are also demonstrated to stimulate greatly feeding behaviour of O. nubilalis larvae. C. pomonella neonate larvae nibbling is stimulated by fructose, and sugar-alcohols. These subtances are also arrestant. Metabolites present on plant surface have a decisive role in host selection for lepidoptera oviposition and dispersion of neonate larvae. For the generalist as well as for the specialist, nutrients like sugars play a major role in these key steps of colonisation.

Index terms: Ostrinia nubilalis, Cydia pomonella, carbohyrate, sugar-alcohol

[0660] APHIS GROOSYPH MODEL WITH COMPLEX LIFE HISTORY

L. Dianmo & Ma Zufei, The State Key Lab of Integrated Management of Insect Pests & Rodents, Institute of zoology, Chinese Academy of Sciences, Box 70, E-mail Lidm@panda.ioz.ac.cn, Beijing, 100080, P. R. China.

Cotton aphid is one of main cotton pest in the Yellow River valley between May and August. We have built a real model of *Aphis groosypii* Glover (cotton aphid) to test complexity dynamics in natural conditions. For this objection, we simulated a series of life cycle of this insect in field, and replaced the astronomic time with physiological time to counteract the effect of temperature on the model. Every parameters in the model in a wide parameter region. The model has complex structure (we considered the generations overlap, non-linear density feedback, wing aphid ratio and reproduction with age structure (as 100 k, means a series life history in a more complex aphid life cycle, per k is one quip and per quip is 7 dayx...) the output of model seems nearly chaotic. But in long term (as 10,000 k, means a simpler life cycle of aphid) the output appears as cyclic. This result proves that life history (in someway, its structure not only mortality and reproduction rates) is very important to population dynamics.

[0661] DETERMINING THE SUSCEPTIBILITY OF LESSER CORNTALK BORER IN RICE (*ELASMOPALPUS LIGNOSELLUS*) TO INSECTICIDES

<u>E Ferreira</u>¹ & J. A. F. Barrigossi¹, ¹National Rice and Bean Research Center (Embrapa Arroz e Feijão), Caixa Postal 179, Santo Antônio de Goiás, GO, Brazil, 75375-000, Email: evane@cnpaf.embrapa.br.

The lesser cornstalk borer, E. lignosellus, is a common pest of seedling upland rice in Brazil. Outbreaks are more likely under hot and dry conditions. Feeding by lesser cornstalk borer leads to the death of the shoot, resulting in the formation of 'dead heart'. Although control is difficult with soil applied insecticides due to the subterranean habit of this pest, seed dressing with insecticides have provided an efficient control. In this study, we evaluated the performance of three insecticides as seed treatments to control E. lignosellus larvae, under artificial and natural infestations. In addition, we tested and described field infestation techniques for the lesser cornstalk borer in rice. Three field experiments were conducted during the summer of 1998 at Embrapa Arroz e Feijão near Santo Antônio de Goiás, GO, Brazil. Rice plantings were made on November 6, November 26, and December 6, 1998. The experimental design was a Latin square 6x6. The experimental unit consisted of seven rows, 3 m long. Treatments consisted of the following insecticides and doses applied to the seeds: thiamethoxan (52.5, 70.0, and 105 g a.i./100 kg seeds), furathiocarb (320 g a.i./100kg seeds), and carbofuran (525 g a.i./100kg seeds). An untreated control was also included. At the end of the border rows of each plot, two groups of three randomly selected tillers were confined in a cylinder with 0.25 m and 0.20 m diameter. These cylinders were buried at 5 cm depth in the soil to prevent the escape of larvae from the cylinders after infestations. These plots were established 25, 33 and 44 days after planting. Then, 1, 7, and 14 days after plots were established, tillers were infested with the 2nd instar cornstalk borer larvae/cylinder. Immediately after infestation, each plot (cylinder containing three rice tillers) was covered with a transparent plastic bag (20 I capacity) to keep rain away from the larvae. Plots were evaluated 20 days after infestations, to determine the number of tillers exhibiting symptoms of 'dead heart'. Naturally infested plots were also evaluated to determine the number of injured-tillers by examining tillers located in the three center rows of each plot at 15, 44, 74, and 105 days after planting. All seed treatment insecticides reduced larval survival significantly for 60 days after planting compared to the untreated control. Thiamethoxan had a better efficiency in reducing injury from E. lignosellus larvae than furathiocarb and carbofuran at the doses used in this study. Artificial infestations, used in this study, increased the proportion of damage 30 fold, compared to plots without artificial infestation (untreated control).

Index terms: lesser cornstalk borer, Elasmopalpus lignosellus, insecticides

[0662] PHYSIOLOGICAL STATE AND ASSOCIATIVE LEARNING DETERMINE RESPONSE OF PREDATORY MITE TO FOOD-RELATED AND OVIPOSITION-RELATED VOLATILES

F. Faraii, A. Janssen & M. W. Sabelis, University of Amsterdam, Institute for Biodiversity and Ecosystem, Section Population Biology, Kruislaan 320, 1098 SM, Amsterdam, The Netherlands, E-mail: faraji@bio.uva.nl

Females of the predatory mite *Iphiseius degenerans* visit flowers for feeding but oviposit on leaves. We conducted Y-tube experiments to test the hypothesis that preference for cues related to these feeding and oviposition sites (flower and leaf odours) depends on the physiological state (hungry or fed) and experience of individuals. Females collected from pepper plants were either starved in the absence of any stimulus or were allowed to feed by placing them in pepper flowers, where flower odours are associated with the presence of food (pollen). When tested in a Y-tube olfactometer, fed females, that had thus been conditioned to flower odours, strongly preferred the odours of pepper leaves over flower odours, whereas starved females preferred flower odours. Females with no experience on pepper plants, by contrast, showed a weak preference to only leaf odours either when fed or starved. Our results can be explained by the fact that fed females mainly search for oviposition sites on leaves, whereas starved females try to localise food. These results suggest that the foraging behaviour of *L degenerans* is influenced by a combination of associative learning, innate response and the physiological state of individuals. Index terms: *Iphiseius degenerans*, experience, flower and leaf volatiles, olfaction.

Table I. Relationship between the catches and the field investigation (1st generation adult male moth and 2nd generation larvae, 99, Chanshan) (according to the transitions)

Quantitative (decontaining to any external provide and and and and and and and and and and		
	the number of the trapping positions in which the larvae were found	the number of the trapping positions in which the larvae weren't found
the number of the trapping positions in which the moths trapped were found	3	9
the number of the trapping positions in which the moths trapped weren't found	11	74

(coefficient related: (3+74)/(3+74+11+9)=79.38%)

Table2. Relationship between the catches and the field investigation (1st generation adult male moth and 2nd generation larvae, 99, Qianshan) (according to the transitiont to the transition to the transition to

	the number of the trapping positions in which the larvae were found	the number of the trapping positions in which the larvae weren't found
the number of the trapping positions in which the moths trapped were found	4	1
the number of the trapping positions in which the moths trapped weren't found	2	11

(coefficient related: (4+11) / (4+11+2+1)=83.33%)

ABSTRACT BOOK I - XXI-International Congress of Entomology, Brazil, August 20-26, 2000

[0663] AN INTUITIVE APPROACH TO SELECTING UTILIZABLE ATTRACTANTS FOR A GENERAL FRUIT-FEEDING PEST: THE FRUITPIERCING MOTH EXPERIENCE

H. A. C. Fay & K. H. Halfpapp, Queensland Horticulture Institute, Department of Primary Industries, P O Box 1054, Mareeba, QLD 4880, AUSTRALIA, E-mail fayh@prose.dpi.qld.gov.au

Fruitpiercing moths (Lepidoptera:Noctuidae) are known to attack at least 50 different kinds of fruits, and can be significant pests of tree and vine crops in the Old World tropics and sub-tropics. They pierce fruit as it ripens, and when the odour composition is changing rapidly. Different fruits emit odours composed of hundreds of different chemical compounds, many of which are unique to a fruit and impart the characteristic smell. However, different fruits also have in common a range of general chemical volatiles which change in prominence through the ripening process. Such compounds were thought responsible for the attraction of moths to fruit at a specific stage of crop development. A number of these compounds were selected from the considerable literature on fruit volatiles, and the responses to them assessed by electroantennogram (EAG) in Eudocima fullonia and Eudocima materna. These responses were compared against those obtained for compounds specific to particular fruits. Of the individual synthetic fruit odours, the general fruity esters (such as n-butyl acetate and methyl butyrate) elicited the greatest response. However, combinations of volatiles, particularly where different chemical groups were involved, produced responses greater than expected from the observed responses to the same chemicals offered singly. This implied that combinations of general odours are probably involved in a moth's recognition of a crop with acceptable fruit. Flight cage tests with sugared-agar baits containing designated concentrations of particular fruit volatiles (esters, aldehydes and alcohols) suggested that moths seek out fruit of a certain level of ripeness based solely on the proportions of the volatile components produced. Ripe (58% esters) 'fruit', as opposed to mature (6%) or very ripe (92%), were preferred. Varying the type or proportions of the non-ester components appeared to influence bait selection. Trials in early maturing citrus through the susceptible life of the crop have shown that baits containing 3 esters, 3 aldehydes and an alcohol (totalling 25(1/25g bait) attracted 85% of moths on baited trees (with several hundred fruit/tree) through to the first week of harvest. This then fell to 75%, if the response of E. materna (the least responsive species) is ignored. Two severe pest species, E. fullonia and Eudocima salaminia, were particularly attracted to the baits, with 100% being attacked some nights. Recent studies have concentrated on prolonging bait life in the field and testing the technique in other crops.

Index terms: Eudocima fullonia, Eudocima materna, fruit, volatiles, EAG.

[0664] PLANT HYPERSENSITIVE RESPONSE TO GALL INDUCTION ACROSS HOST TAXA

<u>G. W. Fernandes¹</u> & D. Negreiros¹, ¹Ecologia Evolutiva de Herbívoros Tropicais, DBG/Universidade Federal de Minas Gerais, CP 486, 30161-970 Belo Horizonte, MG Brazil, Email gwilson@icb.ufmg.br

Hypersensitive reaction is an important type of induced defense by which the plant elicits a defense response to pathogens and insects. Hypersensitive reaction has been argued to be the most common plant resistance mechanism against insect herbivores that have intimate associations with their host plants. This study attempted to establish how important and widespread hypersensitive reaction might be against gall-forming species across host taxa. Hypersensitive reaction was the most important mortality factor against gall formation across host plant taxa in seven out of eight cases. The number of insect galls correlated with the size of the leaves but module (leaf) size was a weak factor influencing the incidence of plant hypersensitive reaction to galling. Insect galls and hypersensitive reactions occurred in genetically distant as well as geographically widespread host plant taxa.

Index terms: Hypersensitivity, Insect galls, Plant defenses, Plant induced defenses.

[0665] EFFICIENCY OF DIFFERENTS LURES AND THEIR PROBABLE INTERACTION IMPROVING RHYNCHOPHORUS PALMARUM ADULTS ATTRACTION TO THE TRAPS

J.M.S. Ferreira¹, R.P.C. Araujo² & <u>F.B. Sarro³</u>, ¹Lab. of Entomology, Embrapa/CPATC, P.O. Box 44, Aracaju, CEP 49025-040, Brazil;² Dept. of Biotecnology, Unesp, Araraquara, P.O. Box 355, CEP 14801-970, Brazil; ³ Dept. of Plant Protection, Unesp, Botucatu, P.O. Box 237, CEP 18603-970, Brasil, E-mail (bsarro@unesp.br.

Adults of Rhynchophorus palmarum are considered the main vector of the nematode Bursaphelenchus cocophilus, the causal agent of red ring, a lethal disease of coconut and other palms. Attractive lures and the male-produced aggregation pheromone are been used to monitor adult activities, to reduce pest population and to prevent red ring disease dissemination on palm plantations. The present work was carried out at Embrapa Coastal Tableland Research Center (CPATC) Sergipe, Brazil aiming to determine the efficiency of differents lures and to study their probable interaction in the capture of R.palmarum. Traps were randomly distributed around a coconut plantation, located at Itaporanga D'Ajuda County, Sergipe, Brazil, distant 200m from each other. The adults were captured for one year. The experimental design was completely randomized. The attractive lures sugar cane (C), aggregation pheromone (F), ethyl acetate (A), and molasses (M) were tested alone, combined 2 by 2 and 3 by 3, totalizing 12 treatments, namely: T1- C; T2 - F with change of the pheromone capsule every three month; T3 - F without change of the pheromone capsule; T4 - A; T5 - M; T6 - C+F with change of the pheromone capsule; T7-C+F without change of the pheromone capsule, T8 - C+A; T9- C+M; T10 - C+A+F with change of the pheromone capsule; T11 - C+A+F without change of the pheromone capsule; T11 - C+A+F without change of the pheromone capsule; T12 - C+A+M. "Plastic Buckets" (50 litres capacity) were used as traps to catch the adults. Every fifteen days, the traps were changed from site to site among themselves to avoid the spot effect on the weevil capture. A total of 5184 adults of *R.palmarum* was captured during the experimental period. The treatment T10 and T6 were the most efficient ones. They were able to attract 30,71% and 21,32% adults, respectively, totalizing 52,03% of the total adults captured. The lures tested alone shows an efficiency level of 4,38% of the total captures, showing the importance of the interaction of lures to promote a sinergistic effect by increasing attraction of adults of R. palmarum in the field. The number of adults attracted by each lures did not differ significantilly among the sites, showing no spot effect on the weevil capture. Index terms: palms, red ring, pheromone, coconut, trapping system

[0666] EVALUATION OF THE "PET" TRAP EFFICIENCY ON THE CAPTURE OF ADULTS OF RHYNCHOPHORUS PALMARUM AND THE COST/BENEFIT ANALISYS

J.M.S. Ferreira¹, R.P.C. Araujo² & <u>F.B. Sarro³</u>, ¹Lab. of Entomology, Embrapa/CPATC, P.O. Box 44, Aracaju, CEP 49025-040, Brazil;² Dept. of Biotecnology, Unesp, Araraquara, P.O. Box 355, CEP 14801-970, Brazil, E-mail coqueirat@mar.com.br; ³ Dept. of Plant Protection, Unesp, Botucatu, P.O. Box 237, CEP 18603-970, Brazil.

Several traps designs are being proposed to capture adults of Rhynchophorus palmarum on coconut and oil palm plantations using in most of them sugarcane and the aggregation pheromone (Rhynchophorol) as attractive baits. Nowadays, the "bucket" trap design is the one broadly recommended and adopted by brazilian farmers. The great disadvantage of using this design is related to factors like, trap container damage, cost and theft. This work was carried out by Embrapa Coastal Tableland Research Center - Aracaju, Sergipe State, Brazil (CPATC) aiming to evaluate the efficiency and feasibility of a "pet" design trap in capturing adults of R. palmarum and to evaluate the cost/benefit rate of use it as an alternative trap in a field control program. A number of five "pet" traps and five "bucket" traps were distributed around a coconut plantation, approximatelly 200m away from each other, in the County of São Cristovão/SE, Brazil. Each trap, does contain pieces of sugarcane (25 to 30cm long) and aggregation pheromone in it, as attractive source. The 'pet" trap is made with three plastic softdrinks bottles. The capture chamber of this trap measures approximatelly 0.151 m², that means, 3.73 times smaller than the capture chamber of the conventional "bucket" trap used on this experiment. The sugarcane pieces were weekly renovated from the "pet" trap and quartelly from the "bucket" trap, for a year period, and the number of captured adults recorded. The pheromone capsules were renovated every three months. The number of insects captured, transformed to m² of the capture chamber, was the parameter used to measure the traps efficiency. The net price of plastic containers and pheromone was the parameter used to evaluate the cost/benefit rate of both traps. The results showed a total of 2222 adults captured during the experimental period in the "pet" traps against 2836 adults in the "bucket" trap, which represents 43.9% and 56.1% of the total captures, respectivelly. However, by comparing these numbers of captures and the trap size (transformed in square meter of trap area) an efficiency level of 74,51% was obtained in the "pet" and 25,48% in the "bucket" trap. The "bucket" trap has an estimated cost of U\$12 while the "pet" trap U\$2,8. Considering all those parameters (adults captures, trap size and trap cost) it can be concluded that the "pet" trap is the most efficient ones. Besides to have a capture area 3,73 times smaller than the " balde" trap, it was able to capture 49,02% more adults than the former one and to give an economy level of U\$9,8 to the farmer which is equivalent to the cost of 3,5 pheromone capsules. Besides to be less attractive to thefts.

[0667] COPULATION PHEROMONE OF THE VECTOR OF CHAGAS DISEASE, TRIATOMA INFESTANS: IDENTIFICATION AND BIOASSAY

<u>A. Fontán</u>¹, P. González Audino¹, A. Martínez¹, R. Alzogaray¹, E. Zerba¹, F. Camps³ & A. Cork²; ¹Centro de Investigaciones de Plagas e Insecticidas (CIPEIN/CITEFA-CONICET), Zufriategui 4380, 1603 V. Martelli, Buenos Aires, Argentina. cipein@citefa.gov.ar. ²Natural Resources Institute, Central Avenue, Chatham Maritime, KENT 4TB, UK. a.cork@greenwich.ac.uk. ³Centro de Investigación y Desarrollo, Depto de Química Orgánica Biológica. Jordi Girona, 18-26, Barcelona, España. fcdqob@cid.es. Supported by INCO-DC EU Program, CONICET, Ag. Prom. Cient. de Argentina.

The haematophagous bug T. infestans is the major vector of Chagas Disease in South America. Behavioral and electrophysiological assays have demonstrated the existence of a copulatory pheromone emitted during copula, that is attractive to male T. infestans. This study was undertaken to identify the chemical components in the pheromone by studying the electrophysiological and behavioral responses elicited by chemicals collected from volatiles emitted by male and female before and during copula. Volatiles were collected on Porapak-Q from charcoal filtered air (100 ml/min) pass through a Pyrex glass entrainment apparatus containing 7 male and 7 female. The volatiles were desorbed into dichloromethane and analysed by GC and GC-MS after confirmation of its attractant effect in an arena bioassay. Studies carried out on polar and non polar GC columns demonstrated the presence of a complex mixture of compounds, identified as: 2- and 3-methyl-butan-1ol in a 2:1 ratio; short chain acids (ethanoic to nonanoic); long chain acids (decanoic to (Z)-9-octadecenoic acid); aliphatic aldehydes and other compounds such as benzaldehyde and propane,1,1-thios. EAG studies were carried out with a homologous series of aliphatic aldehydes on female and male. The results showed an increase in EAG response, for a given dose, with increase in chain length up to nonanal, after which the EAG-activity declined. The attractiveness of the major compounds identified in the volatiles formulated in polyethylene glycol 400 were tested on female and male in a 20 cm diam circular arena bioassay for 30 min using a video tracking method. No significant responses were obtained with mixtures of (S,R)2 and 3-methylbutan-1-ol in a 4:1 ratio. Aliphatic C7 to C10 aldehydes were tested: hexanal (1-100 µg) and heptanal (0.1 µg) elicited an attractant response from females that were equivalent to that elicited by benzaldeyde (5-10 ng). Nonanal (10 - 100 ng) elicited an attractive response from males. Blends of hexanal:benzaldehyde (20:1 and 40:1) showed an additive effect on attraction when tested on female. The study has demonstrated the presence of electrophysiologically and behaviorally-active compounds in the volatiles emitted by T. infestans in copula and it is hope that an optimised blend will be identified that can be used to form the basis of an attractant for a biocidal trapping system.

Index terms: haematophagous bug, copula-attractants

[0668] NITROGENOUS COMPOUNDS AS ATTRACTANTS OF TRIATOMA INFESTANS

<u>A. Fontán</u>¹, R. Alzoguray¹, P. Santo Orihuela¹ E. Zerba¹, D. Fernández⁴, F. Camps ³ & A. Cork², ¹Centro de Investigaciones de Plagas e Insecticidas (CIPEIN/CITEFA-CONICET), Zufriategui 4380, 1603 V. Martelli, Buenos Aires, Argentina. cipein@citefa.gov.ar. ²Natural Resources Institute, Central Avenue, Chatham Maritime, KENT 4TB, UK. a.cork@greenwich.ac.uk ³Centro de Investigación y Desarrollo, Depto de Química Orgánica Biológica. Jordi Girona, 18-26, Barcelona, España. fcdqob@cid.es. ⁴Inst de Investigaciones Químicas y Ambientales de Barcelona (CID-CSIC). Supported by INCO-DC EU Program, CONICET, Ag. Prom. Cient. de Argentina.

The haematophagous bug Triatoma infestans is the major vector of Chagas Disease in South America. The ability of its own feces to elicit aggregation in nymphs and adults is well known. The presence of nitrogenous compounds such as 4-methyl and 2,4 dimethyl quinazolines and the emission of NH3 were reported. Other authors could verify no attractant effect when doses of 0.1-100ng of quinazolines were tested in immature stadiums. Behavioral and electrophysiological assays have demonstrated the capability of NH3 to attract nymphs and the presence of NH3 antenna receptors. However, for practical purposes the finding of an active source of NH3 is indispensable. In this work, the activity of a number of hygroscopic ammonium salts with different NH3 release rates was tested. Ammonium chloride, ammonium acetate and ammonium carbonate were tested using a video tracking system on a circular arena, 20-cm diameter. After 30 minutes of acclimatization of the insect, 2 mg of the compound to be tested was introduced in the middle of the arena on thin glass. The approach of the insect around the compound source was recorded for 30 minutes. The attractant effect was quantified as the number of visits of the insect to the centeral zone during the assay. Ammonium carbonate or acetate did not elicit any response on nymph V. However, ammonium chloride proved to be attractive, increasing significantly the mean number of visit to the center zone (from 0.1 to 2.7). Aqueous solutions of methyl amine ranging from 10⁻³ to 10⁻¹ M significantly increased the mean number of visits of nymph V around the source from 0.1 to 1.3. No significant effect was observed when 2 mg of ethylammonium chloride was tested. A mixture of synthetic quinazolines obtained from 2-aminoacetophenone, in a ratio similar to that found in feces (1:1) was tested on females and males. Mixtures containing 50µg of each compound elicited a very significant attractive effect on females. Toxicological assays are now in progress to establish if placing quinazolines in a pyrethroid film would enhance the kill of T.infestans.

Index terms: haematophagous bug, feces compounds

[0669] IDENTIFICATION OF HOSTPLANT VOLATILES ATTRACTIVE TO THE SPHINX MOTII, MANDUCA SEXTA

A. M. Fraser, W. L. Mechaber & J. G. Hildebrand, ARL Div. of Neurobiology and Center for Insect Science, Univ. of Arizona, Tucson, AZ 85721-0077, USA, E-mail: afraser@neurobio.arizona.edu

Female Manduca sexta moths (Lepidoptera: Sphingidae) exhibit upwind orientation and egg laying-related behavior when exposed to volatiles released by their hostplants. We collected headspace volatiles from three solanaceous hostplants (Lycopersicon esculentum, Capiscum annuum and Datura wrightii: Solanaceae) and one non-solanaceous host (Probiscidea louisianica: Martinyaceae) and used coupled gas chromatography-electroantennographic detection (GC-EAD) to determine what components stimulated olfactory receptors in the antennae of female moths. Antennae responded to an array of peaks in the GC traces of headspace volatile blends. A majority of the significant antennal responses corresponded with intermediate or minor GC peaks, suggesting that these less abundant components might be behaviorally important. Response-evoking GC peaks were identified by gas chromatography-mass spectrometry (GC-MS) and verified with synthetic standards. Electrophysiologically-active components included aliphatic, aromatic and terpenoid compounds. Data from GC-EAD studies were used to prepare a series of synthetic hostplant volatile blends for testing in wind tunnel behavioral bioassays. Index terms: electroantennography, GC-EAD, olfaction, plant volatiles, hostplant

[0670] MATING DISRUPTION PHEROMONES RELEASE IN PORTUGAL

C. Frescata, Biosani Lda., Casal Sto. Isidro, Serra do Louro, 2950-305 Palmela, Portugal, E-mail: biosani@mail.telepac.pt

In Portugal, during 1999, was done a study by Biosani company in co-operation with Shin-Etsu company about the release of the pheromones of the mating disruption dispensers of "Isomate-C Plus" for *Cydia pomonella*, "Isonet-L" for *Lobesia botrana* and "Isomate-OFM" for *Cydia molesta*. For each kind of dispenser was sampled 5 dispensers per month since the field application, done just before the start of the pest flight, till the harvest time. "Isomate-C Plus" applied in one pear orchard on 17/4/99 in "Oeste" region, after 156 days, on 20/9/99 still had 46 % of the active ingredient. "Isomet-L" applied in one vineyard on 15/3/99 in Settibal region, after 163 days, on 25/8/99 still had 6 % of the active ingredient. "Isomate-OFM" applied in one peach orchard on 12/4/99 in Terceira Island (Azores), after 143 days, on 2/9/99 still had 14 % of the active ingredient. So, in the places studied and for their usual weather conditions is possible to use the researched mating disruption dispensers doses over the years, due to the reduction of the pest population in the mating disruption fields, make this efficient pest control method an attractive alternative to the toxic insecticides.

Index terms: Cydia pomonella, Lobesia botrana, Cydia molesta.

[0671] VARIATION AND SPECIFICITY OF HERBIVORE-INDUCED PLANT ODORS AS FORAGING CUES FOR PARASITOIDS

<u>S. Gouinguené</u>, **T. Degen & T. Turlings**, Univ, Of Neuchâtel, Inst. of Zool., Lab. of Animal Ecology and Entomology, C. P. 2, Ch-2007 Neuchâtel, Switzerland. sandrine.gouinguene@zool.unine.ch

Many parasitoids that attack phytophageous insects make use of plant odors to locate the habitat of their host. In maize large amount of these odors are specifically emitted by a plant after it has been damaged by a herbivore, but not after mechanical damage. The odor emissions occur systematically throughout the plant. Factors in the oral secretion of the herbivores are the main elicitors of the plants' reaction. The induced maize odors are useful cues for the parasitoids and indicate the presence of a potential host. This odor is mainly composed of terpenoid compounds. We have studied different abiotic and biotic factors that determine the specificity and variation of the signal emitted by maize plants in response to caterpillar damage. Light intensity is the most important factor, but odor emissions were also affected by the soil and air humidity, temperature and the degree of fertilization. We found enormous quantitative and qualitative differences among maize genotypes. The absolute amount of volailes emitted was negatively correlated with the plant age, while larval instar appeared to have little or no effect. We discuss these results in the cortext of reliability of plant-induced signals as cues that allow parasitic wasps to find a suitable host.

[0673] ECONOMIC INJURY LEVEL AND SEQUENCIAL SAMPLING FOR BEMISIA TABACI IN TOMATO

M.R.Gusmão¹, M. Picanço¹, J.A.F. Barrigossi², A.L.B.Crespo¹ & T.L.Galvan¹, ¹ Dept. de Biol. Animal, Univ. Fed. de Viçosa, CEP 36571-000, Viçosa, MG, Brazil, ²EMBRAPA-CNPAF. E-mail picanco@mail.ufv.br.

This research aimed to determine the density of *Bemisia tabaci* (Homoptera: Alevrodidae) capable of causing economical damage in tomato and to determine a sequencial sampling for this species in this crop. Adults and nymphs densities of B. tabaci were evaluated in 14 squares of 9 commercial field of tomato in Coimbra, Guidoval and Viçosa, State of Minas Gerais, Brazil. The whitefly adults sample was accomplished through the beat of 2 medium leaves in white plastic tray, while the sampling of nymphs was accomplished by the direct count of the insects in 2 medium leaves. The relationship between densities of insects and crop productivity was determined by regression analysis. For the economic injury level determination, the cost of 1, 3 and 6 control applications of insecticides was considered. Variation on the commercialization price of tomato was also considered, from 181,82 R\$/ton. (low price), to 454,45 R\$/ton. (medium price) and 1136,36 R\$/ton. (high price). Stablished the economic injury level, the sequencial sampling for whitefly adults and nymphs was settled. Initially the densities of the insects data were adjusted using the model of binomial negative distribution. Later the degree of aggregation of the sampling data was calculated by the methods: reason variance-average, Green and K parameter of the binomial negative distribution. As the sampling data to the distribution model, was settler the limits of decision making in agreement to the methodology based on the test of the reason of sequencial probability of Wald. Were determined the critical densities of 1/3 and 2/3 of the economic injury level and a 10% mistake probability in the classification of the densities were considered. The economic injury level varied with the cost of control of the insects and the price of tomato commercialization, the smallest critical densities were verified in the situations of high price of the tomato and smaller control cost. For each critical density responsible for causing economical damage a plan of sequencial sampling characterized by a minimum and maximum size of samples was obtained for the decisions to be taken. An economy from 30% to 58% was verified in comparison with the conventional sampling plan.

Index terms: Whitefly, Integrated Pest Management, Decision making

[0672] ATTRACTIVITY OF PROTEIN HIDROLISATE AND SUGARCANE MOLASSES ON ADULT FRUIT FLIES ANASTREPHA SP. AND CERATITIS CAPITATA (DIPTERA: TEPHRITIDAE) ON CITRUS ORCHARD

<u>S. Gravena</u>¹, S.R. Benvenga¹, J.L. Silva¹, N. Araújo¹ & M.S. Linardi¹, ¹Gravena ManEcol Ltda, Rua Monteiro Lobato 856, 14870-000, Jaboticabal/SP, Brazil. E-mail gravena@asbyte.com.br

The fruit flies Anastrepha sp. and Ceratitis capitata still are important pests on productive citrus orchards due to the fruit injuries, resulting losses of commercial production of yield and dificulties to the Brazil's trade of fresh fruits. To estimate fruit fly densities properly for IPM purposes, a trial was carried out on an orange orchard (*Citrus sinensis*) variety Pera during a year. The substances tested were: 1- Corn protein hydrolisate at 0.3, 0.4 and 0.5%, 2-Sugarcane molasses at 10% and 3- Mixed of protein hydrolisate at 0.5% and molasses at 5%, conditioned in 2 types of traps: Serum Flask with 0.2 liters and Beverage Pet Plastic Bottle with 0.4 liters of attractive. The traps were installed at 1.5 meter high on alternated plants and rows, covering 140 square meters each one. The trial was carried out during a year with evaluations once a week and attractive replacement weekly. The Anastrepha sp. occurred on all the seasons and C. capitata mostly on winter and spring season. The later specie was more abundant. All the substances tested in its concentrations showed similar attractivity of both species.

[0674] CHEMICAL VARIATION AND ITS FUNCTIONAL SIGNIFICANCE IN GRASS-CUTTING ANT ALARM PHEROMONES

<u>W. O. H. Hughes</u>, P. E. Howse & D. Goulson, Biodiversity & Ecology Division, School of Biological Sciences, Bassett Crescent East, Univ. of Southampton, Southampton, SO16 7PX, UK

Leaf-cutting ants live in large colonies that are highly polymorphic and polyethic. They are adept at recognising non-nestmates and react to them, as well as to any other threats, with an aggressive alarm response. This reaction is governed by an alarm pheromone released from their mandibular glands. The compositions of the alarm pheromones of two grass-cutting species, Atta bisphaerica and A. capiguara, were examined, and caste and colony variations quantified. The pheromones of A. bisphaerica and A. capiguara were remarkably similar, and were composed of a complex mixture of volatiles in which 4-When the most abundant methyl-3-heptanone was one of the major components. compounds were tested in simple field bioassays, 4-methyl-3-heptanone was also found to be the compound that stimulated the greatest level of alarm behaviour in both species. The results support the view that alarm pheromones are rarely species specific. However, the ketone did not stimulate the same level of response as that resulting from a crushed ant head, suggesting that other compounds are also important. Small but consistent intraspecific differences were found between the worker castes and between individual colonies. The possible functional importance of intercolony variation is discussed. Key words: Atta; leaf-cutting ants; mandibular gland.

[0675] JUVENILE HORMONE – ITS EFFECT ON AGGREGATION BEHAVIOUR AND CENTRAL NERVOUS PROCESSING OF AGGREGATION PHEROMONES IN THE DESERT LOCUST

R. Ignell & S. Anton, Dept. of Ecology, Lund University, 22362 Lund, Sweden, E-mail Rickard.Ignell@ekol.lu.se

Juvenile hormone (JH) was shown to effect the central nervous processing of aggregation pheromones in the antennal lobe (AL) of the desert locust, Schistocerca gregaria resulting in changes in the aggregation behaviour. The aggregation behaviour of gregarious male and female desert locusts was monitored for individual control insects or insects subjected to either of three treatments; allatectomy, sham-operation and JH-injection. Two parameters were recorded to characterise aggregation behaviour (a) tendency to aggregate and (b) changes in behavioural activity, in a two-choice bioassay applying the main adult aggregation pheromone component phenylacetonitrile (PAN) in the treatment arena. Individual locusts were monitored at days 1, 8, 15, 22 and 29 after adult emergence in order to evaluate behavioural changes over time. Both male and female control and shamoperated locusts displayed behavioural changes coinciding with the naturally fluctuating JH-titre. Locusts generally displayed an increase in aggregation tendency and in behavioural activity up to days 8 and 15, which coincided with a low titre of JH. At days 15, 22 and 29, coinciding with a high JH titre, locusts displayed an initial (days 15 and 22) increase in behavioural activity and a tendency to avoid the treatment area followed by a low behavioural activity and no apparent attraction or repellency (at day 29). Locusts that were deprived of (allatectomised) or injected with JH either displayed a high behavioural activity and a high tendency to aggregate or did not show any specific behavioural response respectively. Intracellular recordings from projection neurons (PNs) in the antennal lobe of 8 and 29 days old control, allatectomised and JH-injected locusts revealed differences in the central olfactory processing; low JH-level (young and allatectomised) locusts displayed a fully functional olfactory system whereas high JH-level locusts displayed impairments in the olfactory system. In order to exclude the possibility of a diminished sensory input to the AL, electroantennograms (EAG) were performed. No significant differences in EAG amplitude between the three groups were observed. We conclude that the observed changes in aggregation behaviour may be regulated through a direct or an indirect effect of JH on the central nervous processing. We postulate that the observed behavioural indifference to PAN in high JH-level locusts arise due to a significant changes in the central nervous processing of aggregation pheromone components.

Index terms: Schistocerca gregaria, aggregation pheromone, electrophysiology

[0676] AREAWIDE MAPPING OF MAJOR PESTS ABUNDANCE WITH THE SEX PHEROMONE TRAPS AND MASS-TRAPPING IN HOT SPOTS ON VEGETABLES IN THE FORMER SOVIET UNION

<u>A. L. B'ichev</u>¹, Central Institute for Agrochemical Services, Moscow, former Soviet Union; ¹Present address: Inst. of Sustainable Irrigated Agriculture, P.O.Box 1, Tatura, Victoria 3616, Australia.

Integrated Pest Management (IPM) practices have been used for many years to control agricultural pests in the former Soviet Union. Areawide IPM has been applied not only in orchards as well-known, but also in vegetable crops. This abstract describes areawide monitoring, mapping and mass-trapping of major vegetable pests in 220 hectares (ha) of the Issyk-Kuhl Lake region of Kirghizia and in 110 ha of the Crimea region of Ukraine during 1987-1990. The pheromone traps "Attracon AA" with sticky base "Pestifix" (Flora Ltd., Tartu, Estonia) and sex pheromone dispensers for Noctuid moths Agrotis segetum Schiff., Agrotis exclamationis L., Amathes c-nigrum L., Autographa gamma L., Mamestra brassicae L., Scotogramma trifolii Hbn., were used for monitoring and control. The sex pheromone traps were distributed in the following way: 1 trap per 3-5 ha for each species for monitoring of initial pest population, I trap per ha for detailed mapping and identification of hot spots and 4 traps per ha for mass-trapping in hot spots. A daily average of 0.8 A. segetum, 1.7 A. exclamationis, 0.6 Am. c-nigrum, 0.8 S. trifolii per trap were recorded during mapping (880 traps in 220 ha) of the tomato fields in Issyk-Kuhl Lake. These levels of infestation were below the recommended economic threshold and regular insecticide applications were postponed. A daily average of 4.8 A. segetum, 6.2 A. exclamationis, 2.6 Au. gamma, 6.4 M. brassicae per trap were recorded during mapping (440 traps in 110 ha) of the tomato and cabbage fields in Crimea. These levels were above the recommended economic threshold and hot spots of each species were identified. Masstrapping in the identified hot spots with the use of 4 traps per ha for each pest resulted in the reduction of the infestation level and helped to avoid insecticide applications. The detailed mapping of species distribution and movement with pheromone traps indicated that such cutworms as A. segetum and A. exclamationis mostly concentrated on the edges of the vegetable fields, but armyworms M. brassicae, S. trifolii and Au. gamma distributed randomly and concentrated in hot spots throughout the field. The areawide application of mapping and mass-trapping for control of vegetable pests and reduction of regular insecticide application during 4 consecutive seasons will be discussed.

Index terms: areawide IPM, Noctuidae, sex pheromone trap, mapping, mass-trapping.

[0677] OLFACTORY RESPONSES BY MONOCHAMUS CLAMATOR, MONOCHAMUS SCUTELLATUS AND MONOCHAMUS OBTUSUS (COLEOPTERA: CERAMBYCIDAE) TO BARK BEETLE PHEROMONES

J. D. Allison¹, R. L. McIntosh² & J. H. Borden¹, ¹Simon Fraser Univ., Dept. of Biological Sciences, 8888 Univ. Drive, Burnaby BC, Canada, V5A 1S6; ² Saskatchewan Environment and Resource Management, Forest Ecosystems Branch, Box 3003 McIntosh Mall, Prince Albert, SK, Canada, S6V 6G1.

In the process of host selection, foraging woodboring beetles should exploit all information available to them including olfactory cues. Kairomonal responses by bark beetle predators to bark beetle pheromones are well documented, but only two examples occur in the literature of cerambycid beetles, *M. titillator* and *M. clamator*, responding to sympatric bark beetle pheromones. It appears that these species may have expanded their resource base through the development of a kairomonal response. We have demonstrated that multiple-funnel traps baited with a blend of bark beetle pheromones (ipsenol, ipsdienol, MCH and Frontalin) captured significant numbers of *M. clamator*, *M. scutellatus* and *M. obtusus*. Response to these bark beetle pheromones occurred whether or not they were offered with the host kairomones ethanol and α -pinene. Response by cerambycid beetles to the pheromones of sympatric bark beetles would be adaptive for two reasons: 1) the pheromones would indicate suitable host material; and 2) heterospecific cannibalism on bark beetle larvae may positively influence brood development. Index terms: kairomone, chemical ecology, host selection

[0678] CHEMICAL DEFENSE IN THE PLANT BUG LOPIDEA ROBINIAE

J. K Staples¹, R. J. Bartelt², & D. W. Whitman⁴, 4120 Biological Sciences Illinois State Univ. Normal, Illinois 61790, USA, E-mail jstapl@ilstu.edu; dwwhitm@ilstu.edu; ²USDA, ARS National Center for Agricultural Utilization Research, Bioactive Agents Research Unit, Peoria, IL 61604, USA, E-mail bartelrj@mail.ncaur.usda.gov.

Secretions from the metathoracic glands (MTG) of the black locust bug, Lopidea robiniae (Heteroptera: Miridae) contained six major compounds including: (E)-2-hexenal, (E)-2-hexenal, (E)-2-octenol (E)-2-Heptenal, and (?)-3-Octenol. Males and females did not differ significantly in the relative compositions of identified compounds. In feeding trials, six bird species demonstrated feeding aversions towards L. robiniae, implying that black locust bugs are chemically defended. Bugs discharged the liquid contents of their MTG's when attacked, thereby producing a strong and distinct odor. Some birds immediately ejected bugs out of their mouth after biting them, suggesting that the MTG secretion was a deterrent.

Index terms: Heteroptera, Miridae, allomone

[0679] USE OF MATING DISRUPTION IN COTTON IN NORTH AMERICA

J. W. Jenkins, Pacific Biocontrol Corporation, 620 E. Bird Lane, Litchfield Park, AZ, 85340, USA, E-mail jenkins@doitnow.com.

The pink bollworm, *Pectinophora gossypiella*, is one of the most serious pests of cotton worldwide causing losses in both yield and quality. Control with conventional insecticides is difficult because the pest is well protected within cotton squares and bolls. Furthermore insecticide costs are high and applications of broad-spectrum materials have contributed to outbreaks of secondary pests. Mating disruption has provided a viable alternative for pink bollworm control. Development of mating disruption for the pink bollworm began 25 years ago and the first Environmental Protection Agency registration of a pheromone formulation for mating disruption was issued for the pink bollworm in 1978. Since that time many formulations have been developed and commercialized. These materials represent various use methods and modes-of-action. The effectiveness of these formulations has been demonstrated in several areawide programs. These programs integrate pest management techniques conducive to mating disruption and avoid some of the factors detrimental to the technique.

Index terms: pink bollworm, Pectinophora gossypiella, mating disruption, pheromone, gossyplure

[680] OLFACTORY RESPONSES TO ISOAMYL ACETATE AND ADULTS OF THE LARGE MILKWEED BUGS (ONCOPELTUS FASCIATUS, HETEROPTERA:LYGAEIDAE) IN MALE AND FEMALE ANTENNAE OF THE SAME SPECIES

T. Jocys¹, O. Giannotti¹, A.Shpitz² & D. Fell¹, ¹.Instituto Biológico. Av. Conselheiro Rodrigues Alves, 1252. Vila Mariana. 04014-002. São Paulo, SP. Brasil. E-mail jocys@biologico.br; ². Consultant.

The interspecific communication among insects, with the exception of sexual attraction, has not been intensely investigated. Several authors identified pheromone presence with different functions of the *O*_i*fasciatus* Dallas. In the present paper the olfactory response of milkweed bug male and female antennae to odour source from live male and female adults, instead of insect extracts or dissected odour glands is investigated. We observed that recently emerged male adults, ten or more days old, as an odour source are capable of male and female antennae stimulation; while females, under the same conditions, did not produce any stimulation effect. The antennae stimulation response was measured by electroantennogram. The response to control (air) and female odour was in the order of 26.0 to 116.9 microvolts while the male odour response was 352.0 to 389.1 microvolts. As a standard a chemical stimulant: isoamyl acetate was used, resulting in a 413.9 to 463.4 microvolts response.

Index terms: Oncopeltus fasciatus, pheromone, electroantennogram.

[0681] PHEROMONE-BASED MANAGEMENT PROGRAM FOR SIMULTANEOUS CONTROL OF CODLING MOTH AND LEAFROLLERS IN BRITISH COLUMBIA'S COMMERCIAL ORGANIC APPLE PRODUCTION SYSTEM

<u>G.J.R. Judd</u>, Agriculture and Agri-Food Canada, Pacific Agri-Food Research Centre, 4200 Hwy 97S, Summerland, British Columbia, CANADA V0H 1Z0. E-mail juddg@em.agr.ca

A three-year study has demonstrated the utility of Isomate-CM/LR as an important management tool in simultaneously controlling codling moth, Cydia pomonella and four leafroller species (Lepidoptera: Tortricidae), Choristoneura rosaceana, Pandemis limitata, Archips argyrospilus and A. rosanus by mating disruption in an organic apple production system. Trapping with synthetic pheromone baits, mating of clipped-wing females in mating tables, and damage assessments at harvest, respectively, demonstrated that it is possible to significantly disrupt pheromone communication (89 - 100%) and mating (70 -100%) in each of these species and maintain overall crop damage below economic levels (2%) compared with conventionally-treated and untreated orchards, by releasing an incomplete mixture of these species individual pheromone components from the Shin-etsu rope-type dispensers applied at a rate of 500 dispensers / ha. To achieve these results organic orchards were treated once with Dipel[®] Bacillus thuringiensis in year 1 of the study to reduce initial populations of leafrollers to manageable levels. Over the three years trap catches and damage from leafrollers decreased in four of the five orchards treated with pheromone, but in one orchard catches and damage from leafrollers increased as a result of moth immigration into the test orchard from an adjacent organic cherry orchard. Levels of mating disruption among leafrollers was apparently density dependent and damage from leafrollers at harvest was positively correlated with seasonal total leafroller catches in pheromone traps placed at a density of 1 / ha. Catches of codling moth in synthetic pheromone traps deployed at a density of 1 / ha and baited with 10 mg of codlemone (E,E-8,10-dodecadien-1-ol) declined from a mean of 0.7 moths / trap / orchard in 1997 to 0 in 1999. Mean numbers of overwintering codling moth larvae caught in cardboard tree trunk bands declined from a mean of 4.7 larvae / ha / orchard in 1997 to 0 in 1999. Codling moth damage was undetectable in any of the orchards in any year of this study. This study has shown it is biologically and economically feasible to grow organic pome fruits in British Columbia by overlaying a pheromone-based management system for control of leafrollers and codling moth on top of the codling moth sterile insect release program that is ongoing in this tree-fruit production area.

Index terms: Tortricidae, Cydia pomonella, Choristoneura rosuccana, Pandemis limitata, Archips argyrospilus, A. rosanus, pheromones, mating disruption, organic apple production

[0682] CONTROL OF SCAPANES AUSTRALIS A MAJOR PEST OF COCONUT USING SEMIOCHEMICALS

T.K. Kakul¹, S. Laup¹, L. Ollivier^{1,2}, J-P. Morin² & D. Rochat³, ¹Dept. of Entomology, Cocoa and Coconut Research Institute, P. O. Box 1846, Rabaul, Papua New Guinea, ²CIRAD-CP, BP 5035 Montpellier, France; ³INRA, Unité de Phytopharmacie et Médiateurs Chimiques 78026 Versailles Cedex, France. Research with funding from the EU under INCO project No. RB-IC18CT970199

Scapanes australis Bsdy, (Colcoptera, Scarabaeidae) native to the Melanesian region is a major economic pest of coconuts in Papua New Guinea. Adults attack and kill young palms up to 2 years old and feeding sites left on older palms (2 to 7 years) are invaded by the secondary pest Black Palm Weevil, Rhynchophorus bilineatus (Coleoptera, Curculionidae), the larvae of which can kill the coconuts. S. australis is a very difficult pest to control because of its long life cycle (356 days) and can also attack palms for up to 7 years. There has been no effective method of controlling the pest in the past because of the poor knowledge of the insect's biology and ecology. New information on the biology and chemical ecology has recently enabled a mass trapping of the beetle. Various field experiments were carried out to evidence the existence of a long range active pheromone. Field collection of Scapanes during day and night observations had indicated that male Scapanes perform a calling behaviour and emit an aggregation pheromone. Traps were developed initially using cage with calling male as bait. After a year the pheromone was identified and synthetic pheromone became available and was used as attractant. Trapping S. australis first with calling males and latter with synthetic pheromone caused a decline of the population of Scapanes over a period of two years. Whereas trapped females cause the next generation to decline, removed males are prevented from attacking coconuts. Continuous trapping lowers the population of Scapanes overtime hence reduces the threat to coconuts to be attacked by the beetle. Preliminary data had indicated a reduction in the number of coconuts being damaged.

Index terms: Scapanes, communication Rhynchophorus, coconut, pheromone, trapping, live male.

[0683] EFFECT OF WHEAT INFESTED BY LARVAE OF THE HESSIAN FLY, MAYETIOLA DESTRUCTOR, ON OVIPOSITION BEHAVIOR OF THE HESSIAN FLY FEMALES

II. Kanno & M. Harris, Horticulture and Food Research Institute of New Zealand, Mt Albert Research Center, Pribate Bag 92169, Auckland New Zealand

The Hessian fly (HF) females lay less eggs on wheat leaves infested by HF larvae than uninfested ones. The wheat plant infested by HF larvae indicates particular symptoms,

th as stunting and color changing to more dark. It was confirmed that the both plant areght and leaf color are very important physical factors affecting the oviposition behavior of HF females. The chemical factors in the infested and uninfested wheat plants were also examined. The number of eggs laid on the paper models treated extracts of infested wheat leaves was significantly lower than that on the models treated extracts of infested wheat extracts. Recently, the two compounds, 1-octacosanal and 6-methoxy-2-benzoxazolinone (MBOA) , were identified from wheat leaves as the oviposition stimulants for HF females (Morris et. al., in press). Therefore, the chemical composition including these two stimulants in the both infested and uninfested wheat extracts are now analyzing to elucidate the differences on leaf surface chemicals between infested and uninfested wheat. The effect of volatile chemicals emitted by infested and uninfested wheat are also investigating using Y-tube olfactometer. The results of these analyzing and experiment will be discussed in a poster. [0685] AMINO ACID SECRETION IN DIGESTIVE JUICE: COUNTERADAPTATION OF HERBIVOROUS INSECTS AGAINST PROTEINDENATURING ACTIVITY OF PLANT IRIDOID GLYCOSIDES ACTIVATED BY PLANT \Box -GLUCOSIDASE

K. Konno, C. Hirayama, H. Yasui, S. Okada, F. Yukuhiro, H. Shinbo & M. Nakamura, Natl. Inst. of Sericultural and Entomological Sci., 1-2 Ohwashi, Tsukuba, Ibaraki 305-8634, Japan, E-mail: konno@nises.affrc.go.jp.

We found the existence of high concentrations (0.4-0.8 %) of free glycine in the digestive juice of several Lepidoptera and Hymenoptera larvae, particularly in the digestive juice of the species which feed on the privet tree, Ligustrum obtusifolium (Oleaceae) [1,2]. In one of such species, Brahmaea wallichii (Brahmaeidae), glycine was secreted in midgut lumen in an active and selective manner. Leaves of the privet tree Ligustrum obtusifolium contains oleuropein (3% per wet weight), a phenolic iridoid, probably as a defense chemical [3,4]. When the leaf cells are damaged, enzymes in organelles, □-glucosidase and polyphenol oxidase, activates oleuropein into a very strong protein-denaturant[4]. When, in particular, \Box -glucosidase deglucosidate the iridoid-glycoside moiety of oleuropein, this moiety is converted into glutaraldehyde-like structure and crosslinks protein molecules to form high molecular weight complexes [3,4] and makes protein nonnutritive by decreasing the lysine content[1,3,4]. Several other iridoid glycosides such as aucubin and geniposide are similarly activated by D-glucosidase. The fact that 1% glycinc could completely inhibit these activities [1,3] suggested that free glycine is secreted in the digestive juice as an adaptation mechanism to chemical defense of host plants. Our data indicate that amino residue in free glycine is responsible for the inhibition. We also found that, in some Lepidoptera species, high concentrations of other amino acids such as GABA and I-alanine exist in the digestive juice, which seem to play the same role as glycine does. Our results would be a good and clear example of coevolution of plants and herbivores mediated by chemicals.

Index terms: Ligustrum obtusifolium, Brahmaea wallichii, glycine, oleuropein, plantherbivore interactions

[0684] REPELLENT PROPERTIES OF CASSIA SOPHERA (CAESALPINIACEAE) AGAINST THE RICE WEEVIL SITOPHILUS ORYZAE (COLEOPTERA; CURCULIONIDAE); POTENTIAL AS A STORAGE PROTECTANT

C. Kestenholz & P.C. Stevenson, Natural Resources Institute, Univ. of Greenwich, Central Ave., Chatham Maritime, Kent ME4 4TB, United Kingdom.

Rice is one of the major staple crops world-wide and is gaining renewed importance in northern Ghana where it is traditionally grown by women. In particular, rice represents an additional source of income and thus improves the significance of women in their social groups. Post-harvest losses in small scale farming systems represent a serious problem for farmers and their families particularly since the introduction of exotic or high yielding rice varieties, which tend to be more susceptible to insect damage than the traditional but lower yielding varieties. The use of synthetic pesticides in food stores is still the major tool available to many farmers for managing insect damage but this is expensive for resource poor farmers and potentially dangerous. Moreover, inappropriate use has lead to the development of insecticide resistance. Small-scale farmers in the Northern Region of Ghana currently use different endemic plants as storage protectants. Cassia sophera is a widespread species, which occurs primarily on waste ground and is traditionally mixed to stored grain in form of powdered leaves. Preliminary investigations on this plant species confirmed its toxicity and F1 reduction against S. zeamais, Callosobruchus maculatus and Rhyzopertha dominica and consequently this plant has been selected for further investigation. In this study, S. oryzae was chosen because it is one of the main pests of tropical stored products not only in Ghana, but world-wide and therefore its control will be of great economic impact. Adults of S. oryzae were given the choice to feed on rice treated with the crude methanol extract of C. sophera at 1000 ppm or control rice (untreated) and were significantly repelled from the treated rice (p<0.001). The number of the F1 generation emerging on treated rice was also less than on untreated rice. Phytochemical analysis and bioassay of fractions of C. sophera, showed that the repellent activity was present in non-polar fractions of either 100% methanol, 100% acetone or 75/25 hexane/ethyl-acetate (p<0.005). The active fractions are currently being fractionated further and tested for their activity against adult S. oryzae and C. maculatus. The results of this study were reconfirmed by recent field trials with C. sophera in northern-Ghana, showing a reduced level of infestation in commodities treated with the plant powder. This study is particularly important since S. oryzae is tolerant of many control agents and pesticides and therefore difficult to control. Moreover chemicals with repellent properties to this species have the potential to be toxic or repellent to other stored products pests.

Index terms: Sitophilus oryzae, stored products pests, phytochemicals, bioactivity

[0686] USE OF MICROENCAPSULATED PHEROMONE OF THE ORIENTAL FRUIT MOTH FOR MATING DISRUPTION IN BRAZIL

<u>A. Kovaleski</u> & J.F.S. Protas, Embrapa Uva e Vinho, Estação Experimental de Vacaria, CP 177, CEP 95.200-000, Vacaria, RS, adalecio@cnpuv.embrapa.br, Brazil.

The efficiency of a microencapsulated formulation of the sex pheromone (MEP) of Grapholita molesta as a mating disruptant under the conditions of Brazilian apple orchards was evaluated. The product was recently developed by 3M. Experiments were conducted in two commercial orchards in Fraiburgo, SC, each one containing blocks of 'Gala' and 'Fuji'. 10-ha blocks were used in each orchard, being half of the area treated with the MEP. The remaining 5 ha were treated with insecticides, according to adult population density. Sprays of the MEP (37.5 g.ha-1) were initiated during the period of emergence of the spring generation of the pest and then applied at 25-days intervals (range 17-42 days). Population was monitored in all areas, using three delta traps and synthetic sexual pheromone. Damage was evaluated five months after set up of the experiment, being 50 fruits and 50 shots checked from each of 20 randomly chosen trees. Adult population density was higher in areas treated with insecticides, surpassing 40 males.trap-1.week-1 in the beginning of the experiment (spring) and in one of the areas of the cultivar Fuji in January. Total damage was unexpressive in shots in all areas. Damage to fruits was higher in 'Fuji', as a result of higher adult population density. Results show that the damage in areas treated with the MEP occurs at acceptable levels, with the advantage of low or even no (Orchard 2, both cultivars) insecticide application. Sprays of the MEP at shorter intervals would probably lead to better control of the pest. Index terms: Apple pest, Grapholita molesta, IPM, Lepidoptera, Tortricidae

[0687] THE EFFECTS OF HOST PLANT ODOURS ON THE CALLING BEHAVIOUR, EGG MATURATION AND MATING SUCCESS OF THE COTTON BOLLWORM, *HELICOVERPA ARMIGERA* (LEPIDOPTERA: NOCTUIDAE)

O.L. Kvedaras¹, P.C. Gregg¹, A.P. Del Socorro¹, D. Alter¹ & C. Moore², ¹School of Rural Science and Nat. Res., Univ. of New England, Armidale, New South Wales, Australia 2351, E-mail okvedara@metz.une.edu.au; ² Queensland Dept. of Primary Industries, Yeerongpilly, Queensland, Australia 4105.

The influence of host plant odours on the calling behaviour and egg maturation of the female cotton bollworm, Helicoverpa armigera was investigated. Host plants included flowering cotton, maize and pigeon pea. Females were held in cages for a period of 6 days from the time of emergence and exposed to either no host (control) or a host plant. The time calling was initiated, time spent calling and the mean number of calling bouts were recorded. A selection of females that initiated calling for the first time 1-6 days after emergence were sacrificed to determine the stage of ovarian development at the onset of calling. In a separate experiment the sex pheromone released by individual calling females of H. armigera was trapped within the stem of Pasteur pipettes. Individual females were exposed to host plant odours and one female was exposed only to filtered air as a control. Host plants included, cotton, pidgeon pea and sunflower. The time spent calling was recorded and the amount of pheromone trapped quantified. Pheromone collection and behavioural observation commenced halfway into scotophase which is generally when female H. armigera start calling. Trapped pheromone was analysed by Gas Chromatography-Mass Spectrometry. Field studies were conducted in the Darling Downs, Queensland, Australia, during the 1996/97 and 1997/98 cotton growing seasons. Mating tables were used to determine the mating success of *H. armigera*. Moth abundance was assessed using light and pheromone traps. A series of comparisons of three or four crops were used. They included: mature corn; immature, flowering and mature cotton and soybeans; immature and flowering sunflower and sorghum. Fallow land was also included. Laboratory reared virgin females with their wings clipped were placed in mating tables in various crops where they remained until collection and dissection the following morning to determine whether they had been mated. These studies indicate that host plants did not significantly influence the chance of being mated, despite substantial variation in moth abundance between the crops.

Index terms: Helicoverpa annigera, host plants, mating tables, ovarian development, sex pheromone

[0688] JAVA GRASS (CYMBOPOGON WINTWRIANUS) ESSENTIAL OIL EFFECTS ON SPODOPTERA FRUGIPERDA BIOLOGY AND BEHAVIOR

<u>A.M. Labinas</u>¹ & W. B. Crocomo², ¹Dept. of Ciências Agrárias - Univ. of Taubaté - 432 Quatro de março St. Taubaté - SP - Brazil, 12020-270, E-mail <adianal@tecsat.com.br>; ² Dept. of Vegetable Production - FCA - UNESP - P. O. Box 237, Botucatu - SP - Brazil, 18603-970, E-mail <wcrocomo@fca.unesp.br >

This research, developed at the Entomology Laboratory of Vegetable Production Department, from FCA -UNESP (Botucatu, SP), in temperatures ranging from 23 to 27°C, 70% of relative humidity and 14 hour of photophase, was held to evaluated the effect of Java Grass (Cymbopogon winterianus) essential oil, in 0,001, 0,005, 0,01, 0,05, 0,1, 0,5 and 1,0% of concentration in Spodoptera frugiperda biology and behavior . The laboratory tests followed randomized experimental design, with 8 treatments including the check treatment. These dosage were added to the artificial diets to observe the larval and pupal periods, larval and pupal viability, 24 hours pupal weight, male and female adults longevity and the effects on laid eggs. The obtained data reveled the essential oil alters all S. frugiperda biology phases, without showing correspondence between dosage and effects. Corn leaves were deepen in solution containing those concentrations and were offered to recent hatched larvae, showing its repellency effect. Eggs were also deepen in those same solution to verify the essential oil effects on their viability, conforming its ovicide action. To estimate its possible insecticide use, a field test was conducted in a corn crop, following a randomized experimental design with the same treatments and 4 replications, permitted to conclude that the highest dosage (1,0 e 0,5%) showed the best control efficiency causing , however, phytotoxicity, in newer leaves

Index terms: Spodoptera frugiperda, Cymbopogon wintwrianus, biological insecticide, citronela

[0689] SCREENING GENOTYPES OF SESAME (SESAMUM INDICUM) FOR RESISTANCE TO WHITEFLY (BEMISIA TABACI)

H.E. Laurentin¹ & <u>C.J. Pereira</u>², ¹² Departamento de Ciencias Biológicas, Universidad Centroccidental Lisandro Alvarado, Apartado 400, Barquisimeto, Venezuela. helauren@yahoo.com entm96@hotmail.com

To evaluate incidence of whitefly in the genotypes 37-1, 37-3, 19x10, 43x32, UCV-3 (resulting from plant breeding for high yield before whitefly) and the cultivar Fonucla, field experiments were established in Turen, Portuguesa state, Venezuela, in 1998 and 1999, using ramdomized complete block design with four replications. Whitefly natural infestations appeared five weeks after establishment of experiments. Afterward, six consecutive weekly samples were taken each year from each plot. Samples consisted of five leaves from each third of the plant: apical, medium and basal. Leaf area, number of eggs(E), number of nymphs(N), E/cm² and N/cm² were estimated on each leaf. Log transformed data were analyzed as split plots in time. A combined analysis for years was conducted using the model AMMI (additive main effects and multiplicative interactions) for interactions. A genotype by week significant interaction (P<0.01) was detected for all variables measured (except leaf area) in both years. However, a trend to form two distinguishable groups was observed, with 37-1 and 43x32 genotypes in one group showing the lowest incidence and the rest in another group with the highest incidence. AMMI model confirms the potential value for resistance of these two genotypes, indicating 43x32 and 37-1 with both the lowest values and highest stability. Key words: *Sesanum indictum - Bemisia tabaci -* resistance – plant breeding

[0690] BIOCHEMICAL ADAPTATION OF BIRD CHERRY-OAT APHID TO PLANT PHENOLICS

<u>B. Leszczynski</u>¹, **B. Jozwiak**¹, **I. Lukasik**¹, **A. Urbanska**¹ & A.F. Dixon², ¹Dept of Biochemistry, Univ. of Podlasie, Prusa 12, PL-08110 Siedlee, Poland, E-mail leszczb@ap.siedlee.pl, ²School of Biol. Sci., Univ. of East Anglia, NR4 7IJ, Norwich, UK

Bird cherry-oat aphid, *Rhopalosiphum padi* L. belongs to host alternating species. It alternates between woody plants (*Prunus padus* L.) and herbaceous Gramineae. There are two migrations in the aphid life cycle. The spring migration, from primary (winter) host onto secondary (summer) hosts takes place in the middle of April. The autumn migration, from summer host onto bird cherry occurs in late September. Phenology of this phenomenon is quite well known, however chemistry of the host-plant alternation by the bird cherry-oat aphid was not extensively studied. The present paper reports on role of the plant phenolics in the aphid host plant interactions. While the aphid population developed on *P. padus*, an increase in content of phenolics in the bird cherry leaves was observed. During the spring migration, there was about 4-fold higher concentration of the phenolic compounds in the primary host than in the secondary ones. In addition, during the spring migration an increase in activity of the aphid enzymes involved in the phenolics metabolism was found. The obtained results suggest that content of the plant phenolics in factor that induces the spring migration of the bird cherry-oat aphid. Index terms: *Rhopalosiphum padi*, phenolics, host alternation

[0691] MONITORING MASSON PINE CATERPILLAR (DENDROLIMUS PUNCTATUS) WITH SYNTHETIC SEX PHEROMONE IN CHINA

⁴ <u>D. M. Li</u>, A. B. Zhang, The State Key Lab of Integrated Management of Insect Pests & Rodents, Institute of zoology, Chinese Academy of Sciences, Box 70, E-mail Lidm@panda.ioz.ac.cn, Beijing, 100080, P. R. China.

The distribution of the masson pine caterpillar (Lepidoptera: Lasiocamidae)lies in South China and SouthEast China. When the masson pine caterpillar breakout, needle leaves of masson pine were caten out. The traps baited with new resin pheromone lures, which can release sex pheromone at least 30d, were used to monitor masson pine caterpillar in this study, and field investigations were conducted at the same time in order to study the relationship between the number of male adult moths trapped and the trend of emergence of the larvae in the field. We found the number of male adult moths trapped was correlated with the number of larvae in the field. The average number of male adult moths trapped per town had the same trend as the percentage of pine trees that had larvae and the average insect population (the number of larvae per tree). In the present study, monitoring a field population with synthetic sex pheromone indicates that it is possible to predict the population dynamics in Qianshan, Anhui, China, especially in low-density population. Index terms: Dendrolinius punctatus (Walker) Monitoring Sex pheromone

[0693] MANAGING TEMPERATE FRUIT PESTS IN BRAZIL USING SEMIOCHEMICALS

A. Mafra-Neto⁶, A. Kovaleski¹, M. Botton¹, A. Eiras², E. Vilela³, R. Sugayama⁴ & L. Mafra⁵, ¹EMBRAPA/CNPUV, CP 177, CEP 95200-000, Vacaria, RS; ²Universidade Federal de Minas Gerais, Belo Horizonte, MG; ³Universidade Federal de Viçosa, Viçosa, MG; ⁴Universidade de São Paulo, SP; ⁵ISCA Tecnologias Ltda, Ijuí, RS, BRAZIL, ⁶ISCA Technologies, Inc., Riverside, CA USA.

There are four major pests identified in the apple growing region of the south of Brazil, which is comprised of 28,000 ha. Anastrepha fraterculus (Tephritidae), Bonagota cranaodes, and Grapholita molesta (both Tortricidae) are well known in commercial orchards. Cydia pomonella (Tortricidae) has never been detected in commercial orchards, but is present in urban areas. Semiochemicals have been used to manage these pest populations with good success. The best tool to monitor populations of *A. fraterculus* under our conditions are McPhail traps lured with 25% grape juice or turula yeast. Research on host fruit and food attractants of A. fraterculus is underway to improve this monitoring system. The sex pheromone of B. cranaodes was identified, synthesized, and formulated for use in monitoring and control techniques. Control of B. cranaodes was achieved using ISCACIDA formulation, an attract-and-kill technique. A single application of ISCACIDA-Bonagota at a density of 200 units/ha promotes monitoring trap shutdown for over two months and results in significant reduction of fruit damage at harvest. Two applications of ISCACIDA-Grapholita promoted monitoring trap shutdown and effective suppression of G. molesta in pome and stone fruit orchards throughout the fruit cycle. A single application of ISCACIDA-Cydia in urban host plants at a density of 45 units/ha resulted in monitoring trap shutdown that lasted for over 100 days. Monitoring pheromone traps have been widely accepted by apple growers and trap captures are used for management decision making. As pheromone tools to monitor the main apple pests became available, the frequency of cover applications of insecticide was reduced from 14 to 24 in 1996/97 to 4 to10 in 1998/99. As the number of cover sprays is reduced, opportunist pests currently kept under control by the insecticides may achieve the status of primary pests. We believe that the adoption of efficient monitoring systems coupled with the above mentioned environmentally sound pest managementtechniques will lead to an even more efficient and judicious use of insecticides in the apple growing regions of Brazil.

Index terms: Anastrepha fraterculus, Bonagota cranaodes, Grapholita molesta Cydia pomonella, managing

[0692] TIME-DEPENDENT VARIATIONS IN ESTERASE 9B FREQUENCY AND MALATHION-RESISTANCE OF THE DIAMONDBACK MOTH (*PLUTELLA XYLOSTELLA*) IN TAIWAN

C. J. W. Maa, Institute of Zoology, Academia Sinica, Taipei, Taiwan, 115, ROC.

EST 9b was recognized as an esterase allozyme associated with malathion resistance in the diamondback moth (DBM), Plutella xylostella L.. In 1987, Geou-Fang DBM population was significantly (P < 0.05) differentiated from other 14 local DBM populations in Taiwan based on EST 9b frequency. Meanwhile, Geou-Fang DBM was the most susceptible population found in Taiwan. Two years later Geou-Fang DBM was no longer being differentiated from other DBM populations based on the EST 9b frequency. In fact, EST 9b frequency of Geou-Fang DBM increased from 13% to 35% within the two years of 1987~1989; and no insecticide was applied in Geou-Fang area during that time period. A statistically significant (P < 0.02) linear regression was existed between the EST 9b frequency and malathion resistance of the 14 DBM populations, and this correlation lasted till 1991. Although the two regression lines of 1989 and 1991, respectively, showed different slopes, they shared the same interception point to the horizontal axis of EST 9b frequency. This phenomenon implicated that EST 9b frequency of Taiwan DBM might vary from year to year, and accordingly, resistance of DBM might also fluctuate from time to time. So the EST 9b frequency could be suggested as an indicator protein for monitoring malathion resistance in the DBM. However, by 1997 the regression line between EST 9b frequency and resistance of the DBM was neither statistically significant nor sharing the same interception point with that of 1991 and 1989. This might implicated some variations between the EST 9b frequency and the resistant mechanism from 1989 to 1997. In view of these consecutive accounts of the variation in EST 9b frequency and malathion resistance through the passed ten years, significance of the above-mentioned events was discussed. The adaptive phenomenon of the DBM to the changing circumstance in Taiwan was also discussed.

Index terms: Plutella xylostella L., esterase 9b, malathion-resistance, variation, adaptation

[0694] SEMIOCHEMICALS INDUCING DEFENSIVE BEHAVIOR OF APIS CERANA JAPONICA AGAINST VESPA MANDARINA

<u>S. Matsuyama¹</u>, T. Suzuki¹ & H. Sasagawa², ¹Inst. of Applied Biochem., Univ. of Tsukuba, 1-1-1, Ten-nou dai, Tsukuba, Ibaraki, 305-8572, JAPAN, E-mail honeybee@sakura.cc.tsukuba.ac.jp; ²Natl. Inst. of Seric. & Entomological Sci. (NISES), 1-2 Oowashi, Tsukuba, Ibaraki, 305-8634, JAPAN.

The Japanese honey bee, Apis cerana japonica Rad. (Acj), is known to perform a unique thermal defense against hornets such as Vespa mandarina (Vm) and V. simillima xanthoptera. The other interesting defensive behaviors of Acj are 1) cessation of foraging and hiding inside the hive and 2) shriving off the forage-site marking pheromone deposited from sternite gland (van der Vecht gland) by the hornet with mandibles. this study, we tried to identify semiochemicals inducing these defensive behaviors of Acj by using GC/EAD and GC/MS. a) Volatiles from live Vm worker were introduced into Super Q column and washed with ether. GC/MS analyses showed that the volatiles were composed of more than 30 components including hydrocarbons, 2-alkanones, alcohols, and esters. b) By using Acj worker antenna as a sensing element, etheral washings from Super Q were subjected into GC/EAD. At least four compounds elicited reproducible response by Acj antenna. c) From GC/MS analyses, a peak eliciting strongest antennal response was suggested as heptadecene, which was further identified as (Z)-8-heptadecene by GC/MS analysis of DMDS adduct and by GC comparison of geometric isomers. d) Sternite gland extract contained long chain hydrocarbons and fatty acids in the low volatile region. Main component in the high volatile region was (Z)-8-heptadecene. e) (Z)-8heptadecene, heptadecane, dehydromevalonic lactone were identified in both volatiles Behavioral studies using natural and from live Vm workers and sternite gland extract. synthetic compounds against both Acj and Vm are conducted in order to determine which compound(s) is necessary to induce defensive behavior in Acj, and/or to elicit aggregation of Vm.

Index terms: aggregation pheromone, forage-site marking pheromone, sternite gland, kairomone, GC/EAD.

[0695] SEX AND CRIME IN A BEETLE: FEMALE CHOICE AND DEADLY MALE - MALE AGGRESSION IN MALACHIUS BIPUSTULATUS

T. Meiners¹ & E. Strohm², ¹Institut für Biologie, Freie Universität Berlin, Haderslebener Str. 9, D-12169 Berlin, Germany, e-mail meito@zedat.fu-berlin.de; ²Zoologie III, Biozentrum, Am Hubland, D-97074 Würzburg, Germany.

Sexual selection has given rise to the evolution of unique and bizarre structures and behavioural traits. Male beetles of the coleopteran family Malachiidae are endowed with remarkable chitinous structures that are associated with complex glands (= exciter organ). The elaboration and location of these organs vary considerably among the Malachiidae. We hypothesised that these exciter organs play a role during courtship and might provide females either with valuable substances and/or with a signal of male quality. In M. bipustulatus the exciter organ is located on the forehead. Its structure allows females to insert their mouthparts in a fashion that looks like the female would bite into the male's head. Field observation of a total of 123 courtship interactions of this species revealed that interactions lasted 31 ± 36 min (range: 1-160min, n = 92). During courtship the female repeatedly bit into the exciter organ. The mean duration of single bites was 25 ± 17 s (range: 2-26s, n = 25). The total duration of female contact with the male exciter organ was 28 ± 28 min (range: 1-100 min, n = 26). In some cases the occurrence of droplets at the exciter organ or female's mouthparts suggested that actually some substance was transferred from the male to the female. After each biting the female turned around and the male touched the female's abdomen tip with its mouthparts. In 85 out of 123 cases the female left without copulation; only 10 interactions resulted in a final copulation (mean duration: 26 ± 9s, range: 17-39s, n = 9). In 21 cases, other males aggressively interfered with courting pairs and seemingly tried to take-over the females. Six M. bipustulatus males were found in the field feeding on other males (preferably on the head). Even direct attacks and killing of paired and unpaired males was observed in four cases. This was surprising since malachiids are actually pollen feeders. Our observations suggest that males offer valuable secretions during courtship to the female. Males try to attain these secretions even by killing and feeding on congenders. Whether female choice is based on qualitative or quantitative aspects of the secretion is not yet known.

Index terms: Malachiidae, courtship feeding, female choice, male competition, cannibalism

[0696] THE ROLE OF INDUCED PLANT VOLATILES FOR EGG PARASITOIDS AND THEIR POTENTIAL FOR SEMIOCHEMICAL CONTROL

T. Meiners & M. Hilker, Institut für Biologie, Freie Universität Berlin, Haderslebener Str. 9, D-12169 Berlin, Germany, e-mail meito@zedat.fu-berlin.de

Parasitoids of herbivorous hosts face the problem that they have to utilize reliable and detectable cues during host location. It has been shown that larval parasitoids can solve this problem by orientating towards plant odors that are released after herbivore feeding damage. The role of induced plant volatiles for egg parasitoids is almost unknown. Its elucidation, however, may contribute to the enhancement of performance of egg parasitoids utilized as biological control agents. The egg parasitoid Oomyzus gallerucae (Hymenoptera, Eulophidae) attacks eggs of the elm leaf beetle Xanthogaleruca luteola (Coleoptera, Chrysomelidae), which is a serious defoliator of different elm species in Southern Europe, North America and Australia. O. gallerucae has been repeatedly introduced into the United States for biological control of the elm leaf beetle. In Southern France 30 -70 % of elm leaf beetle egg masses sampled on different locations and during different years were parasitized by O. gallerucae. These high discovery efficiencies of female egg parasitoids might be mediated by volatile synomones. Our olfactory studies on host location of O. gallerucae proved that these egg parasitoids are attracted to the odor of field elm (Ulmus minor) leaves that are carrying eggs of the elm leaf beetle. Oviposition of X. luteola induces a change of the volatile pattern emitted by the field elm leaves resulting in the attraction of the egg parasitoids. The plant's reaction to oviposition is systemic; the leaves without eggs adjacent to those with eggs also emit attractants. Females O. gallerucae also react to odor of elm leaves treated with jasmonic acid. Jasmonic acid is known as mediator of plant responses induced by feeding of herbivorous arthropods. Plants that are able to respond to oviposition of herbivores may defend themselves by emission of volatiles which "call" for egg parasitoids. This potential might be used to enhance the performance of egg parasitoids for semiochemical control of herbivores. Index terms: Oomyzus gallerucae, elm leaf beetle, egg parasitoid, synomone induction,

Index terms: *Oomyzus gallerucae*, elm leaf bectle, egg parasitoid, synomone induction, biological control

[0697] CHEMICAL SIGNALLING BETWEEN HOST PLANT AND EGG PARASITOID OF A GALERUCINE LEAF BEETLE

T. Meiners & M. Hilker, Institut für Biologie, Freie Universität Berlin, Haderslebener Str. 9, D-12163 Berlin, Germany, e-mail meito@zedat.fu-berlin.de

Eggs of the elm leaf beetle Xanthogaleruca (Pyrrhalta) luteola (Colcoptera, Chrysomelidae) experience heavy parasitization by the egg parasitoid *Oomyzus gullerucue* (Hymenoptera, Eulophidae) in the field. We investigated the tritrophic interactions between the elm leaf beetle, its host plant, the field elm (Ulmus minor = U. campestris = U. procera), and its egg parasitoid. We found that oviposition of X. luteola induces the elm leaves to release volatiles that attract the egg parasitoid (induced symonones). Studies on the mechanism of this synomone induction revealed that neither intact elm leaves nor leaves damaged by feeding beetles released attractive volatiles. But oviduct secretion of X. luteola which glues the eggs onto the leaves was proved to elicit the emission of the attractive synomones. The eggs are always glued onto a small epidermal wound, which is inflicted to the lower leaf surface by the female prior to oviposition. The oviduct secretion only functions as synomone elicitor when applied onto such a wound. Scratching a leaf by a scalpel to mimic the wound and application of oviduct secretion results into the release of synomones. Our studies on the specificity of the synomone induction show that the attractiveness of induced volatiles was specific both for the Ulmus species and the herbivore species depositing eggs. Further steps in the egg parasitoid's host location process are mediated by kairomones from host faeces and egg masses. These kairomones were also shown to be host specific, since O. gallerucae clearly discriminates between host and non-host (e.g. *Galerucella lineola*) cues during host finding and host recognition. The tritrophic system studied here is characterized by oligophagous and monophagous relationships on the second and the third trophic level. These intrinsic characteristics of the tritrophic system might have been a prerequisite for the development of such selective responses of a parasitoid towards specific infochemicals and of the specific indirect defense reaction of the plant to oviposition of the chrysomelid host.

Index terms: elm leaf beetle, Oomyzus gallerucae, oviposition behavior, synomones

[0698] MASS TRAPPING EXPERIENCE OF CERATITIS CAPITATA (DIPTERA: TEPHRITIDAE) WITH SYNTHETIC FEMALE FOOD ATTRACTANTS IN A CITRUS ORCHARD (MALLORCA, SPAIN)

M.A. Miranda, R. Alonso, C. Blasco & A. Alemany, Univ. of Balearie Islands. Cra. Valldemossa km 7,5, CP: 07017, Palma de Mallorca, Spain, E- mail: analem@clust.uib.es

Mass trapping of *Ceratilis capitata* females has been carried out in an isolated plot of orange trees in Mallorca. 125 traps baited with synthetic food attractants (putrescine, ammonium acetate and trimethylamine), and 10 traps baited with Trimedlure for male monitoring, were used. This experience was begun with the first adult emergences at the beginning of summer (June '99) and ended with the disappearance of the Mediterranean fruit fly population, which occurred with the arrival of the first cold spells in November. Catches were monitored on a fortnightly basis. The aim was to check whether, with this method, it was possible to control the pest until harvest-time - due in the second fortnight of August. Results showed an adequate control of the pest up until that time, since the oranges were harvested without signs of being attacked. However, the presence of several of the host species Ficus carica, brought about a subsequent notable increase in the catches, as a consequence of the high infestation produced when the figs ripened at the end of August. Whereas mass selective female trapping may be a control strategy which brings about the elimination of or at least a reduction in insecticide treatment, in this experience it can be seen that figs cause the pest to multiply. In Mallorca, this is a very important fact as these fruit trees are scattered all over the island, and the figs are not usually collected, thus making them a considerable egg-laying source for C. Capitata. No differences were found between synthetic food attractants and Trimedlure as far as the detection capacity for first emergences are concerned. We discuss the causes determining a change in the sex ratio of flies captured with synthetic food attractants, as well as with Trimedlure, throughout the experience

Index terms: Ceratitis capitata, mass trapping, synthetic attractants

[0699] LUFENURON EFFICIENCY EVALUATION TO CONTROL THE MITE ACERIA GUERRERONIS THAT CAUSES NECROSIS IN THE COCONUT PALM

J.O.T. Moreira¹ & M. R. Lavorenti², ¹ Dept. de Tecnol. e Ciências Sociais/Univ. do Est. da Bahia, C. Postal 171, CEP 48900-000 Juazeiro-BA-Brasil, E-mail: osmateles@bolc.com.br; ² Dept. Técnico da Novartis Biociências S.A. – R. Domingos Ferreira, 222 - sala 101 CEP 51.020-030 Recife-PE-Brasil. E-mail: cleber.oliveira@cp.novartis.com

Among the mites associated to the coconut crop, one of the most important ones is Aceria guerreronis, because of the damage that it causes in young plants and fruits producing necrosis by its feed activity. The chemical control associated to other methods like better crop management, natural biologic control, can be adopted to keep this specie in an acceptible population level. This work evaluated the Lufenuron (MATCH CE) efficiency to control *A. guerreronis* in irrigated green dwarf coconut crop, *Cocos nucifera*, and was done from August to October 1999 in two farms in Nilo Coelho Senator Irrigated Perimeter, San Francisco Valley, Petrolina – Pernambuco – Brazil. The results showed that MATCH CE, 80 ml/100 I water, was efficient to control the mite at the time that the flower begin to open and compared with the standard MARSHAL 200 SC 50 ml/100 I water.

Index terms: Eriophyidae, coconut, Aceria guerreronis, lufenuron

[0701] ABAMECTIN EFFICIENCY EVALUATION TO CONTROL THE MITE ACERIA GUERRERONIS THAT CAUSES NECROSIS IN THE COCONUT PALM

J.O.T. Moreira¹ & M. R. Lavorenti², ¹ Dept, de Tecnol, e Ciências Sociais/Univ. do Est. da Bahia, C. Postal 171, CEP 48900-000 Juazeiro-BA-Brasil, E-mail: osmateles@bol.com.br; ² Dept. Técnico da Novartis Biociências S.A. – R. Donningos Ferreira, 222 - sala 101 CEP 51.020-030 Recife-PE-Brasil. E-mail: cleber.oliveira@cp.novartis.com.

Among the mites associated to the coconut crop, one of the most important ones is Aceria guerreronis, because of the damage that it causes in young plants and fruits producing necrosis by its feed activity. The chemical control associated to other methods like better crop management, natural biologic control, can be adopted to keep this specie in an acceptible population level. This work evaluated the Abamectin (VERTIMEC 18 CE) efficiency to control A. guerreronis in irrigated green dwarf coconut crop, Cocos nucifera, and was done from August to October 1999 in two farms in Nilo Coelho Senator Irrigated Perimeter, San Francisco Valley, Petrolina – Pernambuco – Brazil. The results showed that VERTIMEC 18 CE, 75 mi/100 I water, was efficient to control the mite at the time that the flower begin to open and compared with the standard MARSHAL 200 SC 50 mi/100 I water.

Index terms: Eriophyidae, coconut, Aceria guerreronis, abamectin

[0700] DIAFENTIURON EFFICIENCY EVALUATION TO CONTROL THE MITE ACERIA GUERRERONIS THAT CAUSES NECROSIS IN THE COCONUT PALM

J.O.T. Moreira¹ & M. R. Lavorenti², ¹ Dept. de Tecnol. e Ciências Sociais/Univ. do Est. da Bahia, C. Postal 171, CEP 48900-000 Juazeiro-BA-Brasil, E-mail: osmatels@bol.com.br; ² Dept. Técnico da Novartis Biociências S.A – R. Domingos Ferreira, 222 - sala 101 CEP 51.020-030 Recife-PE-Brasil. E-mail: cleber.oliveira@cp.novartis.com.

Among the mites associated to the coconut crop, one of the most important ones is Aceria guerreronis, because of the damage that it causes in young plants and fruits producing necrosis by its feed activity. The chemical control associated to other methods like better crop management, natural biologic control, can be adopted to keep this specie in an acceptible population level. This work evaluated the Diafentiuron (POLO 500 PM) efficiency to control A. guerreronis in irrigated green dwarf coconut crop, Cocos nucifera, and was done from August to October 1999 in two farms in Nilo Coelho Senator Irrigated Perimeter, San Francisco Valley, Petrolina – Pernambuco – Brazil. The results showed that POLO 500 PM, 150 g/100 l water, was efficient to control the mite at the time that the flower begin to open and compared with the standard MARSHAL 200 SC 50 ml/100 l

Index terms: Eriophyidae, coconut, Aceria guerreronis, diafentiuron

[0702] VOLATILE BIOACTIVE CONSTITUENTS FROM THE FLOWERS OF TAGETES ZYPAQUIRENSIS (ASTERACEAE)

 B. Moreno-Murillo,¹ B. Téllez,² A. Ortiz ³ & M. Suárez ⁴, ¹⁴ Departamento de Química-Facultad de Ciencias, Univ. Nacional de Colombia, e-mail: bmorenom@ciencias.ciencias.unal.edu.co AA27586, Santafé de Bogotá, DC1, Colombia; ² Facultad de Agronomía, Univ. Nacional de Colombia, A.A 27586, Santafé de Bogotá, DC 1, Colombia. ³ Centro Nacional de Investigaciones de Café CENICAFE, Chinchiná A. A. 2427 Manizales, Caldas, Colombia.

Tagetes zypaquirensis is a medicinal, perennial shrub, which occurs through temperate areas from the Colombian Andean region(1,2) From other Tagetes species, α -therthienyl derivatives with insecticide properties have been isolated, and today those compounds are commercialized in USA and Canada. Preliminary olfactometric assessment of the ethereal extract of the flowers, have shown notable attractive effects on the coffee borer adults females (Hypothenemus hampei Ferrari (Scolytidae:Coleoptera). The volatile fraction by HRCG and HRGC-MS was analyzed and the identification was made by comparative dihydrotagetone, cis-tagetone, fatty acids and their ethyl esters among other compounds. We are grateful to Colciencias and DIB–Universidad Nacional de Colombia for financial support and Cenicafé for their collaborative work.

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Morales, G. -1998 Las Plantas Medicinales en el Jardín Botánico de Bogotá 10. Keywords Hypothenemus hampei, Olfactometry, HRGC and HRGC-MS. [0703] SUSCEPTIBILITY TESTS OF 4,5-DIIDROPIPERLONGUMININA ISOLATED FROM *PIPER TUBERCULATUM* SEEDS ON VELVETBEAN CATERPILLAR

A.T. Murata¹, H.M.D. Navickiene³, J.E.Miranda², V.S. Boizani³, M. Furlan³, M.J. Kato⁴, G.E.D. Paredes⁵ & S. A. De Bortoli², ¹Dept. de Biologia, Fac. Filosofia, Ciências e Letras de Ribeirão Preto, Univ. de São Paulo, Av. dos Bandeirantes, 3900, 14040-901, Ribeirão Preto, SP, Brasil (Bolsista Fapesp), E-mail: murataat@asbyte.com.br; ²Dept. de Fitossanidade, , Unv. Estadual Paulista, 14884-900, Jaboticabal, SP, Brasil; ³Dept. Química Orgânica, Instituto de Química, Unesp, Araraguara, SP, Brasil; ⁴Dept. Química Fundamental, IQ, USP, SP, Brasil; ³FCB, Univ. Nacional Pedro Ruiz Gallo, Lambayeque, Peru.

In the family Piperaceae, the most important genus is Piper, whose species are especially diffused in tropical area, particularly the amazon area. Some of then are being cultivated until commercially for used like alimentary seasonings and to elaborate pharmochemicals products. Some studies indicate that the genus Piper has insecticidal and molluskcidal properties. Besides, the specie Piper tuberculatum Jacq, is known as " pepper-long" and, it has been used in Parafba State, Brazil, as sedative and antidote for snakes bites. In this way, the present work was carried out to evaluated the insecticide activity of the amide 4.5-diidropiperlongulina extract from P. tuberculatum, on Anticarsia gemmatalis Hueb. 1818 (Lepidoptera: Noctuidae). P. tuberculetum was collected in Manaus, Brazil, in July, 1998. The seed (24.33 g) were extracted (2x) in CH₂Cl₂:MeOH (2:1). The first extract (2.00 g) was submitted on CC of silica gel being used hexane: etil acetate in polarity gradient, supplying the fraction 13, that, after wash in CHCl3, it took to the isolation of the amide. The relationships dose-answer was compared by the Probit analysis to determine the susceptibility rate, measures in terms of the ia/insect mg. The trials consisted of topical applications in the following concentrations 0.0; 0.04mg; 0.06mg; 0.08mg; 0.10mg; 0.12mg and 0.14mg of i.a. /insect. In relation to dose-answer obtained by the analysis of Probit analyses, it could be observed that 4,5-diidropiperlongulina presents great insecticidal potential.

Index terms: amide, Anticarsia gemnunatalis, piper-long, insecticide.

[0705] INCREASE OF TRAP CATCHES BY A COMBINATION OF MALE SEX PHEROMONES AND FLORAL ATTRACTANT IN LONGHORN BEETLE, ANAGLYPTUS SUBFASCIATUS (COLEOPTERA: CERAMBYCIDAE)

K. Nakamuta¹, T. Gotoh², M. Tokoro¹ & T. Nakashima¹, ¹Forest Biol. Div., Forestry & Forest Prod. Res. Inst. (FFPRI), P. O. Box 16, Tsukuba Norin Kenkyu Danchi-nai, 305-8687, Tsukuba, Japan, E-mail: nakamuta@ffpri.affrc.go.jp; ²Tohoku Res. Center, FFPRI, Nabeyashiki 72, Shimokuriyagawa, Morioka, 020-0123, Japan

Anaglyptus subfasciatus (Coleoptera: Cerambycidae) is one of the most harmful insect pests of the Japanese cedar, Cryptomeria japonica, and the Japanese cypress, Chamaecyparis obtusa, the most abundant tree species of forest plantations in Japan, Females of the beetles lay their eggs on the dead twigs of the cedar or the cypress and the larvae bore into the twigs and migrate further into the tree trunk. Feeding by the larvae on sapwood followed by fungal infection causes discoloration and decay of the wood, resulting in a decrease of the commercial value of timbers. Since A. subfasciatus males and females were known to congregate on several species of flowers for feeding, floral scents and their structural similarities have been screened both in the laboratory and in the field. Methyl phenylacetate has been demonstrated as the most attractive and highly specific to A. subfasciatus and has been used as the most reliable floral attractant for A. subfasciatus in practice. A. subfasciatus females were attracted to males in a wind tunnel and that a male-specific cuticular structure in the pronotum seems to be an organ of pheromone excretion. Furthermore, the male-released sex pheromone constituents of the beetle are identified as a 7:1 blend of (R)-3-hydroxy-2-hexanone and (R)-3-hydroxy-2octanone. We have observed that the beetles were attracted to the trap baited with floral attractant alone, but they walked around the tree trunks or logs near the trap. Therefore we tested whether a combination of male sex pheromone constituents and the floral attractant improved pinpoint location of the beetles and increased the trap catches. In the present paper we report that the trap catches of the female beetles were increased by a combination of male sex pheromone constituents and the floral attractant.

Index terms: attraction, Methyl phenylacetate, (R)-3-hydroxy-2-hexanone, (R)-3-hydroxy-2-octanone

[0704] INFLUENCE OF EXPERIENCE ON THE OLFACTORY RESPONSES OF A PREDATORY BEETLE, *TROGOSSITA JAPONICA* (COLEPTERA: TROGOSSITIDAE) TO VOLATILES OF ITS PREY-HOST TREE COMPLEX

K. Nakamuta¹, P. Usha Rani. ^{1, 2}, M. Tokoro¹ & T. Nakashima¹, ¹Forest Biol. Div., Forestry & Forest Prod. Res. Inst., P. O. Box 16, Tsukuba Norin Kenkyu Danchi-nai, 305-8687, Tsukuba, Japan, E-mail nakamuta@ffpri.affrc.go.jp; ² Hort Res., Mt. Albert Res. Center, P. O. Box 92169, Auckland, New Zealand

The predatory beetle, Trogossita japonica (Coleoptera: Trogossita), feeds on wood boring insects in the forests. The Japanese pine sawyer, Monochamus alternatus, (Colcoptera: Cerambycidae), that transmits the pine wood nematode, Bursaphelenchus xylophilus, the pathogen of the pine wilt disease of Japanese red pines (Pinus densiflora) and black pines (Pinus thunbergii) is one of its prey species. M. alternatus utilizes monoterpenoids, especially alpha-pinene, which are emanated from nematode-infected pine trees, to orientate towards the host trees for oviposition. For T. japonica, it is advantageous to adopt a similar tactic as M. alternatus to locate the oviposition site, since the larvae of T. japonica feeds on the immature stages of M. alternatus in pine forests. We, therefore, analyzed the olfactory response of T. japonica to certain monoterpenoids in an open Ytrack olfactometer and also compared the responses between field-collected (experienced) beetles and artificially reared (inexperienced) beetles. Both experienced and inexperienced beetles showed strong responses to alpha-pinene, beta-pinene and a combination of alpha-pinene and EtOH. However, the time taken to locate an odor source by experienced beetles was much shorter than the inexperienced beetles. To delineate the role of pre-exposure to the prey-host tree odor complex by the predator, we further analyzed the responses of the artificially reared beetle, which have had an experience of feeding a prey with pine logs. This had a positive effect on the beetles and the preexposure to the pine volatiles certainly enhanced their attraction to the odors. These predators are faster in orienting towards the volatiles, as evident by the lesser time taken to locate an odor source than the inexperienced beetles, thus, demonstrating that the experience modifies the odor location in T. japonica.

Index terms: Terpenoids. Trogossita juponica, pine, predator, alpha-pinene.

[0706] SUITABILITY OF SEVERAL RUTACEOUS PLANTS FOR A PAPILIONID BUTTERFLY, PAPILIO POLYTES

T.Nakayama¹, T.Murakami², K.Honda², N.Hayashi² & K.Matsuda¹, ¹Laboratory of Insect Science and Bioregulation, Graduate School of Agriculture, Tohoku University, Sendai 981-8555, Japan, E-mail:tadanobu@bios.tohoku.ac.jp; ²Division of Environmental Sciences, Faculty of Integrated Arts and Sciences, Hiroshima University, Higashihiroshima 739-8521, Japan.

Papilio polytes is a rutaceae-feeding papilionid butterfly inhabiting Southeast Asia and Southwestern Islands of Japan. We have examined the affinity of the butterfly to two major host plants, Toddalia asiatica(TA) and Citrus deperessa(CD), and to other potential hosts: Murraya paniculata(MP), Evodia melifolia(EM), Fagara ailanthoides(FA), hosts: Murraya paniculata(MP), Evodia melifolia(EM), Fagara ailanthoides(FA), hellodendron amurense(PA), and Orixa japonica(OJ). [Latval performance and oviposition preference] Larval survivorships (1st and 5th instars) as an estimate of fitness on and oviposition responses to these plants were evaluated. While larvae performed well on TA, CD, FA, and PA, and all these plants were acceptable to ovipositing females, EM was found not to be very suitable for the larval growth and females showed much less preference for the plant. In contrast, both larvae and females almost completely rejected MP and OJ.[Oviposition deterrent in MP] Since preliminary experiments suggested the presence of oviposition deterrent(s) in MP, we attempted to identify active compound(s) from the MeOH extract(1) of MP, which, in the natural habitat of *P. polytes*, is abundant and grows sympatrically together with TA, the most important host plant. The extract(1) was separated by solvent partition into four fractions:CHCl3(2), i-BuOH(3) and water(4). Strong deterrent activity resided in Fr.4, from which one of active compounds was isolated by column chromatography and preparative TLC. The compound, identified as trigonelline by its FAB-MS and ¹³C-NMR spectra, showed noticeable deterrent effect on egg-laying. Index terms; Papilio polytes, Rutaccae, Murraya paniculata, trigonelline, oviposition deterrent

[0707] ODOUR-MEDIATED INDIRECT INTERACTIONS IN FOOD WEBS

<u>A. Pallini¹</u>, A. Janssen² & M. W. Sabelis², ¹Department of Animal Biology, Federal University of Viçosa, 36571-000, Viçosa MG, Brazil, E-mail pallini@mail.ufv.br; ²Section Population Biology, University of Amsterdam, Kruislaan 320, 1098 SM, Amsterdam, The Netherlands, E-mail janssen@bio.uva.nl.

Arthropods use odours associated with the presence of their food, enemies and competitors while searching for patches of food. Responses to these odours therefore determine the spatial distribution of animals, and are decisive for the occurrence and strength of interactions among species. We studied odour-mediated indirect interactions in an artificial arthropod food web that occurs on eucumber plants in greenhouses where biological control is applied. We investigated indirect effects in very simple subsets of this food web, considering (a) plant-mediated indirect interactions between two herbivores, the two-spotted spider mite Tetranychus urticae and the western flower thrips Frankliniella occidentalis, (b) responses of the two herbivores mediated by their predators (the phytoseiid mites Phytoseiulus persimilis, Neoseiulus cucumeris, and N. californicus) and (c) interactions between predators mediated by their prey. We found that odour-mediated indirect interactions are an important organising force in this arthropod food web. Spider nites and thrips can interact indirectly both through their common host plants and through predators, whilst predators may interact indirectly through prey. Indirect interactions as these may produce effects in food webs that are as important as those of direct predatorprey interactions, which may cause both positive and negative effects on biological control of herbivores. We will argue that the importance of odour-mediated indirect interactions in determining community-level interactions both in artificial and in natural food webs should not be underestimated.

Index terms: Frankliniella occidentalis, Tetranychus urticae, Phytoseiulus persimilis, Neoseiulus cucumeris, behavioural responses.

[0709] LABORATORY AND FIELD TEST OF SEX PHEROMONE OF SPODOPTERA EXIGUA (LEPIDOPTERA: NOCTUIDAE)

<u>A. D. Permana</u>¹ & Rostaman², ¹Department of Biology, Institut Teknologi Bandung, Ganesa 10, Bandung 40132, Indonesia. e-mail : agus@bi.itb.ac.id ; ²Polytheenic of Agriculture, Nusa Cendana University, Kupang. Indonesia.

Spodoptera exigua is one of the important pests in shallot. Test of sex pheromone of S. exigua was carried out at the laboratory and shallot field. The sex pheromone was extracted from abdominal tips of the virgin female moth 2-4 days old. Based on GC analysis, the crude extract at least contains Z-9 tetradecenol (Z9-14OH), Z-9 tetradecenyl acetate (Z9-14Ac) and Z9E12 tetradecadienyl acetate (Z9E12-14Ac). These components indicated as same as the commercial sex pheromone (Ugratas). The result of laboratory test using Y-olfactometer showed that the male moths give positive responses to the standard sex pheromone (blend of Z9-14OH : Z9E12-14Ac; 10:1), and statistically not different with the responses by the male moth to the virgin female. In field test, the male moth taraped by all sex pheromone tested, and Ugratas showed the best response. Index terms: Spodoptera exigua, Z-9 tetradecenol, Z-9 tetradecenyl acetate, Z9E12 tetradecadienyl acetate.

[0708] INFLUENCE OF PRE- AND POST- IMAGINAL EXPERIENCE ON HOST-FINDING BEHAVIOR OF *HYPOTHENEMUS HAMPE*I

<u>R.C. Pereira</u>, A. M. Viana Bailez & J. O. G. de Lima, Department of Plant Protection, Universidade Estadual do Norte Fluminense, Campos, RJ 28015-620, Brazil, E-mail rozimarcp@uol.com.br.

The Coffee Berry Borer (CBB), Hypothenemus hampei (Ferrari, 1867) (Coleoptera: Scolytidae), stands out as one of most the important pest of the coffee, representing a threat to for the viability coffee cultivation in many countries. CBB attacks the fruits in the several development al stages: green, mature or dry fruits. It is known that visual characteristics play an important role in host finding of CBB. At long distances, it is probably attracted by color and the characteristic shine of the coffee bean at short distances the color, the size and the appearance of the fruit could be the primary factors in selection of the host. This work evaluated the visual cues for locating fruit. These were investigated under laboratory conditions. The tests under takern between the months May and July 1999. Adult females were obtained from grains of coffee (Coffea arabica) in three different maturation stages (dry fruit - black color; fruit cherry - red color and green fruits - green color), collected in Viçosa - Minas Gerais. The preference of CBB originating from the three stages was evaluated (green, red and black colors) for natural and artificial fruits of coffee (green, yellow, red and black), that were suspended by means of pins and fastened in the bottom of an arena divided in four quadrants. After three hours the preference of CBB was evaluated by noting positon of the insect or penetration of the fruit. It was shown that there was a preference for boring into the same color as the original fruit for all the insects tested . In the natural fruits the percentage of females on the fruit, was superior to the percentage in the quadrant. Insect takem from green fruits, had a clear preference for green fruits which was also the case for insects from other colors, and natural fruits. The yellow color was, least attractive.

Index terms: Search behavior, visual incentives, Hypothenemus hampei, Coffee Berry Borer, Scolytidae

[0710] CONVENTIONAL SAMPLING PLAN FOR VECTORIAL INSECTS OF VIROSES, PREDATORS AND PARASITOIDS IN TOMATO

<u>M. Picanco¹</u>, M. R. Gusmão¹, D.J.H. da Silva² & R.N.C. Guedes¹, ¹ Dept. de Biol. Animal, ²Dept. de Fitoteenia, Univ. Fed. de Viçosa, CEP 36571-000, Viçosa, MG, Brazil, E-mail picanco@mail.ufv.br.

This research was accomplished from February to July, 1999 in Coimbra and Viçosa, State of Minas Gerais, Brazil and it aimed to determine a conventional sampling plan for vectorial insects of viroses, predators and parasitoids in tomato. The densities of the Mitelly Remisia tabaci (Homoptera: Aleyrodidae), greenbugs Myzus persicae and Macrosiphum euphorbiae (Homoptera: Aphididae), thrips Frankliniella spp. (Thysanoptera: Thripidae), predators and parasitoids in eight squares of four commercial fields of tornato were evaluated. The determination of the best sampling technique and sample size was made with basis in the variance and relative precision. After the best sampling technique and size of the sampling unit, were determined the numbers of samples to compose conventional sampling plans with precision of 5, 10 and 25%. The basal part of the canopy of the tomato plant was the most representative place for virose vectors, parasitoids and predators sampling, simultaneously, being the composed samples of two leaves the most precise sample size. For a the numbers of whitefly nymphs the direct count on the leaves was the most precise technique. However, in the whitefly adults sampling, greenbugs, thrips, predators and parasitoids the beat of leaves in tray was the most precise technique. In relationship to the number of samples necessary for sampling the populations of viroses vectors, predators and parasitoids, 65 samples were necessary. Index terms: Bemisia tabaci, Myzus persicae, Macrosiphum euphorbiae, Frankliniella

[0711] ROLE OF NEZARA VIRIDULA (HEMIPTERA:PENTATOMIDAE) ON INDUCING THE PRODUCTION OF FLAVONOID IN SOYBEAN GENOTYPES

G.C. Piubelli^{1,5}, LC Arruda², J.C. Franchini³, F. M. Lara¹ & C.B. Hoffmann-Campo^{2,4}, ¹ Dept. de Fitossanidade (FCAV/Unesp), Via de Acesso Prof. Paulo Donato Castellane, Km 05, 14870-000, Jaboticabal, SP, Brasil; ² Pronex (Núcleo Manejo Integrado de Pragas); ³ Bolisitat recém-doutor CNPq; ⁴ Embrapa Soja, C. Postal 231, CEP 86001- 970, Londrina, PR, Brasil. ⁵ Present address: Universidade Federal do Paraná, Departamento de Zoologia, Caixa Postal 19020, CEP 81531-900, Curitiba, PR, Brasil Email: giorla@enpso.embrapa.br

Induced response to insect damages can result in chemical alteration in plants. The ability of Nezara viridula to induce the production of flavonoids in seeds of soybean genotypes ('BR-16', 'IAC-100', PI 227687, PI 229358, PI 274454) was investigated at greenhouse conditions. Cages with four stink bugs were placed on soybean plants, during 18 hours. Soybean pods were collected 72 hours after stink bugs have been removed and the damaged parts were identified up ut and ground. A sample of 0,100 mg from each genotype was homogenised with 0,5 ml of 80% methanol (MeOH). After centrifugation, the supernatant was dried in N2, redissolved in 100 µL 80% MeOH and an aliquot of 20 µL were injected in HPLC (High Performance Liquid Chromatograph) for flavonoid analysis. The genotype PI 227687 damaged by N. viridula presented the highest concentration (0.35 mg/nl) of daidzin (daidzein 7-0-glucoside); the lowest concentration of isoflavone was observed in PI 229358 (0.03 mg/ml). The same tendency was observed with genistin (genistein 7-O-glucoside); PI 227687 presented 0.14 mg/ml, PI 274454, 0.03 mg/ml and PI 229358, 0.04 mg/ml of genistin. In general, genotypes damaged by stink bugs, produced higher isoflavones contents (daidzin and genistin), compared to controls (without stink bug damage). However, after being damaged by stink bug, PI 274454 and PI 229358 produced less genistin than the other genotypes and no difference in concentration between damaged plants and non-damaged was observed. N. viridula increased concentration or induced daidzin and genistin productions in PI 227687 seeds. Therefore, further studies must be carried out to elucidate their role on soybean defence against stink bugs.

Index terms: resistance, green stink bug, daidzin, genistin.

[0713] RESEARCH DIRECTIONS OF USING THE SYNTHETIC SEXUAL PHEROMONES ON FIELD CROPS IN ROMANIA

<u>C. Popov</u>¹ & I. Rosca², ¹Research Inst. for Cereals and Industrial Crops, 8264 Fundulea, N. Titulescu Str., 1, Calarasi District, Romania, E-mail:fundulea@cons.incerc.ro; ² Univ. Agricultural Sciences and Veterinary Medicine, Ave. Marasti 59, Bucharest, Romania.

The paper presents the results obtained in Romania during 1982-1998 in field trials with pheromone formulations, at Fundulea and different other agricultural research stations, for identifying of specificity and effectiveness of sexual pheromones synthesized in Romania. for species: Agrotis segetum, Agrotis exclamationi, Cnephasia pasiuana and Ostrinia nubilalis, (pests of wheat and corn), for Autographa gamma, Mamestra oleracea, Amathes c-nigrum, Discestra trifolii, for forage plants, Plutella maculipennis for rape, Etiella zinckenella for soybean. Methods. It was used pheromone traps type F-1 in 2-4 replicates, at 50-m distance between traps and a glue based on polyizobuthilen. Generally, pheromonal lures were changed once/month, and adhesive parts twice or once/month-Registrations were done with changing of adhesive parts, being noted number of captured target males and of others lepidopterous species. It was registered pheromone efficacy (number of target males species captured/trap) and specificity (percentage of target species and other different lepidopterous species, macrolepidopterous and microlepidoptererous). Results. Sexual synthesis pheromones for studied species were specific and efficient, captured number of target species has depended on year and locality and it is possible to use pheromones in establishing of pest spreading, flight curve and pest biology in generally. New spreading areas for *Cnephasia pasiuana* have been established. There is a relatively good enough formulation of Z and E sexual synthetic pheromone for Ostrinia nutrition good onlogin formation of D and D ortan of January photometer of mutual of mutual and it was stated that in Romania Z pherotype is predominant. Control of European Corn Borer by mass trapping of males or male disorientation has failed in small cornfield surrounded by forest, but pheromones are helpfulness in a future integrated control system of this pest by determination of releasing Trichogramma spp., or males with inherited sterility. Conclusions. Sexual synthesis pheromones for studied species were specific and efficient. Pheromones traps gave essential information for Insect Pest Management, referring to the pest area, level of pest population and dynamic of pest on area and during the year. These make possible reducing, in the future, using of pesticide, minimal effects on useful organisms, reducing of chemical treatments which will reduce risk of developing of pesticide resistant pest populations and especially a better timing for chemical control, which mean time and money economy.

Index terms. Lepidoptera, synthetic sexual pheromones, field trials.

[0712] BEHAVIOURAL AND ELECTROPHYSIOLOGICAL RESPONSES OF SILVER Y MOTH, AUTOGRAPHA GAMMA (LEPIDOPTERA: NOCTUIDAE), TO FLORAL VOLATILES

<u>D. Plepys</u>¹, F. Ibarra², C. Löfstedt¹, B. Hansson¹ & W. Francke², ¹Department of Ecology, Lund Univ., S-223 62 Lund, Sweden; ²Institute of Organic Chemistry, Univ. of Hamburg, Martin-Luther-King-Platz 6, D-20146 Hamburg, Germany.

Flowers produce volatile chemical compounds that attract pollinators. Silver Y moth Autographa gamma in nature is observed to be attracted to a variety of flowers. Attractivity of flowers from five different families, *Platanthera bifolia* (Orchidaceae), *Trifolium pratense* (Fabaceae), *Cirsium arvense and Centaurea scubiosa* (Asteraceae), Saponaria officinalis (Caryophyllaceae), Nepeta faasseni (Labiatae), and their headspace extracts to Autographa gamma was tested in a wind tunnel bioassay. Headspace samples from flowers were collected and analysed by GC-EAD. Both female and male moths were attracted to plant species, listed above, except Nepeta faasseni, and respective headspace extracts. Antennae responded to 6-15 compounds from each extract. Both male and female antennae responded to the same conpounds. There was no a single electrophysiologically active compound found in all the plant species. Benzyl benzoate was found in four of five attracted to genese. *Platanthera bifolia, Trifolium pratense, Cirsium arvense* and *Saponaria officinalis*, Methyl salicylate was present in *Platanthera bifolia* and *Cirsium arvense*. The rest of compounds were unique for each species. Attractivity of electrophysiologically active compounds was tested in a wind tunnel both individually and in mixtures. Single cell recordings of the EAD active compounds are in progress. Results will be presented. Index terus: floral volatiles, nectar foraging

0714] HABITUATION OF JAPANESE BEETLES (COLEOPTERA: SCARABAEIDAE) TO AZADIRACHTIN APPLIED AS A FEEDING DETERRENT

D. A. Potter¹, D. W. Held¹ & T. Eaton¹, Dept. of Entomology, Univ. of Kentucky, S-225 Agric. Sci. Bldg. N., Lexington, KY 40546-0091, USA, E-mail dapotter@ca.uky.edu.

The Japanese beetle, Popillia japonica, is an polyphagous scarab whose grubs feed on roots of turf and pasture grasses, and whose adults are serious pests of shade trees, ornamental shrubs, flowers, tree and small fruits, and garden crops in the eastern United States. Concern about hazards of pesticide use has stimulated interest in less-toxic alternatives, including botanical repellents, for managing this introduced pest. Azadirachtin is a bitter and biologically-active limonoid derived from seeds of the neem tree, Azadirachta indica. Several azadirachtin-based products are labeled as repellents for use against Japanese beetles attacking shade and ornamental plants. We tested the potential for the beetles to become desensitized to one such product following intermittent or prolonged exposure to residues on linden, Tilia cordata, a preferred host plant. Linden leaves were spraved with 3% azadirachtin (Azatin XL) at label rate (1.25 ml/liter) or 0.25 label rate and allowed to dry. Leaf discs from treated or control leaves were exposed to beetles in no-choice or choice tests. Particular beetles were tested for 4 h per day, over 4 consecutive days, and relative consumption of treated or untreated foliage was measured. Potentially confounding effects of hunger were mitigated by allowing beetles to feed on untreated foliage between each 4-h trial. In another experiment, groups of beetles were conditioned by confining them for 24 h with either treated foliage, untreated foliage, or a mixture of both types of leaves. Relative sensitivity to azadirachtin was then tested as before. Both rates of azadirachtin significantly deterred feeding by naïve beetles, but deterrence declined upon successive exposures. In no-choice tests, beetles became desensitized to the lower rate, but not to the higher rate. Beetles conditioned for 24 h with untreated foliage, or the mixed treatment, were repelled by azadirachtin, whereas those conditioned with treated leaves were not. This study suggests that Japanese beetles may habituate to azadirachtin-based repellents used for plant protection.

Index terms: Popillia japonica, neem, desensitization, feeding repellent

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[0715] AZADIRACTA INDICA AND BOUGAINVILLEA SPECTABILIS EXTRACTS TO CONTROL VELVETBEAN CATERPILLAR

E. L. V. Primiano¹, H.V. Vescove², P. Fortes², L. Vieira², G. Bissoli², S. A. De Bortoli², J. E. Miranda⁴ & A. T. Murata⁴, ¹CREUPI, Fund. Pinhalense de Ensino, Av. Helio vergueiro Leite s/n, 13990-000 Espírito Santo do Pinhal, SP, ²Dept. de Fitossanidade, Univ. Estadual Paulista, 14884-900, Jaboticabal, SP, Brasil; ³Dept. de Biologia, Fac. Filosofia, Ciências e Letras de Ribeirão Preto, Univ. de São Paulo, 14040-901, Ribeirão Preto, SP, Brasil (FAPESP fellowship), E-mail: murataat@asbyte.com.br.

The tetranortripenoid Azadirachtin is the principal constituent from the neem tree Azadiracta indica (A. Juss), and it is the main biologically active compound of neem seed insecticides. This semiochemical has strong antifeedant activity against many insects, which is supplemented also by marked insect growth regulatory and sterilizing effects. The objective of this work was comparing the use of the aqueous extracts of A. indica and Bougainvillea spectabilis to the chemical control of Anticarsia gemmatalis larvae. This work was conducted in the Laboratory of insect Biology located at University of São Paulo State, Jaboticabal, and the neem and B. spectabilis leaves were collected from trees in the field. The leaves were triturated in blender in the proportion of 5 L/water: 0.5 Kg/leaves. Was used caterpillars of third instar and 8 treatments (control water; control with pyrethroid insecticide; neem; B. spectabilis) sprayed on the leaves and insects. It was made 10 repetitions with 5 insects each, and verified mortality, larvae and pupae development and pupae weight. It was observed that the extracts of neem sprayed on the leaves (30%) and B. spectabilis (38%) sprayed on insects caused larger mortality: neem sprayed on the leaves showed the largest larvae and pupae period and smallest pupae weight. It can be concluded that neem and B. spectabilis have insecticide potential to A. gemmatalis.

Index terms: Anticarsia gemmatalis, neem, insect control

[0717] FEMALE SEX PHEROMONE OF CASTNIA LICUS (LEPIDOPTERA:CASTNIIDEA): IDENTIFICATION AND FIELD APPLICATION

L.M.C. Reboucas^{*1}, M. Socorro Caraciolo¹, F.A.C. Griepink², A. S. De Bruin², F.A.O. Paulino¹, C.A. Monte¹, G. C. Santos Jr. ¹ & A. E. G. Sant'Ana¹, 1-Depto. Quimica-CCEN-UFAL-Tabuleiro dos Martins-57072-970 - Maceió - AL-Brasil 2-Research Institute for Plant Protection IPO-DLO-Binnenhaven 5 - 6700 GW-Wageningen The Nerthelands. Finacial support: Cooperativa dos Usineiros do Estado de Alagoas-NATT e ASSUCAL

The giant moth borer, Castnia licus Drury, 1770 (Lepidoptera: Castniidae) is considered one of the most important pest of sugarcane in Northeast of Brazil, especially in the State of Alagoas and Pernambuco. The larvae of this moth enter the cane from the bottom, close to the root, and then working upward through and gradually excavates a long vertical tunnel (30 to 100 cm). It spends the rest of they life in this tunnel and can survive from some days to 8 months. Hexane extracts of Castnia licus abdominal gland show activity by EAG and GC/EAD. The GC/EAD shows that the compound with the same retention time and mass spectrum of the diunsaturated alcohol 3,13-LEF was active. The four geometric isomers (Z,Z)-3,13; (Z,E)-3,13; (E,E)-3,13 and (E,Z)-3,13 LEF were tested separately by EAG and only (E,Z)-3,13 and (E,E)-3,13 LEF show activity. These compounds are sex pheromone components for many other lepidopteran species. Field experiments so far show fewer attraction of the male adults to the (E,Z) 3,13 LEF isomer. Besides the alcohol 3,13-LEF other compounds were identified in the hexane extract of the C. licus abdominal glands. The total ion chromatogram show by comparison with standards the presence of saturated fatty acids as hexadecanoic and octadecanoic; saturated and unsaturated fatty acids esters as methyl hexadecanoate, methyl 9,12-octadecadienoate, methyl 9-octadecenoate, methyl octadecanoate, ethyl hexadecanoate and n-butyl hexadecanoate. This paper will discuss the identification and the field results. Index terms: EAG, GC-EAD, mass spectrum, giant moth, and sugarcane.

[0716] EFFECT OF ORYCTES RHINOCEROS PHEROMONE (ETHYL 4–METHYLOCTANOATE) DIFFUSION RATE ON THE SIZE OF PEST CATCHES*

R. Purba¹, R. Desmier de chenon^{1,2}, S. Prawirosukarto¹, <u>I-P. Morin²</u> & D. Rochat³, ¹IOPRI, P.O. Box 1103, Medan 20158, Indonesia; ² CIRAD-CP, TA 80 / PS3 Boulevard de la Lironde, 34398 Montpellier Cedex 5, France, e-mail : jean-paul.morin@cirad.fr: ³ INRA, 78026 Versailles Cedex, France. *Research with funding from the EU under INCO project No. RB-IC18CT970199.

Oryctes rhinoceros (Coleoptera, Scarabaeidae, Dynastinae) is one of the most important pests to be considered when replanting coconut and oil palm. Mass trapping with the insect's pheromone (ethyl 4-methyloctanoate or E 4-MO) as an attractant offers new prospects for control. We describe the results of a trial comparing catches obtained with different dispensers in an oil palm plantation (in North Sumatra, Indonesia). The trial covered 163 ha and took place over 15 weeks. Total catches over 14 weeks (week 2 was not considered due to trap thefts) amounted to 11,482 insects (33% males and 67% females). The higher the pheromone dose, the greater were the catches. There was a very good linear relation between log(dose) and the catches: figure 1. Given the current cost of E 4-MO, the highest 2 doses are too expensive to consider their use in plantations. Nevertheless, it can be hoped that synergistic compounds will make it possible to reduce the doses required and consequently the cost price. Mass trapping of O. rhinoceros with synthetic attractants is a very promising control method to reduce pest populations and prevent damage in the early years after planting

Index terms : Replanting, oil palm, rhinoceros beetle, mass trapping, Indonesia



[0718] INTERACTION BETWEEN VISUAL AND OLFACTORY CUES IN THE ASSEMBLING BEHAVIOUR OF THE HAEMATOPHAGOUS BUG TRIATOMA INFESTANS

C. E. Reisenman¹, A. N. Lorenzo Figueiras¹, M. Giurfa² & C. R. Lazzari¹, ¹Lab. de Fisiología de Insectos, Fac. de Cs. Exactas y Naturales, Univ. de Buenos Aires, Ciudad Universitaria, (1428) Buenos Aires, Argentina, E-mail: carolina@bg.fcen.uba.ar; ²Inst. für Neurobiologie, Freie Universität Berlin, Königin-Luise-Str. 28/30, 14195 Berlin, Germany. Supported by Univ. Buenos Aires, CONICET (Argentina) and WHO (TDR)

The aggregation behaviour of triatomines is mediated by thigmotaxis, chemical signals and negative phototaxis. The present work analyses how the aggregation behaviour of the haematophagous bug Triatoma infestans is modulated by the convergence of chemical factors and the spectral composition of the light associated to potential refuges. Secondinstar larvae were presented with two refuges of filter paper disposed in a two-sector circular arena. In each trial, each refuge presented a chemical cue (presence or absence of a piece of paper impregnated with dry facces) and a visual cue (a dark vs. a coloured spot, both on a white background). Coloured lights used were blue, green and red to humans. Results show that: 1) in absence of facces bugs assembled in the dark sector, 2) bugs rejected refuges associated with green light regardless of the presence or absence of faeces; 3) orientation towards chemical cues was more relevant than negative phototaxis to red light. Such a light was avoided in the absence of faeces but was irrelevant in their presence; 4) negative phototaxis towards blue light can be counteracted by orientation to chemical cues: insects distributed randomly between a blue-light refuge with faeces and a clean dark refuge. We conclude that: 1) in the absence of olfactory signals, a photonegative reaction guides the assembling behaviour of T. infestans, 2) in the presence of visual and olfactory signals, both inputs can interact and control the aggregation behaviour; 3) this interaction depends on the colour of the light (e.g., green light induces a stronger photonegative response than blue or red light).

Index terms: triatomines, colour, faeces.

[0719] DEVELOPMENTS IN SPRAYABLE PHEROMONE DELIVERY SYSTEMS FOR MATING DISRUPTION

<u>R. E. Rice</u>¹, ¹Univ. of California, Dept. of Entomology, One Shields Ave., Davis, CA 95616, USA.

Mating disruption (MD) for control of pests in agricultural, urban, and forestry environments has become a major component of pest management programs throughout the world. In addition to the known advantages over conventional insecticides, MD is becoming an increasingly preferred strategy for control of pests on food crops destined for international markets. Over the past 15 years the majority of successful control programs using MD for various pests have required application of synthetic pheromones in a variety of plastic or polymer reservoirs applied by hand. In spite of these successes, however, growers, pest control advisors, and suppliers of pheromone products have all recognized that a preferred method of applying pheromones would be with some form of reservoir or dispenser that would not require hand application. Improving technologies of polymer synthesis and dispenser design have led to several types of pheromone formulations that can be applied mechanically. This paper presents formulation, application, and efficacy data on three relatively new sprayable pheromone delivery systems. Products developed by Cousep, Inc., Oregon, USA; 3M Corporation, Minnesota, USA; and the University of California, will be presented. Sprayable products from Consep and 3M are essentially sprayable polymer bead reservoirs in micron diameters, while the University of California system was designed around water soluble paraffin emulsions with the pheromones incorporated into the paraffin base. As with any new technology, there are both advantages and disadvantages to using sprayable formulations for MD pheromones. Advantages of sprayable pheromone delivery systems over conventional hand-applied pheromone reservoirs include more timely application over large acreages requiring less labor, and providing better coverage. The polymer bead formulations can also be tank mixed with other agricultural pesticides, particularly fungicides, that are applied throughout the season. In many cases grower equipment can be used, which reduces the cost of application. A major disadvantage of polymer bead formulations is a shorter residual, requiring more frequent application of the pheromones in comparison to handapplied dispensers. However, the consensus among all users and pheromone formulators is that sprayable pheromone technology has now reached the stage of development that will encourage increased grower acceptance and use of mating disruption pheromones. Index terms: pheromones, mating disruption

[0720] DESIGNING EFFECTIVE MULTIMEDIA TEACHING PACKAGES FOR ENTOMOLOGY

D. J. Robinson, Dept. of Biological Sciences, Open University, Milton Keynes, MK7 6AA, U.K. Email d.j.robinson@open.ac.uk

Educational multimedia is a relatively new field and fully evaluated examples of good design are not yet widely recorded in the literature. However, there are a number of rules that can guide the designer of teaching and learning packages and arguably the key rule to the design of effective multimedia teaching packages is to provide a substantial level of interactivity. In designing teaching and learning material for distance education in biology, it has been necessary to simulate on the computer, some of the exercises that students would undertake in laboratory or field situations. No simulation can recreate the real experience perfectly, but a simulation can teach a range of skills necessary for the entomologist in the laboratory or field. As part of the investigation of a section of woodland, students are required to collect data on insects that could form food for predators. By analysis of the energy content derived from the food, the students can build up a picture of the ecological relationships between the animals in the food chain and quantify the energy levels between one trophic level and the next. In addition to teaching ecological methods, the students learn about the use of field guides, insect life cycles and the distribution of insects within a woodland, at different seasons. The entire exercise is carried out by students learning in their own homes, using a computer. They receive the exercise on a CDROM that has been sent to them through the post. The taxonomy of the insects is also taught using a CDROM. A hierarchical browser is provided, which allows students to see the relationships between different groups and the characters that are used to distinguish between taxa. The browser is well illustrated with still pictures, video and sound. While these CDROMs were produced for use in distance education, they have a wider utility for biological education since the skills they teach are generally applicable and they have interactivity as the basis of their design.

[0721] MALE EMITTED SEX PHEROMONES IN CONFUSED FLOUR BEETLE-BEHAVIOUR AND POSSIBLE PRODUCTION SITE

C. Rvne, C. Olsson & C. Löfstedt, Dept. of Chemical ecology, Lund University, Sölveg. 37, SE-223 62, Lund, Sweden, E-mail camilla.ryne@ekol.lu.se

Behavioural studies show that confused flour beetle, Tribolium confusum (Coleontera: Tenebrionidae) males emit a substance that is highly attractive to conspecific females (p<0.001). Males, however, are not attracted to conspecific males. The studies were conducted in a four-choice olfactometer, and the females and males were tested individually. It has been stated that the species specificity in the aggregation pheromones emitted by the males in *Tribelium* depend on the ratios of the stereoisometric configurations of the substance 4,8-dimethyldecanal. The emitted pheromones are called aggregation pheromones, since they appear to attract both males and females. Racemic 4,8-dimethyldecanal was tested in the olfactometer as a dose-response assay and showed no significantly attraction to the females. The contradicting data from the olfactometer tests imply that T. confusum males emit another active substance, which gives rise to the female attraction. Different tests in the olfactometer conclude that the sex pheromone is emitted actively by the live male. Leg extracts were significantly (p<0.01) attractive to females, but not legs from taken from live males, suggesting that the substance is not present as soon as the male is dead. Scanning electron microscopic pictures show that T. confusum males differ from the closely related species T. castaneum in that T. castaneum males have production sites only on the prothoracic femurs, whereas they are present on all three pairs of femurs in T. confusum males. GC-analyses of whole body-, leg-, or headspace extracts show no peak corresponding to 4,8-dimethyldecanal. A re-occurring peak in all extracts, including female extracts, is identified as 1-pentadecene, which is previously reported as being a surfactant that is facilitating absorption of odour molecules. 1pentadecene may not be the active substance since it is present in the female extracts as well as in the male extracts. The results point to the fact that aggregation pheromones may not exist in T. confusum, but instead a system based on sexual pheromones emitted by the male attracting the female.

Index terms: Tribolium confusum, pheromones, behaviour, SEM.

[0722] VIRTUAL REALITY IN A WALKING MALE SILK WORM MOTH ON A SERVO-SPHERE

M. Sakuma, Lab. of Insect Physiology, the Graduate School of Agriculture, Kyoto Univ., 606-8502, Kyoto, Japan, E-mail sakuma@kais.kyoto-u.ac.jp.

The pheromonal orientation of a male silkworm moth (Bombyx mori) towards a female was analyzed on 'Servo-sphere' apparatus (or Kramer's treadmill). The sphere is driven by a pair of AC-servo motors controlled by a computer, which provides negative feedback to the positional shift of a test insect transmitted regularly from a high-speed video tracker. A built-in encoder on each motor reports periodically an actual position of a motor-axis, and this conversely indicates the track of the insect traveling on the sphere. When a calling female moth on a perch was placed beside the sphere in still air conditions, the male being tethered dynamically on the sphere beat his wings and walked straight towards the female 7 - 28 cm away from him. Moreover, he oriented not only towards a pheromone plume passing by, but also towards its downwind side as the airflow rate increased. Although a unilaterally antennectomized and pterectomized (wing-amputated) males oriented towards a female in the still air condition, bilaterally amputated ones never exhibited directed movements. These results support the idea that his wing-fanning introduced pheromonally odoured air onto his antennae only when he directed towards the pheromone source and/or plume, and this precise timing could be a crucial behavioural component for him to set direction towards the source: the resulting consecutive pheromonal odour pulses may change his circling into a straight walk by resetting frequently the 'flip-flopping' activity in the CNS. This idea was demonstrated by virtual reality experiments in terms of odour pulses. The experiments were conducted in a small wind tunnel covering the servo-sphere, and a three-way solenoid valve attached to the tunnel generated the pulses. A driver program of the sphere enabled to switch the valve to a bombykol-impregnated reservoir when a male directed towards a virtual odour source. Under the control of this program, both intact and bilaterally pterectomized males reached the source irrespective of the wind direction. These results strongly suggest that timing odour pulses during circling, by drawing odourous air through the antennae with fanning wings, is essential to the orientation of a walking male silkworm moth towards the odour source. Index Terms: Bombyx mori, flip-flop, orientation, pheromone, treadmill

[0723] EFFECT OF BUCCAL CAVITY SECRETIONS OF PARASITISED AND UNPARASITISED CHILO INFUSCATELLUS LARVAE ON THE SYNOMONAL ACTIVITY OF SUGRACANE PLANT

K. P. Salin, N. Mukunthan, R. Nirmala & Y. S. Goud, Sugarcane Breeding Institute, Coimbatore - 641 007, India, E-mail: sugaris@md3.vsnl.net.in

Seven sets of experiments were conducted to understand the role of parasitisation of the herbivore in the production of synomone which acts as kairomone to the parasitoid, Cotesia flavipes. Our earlier studies have shown that the sugarcane shoots damaged by the shoot borer, Chilo infuscatellus attracts the parasitoid C. flavipes, an oligoparasitoid adapted to sugarcane ecosystem. The experiments were conducted in 'Y' tube olfactometer with freshly emerged mated females of C. flavipes reared on C. infuscatellus over ten generations. The experiments included (1) Mechanically injured (MI) shoots and normal shoots, (2) MI shoots and MI shoots smeared with buccal cavity secretion (BCS) of normal larva, (3) MI shoots and MI shoots smeared with BCS of parasitised larva. (4) shoots with normal larva feeding inside and normal shoot, (5) shoot with normal larva feeding inside and MI shoot smeared with BCS of normal larva, (6) shoot with normal larva feeding inside and MI shoot smeared with BCS secretion of parasitised larva and (7) shoot with parasitised larva feeding inside and MI shoot smeared with BCS of parasitised larva. Seventy female parasitoids were subjected to observation in each experiment. The parasitoid exhibited significant (p=0.025) preference for shoot damaged by normal larva and the MI plant smeared with the BCS of normal larva. No distinct preferences were shown by the parasitoids to the shoots damaged by the parasitised larva or the MI shoot smeared with BCS of parasitised larva. The physiological state of the herbivore is known to be altered by parasitisation which affect the food consumption. The salivary secretions of the feeding larvae contains chemicals which trigger the production of the synomones. It could be possible that the altered physiological state of the larva due to parasitisation alter the quantity / quality of the synomone of the plants through the modified salivary secretions which the foraging parasitoid could discriminate between. However further detailed studies on the chemical composition of the volatiles produced by the different set of plants used in the present experiments and the electroantennogram studies would establish conclusively the differences in plant reaction to the differential physiological state of the herbivore.

Index terms: Cotesia flavipes, Chilo infuscatellus, Chilo sacchariphagus indicus, Chilo partellus.

[0724] BIOLOGICAL ACTIVITY OF WORKER MANDIBULAR ACIDS IN APIS CERANA AND APIS MELLIFERA

II. Sasagawa¹ & S. Matuysma², ¹PRESTO, JST; Natl. Inst. of Seric. & Entomological Sci. (NISES), 1-2 Oowashi, Tsukuba, Ibaraki, 305-8634, JAPAN, E-mail sasagawa@nises.affrc.go.jp; ²Inst. of Applied Biochem., Univ. of Tsukuba, 1-1-1, Tennou dai, Tsukuba, Ibaraki, 305-8572, JAPAN.

The Oriental honey bee, Apis cerana (Ac), is tolerant against diseases, does not collect propolis, and highly tolerant against parasitic mite, Varroa jacobsoni especially in the case of the Japanese honey bee, Apis cerana japonica (Acj). In the course of our study on chemical ecology in honey bees in Asia, (R)-(-)-3-hydroxyoctanoic acid (3-HOA) was identified as forager specific mandibular gland components in Ac. By using Acj, age and task related changes in worker mandibular acids were demonstrated. Workers younger than 18 days old produced 10-hydroxydecaoic acid (10-HDAA) and (2E)-10hydroxydecenoic acid (10-HDA) as major manbubular gland components (<5 micro g/bce). On the other hand, 21 days old workers and foragers were found to posses more than 10 micro g of 3-HOA as a main component. In this study, biological activity of forager mandibular acids was tested. By using a conventional pollen germination test (10% sucrose-agar), ether extracts of both Acj and Am mandibular glands surpressed pollen germination completely at 1.0 head equivalent /ml and 0.5 head equivalent /ml and above respectively. Synthetic 3-HOA showed 100% surpression of pollen germination at 50 ppm (50ng/ml) and above. GC analyses after methylation by diazomethane showed that Acj foragers had an average of 28 micro g of 3-HOA/bee, while Am foragers possessed averages of 43 and 187 micro g of 10-HDAA and 10-HDA respectively. 3-Hydroxydecanoic acid (3-HDA, major) and 3-HOA (minor) were first identified form the Hydroxydecatiol act (FIDA, hajo) and 3-HOA (innor) where this manufacture action and in a manufacture action A is a standard s several Bombus species in Japan. So far, 3-HOA was identified in forager mandibular gland of Apis cerana collected in Japan, Korea, Taiwan, Vietnam, China, Nepal and Thailand. Other Apis species do not produce this acid. Distribution and biological function of these 3-hydroxy fatty acids among hymenopteran insects will be discussed.

Index terms: antifungal activity, pollen germination, 3-hydroxyoctanoic acid (3-HOA), 10-HDAA, 10-HDA

[0725] POLLINATOR ATTRACTION BY PHEROMONE-MIMICKING VOLATILES IN AUSTRALIAN AND EUROPEAN ORCHIDS

F. P. Schiestl¹, R. Peakall¹, F. Ibarra² & W. Francke², ¹Division of Botany and Zoology, The Australian National University, Canberra, ACT, 0200, Australia; Email: florian.schiestl@anu.edu.au; ² Institute of Organic Chemistry, University of Hamburg, Germany

Flowers of sexually deceptive orchids mimic the sex pheromones of their pollinator species. Pollination occurs when the male pseudocopulates with the flowers. We investigated the "pseudopheromones" of orchids as well as the sex pheromones and mating behavior of their respective pollinator species in the Australian orchid genus Chiloglottis, which is pollinated by thynnine wasps (Hymenoptera: Tiphiidae), and the European genus Ophrys, pollinated by solitary bees (Hymenoptera: Apoidea). We examined semiochemicals and their detection by the males using gas chromatography with electroantennographic detection (GC-EAD). Gas chromatography - mass spectrometry was used to identify odor compounds and behavioral tests to investigate reactions of males to natural and synthetic odor compounds. Behavioral tests with flowers of Chiloglottis trapeziformis showed that males of its pollinator species, Neozeleboria cryptoides, are attracted over long distances, which relates to their mating behavior. Female thynnines are flightless and call for males by releasing sex pheromones from a low perch. They are rapidly located by the males and transported to a feeding site. In GC-EAD experiments with C. trapeziformis volatiles, only one peak elicited electroantennographic reactions in male antennae. This peak was found in the labella as well as in the sepals of the flowers. C. valida, which occasionally share the same pollinator species, produces the same compound(s), in labella and sepals. Although identifications and field tests remain to be done, this suggests that the mimicry of the sex pheromone requires only a few compounds. In Ophrys sphegodes, on the contrary, 14 alkanes and alkenes have been found to clicit electroantennographic responses and were shown to elicit copulation behavior in the pollinator bee species, Andrena nigrouenea (Schiestl et al. 1999, Nature 399: 421-422). These compounds also constitute the sex pheromone. The low volatility of these compounds suggest them to act primarily at close distance, which is in accordance to the mating behavior of the bee species. Andrena nigroaenea males search for females in aggregations on odor marked trails. Females are thought to fly in an aggregation where mating occurs. Differences between the mating behavior in thynnine wasps and solitary bees appears to have led to the evolution of different pheromone communication systems. Thus Australian and European sexually deceptive orchids, have recruited male pollinators with contrasting chemical communication systems.

Index terms: Neozeleboria cryptoides, Chiloglottis, Andrena nigroacnea, Ophrys sphegodes, orchid pollination

[0726] SAPONINS IN THREE ALFALFA (*MEDICAGO SATIVA*) VARIETIES AND THEIR RELATION TO APHID RESISTANCE

<u>A. A. Silva¹</u>, E. M. Varanda¹ & N. P. Lopes². ¹Dept. de Biologia, FFCLRP – USP, Av. Bandeirantes, 3900, Ribeirão Preto – SP - Brasil, CEP 14050 901, E-mail alealsil@usp.br; ²Dept. de Física e Química, FCFRP – USP, Via do Café, SN, Ribeirão Preto – SP – Brasil, CEP 14040 903.

Several studies concerning the secondary compounds of plants and their relation to herbivory suggest that they may play an important role in host selection by herbivores. Qualitative and quantitative variation are present in different species varieties, and therefore, are supposed to be related to resistance to herbivores. It is known that saponins are responsible for the antinutritional effects related to deterrency as a result of their bitter taste to monogastric animals. They can also make complexes with cholesterol thus decreasing its availability in the diet and causing non-specific inhibition of several enzymes, such as proteases. Three alfalfa (Medicago sativa) varieties, P30 (susceptible), CUF 101 (resistant) and Crioula (most frequently cultivated in Brazil), with different levels of resistance to aphids were cultivated at Fazenda Canchim\CPPSE\EMBRAPA -Brazil and the number of aphids were counted monthly from September/97 to August/98. The average number of Therioaphis trifolii and Aphis craccivora aphids in the CUF 101 variety was significantly smaller than that presented by the two other varieties, which indicates a possible resistance to these species. Although CUF 101 had been previouly described as resistant to Acyrthosiphon spp aphids, that is A. pisum and A. kondoe, there were no significant differences in the number of such aphids among the three varieties. The saponin profile of the three varieties, obtained by using HPLC, was determined and a correlation between such profile and the resistance in the CUF 101 variety to the *T. trifoli* and A. craccivora aphids was observed. However, the results suggest few differences in the saponin profile and in the concentration of major components among the three studied varieties, which seems to indicate that they may not be related to resistance to T. trifolii and A. craccivora aphids.

Index terms: aphids, resistance, herbivory, chromatography, saponins

[0727] CHARACTERIZATION OF *TRICHOGRAMMA* FEMALE VOLATILES LIKELY INVOLVED IN COURTSHIP BEHAVIOUR AND THEIR POTENTIAL USE IN TAXONOMY

I.M.M.S.Silva¹, M. A. Posthumus², R. Stouthamer¹ & T. A. van Beek², ¹ Laboratory of Entomology, Wageningen Univ. and Research Centre, P.O Box 8031, 6700 EH Wageningen, The Netherlands. ² Laboratory of Organic Chemistry, Wageningen Univ. and Research Centre. Dreijenplein 8, 6703 HB Wageningen, The Netherlands.

Egg parasitoids of the genus *Trichogramma* (Hymenoptera, Trichogrammatidae) are widely used in biological control against lepidopterous pests. In order to find taxonomic tools for this group of natural enemies, we characterized volatiles produced by virgin females of several *Trichogramma* species. These compounds are possibly involved in sexual communication of *Trichogramma* wasps. Collection of volatiles was done by Solid Phase Micro-Extraction (SPME). Chemical analyses were performed by means of Gas Chromatography and Mass Spectrometry (GC and GC-MS). For *Trichogramma turkestanica*, volatiles were identified that had not been previously recorded for insects. Index terms: *T. turkestanica*, *T. cordubensis*, *T. pintoi*, *T. evanescens*, *T. bourarchue*

[0729] BIOLOGICAL ACTIVITIES OF PLANT SECONDARY METABOLITES TOWARD INSECTS

<u>M. E. Sosa¹</u>, C. E.Tonn² & O. S. Giordano², ¹ Area de Zoología; ² Química Orgánica INTEQUI-CONICET- Fac. de Química, Bioquímica y Farmacia, Univ. Nac. de San Luis, Chacabuco y Pedernera, 5700, San Luis, Argentina. E-mail:molitor@unsl.edu.ar.

Nowadays the study of allelochemical interactions between insects and plant-secondary metabolites is an important subject in chemical ecology. Plants have developed highly elaborated chemical defences against insect attacks, and that provides a rich source of biologically active compounds. The need to protect our food supply from predatory attack using more ecologically acceptable methods has led to a rapidly growing interest in behaviour-modifying chemicals from natural sources. As a part of our research on plant natural products we started a systematic investigation about the bioactivities of secondary metabolites and chemical derivatives from Compositae and Labiatae families toward Tenebrio molitor L.(Coleoptera: Tenebrionidae) larvae. The structure-antifeedant activity relationship of several clerodane type diterpenoids as well as the role that the hydrophobicity plays in the bioactivity, have been studied. Results suggest that among the furanditerpenes tested , the possession of an α,β -unsaturated - γ -lactone moiety or a C-4 epoxy with C-5-methylacetoxy or C-12 acyloxy substitution are essential for imparting antifeedant and repellent activities in the test system used. On the other hand, the toxicity of sesquiterpene lactones has been determined. The comparison showed that both conjugated a-methylen-y-butyrolactone system and a, B-cyclopentenone ring, were important for the bioactivity. Growth-inhibitory activities of selected natural benzofurans, trans-cinnamic acid derivatives, chromene compounds, and some semi-synthetic derivatives, were determined in last instar larvae via topical administration in acetone. The most inhibitory of the tested compounds, were 3-00-dimethylallyl-p-coumaric acid and the benzofuran derivative 12-(p-cumaroyloxy)-tremetone, the former compound acting on the pupae and the latter on the last instar larvae. Several developmental deficiencies were observed, and some structure-activity relationships were discussed. Finally, nineteen flavonoids were evaluated, in this group of secondary metabolites quercetin reduced significantly the growth of larvae. This report extends that T. molitor is an sensitive insect to plant natural products. These data also identify potential or alternative sources for synthesis of compounds that mimics the aforementioned bioactivities.

Index terms: Tenebrio molitor L.; allelochemicals; antifeedants; growth-regulators

[0728] POLYSACCHARIDASES IN NESTS OF THE LEAF-CUITING ANT ATTA SEXDENS

C. G. Siqueira, M. Bacci jr., F. C. Pagnocca, O. C. Bueno & M. J. A. Hebling, Centro de Estudos de Insetos Sociais, Universidade Estadual Paulista, Rio Claro, SP. CEP.13506-900, Brazil. Supported by FAPESP 97/13383-0, 95/04229-2, and 97-05358-6.

The nests of leaf cutting ant Atta sexdens harbor great amounts of a symbiotic fungus called Leucoagaricus gongylophorus. The fungus is a food source for the ants, especially for larvae, and is likely to provide the insects with proteases. A fundamental question concerning the symbiosis is whether the fungus can efficiently degrade the structural polysaccharides of plant material inside ants' nests, and thus support ants utilization of these compounds. In the present investigation we found that isolated cultures of the symbiotic fungus are able to produce great amounts of pectinase, intermediate levels of amylase and xylanase and few amounts of cellulase. The faecal fluid of ants also contained high activity of pectinase followed by amylase, xylanase and cellulase. The same activities were also detected in the sponge inside ants' nest. These results suggest that the symbiotic fungus is the major producer of depolymerases found in the ants faecal fluid as well as in the sponge, where polysaccharide degradation efficiently occurs. The high amount of pectinases detected indicate that the symbionts need the enzyme to macerate plant tissue and then access nutrients from cut leaves. To better characterize the pectinolytic system acting in ants nests, we have determined pectin esterase (PE), endopolygalacturonase (endo-PG) and exopolygalacturonase (exo-PG) activities of the sponge, fungal cultures, and the faecal fluid of ants. All sources of enzymes presented greate amounts of exo-PG, compared to those of endo-PG or PE. This reinforce the concept that the symbiotic fungus is the main responsible for pectinase production inside ants' nests. In addition the fungus was able to produce pectinases on a variety of carbon sources, including pectin from apple, citric pectin, sodium polypectate, starch, cellulose and xylan. This indicates that the pectinolytic system of the symbiotic fungus is not repressed by carbon sources and thus it is able to generate the greate amounts of enzymes seen in ants' nests.

[0730] PHEROMONES SYSTEM OF LEPTOGLOSSUS ZONATUS (HETEROPTERA:COREIDAE)

C. E. P. Souza^{1, 2}, J. Millar², S. Mc Elfresh², B. F. Amaral-Filho³, R. T. Cardé² & A. Mafra-Neto², 1-Fac. Filos. Ciênc. Letras de Ribeirão Preto, Univ. de São Paulo, Av. Bandeirantes, 3900, Ribeirão Preto São Paulo, Brazil, 14040-901; 2-100 A Chapman Hall Univ. of California - Riverside, Riverside, United States, 92521. 3-Univ. Est. de Campinas- Depto. de Zoologia, caixa postal:6109, Campinas, São Paulo, Brazil.

Leptoglossus zonatus is a coreid bug that occurs in Southwestern of United States, Central America and Northern of South America. In recent years I. zonatus has reached new areas of the South American Continent, mainly in Brazil, where it became widely distributed. L zonatus feeds on several economically important plants such as citrus, soybean, sorghum, cotton, among others. The attack due to feeding can cause losses of more than 15% of the corn production. Feeding on the corn seeds cause them to wither, thus facilitating penetration of microorganisms which increases losses. Behavioral and chemical studies were conducted to identify the chemicals involved in the sexual/aggregation communication of L. zonatus. Bioassays in y-tubes and four-arm arenas indicated that adult males were attractive to other adults, whereas females were not. Chemical analysis of airborne collection from immature and adult L. zonatus showed that males emit sexspecific volatile compounds. Further laboratory arena bioassays with the several synthetic male-specific volatile components indicate that these chemicals attract adults of both sexes. Field traps containing individual synthetic male-specific chemicals or their blend captured nymphs and adults, suggesting that the chemical functions as an aggregation pheromone. Our data suggests that L. zonatus has a long distance chemical communication system mediated by pheromone volatiles emitted by the males.

Index terms: Leptoglossus zonatus, leaf-footed bug, coreid, pheromones. corn

[0731] A COMPARATIVE STUDY OF PHEROMONE DISSEMINATING STRUCTURES IN TERGITES OF SOME *LUTZOMYIA* SPP. (DIPTERA: PSYCHODIDAE)

C. N. Spiegel¹, R. P. Brazil² & M. J. Soares¹, 1. Lab. Biologia Celular de Microrganismos, Departamento de Ultra-estrutura e Biologia Celular, Instituto Oswaldo Cruz / FIOCRUZ, 21045-900 Rio de Janeiro, RJ; 2. Lab. de Leishmanioses, Centro de Pesquisas Reneé Rachou / FIOCRUZ, 30190-000 Belo Horizonte, MG, Brazil. This work has been supported by CAPES and FIOCRUZ.

Sex pheromones are widespread in insects and appear as an option for biological control to vectors of some human diseases, such as Leshmaniosis. Pheromone glands are invariably related with cuticular pores, which allow transport of the pheromone granular are invariably gland to the cuticle surface. The cuticle may be adorned with a variety of architectural modification, allowing a greater surface area for pheromone evaporation. Several Lutzomyia species, the insect vectors of Leishmaniosis, have been described to possess sex pheromone disseminating structures (Ward et al. Bull. Entomol. Res., 83:437-445, 1993), associated to pale tergal spots on some abdominal segments. In this study males of four different species of the Lutzomyia genus were analyzed by scanning electron microscopy. Two species belong to the same species complex: L. longipalpis (vector of Leishmania chagasi, the causative agent of visceral leishmaniosis in the New World) and L. cruzi (a related species incriminated as a vector of leishmaniosis in Mato Grosso state, Brazil). Two species of another complex were also analyzed: L. carmelinoi and L. lenti. New observations could be recorded on the presence of pheromone disseminating structures on the tergites of male sandflies. In L. cruzi and L. longipalpis the pheromone glands were present only on abdominal tergites bearing pale spots, characterized as regions where macrotrichia are absent. The glands were morphologically identical and were present either on tergal segments III-IV or only on segment IV. The glands appeared as small round elevations, 2.3-2.8 μm in diameter, presenting a central pore. On the other hand, in L. lenti and L. carmelinoi the pheromone glands were present on tergal segments V and VI. Furthermore, pale spots could not be observed. The round shape was more pronounced in L. lenti and L. carmelinoi, the glands appearing as small papules containing a central pore. In L. carmelinoi the structures were 2.0-2.9 µm in diameter. Further studies are being conducted by transmission electron microscopy to analyze the pheromone gland organization and the gland cells fine structure.

Index terms: Lutzomyia, pheromone glands, ultrastructure.

[0732] LIFE TABLES OF THE CULTURES APPLIED TO PESTS OF MAIZE UNDER INTERCROPPED CULTIVATION

F.A. Suinaga¹, M. Picanço², C.S. Bastos¹ & J.C.C. Galvão¹, ¹Dept. de Fitotecnia, ²Dept. de Biol. Animal, Univ. Fed. de Viçosa, CEP 36571-000, Viçosa, MG, Brazil, E-mail fsuinaga@alunos.ufv.br.

The objective of this work was to study the losses in yield components of maize (Zea mays) intercropped with common beans (Phaseolus vulgaris) under different doses of mineral fertilizer (0, 250 Kg of 4-14-8 + 100 Kg of ammonium sulfate - AS/ha and 500 Kg of 4-14-8 + 200 Kg of AS/ha) and organic fertilizer (0 and 40 m³ of organic matter/ha). The experimental design was in randomized blocks with four replications and it was conducted in the agricultural year of 1996/97. Plant mortality and losses in each of these yield components: ovules, ears and grains were evaluated, as well as their causes. After that, life tables of the cultures were developed. The highest damage level being responsible for 79% of the total losses was ovules abortion. Besides this cause, the attack of *Helicoverpa zea* and *Spodoptera* spp. (Lepidoptera: Noctuidae) to the ovules was the other cause of losses in this yielding component. This loss was positively correlated with the adults of Diabrotica speciosa (Coleoptera: Chrysomelidae) (r = 0.48; p = 0.0084; n = 24) and Spodoptera frugiperda (r = 0.34; p = 0.0538; n = 24) to the leaves. The main causes of losses in plant component were the attack of S. frugiperda (9.31% of losses) and the perforation of seeds by neonate Coleoptera: Elateridae (2.08% of losses). The highest damage level in ears component was "empty ears" (without grain or ovules). In the grains component, the main pests related to these losses were: Sitophilus zeamais (Coleoptera: Curculionidae) (22.82%), H. zea and Spodoptera spp. (5.79%). Mineral and organic fertilization increased pests attack in maize intercropped with common beans. Higher adult populations of D. speciosa and S. frugiperda were verified with organic fertilization. Larger attack of S. frugiperda was also observed with the increase of mineral fertilization. Index terms: Life table, Diabrotica speciosa, Spodoptera frugiperda, Sitophilus zeamais, Helicoverpa zea

[0733] IDENTIFICATION OF *CAMERARIA OHRIDELLA* SEX PHEROMONE AND ITS POSSIBLE USE IN HORSE CHESTNUT PROTECTION

A. Svatos, B. Kalinova, M. Hoskovec, J. Kindl, O. Hovorka & <u>I. Hrdy</u>, Department of Natural Products, Institute of Organic Chemistry and Biochemistry, Academy of Sciences of the Czech Republic, 166 10 Prague 6, Czech Republic. E-mail: svatos@uochb.cas.cz.

The horse-chestnut leafminer Cameraria ohridella Deschka & Dimic (Lepidoptera: Gracillariidae) is presently the most dangerous pest of horse-chestnut, Aesculus hippocastanum L in Southern and Central Europe. At present, the possibilities to control this pest are rather limited (raking of the damaged leaves, spraying with insecticides). Sex pheromone can represent a basis for an alternative - designing an integrated pest management (IPM) program. The major component of a sex attractant released by virgin females of the horse-chestnut leafminer was identified in picogram quantities as (8E,10Z)-tetradeca-8,10-dienal. The spectral methods were not used, the identification relied entirely on alternative analytical methods like (1) gas chromatography with electroantennographic detection (GC-EAD), (2) calculation of Kovats' retention indices of the active principle on different GC phases, and (3) construction of EAG response profiles to C_{12} and C_{14} saturated and unsaturated standards with different functional groups. The synthetic pheromone was prepared by a stereospecific synthesis and shown to be highly active for conspecific males and was proved to be fully comparable to the natural substance in all respects. The potential use of the pheromone to protect horse chestnut trees in Europe is discussed.

Index terms: horse-chestnut leafminer, Lepidoptera, Gracillariidae, EAG, GC-EAD, wind tunnel, field test, delta-traps

[0734] PHEROMONE-BASED MATING DISRUPTION OF THE INDIAN MEAL MOTH *PLODIA INTERPUNCTELLA* (LEPIDOPTERA: PYRALIDAE) USING SINGLE- AND MULTI-COMPONENT BLENDS

G. P. Svensson, C. Ryne & C. Löfstedt, Dept. of Ecology, Lund Univ., Solvegatan 37, SE 223 62 Lund, Sweden.

The Indian meal moth, Plodia interpunctella (Lepidoptera: Pyralidae), is a serious indoor pest on stored products (grains, seeds, dried fruit etc). As populations have developed multi-resistance towards insecticide treatments, there is a need for new methods to control this species. Pheromone-based mating disruption may be an effective alternative to traditional management. The first identified sex pheromone component of P. interpunctella, Z9,E12-14:OAc, was reported in 1971. Recently, a reidentification revealed three additional components as part of the sex pheromone blend, namely Z9-14:OAc, Z9,E12-14:Ald and Z9,E12-14:OH. We performed small-scale mating disruption experiments in a green-house to evaluate the potential to control this species by means of sex pheromones. Male and female moths were introduced into 2.5 x 2.5 x 2.5 m transparent plastic tents under a natural dark-light regime. Insects were recaptured after 24 hrs and mating success was determined as presence or absence of spermatophores in females. Pheromone was emitted from controlled-release devices (MSTRS™). Two disruption blends were used: Z9,E12-14:OAc alone or the complex, four-component, blend. Mating frequencies at different doses (5, 50 or 250 □g of Z9,E12-14:OAc emitted per minute) were estimated. Mating disruption was significantly lower at the lowest dose compared to the two higher doses. However, no difference in mating frequency was observed between blends at similar doses. In addition, the disruption effect at different moth densities (10, 20 or 30 individuals per tent) was investigated. At the lowest and highest densities, surppression of matings was lower compared to the intermediate density. No difference was observed between blends at similar densities. EAG recordings were performed using a portable device in combination with air-sampling to determine the concentrations of pheromone in control and treatment tents. Although the tents were provided with ventilation, a significant increase in EAG responses in the treatment tents during the experiments was observed, indicating ackumulation of pheromone. However, this increase in pheromone concentration was not paralelled with increased surppression of matings. No increase in EAG responses was observed in control tents. Aerial concentrations of Z9,E12-14:OAc and Z9-14:OAc in treatment tents ranged from 52 to 433 ng per m³ and from 29 to 121 ng per m³, respectively. In summary, our results indicate that pheromone-based mating disruption can be an effective way to control populations of P. interpunctella. Surprisingly, Z9,E12-14:OAc alone is as effective as disruptant as a complex blend.

Index terms: sex pheromone, pest control, electroantennogram, MSTRSTM

[0735] FEEDING BEHAVIOUR OF PEA APHID ON ALFALFA

S. Szynkarczyk, <u>B. Leszczvnski</u>, J. Markowski & H. Matok, Dept. of Biochemistry, Univ. of Podlasie, Prusa 12, PL-08110 Siedlee, Poland, E-mail leszczb@ap.siedlee.pl

Pea aphid, Acyrthosiphon pisum Harris is one of the most important insect pests on alfalfa (Medicago sativa L.). Preliminary evidences suggest that the aphid feeding cause foliar damage and increase in cournestrol content in the infested alfalfa plants. On the other hand, it is well documented that alfalfa contains saponins with a variety of biological activities. The present paper reports on feeding behaviour of the pea aphid on alfalfa lines containing different level of saponins. Alfalfa selected lines with high and low content of saponins were used in the experiment. EPG (electrical penetration graphs) recordings of the pea aphid feeding behaviour on thigh and low- saponin lines were performed. There was no clear difference in duration of total tissue probing of the alfalfa. The aphids fed on low-saponin lines showed slightly shorter pathways phase (penetration of epidermis and mesophyll). Phloem phase (salivation into sieve elements and phloem sap ingestion) was prolonged on such lines, and no clear difference was observed during ingestion of xylem sap. Importance of the retaliations between saponin concentration and the pea aphid performance on the alfalfa is discussed.

Index terms: Acyrthosiphon pisum, alfalfa, saponins, EPG

Symposium and Poster Session

[0737] APHID ENZYMES INVOLVED IN DETOXICATION OF CEREAL ALLELOCHEMICALS

A. Urbanska, <u>B. Leszczynski</u> & H. Matok, Department of Biochemistry, University of Podlasie, B. Prusa 12, PL-08110 Siedlee, Poland, E-mail leszczb@ap.siedlee.pl

Cereal xenobiotics e.g. hydroxamic acids, phenolics and flavonoids are involved in resistance to aphids. However, aphids are able to survive on cultivars with relatively high concentrations of these allelochemicals, since they developed specific adaptive enzymes that enable them to detoxify the toxic plant allelochemicals. Present paper reports on participation of several oxidoreductases and transferases of the grain aphid *Sitobion avenae* (Fabr.) and bird cherry-oat aphid *Rhopalosiphum pndi* (L.) in detoxication of the cereal allelochemicals. Activity of polyphenol oxidases, peroxidases, UDP-glucosyl transferases, glutathione-S-aryltransferases, aryl sulphotransferases and phosphotransferases has been found in the aphid tissues. The studied oxidoreductases act both in host-plant tissues, due to the action of secreted aphids' saliva and within their alimentary track. Activity of the second phase transferases is located mostly in the aphids' midgut. Studied enzymes are specific to: monophenolics, *o*-dihydroxyphenolics, methoxyphenolics and flavonoids, naturally occurring in the cereals. However, not always relatively high concentrations of the allelochemicals within the creat issues, induced the activity of the aphid enzymes. Importance of oxidation of the plant phenolics and their conjugation with glucose, glutathione, sulfate and phosphate for chemical interactions between cereal aphids and their host plants is discussed.

Index terms: Sitobion avenae, Rhopalosiphum padi, cereal allelochemicals, detoxifying enzymes.

[0736] A NEW AUTOMATIC BIOASSAY TO TEST THE ATTRACTION OF HOST STIMULI IN CRAWLING INSECTS

S. Trenner, M.Hofmann, H. Bleckmann & H. Schmitz, Institut für Zoologie, Poppelsdorfer Schloß, D – 53115 Bonn. EMAIL: uzsjvm@uni-bonn.de

A semi- automatic setup was designed to test the attraction of various sensory stimuli on crawling insects. Especially in long lasting experiments in which many animals must be tested, our approach has a considerable advantage. The setup consists of a starting box (35 x 20 cm, height 20 cm) with two openings at opposite sides. Each opening leads to a "downfall module" (PCV, 3 x 5 cm, height 13 cm). Inside each module, a turnable plastic cylinder is installed. If an insect crawls into a downfall module, it steps onto the cylinder, which starts to turn. Consequently the insect falls into a corresponding collecting box. In the wall of the downfall module, opposite to the opening in the starting box quadrangular hole (3 x 3 cm) was made. The hole can be closed either by a piece of PVC or a stimulus can be presented through it. All downfall modules are equipped with a photoelectric barrier. With aid of a computer, single downfall events and the time of their occurrence can be registered. To demonstrate the suitability of our setup we tested starved 3^{rd} instars of the Chagas bug Triatoma infestans (N = 12). We offered a natural host stimulus (living mouse) and single components of it (warmed mouse skin, cold mouse skin, warm air gradients). In control experiments no stimulus was presented. In controls 8% and 10% of the bugs were found in the collecting boxes, respectively. When a living mouse was presented, 58% of the bugs were trapped in the corresponding collecting box and 19% in the control collecting box. A warmed mouse skin attracted 45% of the bugs (control: 19%), whereas warm air generated by a Peltierelement (38° C) trapped 42% (control: 13%). All differences were significant (χ^2 -test, p < 0.01). A mouse skin at room temperature was not attractive (7%/7%). With aid of our setup we were able to show with a minimum effort that a living mouse offers all necessary stimuli for the bloodsucking bug Triatoma infestans to approach the host. A thermal stimulus alone was effective as well, but not as effective as a combined thermal/olfactory stimulus (warmed mouse skin). A cold mouse skin did not attract the Chagas bugs. Time profiles of the downfall events showed that the bugs were most active in the first two hours after a 30 min dusk (lasting from 6:30 - 7:00 p.m.). In single cases the activity lasted past midnight. A second smaller peak was observed two hours before dawn (which was set from 6:30 to 7:00 a.m.).

[0738] NEW TOOLS TO CONTROL APHID PESTS: REPELLENT ODOURS

<u>J.H. Visser</u> & W.J. de Kogel, Plant Research International, Business Unit Biointeractions & Plant Health, Wageningen UR, P.O. Box 16, 6700 AA Wageningen, The Netherlands, E-mail j.h.visser@plant.wag-ur.nl

In temperate regions aphids are important pest insects on a large variety of crops, such as potatoes, sugar beets, lettuce, cucumbers, sweet peppers, tulips, lilies and roses. Since aphids transmit plant viruses, current insecticides do not prevent crop damage by non- and semi-persistent viruses. In order to develop new tools to control aphid pests and subsequent virus infections, a programme on plant-odour derived aphid repellents was started at Plant Research International in cooperation with TNO Industry and Dutch experiment stations. The programme addressed a sequence of questions: (a) what do aphids smell, (b) which of the components perceived by aphids are repellent, (c) how do particular repellents affect aphid colonisation and reproduction, and (d) can particular repellents control aphid pests. By means of electroantennogram recordings of aphids, a large collection of plant odour components was tested on Myzus persicae, Aphis fabae, Megoura viciae and Brevicoryne brassicae. The odour response profiles were differentiating for species-specific traits as well as general aphid response characteristics. In special designed olfactometers the behavioural responses of aphids were tested to a range of components selected from the previous electroantennogram screening. A number of volatiles were very repellent to aphids and their repellency was consistent for a number of aphid species including Aphis gossypii. The effect of these repellents on aphid colonisation was tested in dual-choice leaf disk bioassays: one leaf disk sprayed with just the formulation compared to another leaf disk sprayed with the formulation containing the repellent. Aphids avoided the leaf disk sprayed with the repellent formulation, and at a range of concentrations the repellency was consistent over a two-weeks period. One repellent component in a particular formulation showed, in addition, strong effects on mortality and reproduction of sphids: it acted as an insecticide. This repellent formulation was tested in greenhouses in comparisons of treated and untreated plants for Aphis gossypii on cucumbers and Myzus persicne on Chinese cabbage. In both aphid-plant combinations the repellent formulation controlled aphid populations very well. Further field evaluations of this repellent formulation will be performed this summer. Index terms: insecticides, Aphis gossypii, Myzus persicae, Myzus nicotianae

[0739] PRELIMINARY STUDY ON THE BEHAVIOR OF SELECTING HOST OF LONGHORNED BEETLES AND THE ROLE OF THEIR SENSE ORGANS IN THIS PROCESS

F.G. Waug¹, J. X. Zhou² & X. Y. Yaug², ¹ P.O. Box 11, Res. Inst. Of Forest Ecol., Environ. and Protec., Chinese acad. Of Forestry, Beijing 100091, P. R. China, E-mail fugui@prot.forestry.ac.cn, ²Northwest Forestry College, Yangling 712100, Shaanxi, P. R. China.

Longhorned beetles (Anoplophora nobilis) cause serious damage and loss on poplar, willow in north China. Planting mixed forest was thought a better measure to control them, replenish the loss of forest and gradually replace pure forest according to previous research. But how to afforest mixed forest is a mystery which need to be exposed. Hence, the selecting-host behavior of longhorned beetles should he studied as a basis for making a strategic decision. In 1994, the behavior of selecting host of longhorned beetles was observed in a mixed forest consisted of 30 species of trees. The results showed: for different species of trees, the longhorned beetles had different selecting-host behavior respectively. The susceptive host trees in mixed forest, such as acer oliverianum, could finally be selected by a complex, time-consuming and gradual sense behavior. After a few longhorned beetles fed, mated on them, it was sure that more longhorned beetles would be attracted to them, and finally the susceptive trees were damaged seriously. It was obvious that longhorned beetles were attracted by the odor of hosts firstly, then by intraspecific sex attraction. However, for some species of trees, such as platycladus orientalis and robinia pseudoacacia, longhorned beetles loved to approach to them, selected them and sometimes inhabited on them for a long time, but they didn't feed on them and had no mating behavior. It was thought that the odor of host trees apparently influenced this behavior of longhorned beetles. So, mixed forest could only delay the time that longhorned beetles reached susceptive hosts, but it couldn't effectively prevent their invasion. When afforested, many trees, like platycladus orientalis, should be planted and a few susceptive trees, like acer oliverianum or poplar, should be planted as trap trees in mixed forest. Generally, longhorned beetles probed which species of trees they liked by swinging antenna, rubbing tarsus besides vision before they reached them. Beetles' compound eyes or visual sense was the most important sense organ, and the next is antenna and tarsus. If losing vision, longhorned beetles would not know where they should head for, often went around at one place, and lost their most flying ability. Labial palpi and maxillary palp functioned only when longhorned beetles probed which food was flavorful or delicious. Tarsus was useful and indispensable in the whole selecting-host procedure because, together with other sense organs, it often supplied information for longhorned beetles to affirm hosts.

Index terms: Anoplophora nobilis, behavior, selecting host, sense organs, forest.

[0740] LOOKING AT PESTS THROUGH THE ANTENNAE OF THEIR PARASITES: HOST PHEROMONES AND BIOCONTROL

A. Zhang & J. R. Aldrich, USDA-ARS Insect Chemical Ecology Laboratory, Agricultural Research Center-West, B-007, Beltsville, MD 20705, USA, E-mail: azhang@asrr.arsusda.gov.

The southern green stink bug (SGSB), Nezara viridula (Heteroptera: Pentatomidae), is a serious agricultural pest worldwide. Its host range includes soybean and other field crops, a variety of fruits and nuts, and many vegetables. The parasitoid fly, Trichopoda pennipes (Diptera: Tachinidae), is the only native tachinid fly that has naturally adopted the SGSB as a host since its accidental establishment in the southeastern U.S. some 200 years ago. However, T. pennipes introduced into Hawaii from Florida failed to parasitize N. viridula, and *T. pennipes* fails to attack the squash bug, *Anasa tristis* (Coreidae), in California although *A. tristis* is the most common host of this parasitoid in the northeastern U.S. These observations suggest that different strains of T. pennipes exist in the U.S. Sexually mature males of N. viridula release a sex pheromone containing isomers of the sesquiterpenoid, 1,2-epoxy-(Z)-D-bisabolene, and females of T. pennipes use the pheromone as a signal (a "kairomone") to find this host. We report here that geographically isolated populations of T. pennipes gave dramatically different antennal responses to pheromone extracts of N. viridula and certain native host species. This is the first experimental verification that kairomone-strains of T. pennipes exist, and demonstrates that electro-physiological screening of parasitioids prior to classical biological control introductions could avoid inevitable failures. In addition, we have found that the antennae of tachinid parasitoids are commonly 5-10 times more sensitive to the pheromone of their hosts than are the antennae of the host species themselves. Therefore, we plan to try to use the antennae of the T. pennipes strain that prefers to parasitize squash bugs as a means to identify the sex pheromone of this pest.

Index terms: Kairomone, Nezara, Trichopoda, Anasa, bisabolene.

[0741] ANTENNAL AND BEHAVIORAL RESPONSES TO NONHOST ANGIOSPERM LEAF AND BARK VOLATILES BY CONIFER INSECT

O. II. Zhang¹, G.T. Liu², F. Schlyter¹, G. Birgersson³, P. Anderson¹ & P. Valeur⁴, ¹Dept. of Plant Protection Sciences, Swedish Univ. of Agricultural Sciences, P. O. Box 44, S-230–53 Alnap, Sweden, E-mail: qing-he.zhang@vsv.slu.se; ²Baiyinaobao Natural Preserve, 025375 Inner Mongolia, P. R. China; ³Chemical Ecology, Dept. of Botany, Göteborg Univ., Box 461, S-405 30 Göteborg, Sweden; ⁴Dept. of Ecology, Lund Univ., S-223 62 Lund, Sweden.

Leaf and bark volatiles from non-host angiosperm trees were tested on the conifer bark beetle, lps duplicatus by gas chromatographic-electroantennographic detection (GC-EAD) and by pheromone-baited traps in Sweden and Inner Mongolia, China, respectively, GC-EAD analysis of the headspace volatiles from fresh bark chips of Betula pubescens revealed trans-conophthorin, two green leaf volatiles (GLVs): 1-hexanol and (Z)-3-hexen-1-ol, and two C8-alcohols: 3-octanol and 1-octen-3-ol, that consistently elicited antennal responses by I. duplicatus. The identification of these antennally-active compounds was confirmed in further GC-EAD recodrings with synthetic mixtures. Antennal responses were also found to synthetic (E)-2-hexen-1-ol, that has been identifed from the leaves of non-host birch and aspen species. In field trapping experiments, blends of antennally active, GLV alcohols or C8-alcohols, or trans-conophthorin alone resulted in significant reductions (27-60%) in the number of I. duplicatus captured compared with the pheromone-baited trap. The unsuitable host compound, verbenone, also significantly reduced the trap catches up to 60% in both experiments. The strongest disruptive effect resulted from the addition of the combination of GLV-alcohols, Cg-alcohols and Vn to the pheromone trap, which caused 84% of trap catch teduction. The blend of two GLV aldehydes plus the acetate increased the trap catches in 1998 and had no negative or positive effects in 1999. Our results suggest that these nonhost leaf and bark volatiles are important olfactory signals used by *I. duplicatus* in descriminating between host and nonhost species. They may have great significance in developing semiochemical-based management program against the outbreaks of I. Juplicatus by reducing attacks on suitable hosts and thereby decreasing population levels and damage.

Index terms: *Ips duplicatus*, host selection, nonhost volatiles, NHVs, Green leaf volatiles, GLVs,

[0742] INFLUENCES OF PLANT-DERIVED SEMIOCHEMICALS ON BEHAVIOR OF APHIDS

Z. N. Zhang & F. Zhang, State Key Lab. of Integrated Management of Pest Insects & Rodents, Inst. of Zoology, The Chinese Academy of Sciences, Beijing 100080, China, E-mail: zhangzn@panda.ioz.ac.en.

Some plant-derived semiochemicals were found with activity to aphids. A compound extracted from radish, Raphanus sativus L., was identified its' structure as 4isothiocyanato-1-methylthio-1-butene by GC-MS. Myzus persicae and Macrosiphum avenae showed EAG response to the compound in electrophysiological experiment (n=9, P=0.001) and the compound showed high attraction activity to aphids in field test (n=8, P=0,001). A compound extracted from catmint, Nepeta cataria L.- (+)-(4as,7s,7aR)nepetalactone — as one of the pheromone of many aphid species. The contents of nepetalactone in flower, leaves, tender stem were 0.237%, 0.052% and 0.033% respectively. The compound showed high attractive activity in field: M. persicae were caught in large numbers in water traps baited with plant-derived nepetalactone in peach orchard and cabbage garden; Aphis sp. and Schizaphis graminum males were attracted in wheat field. Alate virginoparae were also attracted by plant-derived nepetalactone in the field. The numbers of aphid overwintering eggs of M. persicae were reduced 47.6% as mass trap male aphids by the two synthetic components: nepetalactone plus nepetalactol (1:1) in peach orchard. Benzaldehyde, a major component of the volatile from the Prunus persica extract, enhanced the attractancy of aphid sex pheromone. M. persicae males and gynoparae respond to peach leaf volatiles in the field, but not to benzaldehyde alone. (E)β-farnesene as aphid alarm pheromone existed in some plants. It was found in barley leaves. Host plants influence on alarm pheromone behavior of aphids. The dispersive response of Aphis gossypii Glover to (E)-\beta-farnesenc on Lagenaria siceraria and Gossypisum hirsutum was more sensitive than that on Cucumis sativus. Index terms: Myzus persicae, Aphis gossypii, semiochemicals, behavior

Session 05 – COMPUTER SCIENCE APPLIED TO ENTOMOLOGY

Symposium and Poster Session

[0743] STUDIES OF FORAGING FLIGHTS WITH HARMONIC RADAR.

J. R. Riley, A. D. Smith & D. R. Reynolds, Natural Resources Institute Radar Unit, Univ. of Greenwich, North Site, Leigh Sinton Road, Malvern, Worcestershire WR14 1LL, UK. Email: jriley@nriradar.demon.co.uk.

Most of our current knowledge about the high-altitude flight behaviour of insect migrants has been derived directly from observations made with conventional entomological radars. Until recently, however, it has not been possible to use this very powerful technique to study the foraging behaviour of insects flying close to the ground. This is because the strong echoes reflected from ground features and from vegetation ("clutter"), usually mask the very tiny signals returned from insects. We have overcome this constraint by attaching small transponders to the insects we wish to track. The transponders send back signals at the second harmonic of the radar frequency, and these signals can be detected even in the presence of very strong clutter. The range of detection (900 m) vastly exceeds that of human vision, and the radar also provides dynamic and geometrically accurate records of the insects' flight paths. By presenting some examples of the radar flight trajectories of bumble bees, honey bees and moths, we show that harmonic radar has introduced a new era into the study of insect flight, bees, moths

[0745] TRACKING ALPINE BUTTERFLY MOVEMENT USING HARMONIC 'RADAR'

<u>J. Roland</u>, Department of Biological Sciences, University of Alberta, Edmonton, Alberta, Canada, T6G 2E9., S. Matter, Department of Biological Sciences, University of Alberta, Edmonton, Alberta, Canada, T6G 2E9, and C. Backhouse, Department of Electrical and Computer Engineering, University of Alberta, Edmonton, Alberta, Canada. T6G 2E9.

Dispersal of alpine *Parnassius* butterflies is well estimated for males by the use of markrecapture techniques, but because females are relatively secretive, other methods must be used to adequately estimate their movement. We have developed extremely small (0.4mg) harmonic 'radar' tags which flying butterflies can carry. We use these tags to estimate daily dispersal of female *Parnassius smintheus* butterflies in the Rocky Mountains of Alberta, Canada, by repeated location of tagged females over the period of the study. Data are used to help estimate the effects of changing landscape structure on dispersal and colonizing ability.

Index terms: dispersal, direction finder, alpine, butterfly

[0744] AUTOMATICALLY OPERATING RADARS FOR MONITORING INSECT PEST MIGRATIONS

V.A. Drake, I.T. Harman & II.K. Wang, School of Physics, University College, The University of New South Wales, Australian Defence Force Academy, Canberra, ACT 2600, Australia. E-mail: a.drake@adfa.edu.au.

The Insect Monitoring Radar (IMR) allows insect migration to be observed automatically at remote sites, so that long data series can be accumulated without incurring the high costs associated with maintaining an observer in the field for an extended period. The IMR employs a vertical beam and combines a conical scan with linear polarization, to produce a complex echo signal containing information about the trajectory of an overflying target, and the target's orientation, size, and shape. A second operating mode provides information on target wingbeat frequencies and amplitudes. The IMR operates under computer control, and alternates periods of data acquisition with periods of processing during which the target parameters are retrieved from the recorded signals. The results of these analyses can be downloaded daily to the base laboratory via a telephone link. Summary statistics and graphical representations of the data can then be produced for interpretation by pest forecasters and incorporation into a database. Summaries can also be placed on a server for dissemination to users via the internet. A network of two IMRs connected to a central communications node and server has been operating in eastern Australia since mid-1999. The IMRs are sited in the semiarid zone ~1000 km from the communications node and base laboratory in Canberra. The capabilities of this network will be illustrated with data from the two IMRs, and related to the requirements of operational forecasting of Australian plague locusts *Chortoicetes terminifera* and native budworm Helicoverpa punctigera - two important migratory pests that frequently build up populations within the region where the IMRs are located.

Index terms: Chortoicetes, Helicoverpa, locust, forecast, internet-

[0746] COMPUTERIZED VIDEO TRACKING, MOVEMENT ANALYSIS AND BEHAVIOR RECOGNITION IN INSECTS

L.P.J.J. Noldus, M.O.S. Buma, R. Lievaart, F.J.F.W. van Rijswijk & R.A.J. Tegelenbosch, Noldus Information Technology b.v., Costerweg 5, P.O. Box 268, 6700 AG Wageningen, The Netherlands. E-mail: info@noldus.nl.

During the past decade, video tracking technology has evolved dramatically. Early systems, based on analog video and hard-wired electronics, were only able to track a single animal under very stringent light conditions and in highly artificial environments, Modern systems, based on full-color video frame grabbers and flexible software, can track multiple animals simultaneously against a variety of complex backgrounds. In 1993, we introduced EthoVision[®] as a general-purpose video tracking, movement analysis and behavior recognition system. Based on feedback from users around the world, the system has undergone numerous updates over the years, which has resulted in a very comprehensive package for studies of movement and behavior. The software has recently been redesigned from the ground up for 32-bit Windows platforms, with a highly interactive graphical user interface for display of experiment design, experimental arena and movement tracks. In the talk, we will outline the basics of digital image processing, movement tracking, path analysis and behavior recognition. Special attention will be given to the hardware and software components of a video tracking system. A comparison will be made between video tracking and other detection techniques such as radar, radio tracking and infrared beam activity measurement. Next, the design and operation of EthoVision for Windows will be presented. The focus will be on experiment design, arena definition, data acquisition, visualization and analysis. We will review various quantitative parameters with which insect movement can be described. Finally, we will report on our research into new methods of multi-object tracking and behavior recognition. Algorithms have been developed that allow an objective quantification of interactions between individuals. Examples will be taken from studies of foraging behavior, chemo-orientation. host-parasitoid interaction and social behavior.

Index terms: video tracking, movement analysis, behavior recognition, computer software. EthoVision

[0747] DEVELOPMENT OF AN OPTICAL FLYING INSECT DETECTION AND IDENTIFICATION SYSTEM (OFIDIS)

A. Moore, 57 Belmont Ave., Ottawa, Ontario, K1S 0V2, Canada, E-mail AubreyMoore@home.com.

The Optical Flying Insect Detection & Identification System (OFIDIS) has three components: light source, photosensor, and data logger. The photosensor produces a modulated voltage signal whenever it detects light reflected off the wings and body of a flying insect. This signal is digitized, stored, and analyzed by the data logger. When a typical insect wingbeat waveform recorded by OFIDIS is converted into a frequency spectrum using the fast Fourier transform, several frequency components are revealed: the insect's wingbeat frequency, plus harmonics that occur at integer multiples of the wingbeat frequency. Recent research indicates that wingbeat spectra contain species-specific information, in addition to the wingbeat frequency, that can be used for automated identification of individual flying insects. A prototype system is being evaluated in a variety of laboratory and field studies. This system uses either the sun or an infrared LED array as a light source. The photosensor signal is digitized by the sound card of a personal computer. Wingbeat waveforms are detected and logged by a transient waveform recorder program. Potential applications for OFIDIS are: 1- Automated monitoring of pests and biocontrol agents in integrated pest management programs. 2- Automated monitoring of mosquitoes and other insects of importance to public health. 3- Automated monitoring of pollinator and forager activity. 4- As a research tool for studying insect movement and effects of attractants and repellents. 5- As a taxonomic aid

Index terms: wingbeat waveform, wingbeat spectrum, fast Fourier transform.



[0748] VIDEO ANALYSIS OF APHID FLIGHT BEHAVIOUR

J. Hardie & G. Powell, Aphid Biology Group, Dept. of Biology, Imperial College at Silwood Park, Ascot, Berks SL5 7PY, UK, E-mail j.hardie@ic.ac.uk.

We have used video techniques to study the flight behaviour of aphids over a number of years. Experimental approaches include: 1) assessment of behaviour prior to, and of time to, take-off under defined conditions; 2) two-dimensional analysis of responses to visual stimuli in a video-computer automated vertical wind tunnel; 3) three-dimensional analysis of flight tracks in the laboratory and field. This presentation will concentrate on studies of the host-alternating black bean aphid, Aphis fabac. When young adult winged aphids are placed on host or non-host plant material they may stay and settle or fly off. The use of close-up video has allowed us to show that the autumn winged females of A. fabae (gynoparae) can discriminated between a summer (broad bean, Vicia faba) host and the winter, relevant (spindle tree, Euonymus europaeus) host within a 5-min period. Plant factors detected during brief (epidermal) stylet penetration appear to be responsible for this discrimination. Individual winged A. fabae can be flown for many hours in a vertical wind tunnel when changes in the rate of climb are countered by corresponding changes in air flow. Such control may be automated by coupling the video signal of the flying aphid, through a computer, to air flow control, The flight track of the insect can be saved for later analysis and responses to visual stimuli presented during flight can be observed. Studies have revealed major differences in initial flight behaviour between summer and auturn forms as well as a maximum response to a visual target illuminated with green monochromatic light at *cai* 550 nm. To obtain a more accurate analysis of flight we developed a video technique to examine three-dimensional aspects of aphid flight tracks. By mixing the signals from two cameras with overlapping fields of view, two images of the insect appear on the monitor and the distance between them is proportional to the distance from the cameras. The xyz co-ordinates during flight can then be calculated at up to 50 Hz and flight track parameters computed. We have used this technique for aphids flying in a horizontal wind tunnel in the laboratory and, when coupled to an ultrasonic anemometer, in the field. Studies show that aphids tend to land into the wind Index terms: Aphis fabae take-oft, visual stimuli, three-dimensional

[0749] TRANSMISSION OF MUSCLE POTENTIALS DURING FREE FLIGHT OF LOCUSTS

W. Kutsch, Fakultät für Biologie, Universität, 78457 Konstanz, Germany

One of the most conspicuous features in evolution is the flight capability in insects. For over 40 years scientists have being trying to understand the evolution and ontogeny of flight, and the aerodynamics, morphology and physiology underpinning it. Earlier studies had to be carried out on tethered animals, but recent achievements made it possible to investigate the muscle potentials of insects flying freely within laboratory arenas. We have developed a radio system that transmits muscle potentials during the free flight of the large locust, Schistocerca gregaria. The device, which is mounted to the insect's prothorax weighs only about 10 % of its body's mass, and so does not restrict the animal's ability to fly normally. When combined with video-monitoring the system allows to record the electrical activity of certain muscles (EMG), and then to investigate how this activity is associated with several flight parameters, e.g. flight speed, wing-beat frequency, ascent and body angle. Careful interpretation of the EMG records yields information on the recruitment of muscles at the level of individual motor units and, therefore, reflects the activity of identified motoneurones. Our results corroborated several earlier findings derived from tethered animals, but also produced data that could not be obtained previously. The recordings reveal a basic flight motor pattern that permits free flight, and show how it becomes modified to allow deviation from a straight horizontal flight path. Recent studies supplemented by high-speed video recordings show muscle recruitment correlated to fine movements of the wings. The effects on the motor pattern produced by interfering with peripheral sensory systems were also studied. It is expected that further technical achievements will facilitate the construction of multi-channel devices allowing the transmission of several synchronous events, e.g. several EMGs, EMG and receptor activity, EMG and specific aspects of the wing movement. Index terms: telemetry, video-monitoring, flight parameters

[0750] SIMULATION OF INSECT MOVEMENT WITH RESPECT TO PLANT ARCHITECTURE AND MORPHOGENESIS

J. S. Hauan¹, **P. W. Prusinkiewicz²**, **M. P. Zalucki³**, **S. Dorosh² & D. J. Skirvin⁴**, ¹Centre for Plant Architecture Informatics, The University of Queensland, Australia 4072, Fax: +617-3365-1477, E-mail: jim@cpai.uq.edu.au; ²Dept of Computer Science, University of Calgary, Alberta, Canada T2N 1N4; ³Dept. of Zoology and Entomology, The University of Queensland, Australia, 4072; ⁴ Horticulture Research International, Wellesbourne, UK, CV35 9EF.

A plant represents a highly heterogeneous habitat to an insect moving around or over its surface. Properties of plant parts vary within a complex canopy architecture, and insect damage can induce further changes that affect an animal's movements, development and likelihood of survival. Up to now, however, entomologists, evolutionary biologists and ecologists interested in insect-plant interactions have usually abstracted from the threedimensional (3D) architecture of plants because of the lack of an appropriate methodology for expressing the movements of insects over the plant surface or among plants, and for capturing interaction between the insects and the plants at the scale of individual organs. We present an approach to simulation of insect behaviour around and on growing plants. Models of plant architectural development based on Lindenmayer systems serve as dynamic platforms for the simulations, providing an explicit model of the developing 3D structure of a plant, as well as allowing physiological processes associated with plant growth to be simulated. Movement of phytophagous insects on the plant can be modelled, along with associated behaviours such as feeding. Once feeding has occurred, the plant model can explicitly describe responses to damage, such as release of apical dominance when a meristem is removed, or induction of defences. We extend such models to tritrophic interactions by modelling predators searching for prey on arrays of virtual plants, as well as oviposition behaviour by adult butterflies moving between host plants growing in a virtual field. The latter step closes the loop. Eggs laid on virtual plants hatch to become virtual caterpillars damaging the plants and being subject to predation by virtual predators. We present simple examples of this approach operating at different spatial scales, from caterpillars foraging on an individual plant to interactions of adult male and female butterflies around a patchy distribution of plants in a field. Such models can be used to explore questions about the consequences of changes in environmental architecture and configuration on host finding, exploitation and its population consequences. We have in effect created a "virtual ecosystem" laboratory to address local as well as landscape level questions perlinent to plant-insect interactions, taking plant architecture into account Index terms: insect behaviour model, plant architecture model, Lindenmayer systems

[0751] SPATIAL ANALYSIS OF HELIOTHIS DISTRIBUTION AND ABUNDANCE FOR MEASURING THE EFFECTS OF MOTH MOVEMENT AT THE REGIONAL SCALE

W. A. Rochester¹, M. P. Zalucki¹, A. Ward², M. Miles² & D. A. H. Murray², Department of Zoology and Entomology, The University of Queensland, Brisbane Qld 4072, Australia, E-mail: w.rochester@epitt.uq.edu.au; ². Queensland Department of Primary Industries, PO Box 102, Toowoomba Qld 4350.

The noctuid moth species Helicoverpa armigera and Helicoverpa punctigera (heliothis) are major agricultural pests in Australia. Attributes contributing to their pest status include high mobility, high fecundity, polyphagy and a facultative diapause. Moths of both species undertake long distance migratory flights between regions as well as long- and short-range non-migratory flights within regions. These movements affect pest management in a variety of ways. For example, spring migration from non-cropping regions is a major source of moths early in the season, and also dilutes insecticide resistance genes selected for within the cropping regions. Movements within regions quickly spread problems of resistance or large numbers of moths among properties and between crops of different types. Moth movement is of particular interest to area-wide management because many area-wide management strategies make assumptions on movement patterns. For example, strict management of heliothis in early spring crops will significantly reduce pressure on summer crops only if the majority of summer moths are produced locally rather than by migration from other regions. Also, trap crops will be effective only if moths originating some distance from the trap crops move around enough to encounter them. Moth flight behaviour has been studied with techniques such as radar, aerial trapping, mark-recapture, natural markers and flight mills. These techniques provide information on movement processes that can be used to predict the effects of movement on the distribution and abundance of the insects. Empirical analysis of abundance data provides a means to validate such predictions and to estimate some movement parameters. Commercial crop scouting records are a low-cost source of such data for cotton growing regions in Australia. Regular (roughly twice weekly) counts of the egg and larva lifestages can be obtained for areas large enough for use in studies of regional movement. In this study we tested hypotheses on the movement of moths into and within a cropping region by applying spatial and non-spatial statistics to such scouting data. The study region was a 15×15-km mixed cropping area in the subtropical Darling Downs region of eastern Australia. We illustrate the types of hypotheses that can be tested with this kind of analysis, and discuss the suitability of commercial scouting records for such analysis. Index terms: Helicoverpa, movement, spatial ecology.

[0752] USING THE INTERNET TO SERVE ENTOMOLOGY TEACHING, RESEARCH AND EXTENSION AT IOWA STATE UNIVERSITY

J. K. VanDyk¹, ¹Dept. of Entomology, Iowa State Univ., 411 Science II, Ames, IA 50011-3222, USA, E-mail jvandyk@iastate.edu.

The Department of Entomology at Iowa State University is using the Internet to serve the department in various innovative ways. Distance education courses allow students from diverse geographic areas to participate and learn through instruction, interaction, and simulation. The production of photographically accurate virtual insects aids in instruction. The Entomology Index of Internet Resources serves as a directory and search engine for the discipline of entomology, allowing researchers to quickly locate information on the Internet. Search engine technology being developed within the department organizes integrated pest management information. Several newsletters for agricultural workers, gardeners and homeowners are published in print and via the web using databases and a content management system, emphasizing fast delivery of information to the end user. The website for the general public (http://www.ent.iastate.edu) receives more than one million hits each month. An interactive camera promotes selected insects within the Iowa State University Insect Zoo, serving as marketing for our school outreach program. Videoconferencing and digital cameras are used to identify insects from remote sites within Iowa. The end result is that technology is being used effectively in many ways that serve the mission of the Department of Entomology at Iowa State University. Index terms:Iowa,teaching,extension,WWW,internet

[0753] INTERNATIONAL INFORMATION SYSTEM ABOUT BIOLOGICAL CONTROL OF PESTS THROUGH THE INTERNET

<u>L. A. N. de Sá ¹</u>, D. Canhos ² & N. C. Gattaz¹, ¹Embrapa Meio Ambiente, C.P. 69, 13820-000, Jaguariúna, São Paulo, Brasil, E-mail Ians@cnpma.embrapa.br ; ²Fundação Tropical de Pesquisa e Tecnologia "André Tosello", 13087-010 Campinas, São Paulo, Brasil.

In Brazil, the use of biological control of pests has grown as a means of using less aggressive practices to the environment and maintaining species diversity. As a result of a cooperation between Embrapa Meio Ambiente and the Fundação André Tosello, an international information system on Biological Control was established in 1994, with a view of facilitating the interaction and integration of the scientific community worldwide. The System permits an informal and immediate contact of a great number of people dealing with different activities related to biological control through the internet. A discussion list, open to all interested, was set up to permit the exchange of information and experience among scientists. The list (biocontrol-l@bdt.org br) has 530 subscribers and also has a "read only" version set up as a database on the internet that is freely available (http://www.bdt.org.br/listas/biocontrol-I/). A side from the discussion list, which was the starting point of the information system, a number of databases were structured to further promote the exchange of information. The System, freely available on the internet (http://www.bdt.org.br/biocontrol), has the following information: Directory of Institutions that work with Biological Control of Insects, Who is Who in Biodiversity in Brazil, Who is Who in Risk Analysis of the use of Biocontrol Agents, Who is Who in Entomology, Legislation Relative to Biological Control (GATT: Agreement on the Application Sanitary and Phytosanitary Measures, Legislation of Argentina, Brazil, Chile), COSAVE (Plant Health Committee), Publications on Biological Control available at Embrapa Meio Ambiente and other biological control links. This system has contributed to the dissemination and exchange of information about biological control and shall be further developed in accordance with future demands.

Index terms: internet, biological control, discussion list, databases

[0754] THE INTER-AMERICAN BIODIVERSITY INFORMATION NETWORK -ITS DEVELOPMENT AND ENTOMOLOGICAL FUTURE

J. Quinn

ABSTRACT NOT RECEIVED

[0755] DESIGNING EFFECTIVE MULTIMEDIA TEACHING PACKAGES FOR ENTOMOLOGY

D. J. Robinson, Dept. of Biological Sciences, Open University, Milton Keynes, MK7 6AA, U.K. Email d.j.robinson@open.ac.uk.

Educational multimedia is a relatively new field and fully evaluated examples of good design are not yet widely recorded in the literature. However, there are a number of rules that can guide the designer of teaching and learning packages and arguably the key rule to the design of effective multimedia teaching packages is to provide a substantial level of interactivity. In designing teaching and learning material for distance education in biology, it has been necessary to simulate on the computer, some of the exercises that students would undertake in laboratory or field situations. No simulation can recreate the real experience perfectly, but a simulation can teach a range of skills necessary for the entomologist in the laboratory or field. As part of the investigation of a section of woodland, students are required to collect data on insects that could form food for predators. By analysis of the energy content derived from the food, the students can build up a picture of the ecological relationships between the animals in the food chain and quantify the energy levels between one trophic level and the next. In addition to teaching ecological methods, the students learn about the use of field guides, insect life cycles and the distribution of insects within a woodland, at different seasons. The entire exercise is carried out by students learning in their own homes, using a computer. They receive the exercise on a CDROM that has been sent to them through the post. The taxonomy of the insects is also taught using a CDROM. A hierarchical browser is provided, which allows students to see the relationships between different groups and the characters that are used to distinguish between taxa. The browser is well illustrated with still pictures, video and sound. While these CDROMs were produced for use in distance education, they have a wider utility for biological education since the skills they teach are generally applicable and they have interactivity as the basis of their design.

[0757] REAL ENTOMOLOGY ON COMPUTER: USING MULTIMEDIA TO TEACH PRACTICAL SKILLS

M. J. Hall, Dept. of Biological Sciences, Open Univ., Milton Keynes, MK7 6AA, UK, Email: m.j.hall@open.ac.uk.

The Holly Leaf Miner is a multimedia tutorial on CD-ROM which forms part of the UK's Open University distance-learning course for first-level undergraduate students, \$103 Discovering Science. One of the inherent problems of teaching science to distancelearning students is the difficulty of teaching practical skills. Holly Leaf Miner addresses this issue by introducing some simple practical skills while at the same time providing students with some basis information about insects and their ecology. Students studying the CD-ROM first learn, by means of a series of interactive exercises, about the life-cycle of the holly leaf miner (Phytomyza ilicis) and some the parasitoid wasps that prey on it (using Chrysocharis gemma and Sphegigaster pallicornis as examples). They then go out into the field to collect holly leaves that have been mined by holly leaf miner. This section introduces them to sampling techniques. Guided by the CD-ROM, they then inspect the leaves, dissecting them if necessary, count the proportion of miners that emerged successfully and identify the mortality factors affecting those that did not. This section introduces them to the use of a hand-lens and dissecting equipment, the problems of dealing with biological materials, and the concept of using an identification key. Next, they carry out a k-factor analysis on the data they have collected, and interpret the results in terms of the importance of the various mortality factors for their population. They also compare their own data with similar data collected from a particular holly bush near the Open University over several years. This enables them to consider the reasons for variation in mortality factors between different populations and between different years and interpret the Open University data set in terms of key and regulating mortality factors. The final section looks at the importance of mortality factors in biological control, using data on the whitefly Trialeurodes vaporariorum and the parasitic wasp Encarsia formosa. Index terms: Phytomyza ilicis, Chrysocharis gemma, Sphegigaster pallicornis, distance learning, mortality factor

[0756] THE INTERNET-BASED MULTIMEDIA TAXONOMIC DATABASES AS TOOLS IN ENTOMOLOGICAL EDUCATION

P. Naskrecki, Dept. of Ecology and Evolutionary Biology, University of Connecticut, Storrs, CT 06269, USA, E-mail piotr@neca.com.

The development and explosive growth of the Internet have presented teachers with many new and exciting tools for teaching entomology at levels ranging from primary to graduate. The resources available through the web technology can be as simple as teaching curricula for particular courses, and as complex as complete biological databases of insect taxa. The Internet provides the students not only with the information they need but also an easy way to publish their own findings. The interactive nature of the web encourages further exploration of topics and helps establish contacts between the students of entomology and specialists in particular areas. Taxonomic databases are particularly helpful in initiating student interest in entomology. The very first step in nearly every insect-related project is to identify the study organisms and find what is already known about them. This also used to be the most time consuming and tedious process, resulting in many students getting discouraged at the very beginning of their path. Complete taxonomic databases give a great starting point, regardless of whether the proposed project relates to behavior, distribution, or taxonomy of iasects. In the best case scenarios, such databases allow one to easily generate lists of species of particular taxa and geographic regions, or find relationships between host and parasite species, and locate food plant information. Taxonomic databases available now vary in quality and scope, but there is a clear tendency for making such databases more inclusive, easier to use, and geared towards a user with little entomological background. For example, the Orthoptera Species File Online, a web database of the orthopteroid insects of the world is one of the most complete taxonomic databases currently available, and has been extensively used by students and teachers worldwide for nearly 3 years. It provides users with complete literature references for all species of the Otthoptera, nearly 10,000 images of species, and sound recordings. It has been used in teaching in grade schools, high schools, and graduate research.

Index terms: insect identification, literature references, taxonomy, teaching

[0758] USING INSECTS IN THE CLASSROOM: A DISTANCE LEARNING COURSE

J. G. Stoffolano Jr., Department of Entomology, University of Massachusetts Amheist, MA 01003-2410, Phone 413-545-1046, Fax 413-545-2115, stoff@ent.umass.edu`

The effectiveness of distance learning is greatly influenced by the instructional medium used and the subject matter. Information about insects and their popularity amongst children are unmatched. Insects continue to increase in popularity throughout the world as vehicles to teach science process skills to preK-12 students. In addition to their universal polularity, they are ideal subjects for use in a multimedia distance learning course. They are visually captivating in color, shape and movement. Also, many excellent websites already exist for developing online-lesson based activities. This course capitalizes on the above qualities of insects, the enthusiasm children have for insects, and uses three different delivery systems for helping students most effectively learn how to use insects in their classrooms. Each week there are three different learning activities: (1) Participants view a 60 minute video which contains science content about insects, as well as a visiting guest(s) who discusses a pedagogial topic in the context of insects in the classroom; (2) Based on each video, students take an on-line, web-based quiz using the OWL program developed by the Univ. of Massachusetts. They also engage in an one hour online computer based portion of the course. The online workbook contains questions and activities based on the video, the resource materials, class handouts, and requires the students to use the internet, websites and course listserv; (3) The third portion of the course consists of live, interactive videoinstruction using the PictTel system. A brief discussion of the three different modes of deliver and a demonstration of various intructional materials will be presented.

Symposium and Poster Session

[0759] PHOTOGRAPHIC VIRTUAL REALITY TECHNIQUES FOR ENTOMOLOGICAL DISTANCE EDUCATION

J. K. VanDyk

ABSTRACT NOT RECEIVED

[0761] AN INTERACTIVE INFORMATION RETRIEVAL AND REFERRAL SYSTEM FOR WORLDWIDE ELECTRONIC IPM INFORMATION

W. I. Bajwa & Marcos Kogan, Integrated Plant Protection Center (IPPC), Oregon State University, Corvallis, OR 97331-8530, USA.

The volume and variety of online IPM research and extension information are growing at an exponential rate. This information is poorly organized at present, as it is also for most other specialized fields. The World Wide Web is growing faster than the ability of Internet indices (Yahoo, Excite, Northern Light, Infoseek, HotBot, etc.) to organize access to the information it contains. Database of IPM Resources (DIR), an internet-based information system, was developed as a user friendly interface to online IPM information. DIR is a database of "metadata" that functions as an information system, linking IPM researchers and practitioners through a central network, which can be used by anyone seeking crop protection information. The basic goals of this system are: (a) to assist in IPM information dissemination, (b) raise public awareness about new and emerging techniques for agricultural, forest, livestock and medically-important pests, and (c) provide support for decision-making in IPM. The overall goal of (his system is to promote global IPM development and adoption through rapid access to useful information developed by specialists from all across the globe. The design and schema of this database allow a user to retrieve desired information with minimum efforts in as little time as possible. DIR presents Internet IPM resources in a logical, structured, and searchable way that greatly reduces the frustration and disappointment often encountered when using general search engines on the web. This system is presently a compendium of 2,000 documents, i.e., unique URLs developed specifically for DIR. DIR has three main components including informational databases & knowledgebases, directories of Internet IPM resources, and search engines. Currently, DIR contains four informational databases, seven bibliographic databases, five knowledgebases, and a database with more than 5,500 documented Internet resources and their hyperlinks searchable through its simple and advanced search engines. DIR covers a wide array of crops, pests, control tactics, organizations, technical/scientific societies, educational and research institutions, and related topics in a format that is searchable, highly customized, and user-friendly. DIR is available at www.IPMnet.org/DIR/ and ippc.orst.edu/DIR/.

Index terms: Computers, Databases, Internet, World Wide Web, WWW

[0760] DESIGN AND ANALYSIS OF TIME-MORTALITY BIOASSAYS AND WEB-BASED PROGRAM DISTRIBUTION

J. E. Throne¹, ¹USDA-ARS Grain Marketing and Production Research Center, 1515 College Ave., Manhattan, KS 66502, USA, E-mail throne@usgmrl.ksu.edu.

The design of bioassays to determine the time to death of insects treated with a conventional insecticide or a biopesticide is discussed. Methods for analyzing data from time-mortality assays are reviewed, including the advantages and disadvantages of both non-parametric and parametric methods. Non-parametric methods reviewed include the Kaplan-Meier method. Parametric methods include the logit model developed by Bliss and programmed in ViStat, and an adaptation of the probit analysis method which is suitable for analyzing time-mortality data. The reasons why conventional probit analysis should not be used for time-mortality data are discussed. Examples of data analyzed using the different analysis methods are presented. Advantages of web-based distribution of time-mortality programs are discussed.

Index terms: bioassays, probit analysis, time-mortality data

[0762] PEST MANAGEMENT INFORMATION IN AUSTRALIA

R. W. Sutherst, G.F. Maywald & B. Russell, CSIRO Entomology, Long Pocket Laboratories, 120 Meiers Rd, Indooroopilly, Queensland, Australia 4068. Email R.Sutherst@ento.csiro.au

IPM is an information-dependent practice that increasingly demands rapid access to current information that is applicable under the vastly different environmental conditions around Australia. These demands are driving a range of data storage, organisation, interpretation and dissemination activities. Australia has led innovation in a number of fields that exploit computers to enhance the value of IPM information. DELTA (Description Language for Taxonomy) and Platypus (an databasing system for nomenclature information) were developed and are now being integrated under the name of BioLink. Meanwhile, a parallel effort has been in progress firstly, to digitise information from collection records. INTKEY and LUCID were produced to provide simple, easy tools to generate taxonomic keys. More recently, the databasing initiative has been extended to build seamless links between different specimen collections around Australia and the world, using the internet, to make them machine-readable from any site. These software tools and databases provide a valuable resource for IPM in Australia and their value has been enhanced by the parallel development of interpretative tools. In the 1970s innovative applications were developed in population modelling for IPM, aimed at mostly at aphids and cattle ticks. CLIMEX was developed to model the responses of species to climate for use in quarantine risk assessment, biological control, climate change species to climate for use in qualatione first assessment, biological for population modelling impact assessment, and bio-geography. In the 1990s, the demand for population modelling led to the development of the DYMEX modelling toolkit. DYMEX is designed to be userfriendly for biologists, by employing a Windows-based interface to dialogue boxes, to avoid them having to write computer code. It has since been found to be particularly valuable as a tool with which to build prototype models rapidly in a workshop environment. This has enabled the development of national networks of researchers, managers and academics with the objective of developing national approaches to Australia's key insects, diseases and weeds. Users are invited to pool their modules into a library for distribution to other users in order to avoid wasteful duplication. In addition, computers now play a key role in teaching, with IPM trainces being exposed to many of the above computer-based approaches. Most recent efforts to expedite delivery of IPM information to users are aimed at integrating some of these technologies, linking all information relevant to IPM in a WWW portal, 'IPM Australia' and delivering information from databases and models over the WWW. A number of the above programs have enjoyed widespread, international adoption and will be illustrated. Index keywords: BioLink, CLIMEX, DYMEX, IPM Australia.

[0763] THE EXOTIC FOREST PEST INFORMATION SYSTEM FOR NORTH AMERICA

<u>R. A. Hnack</u>¹ & J. G. O'Brien², ¹ US Dept. Agriculture, Forest Service, North Central Research Station, 1407 S. Harrison Rd., East Lansing, MI 48823, USA; E-mail: rhaack @fs.fed.us; ² US Dept. Agriculture, Forest Service, Forest Health Protection, 1992 Folwell Ave., St. Paul, MN 55108, USA; E-mail: jobrien @fs.fed.us

The Exotic Forest Pest Information System for North America is a project sponsored by the North American Forestry Commission, comprised of members from Canada, Mexico, and the United States. This Internet-accessible database identifies insects, mites and pathogens with potential to become established and cause damage to forest resources in any of the three North American countries. Emphasis is placed on organisms not yet present in North America. Each record in the database consists of a brief pest risk assessment and a pest information section. For each organism, the risk assessment section qualifies risk by probability of establishment, economic impact, and environmental impact. The pest information section provides details on host plants, geographic distribution, methods for detection and identification, means of spread, control measures, general biology, and a bibliography. It is anticipated that this information will prove useful in assessing and managing future pest organisms in both North America and worldwide. The web site and pest records will be available in English, French, and Spanish. The directors of the project are actively seeking authors to write new pest records for the database, as well as qualified people to review current and future records. A new record can be submitted in any of the three official languages: English, French, or Spanish. Once approved and edited in the language in which it was first submitted, each record will then be translated to the other two languages by project members. The original authors and their affiliations are listed for each record. For further information, or to participate in the development of this information system, visit the web site at: http://www.exoticforestpests.org

Index terms: database, exotic pest, quarantine pest, risk assessment

[0764] FARMSOURCE.COM, TRAINING CONSULTANTS ONLINE

J. R. Anderson

ABSTRACT NOT RECEIVED

[0765] COLLABORATIVE SEARCH TOOLS FOR INTEGRATED PEST MANAGEMENT

J. K. VanDyk¹, ¹Dept. of Entomology, Iowa State Univ., 411 Science II, Ames, IA 50011-3222, USA, E-mail jvandyk@iastate.edu.

Integrated pest management information on the internet is not available in a single, organized categorical hierarchy. Instead, it exists on many different webservers . The National IPM network of the United States has developed a categorical search engine that organizes information across disparate servers. A central browsable directory is created from meta information located in web documents. Contributors may submit web pages for inclusion and supply meta information for existing web pages. Each page is indexed using traditional search engine methodology and categorized if appropriate meta information is present. The result is a search engine and categorical directory that can use any class of meta information (author, state, pest) as a criterion or filter. In this way, subject-specific information from the internet can be organized. The software and interfaces for accomplishing this task will be demonstrated.

Index terms: Integrated Pest Management, IPM, WWW, internet

[0766] HYBRID KEYS AND SYNTHETIC DATASETS: NEW DEVELOPMENTS IN INTERACTIVE KEYS WITH LUCID VERSION 2.0

D. K. Yeates^{1,3} & K. Thiele^{2,3}, ¹Dept of Zoology and Entomology, The University of Queensland, Brisbane, 4072 AUSTRALIA, E-mail d.yeates@mailbox.uq.edu.au; ²Australian National Herbarium, G.P.O. Box 1600, ACT 2601, AUSTRALIA; ³Centre for Pest Information Technology & Transfer, The University of Queensland, Brisbane Qld 4072 AUSTRALIA.

Two types of identification key used in systematics are route keys ("dichotomous" keys) and random-access ("interactive") keys. The two key types have very different logical structures, with the strengths of one often the weaknesses of the other. Route keys are inflexible, and users can face unanswerable couplets. Random-access keys solve these problems, but they cannot handle character contingency, a problem especially at higher taxonomic levels. In addition, route keys can be constructed while the key developer only knows a small proportion of the full matrix of characters necessary for the development of a random access dataset. Random-access keys will not supersede route keys, and there is much potential for hybrid structures that combine the strengths of both approaches and avoid their weaknesses. The strengths of a synthetic approach to dataset construction, with the inclusion of molecular, morphological and behavioural characters will also be discussed and demonstrated with an example from the dacine Tephritidae. Index terms: Tephritidae, random access keys, synthetic

datasets.

Symposium and Poster Session

[0767] HYPERTEXT WRITING COMES OF AGE: ECOLOGY KNOWLEDGE PROCESSING AT THE DAWN OF THE MILLENIUM

T. Putter

ABSTRACT NOT RECEIVED

[0769] THE GLOBAL BIODIVERSITY INFORMATION FACILITY (GBIF): WHAT IT IS, WHAT IT WILL DO AND HOW IT WILL BE ESTABLISHED

E. S. Nielsen, CSIRO Entomology, GPO Box 1700, Canberra ACI 2601, Australia (ebbe.nielsen@ento.csiro.au).

An international mechanism is needed to make biodiversity data and information accessible worldwide. The existence of such a mechanism will produce many social and economic benefits. For example, the Convention on Biological Diversity (CBD) obligates nations to implement provisions relating to conservation, use, and equitable sharing of biodiversity. A scientific information resource that could facilitate fulfillment of these obligations is greatly needed. Such a resource will also be a central element in sustainable development. The Subgroup on Biodiversity Informatics of the Working Group on Biological Informatics of the Megascience Forum of the Organization for Cooperation and Development has in 1999 recommended that the governments of OECD countries establish and support a distributed system of interlinked and interoperable modules (databases, software and networking tools, search engines, analytical algorithms, etc.) that together will form a Global Biodiversity Information Facility (GBIF). This Facility was endorsed by OECD Science Ministers in June 1999. They stated that GBIF should be a body in its own right with open-ended membership. It will work in close cooperation with established programmes and organisations that compile, maintain and use biological resources. GBIF is currently being established by an Interim Steering Committee representing the governments of some 15 countries as well as the CBD. GBIF will be open to all countries and peoples, will enable users to navigate and put to use vast quantities of biodiversity information, thereby (1) advancing scientific research in areas such as agriculture, biomedicine, biotechnology, environmental management, pest control, health, education, and conservation, among others; (2) serving the economic and quality-of-life interests of society; and (3) providing a basis from which our knowledge of the natural world can grow rapidly and in a manner that avoids duplication of effort and expenditure. The presentation will detail the development of the GBIF concept, the timetable and principles for its implementation, GBIF characteristics, contents, work programs and organization. The OECD report is available under reports at http://www.oecd.org/dsti/sti/s_t/ms/index.htm and the Ministerial concusions at: http://www.oecd.org/news_and_events/release/nw99http 68a.htm.Index terms: biodiversity informatics, biological informatics

[0768] TECHNOLOGICAL OPPORTUNITIES AND CHALLENGES IN BUILDING A GLOBAL BIOLOGICAL INFORMATION INFRASTRUCTURE

H.Saarenmaa, European Enviroment Agency, Kongens Nytorv 6, 1050 Copenhagen, Denmark; E-mail: hannu.saarenmaa@eea.eu.int.

An overview is given how newest information technologies can help to manage biological information. The possibilities have increased dramatically just over one or two past years. It is important to see the difference between infrastructure, meant to provide shared building blocks, and applications that are just to solve a specific problem. Many of the new possibilities especially enable the building of infrastructure. Several global processes such as the CHM and GBIF are heavily dependent on these new infrastructure technologies. XML (eXtended Markup Language) is a successor to HTML that unifies data management and presentation under document content management. It enables information interchange with both human and computer-readable packages. Using XSL (eXtended Style Sheets) the information can be viewed from various angles. Data Type Definitions (DTD) and XML schemas for biological information should be standardized urgently. Examples of content that should rely on XML from this on include species homepages and observation data. Digitizing of type specimens should be a priority of all collections. It is nowadays very easy and inexpensive with digital cameras and video capture devices. Once digitized, specimen data is safe, does not lose color, and can be accessed world-wide instantly, if so desired. Electronic publishing of descriptions has become practically feasible with the 4th ICZN. A work issued after 1999 in numerous identical and durable copies may be regarded as published even if not printed on paper, provided that identical copies deposited in at least 5 named and publicly accessible libraries are provided. Analogously to Internet's Domain Name System, a stable addressing system for scientific names of organisms could be designed using stable numeric identifiers derived from IPv6. This would be used to overcome the volatility of the Linnéan names, which are not suitable for keys. Using such global IDs for both taxa and names, biological information could be addressable from web services worldwide by broadcasting. Building global directories of expertise, technology transfer, and information resources is now feasible using Directory Services and the Lightweight Directory Access Protocol (LDAP). An information architecture building on the above concepts and glued together by distributed objects is outlined. It should be conceivable as it does not require standardization of local data. Mapping of local data to a global ontology can be done using XML and stable IDs.

Index terms: taxonomy, informatics, standardization, XML, digitizing

[0770] THE TREE OF LIFE PROJECT: A MULTI-AUTHORED, DISTRIBUTED INTERNET PROJECT CONTAINING INFORMATION ABOUT PHYLOGENY AND BIODIVERSITY

D. R. Maddison, Dept. of Entomology, Univ. of Arizona, Tucson, AZ 85721, USA, Email tree@ag.arizona.edu.

The Tree of Life Project (http://phylogeny.arizona.edu/tree/phylogeny.html) is a collaborative effort among biologists providing a collection of information, available over the Internet, about the evolutionary history and diversity of life on Earth. It consists of a series of web pages, each illustrating and discussing an individual species or a group of species, linked together in the form of the evolutionary tree of life. Along with pictures and introductory information of interest to the general public and students of all levels, Tree of Life pages feature specialized sections (on morphology, phylogeny, biogeography, etc.) addressing the needs of researchers in the field. There are currently over 300 biologists (http://phylogeny.arizona.edu/tree/home.pages/participants.html) in 21 countries contributing to the project. The Tree of Life Project is designed to provide comprehensive, authoritative, and up-to-date information on every species of organism, living and extinct, as well as proposals of their origin and relationships (a goal that will never be fully achieved), and to facilitate communication and initiate collaboration between researchers working on the same or related groups of organisms. The current operation and plans for the future of the Tree of Life Project will be described. The next step in the project will be conversion from a static collection of web pages into a database-driven system. This conversion will allow information to be assembled dynamically and in customizable ways, and will provide for greater communication with other biological databases. Index terms: Evolutionary tree, World Wide Web

[0771] ENTOMOLOGY IN COSTA RICA INBio

<u>A. Solís,</u> Instituto Nacional de Biodiversidad, Santo Domingo, Apartado Postal 22 3100, Heredia, Costa Rica. E-mail: asolis@inbio.ac.cr

Since the creation of INBio in 1989, all our activities in the Entomological Department were planned and designed on the way, take into consideration many of the possibilities and advantages offered by the Informatics nowadays. Beginning with the basic objective: "Decrease the information scarcity about the insects, and make this information available to the people of Costa Rica and the rest of the world, for a rational use, and for the conservation and development", we have generated a number of procedures and computerized applications for the capture, storage, management, and publication of the achieved information. The specimens are collected by parataxonomists in lots using various collecting methods, and the data of each lot is captured into INBio's database, where a code is created for each lot. Also, for each specimen a record is created in the database and is linked to its lot information using a distinct identifier represented in the specimen by the bar code label. Later, the specimens are separated by technicians, mostly to the family level, and are put accessible to the Taxasphere, and at that point with the expert's help, the specimens are divided to the lowest possible level. From the experts, we are able to obtain electronic taxonomic dictionaries in their fields of taxonomic expertise. In batch, the identification's information is gathered to each specimen record in the database. The Collection is adequately curated continuously, and each year is profiled in order to get the best accessibility level. We want to facilitate the job of the Taxonomists to the degree that they won't need to waste their valuable time getting the label information or doing some other things. The information of the collection is put accessible through the Web or by others electronic means. Additionally, from the databases, the expert can obtain some natural history information and distribution maps about collected specimens. And an image database is also available for storing or getting draws and pictures. Using all of these support things, the expert can do his traditional taxonomic work, or could generate Basic Information Units (UBIs). The UBIs system allows the integration of the species information including taxonomic history, diagnostic description, distribution, natural history data, maps, illustrations, etc, in order to make it available to all the people using the Web.

Index terms: Inventory, Neotropics, Biodiversity, Informatics

[0772] ISSUES OF QUALITY CONTROL IN LARGE DISTRIBUTED ENTOMOLOGICAL DATABASES

J. Soberon, National Commission of Biodiversity, Mexico. E-mail: jsoberon@xolo.conabio.gob.mx

In recent times an increasing amount labels in museum's specimens is being computerized and often made accessible through the Internet. This opens the door to the creation of large (in the orders of 104 to 106 records) databases that can be used (and are being used) for a number of applications, from basic science, in the exploration of evolutionary questions, to management issues, like the assessment of the potential damage of invasive species, to name just two examples. However, such large database of ahout 50,000 records of Papilionidae and Pieridae butterflies of Mexico, obtained from nearly twenty different museums, to explore some of the major problems of such databases and ways of identifying and correcting them. The thesis of the work is that probably all large, mixedorigin databases are fraught with problems, so great care should be used in using them. Nevertheless, techniques already exist to deal with some of those problems and to extract useful knowledge from the databases. [0773] AN INFORMATION INFRASTRUCTURE FOR GERMAN INSECT COLLECTIONS INCLUDING MULTIMEDIA AND GIS-TOOLS

K. H. Lampe & K. Riede, Zoologisches Forschungsinstitut und Museum Alexander Koenig (ZFMK), Adenauerallee 150-164, D-51113 Bonn, Germany, E-mail: k.lampe.zfmk@unibonn.de; k.riede.zfmk@uni-bonn.de;

The number of insect species on earth and their actual extinction rate is a matter of speculation for several years already, but exact numbers are still not available. This is mainly due to the lack of an efficient information infrastructure. Complete registers of valid taxa only exist for few insect groups, and much of the information stored within museum collections is not readily accessible, because most of it is not digitised. The German Ministry of Science and Education (BMBF) has launched the EDIS-project (Entomological Data and Information System) to digitise and harmonise the rich, but scattered entomological collections housed at various German institutions within one specimen-based collection database. This concept is illustrated for the DORSA-subproject, which will integrate Orthoptera collections within one "Virtual Museum", accessible by an internet-based user interface. As a taxonomic backbone we will use the "Orthopteran Species File" (OSF: Otte & Naskreeki 1997), which is among the few electronic catalogues of named organisms (global species register) already available on the WorldWide Web (http://viceroy.eeb.uconn.edu/Orthoptera). DORSA will integrate specimen-based sound recordings. These species-specific songs will be used as a knowledge base for the development of song recognition algorithms and bioacoustic "Rapid assessment tools". In addition, all localities will be geo-referenced, resulting in a huge dataset of point data, which can be exported into Geographical Information Systems (GIS). These distribution data can be overlaid with other GIS-maps (e.g. on rainforest extension). However, most GIStools are not able to tell the user which species occur in a delimited area in a user-friendly way. We present a customised Java-tool that allows geographic visualisation and retrieval of taxonomic data. This might be a first step to answer simple questions such as 'How many insects have been discovered in a certain area?' or - possibly even more important - 'How many species have been affected by habitat destruction within a certain area?'

Index terms: database, Orthoptera, global species register, bioacoustics, rapid assessment

[0774] INTERACTIVE IDENTIFICATION USING THE INTERNET

M. J. Dallwitz, T. A. Paine & E. J. Zurcher, CSIRO Division of Entomology, GPO Box 1700, Canberra ACT 2601, Australia. E-mail: md@ento.csiro.au.

Computer-based interactive keys have several advantages over conventional keys: a correct identification can be made in spite of errors by the user or in the data; characters can be used, and their values changed, in any order; numeric characters can be used directly, without being divided into ranges; the user can express uncertainty by entering more than one state value, or a range of numerical values; Other features important for efficient and reliable identification include: advice on the most suitable characters to use at any stage of an identification; locating errors which were circumvented by the errortolerance mechanism; notes on the interpretation of characters; illustrations of characters and taxa; finding the differences and similarities between taxa; finding diagnostic descriptions. Interactive identification can be made available over the Internet in the following ways. 1.A helper application for a Web browser. Example: Intkey, http://biodiversity.uno.edu/delta/ 2. A program (Java or JavaScript) running in a Web browser. Example: NaviKey, http://www.herbaria.harvard.edu/software/navikey/ Cooperating programs running in a Web browser and server. Example: DAP, http://www.botanik.biologie.uni-muenchen.de/botsamml/lias/lias.html 4. A program running on a Web server, and generating HTML pages. Example: PollyClave, http://prod.library.utoronto.ca/polyclave/index.html Programs of type 1 must first be installed, and most are available for only one operating system (usually MS-Windows). Programs of types 1 and 2 download the data matrix at the start of a session. The user cannot proceed until the downloading is completed, but afterwards response is fast, and there is no further load on the network and server, except when subsidiary files, such as images, are required. The programs can also be used off line. In programs of types 3 and 4, the data matrix is not downloaded. Each operation requires an Internet transaction, so responses tend to be slow, and a continuing load is placed on the network and server. The programs cannot be used off line. In programs of type 4, the user interface is familiar to Web users, but may become cumbersome for some operations, particularly with large data sets. Programs of types 2-4 are potentially independent of the user's operating system and browser, but in practice there may be problems. Currently available programs of types 2-4 lack many of the features required for efficient and reliable identification. Index terms: DELTA, Intkey, keys.

[0775] NEW APPROACHES TO CREATING GLOBAL SPECIES DATABASES IN ENTOMOLOGY

M.J. Scoble, ¹Dept. of Entomology, The Natural History Museum, Cromwell Road, London SW7 5BD, UK, E-mail: m.scoble@nhm.ac.uk.

Global species databases are, broadly speaking, computerised taxonomic catalogues. Databases have, however, the capacity to be more extensive than catalogues, and they are much more effectively searched. They can also be networked. It is increasingly evident that the kind of information inherent in traditional taxonomic catalogues is of value beyond the systematics community. In particular, it forms the basis for such products as life-lists, biodiversity surveys and inventories, which are needed to meet certain requirements under the Convention on Biological Diversity. The main difference between creating global species databases for insects and most other groups of organisms is that of the size of the task. In this paper I give an example of the steps in creating one such database (on geometrid moths) and the hardcopy catalogue that was derived from it. Although a great deal of effort was required to complete the database in a timely fashion, such large compilations are quite possible given appropriate facilities and the right people. Key features in the production of the work, both material and in terms of human effort, will be discussed. Some other insect databases will be cited. These examples have been created from just a subset of extensive archival sources in natural history museums. Attempts are now being made by the University of Essex and The Natural History Museum, London, to build a Versatile Interactive Archive Document System (VIADOCS). The project proposes a novel interactive method of archive conversion by extending a current commercial optical character recognition system for completing forms. A demonstration interactive conversion system utilizing a particular Lepidoptera index-card archive (on Pyraloidea) will be developed, and evaluated against current manual conversion methods, and in interactive use 'on demand' over the Internet. The aim of producing this system is to provide a means of making accessible extensive quantities of data trapped in typed and hand-written archives. All these efforts should be seen in the broader context of computerising biological data typically associated with biological collections.

Index terms: taxonomic information, catalogues, archival data

[0777] BIOSYSTEMATIC DATABASE OF WORLD DIPTERA: THE FIRST GLOBAL MASTER SPECIES DATABASE IN ENTOMOLOGY

F. C. Thompson¹ & N. L. Evenhuis², ¹Systematic Entomology Lab., ARS, USDA, Washington, D.C. 20560-0169, USA, e-mail: cthompso@sel.barc.usda.gov; ²Bishop Museum, 1525 Bernice St., Honolulu, Hawai'i 96817-0916 USA, e-mail: neale@bishopmuseum.org

The BioSystematic Database of World Diptera (BDWD) is a cooperative effort of the World's leading dipterists to provide a comprehensive index to the names of flies (Order Diptera). The database is disseminated annually on CD-ROM (on the Diptera Data Dissemination Disk) and is available on the World-Wide-Web with quarterly updates at USDA Systematic Entomology Laboratory Diptera the vita (http://www.sel.barc.usda.gov/Diptera).All the nomenclatural details (name, author, year, page, type, current status, valid name, valid author, family) are included. For valid names, abbreviated distributional data are provided. While the database is still being constructed, all name records are available. Those that have been checked by specialists and have been peer-reviewed are identified and dated. Currently the fruit flies and a number of small families have been completed. Altogether, there are more than 160,000 names, including all family-(4,324) and genus-group names (21,000) and about two-thirds of the speciesgroup names (130,000). The reference file includes little more than 7,000 citations. Ultimately the database will contain more than 250,000 names and 25,000 references. Currently more than 100,000 different kinds of flies are known to Science with some 2,000 new ones being described annually. The BDWD has participated with the Species 2000 program and Integrated Taxonomic Information System (ITIS) since their initiation. Likewise, the BDWD will contribute to the Global Biodiversity Information Facility, Electronic Catalog of Names of Known Organisms. The BDWD is endorsed by the Council for the International Congresses of Dipterology, a scientific member of the International Union of Biological Sciences. The BDWD is sponsored by the Systematic Entomology Laboratory, Plant Sciences Institute, Beltsville Agricultural Research Center, Agricultural Research Service, USDA, Washington, D.C. and the Bishop Museum, Honolulu, Hawai'i.

Index Terms: Flies, Nomenclature

[0776] DEVELOPING AND SHARING DATA GLOBALLY: THE 'GLOBAL BUTTERFLY INFORMATION SYSTEM' – GLOBIS

<u>G. Lamas</u>¹, E. S. Nielsen², R. K. Robbins³, C. L. Häuser⁴ & R. de Jong⁵, ¹Museo Nacional de Historia Natural, Universidad Nacional Mayor de San Marcos, Apartado 14-0434, Lima-14, Peru; ²CSIRO Entomology, GPO Box 1700, Canberra ACT 2601, Australia; ³Department of Entomology NHB-127, National Museum for Natural History, Smithsonian Institution, Washington, DC 20560, USA; ⁴Staatliches Museum für Naturkunde, Rosenstein 1, D-70191 Stuttgart, Germany; ⁵Department of Entomology, National Museum of Natural History, PO Box 9517, 2300 RA Leiden, The Netherlands.

Butterflies are beautiful, they make up 1% of all named species of organisms (more than twice the number of birds), and are naturally abundant in a wide variety of ecosystems throughout the world. Despite their obvious aesthetic appeal and well-established value for assessing and understanding biodiversity, there is no universal standard system for knowing what butterflies exist, how to identify them, where they naturally occur, or how to find out what is (and what is not) known about them. GloBIS (Global Butterfly Information System) is a proposal for an internationally-operated, web-based, multimillion dollar program to rectify this deficiency. A collaborative project planned by butterfly specialists from major museums and entomological institutes, GloBIS will give equitable access worldwide to a vast store of information about butterflies never assembled or available before. The core of GloBIS will be a complete list of all scientific names ever applied to butterfly species and groups of species, for the entire world. Linked to that list will be distribution maps and distribution data; images of adult butterflies (both preserved and living), their early stages, morphological details, and habitats; interactive identification keys; hostplant and parasitoid databases; and a bibliographical database.

[0778] BEETLES AND BEETLE LARVAE OF THE WORLD: INTERACTIVE IDENTIFICATION AND INFORMATION SYSTEMS FOR FAMILIES AND SUBFAMILIES

J. F. Lawrence & <u>R. G. Oberprieler</u>, CSIRO Entomology, GPO Box 1700, Canberra ACT 2601, AUSTRALIA. E-mail Rolf.Oberprieler@ento.csiro.au.

Two recently released CD-ROM products (CSIRO Entomology, November 1999) are presented: 'Beetles of the World: A Key and Information System for Families and Subfamilies' and 'Beetle Larvae of the World: Interactive Identification and Information Retrieval for Families and Subfamilies', by J.F. Lawrence, A.M. Hastings, M.J. Dallwitz, T.A. Paine & E.J. Zurcher. These MS-Windows-based products are the first comprehensive interactive identification systems for all families and most subfamilies of beetles. Beetles of the World spans 945 taxa representing all 172 recognized beetle families and most subfamilies, and uses 312 anatomical characters accompanied by clarifying notes plus 17 text characters dealing with classification, distribution, biology and key literature for each taxon. All taxa are illustrated, using more than 2500 colour and black-and-white images, and 75% of the characters are elucidated by means of explanatory images. A Beetle Browser (an illustrated tool for finding the names of major beetle body parts) and a glossary of terms are included. Beetle Larvae of the World (an update of the 1993 MS-DOS version) covers 390 taxa representing 148 families and many subfamilies, and uses 170 anatomical characters plus 9 text characters dealing with classification, distribution, biology and key literature. 40% of the taxa and 60% of the characters are illustrated by means of enhanced drawings in colour. These interactive systems can be used to: identify a beetle or beetle larva from any part of the world to family, usually to subfamily and occasionally to tribe and genus level; for a particular taxon obtain information on distribution and biology, the current valid family name, a printed full description or diagnosis and a list of references; generate a list of beetle groups having a particular attribute or occurring in certain geographical regions; and restrict an identification to one of these areas. The identification process can be automated (allowing the program to suggest the most suitable discriminating characters) or started from any selected character, or set of characters in any sequence, and it allows for uncertainties and errors in character coding and for no matches being found. Copious notes and images facilitate character coding, and identification is easy and efficient. These identification systems are essential tools for researchers, museum curators, teachers, environmentalists, agriculturalists, quarantine inspectors, naturalists and beetle lovers in general Index terms: classification tools, diagnostic characters, key references

[0779] A SOFTWARE ENGINEERING PERSPECTIVE ON DEVELOPING ELECTRONIC FIELD GUIDES: LESSONS FOR BIOINFORMATICS

R. A. Morris¹, M. Passell¹ & <u>R. D. Stevenson</u>², ¹Dept. of Math and Computer Science and ² Dept. of Biology, Univ. of Massachusetts, Boston, MA, USA. E-mail robert.stevenson@umb.edu

Consumers of bioinformatics software have specific needs that must be considered by software designers in order to build systems that will be used. For biologists interested in biodiversity data, experience has taught (1) that a single data model at the species level is inadequate, (2) that software should be extensible and flexible, and usable without the assistance of computer scientists, and (3) that to meet biologists' needs, data models should support data exchange and federation. With these needs in mind, we have begun to design and implement Electronic Field Guide software (http://www.cs.umb.edu/efg). An object-oriented database (OODB, here Object Store) specifies the diversity structure while edge-labeled directed acyclic graphs hold data. Taxonomic schemata are largely uncontroversial so taxa are represented by simple tree graphs. Keys use idiosyncratic and complex character lists with multiple paths to the correct species so they are implemented as acyclic graphs. Java servlets provide the middleware accessible by (to be) public protocols. Output is generated dynamically as HTML and Java applets. OODB tools are not widely accessible to biologists so data from EFG authors are imported through an ODBC/JDBC bridge. Java beans are constructed for each taxon in the import; attributes in import are object properties. These are unknown in advance. (Note that ODBC can not specify order of attributes nor of data when attributes are unknown in advance.) The point of attachment is a path in the data graph. (See semi-structured data literature, especially as described in Abetiboul et al. "Data on the Web", Morgan Kaufman.) Software will be available via the Free Software Foundation's General Public License. Our experiences serve as a foundation to discuss the use of XML for data exchange and federation with other biodiversity databases.

Index terms: Bioinformatics, field guides, software design, object oriented databases,

[0780] THE SPECIES ANALYST - STANDARDS FOR A GLOBAL BIODIVERSITY NETWORK

D. Vieglais

ABSTRACT NOT RECEIVED

ABSTRACT BOOK I - XXI-International Congress of Entomology, Brazil, August 20-26, 2000

[0781] INSECT INFORMATION TECHNOLOGY TRANSFER - SOFTWARE TOOLS FOR IDENTIFICATION, DIAGNOSIS AND IPM DECISION SUPPORT

<u>G. Norton</u>

ABSTRACT NOT RECEIVED

0782] MINING GEOGRAPHICAL DATA FOR BIOLOGICAL INFORMATION R. W. Sutherst, G. F. Maywald & B. L. Russell ABSTRACT NOT RECEIVED

[0783] INSECT INFORMATICS: TO MEET THE CHALLENGE OF MODERN INFORMATION DISSEMINATION

<u>Y. L. Xia</u> & J. Baumgärtner, Dept. of Population Ecology and Ecosystem Science, International Centre of Insect Physiology and Ecology (ICIPE), P. O. Box 30772, Nairobi, Kenya, E-mail: yxia@icipe.org

The "Post-PC Era" is about to come with new opportunities and challenges. Users will access to web, personal, and business data from a variety of devices, relying on wired or wireless communication. There will be available a variety of inter-networkable information appliances with wide range of applicability. For example, voice recognition technology may overcome screen and keyboard limits of information appliances. Insect Informatics is a novel subject dealing with the generation, processing and dissemination of insect information through the use of modern information and communication technology. To meet the challenge of the "Post-PC Era", International Centre of Insect Physiology and Ecology (ICIPE) started the Insect Informatics Initiative in early 1998. Its aim was to integrate and strengthen the delivery of insect-related information via modern information and communication technology, while at the same time contributing to the building of capacity in information technology in Africa through regional partnerships, networking and training. ICIPE's Insect Informatics Initiative has identified the following R&D areas: 1) Methodology-oriented area: Web-based Intelligent Decision Support Information System, GIS, Early Warning/Expert System. 2) Information Dissemination-oriented area: Africa Regional IPM Information Network, Bio-Control Information System, Insect Biodiversity Information system, Multimedia Products on Insects. 3) Commodity-oriented area: Horticulture, Apiculture, Sericulture. 4) Pest-oriented area: Stemborer, Mosquito, Tsetsefly, Tick, Fruitfly, Whitefly, Grasshopper/locust. 5) System Development-oriented area: Virtual Biovillage (community-driven integrated health and resource management system). 6) Other areas: Genome Informatics for Insects, Insect Visual Study, Africa IPVM Virtual training. Highest priority is given to the development of web-based intelligent insect management information systems, which will serve as strategic planning and decision support tools for integrated crop and pest management. Index terms: Insect Informatics Initiative, Post-PC Era, IT, ICT, ICIPE

[0784] INVESTIGATING THE WINGBEAT SIGNALS OF MIGRATING INSECTS USING AN INSECT MONITORING RADAR

<u>V.A. Drake & I.T. Harman</u>, School of Physics, University College, The University of New South Wales, Australian Defence Force Academy, Canberra, ACT 2600, Australia.Email: ian.harman@adfa.edu.au.

In its primary mode of operation, an Insect Monitoring Radar (IMR) employs a rotating offset beam to produce a strongly modulated signal from which target trajectory, size, and shape can be extracted. Any weak modulation in the signal is usually overwhelmed by the larger effects produced by the rotating polarization and conical scan. A second mode of operation in which the beam is stationary has therefore been introduced, to allow the target-characterization capabilities of the IMR to be developed further. In this mode, the echo signals from individual insects show a slow variation arising from the target's transit across the beam and, superimposed, low-amplitude modulations due to wingbeating and, occasionally, breathing. Special software has been developed to automatically extract all the available information from digitisations of these echoes. Automatic observations employing the stationary-beam mode of the IMR are conducted hourly during routine operations and occupy 25% of observing time. Data is acquired from 8 altitude levels spanning 200-1300 m, with each sample gate using a narrow detection window to minimize the probability of acquiring overlapping echoes. A hardware filter passes frequency components in the range 0-128 Hz, which previous studies have indicated covers the wingbeats of moths, grasshoppers and birds. This filter improves the signal-tonoise ratio and eliminates aliasing from higher frequencies. Observations are made sequentially at three polarization angles 60° apart to minimize dependence on target orientation. The data presented derives from observations of moth and locust migrations made with an IMR installed at Bourke, New South Wales, in eastern inland Australia during the spring and summer of 1998-99. The estimated target parameters have been correlated with height of flight, time of night, and season. Index terms: IMR, moth, locust, Australia.



[0785] HOW MIGRATION AFFECTS ECOLOGICAL DIVERSIFICATION OF *APIS DORSATA* POPULATION. AN APPROACH BY SELF-ORGANIZING MAPS PROCESSING

G. Kastberger¹, **D.K. Sharma²**, **E. Hüttinger³ & G. Kranner⁴**, ¹ Department of Zoology, University of Graz, Austria; ² Department of Zoology, University of Gauhati, India; ³ Institute for Bienenkunde, Lunz, Austria; ⁴ eudaptics software gmbh, Helferstorferstraße 5/8, A --1010 Vienna, Austria. Supported by the Austrian scientific foundation, grant P13210-BIO.

The Giant honeybee Apis dorsata occurs in South East Asia, from Pakistan to the Phillipines, from the Himalaya to Borneo and Sri Lanka. This bee nests in the open and is highly migratory, which depend on saisonal aspects of forage and predation. A study on the diversification of dorsata lineages must especially focus upon the local intermix of colonies originating from different regions, and must discriminate samples at colony level, to display the relatedness between different colonies. We investigated ecological variation of dorsata populations in Assam, which is part of the geographical bottleneck between Southeast Asia and the Indian subcontinent. This topographic location is likely to route the dorsata gene streams, passing it either from the Bengali or from the Birmesian regions. Just in the central part of this bottleneck the Brahmaputra river is situated, the second biggest river in the world; its tributaries comprising water and sand banks form areas up to 15 km wide. It is likely that this riparial area functions as an ecological barrier for A. dorsata migration swarms. If so, this river will lessen gene flow, which may divide the A. dorsata population in Assam into two groups, that of the North bank and that of the South bank of the Brahmaputra river. To test this hypothesis, we selected the method of factor analysis of morphometric characters, which has been proved successfully in revealing lineages in Apis species. We introduced a refined multivariate statistics and a powerful primary component analysis, using the self-organising maps (SOM) neighbourhood algorithm to classify 49 A. dorsata samples at the meso- and microlevel by 30 wing characters. In SOMs, multidimensional data spaces are converted into lower dimensional abstractions, unlike the discriminant analysis, which reduces multidimensionality by linear principles. It offers a convenient way to visualise clusters as well as the topological neighbourhood of colonies in data space. This allows to estimate the rate at which swarming colonies migrate within four distinct regions of Central Assam. The calculated transfer rates at which dorsata swarms migrate across the Brahmaputra river were similar in both directions (N-S, S-N), but are only 50% of that rate at which they migrate along the river banks. This is the first evidence that the topographical barrier of the Brahmaputra river induces diversification of Apis dorsata lineages.

Index terms: Self-organizing maps / Giant Honeybee / Apis dorsata / populations / morphometrics / Assam, India

[0786] A PRELIMINARY COMPUTER MODEL OF *GLYPTOTENDIPES PARIPES* (DIPTERA: CHIRONOMIDAE) LARVAL DISTRIBUTION IN LAKES OF CENTRAL FLORIDA, USA

R. J. Lobinske¹, A. Ali¹ & J. C. Allen², ¹Univ. of Florida, Inst. of Food and Agricultural Sciences, Mid-Florida Research and Education Center, 2725 Binion Rd. Apopka, FL 32703-8504, USA, E-mail RLobinske@aol.com; ²Univ. of Florida, Dept. of Entomology & Nematology, Bldg. 970, P. O. Box 110630, Gainesville, FL 32611-0630, USA:

Using larval Chironomidae and selected water and sediments physico-chemical data collected seasonally over a two year intensive sampling of two eutrophic large lakes in central Florida, USA, a preliminary computer model has been developed for distribution of *Glyptotendipes paripes* larvae utilizing the software MatLab, version 5.3. The model uses matrix parameter maps of lake bathymetry and sediment percent dry weight, with varying inputs of water level, Secchi disk transparency and Chlorophyll *a* concentration (as estimators of phytoplankton abundance) to generate matrix maps of predicted larval distribution and relative abundance. Adjusted water depth and sediment dry weight determines the overall areas of likely occurrence of the larvae, and Secchi transparency influences the overall abundance of the simulated population. To examine temporal dynamics of simulated populations, life history functions using Leslie or Lefkovitch matrices are used to simulate survival and development of larval populations, and redispersal of the population during reproduction and egg-laying are simulated using convolution filters.

Index terms: Glyptotendipes paripes, Chironomidae, computer model, urban pests, aquatic entomology.

[0787] MICROSATELLITE MARKERS OF TWO AGRICULTURAL PESTS, THE MEDFLY, CERATITIS CAPITATA AND THE OLIVE FLY, BACTROCERA OLEAE

K. D. Mathiopoulos¹, A. Augustinos¹, E. Stratikopoulos¹, P. Mavragani-Tsipidon², A. Mintzas' & A. Zacharopoulou', 'Dept. of Biology, Univ. of Patras, Greece, e-mail: zacharop@upatras.gr; 2Dept. of Biology, Univ. of Thessaloniki, Greece.

Medfly, Ceratitis capitata, is rated as one of the world's most destructive agricultural pests. A native of eastern Africa, the fly has invaded most of the warmer parts of the world causing immense devastation to more than two hundred fruit species. On the other hand, the olive fly, Bactrocera oleae, is a devastating but highly specialized pest of the olive tree. It is the principal olive pest in all olive oil producing Mediterranean countries and has invaded all new olive producing countries. Microsatellites are tandem arrays of simple sequence repeats. They are extremely useful in genetic and population analyses because they are very abundant, they are randomly distributed along the genome and they are highly polymorphic. They can be easily identified and scored. In addition, the high degree of polymorphisms facilitates genetic mapping by recombination, since microsatellite markers are inherited as co-dominant, Mendelian characters. Using (AT)15, (GC)15, (AC)15 and (GA)15 as probes we acreened microsatellite enriched libraries from the medfly and the olive fly genomes and isolated several microsatellite containing clones. Sequence analysis determined the nature and length of the microsatellite locus. In situ hybridization of the clones on the respective polytene chromosomes determined their cytological position. The degree of polymorphism of specific microsatellito loci was determined by analysis of field collected individuals. Several of these microsatellite loci were conserved between the two species, thus giving the opportunity to PCR amplify a microsatellite locus with the same primer pair for both the medfly and the olive fly. The availability of polytene chromosomes in both the medify and the olive fly provides the additional possibility of linking genetic with cytogenetic data. In situ hybridization of the microsatellite locus on the polytene chromosomes and the polymorphic nature of microsatellites make possible the correlation between genetic and cytogenetic maps and facilitates the construction of integrated maps which is the main focus of this project.

Acknowledgements: This work is being supported by a European Union Return Grant to KDM No ERBFMBICT983067 and by grants of the General Secretariat of Research and Technology, Hellas,

[0788] COMPUTER-ASSISTED TOOLS FOR THE SPECIES RECOGNITION OF ECONOMICALLY IMPORTANT INSECTS AND MITES

. Meijerman & S.A. Ulenberg, Dept. of Entomology, Zoological Museum Amsterdam, Pl. Middenlaan 64, 1018DH Amsterdam, the Netherlands, E-mail meijerman@bio.uva.nl.

The University of Amsterdam, the Expert Centre for Taxonomic Identification, Amsterdam and CAB International, UK, are collaborating in a project aiming to provide both specialists and non-specialists with easy to use and apply tools for the species recognition of insects and mites that cause economic damage in agriculture, horticulture and forestry, and their natural epemies. The end product is a series of interactive CD-ROMs based on ETI's 'Linnaeus II' software for biodiversity documentation and species identification. Each CD-ROM contains up-to-date taxonomic (biodiversity) information on economically important species and related non-pest species, and a computer assisted identification key. A cross reference system for the major host plants, interactive distribution maps, an illustrated glossary for technical terms and a section on methodology are also included. In progress are Tortricidae of Economic Importance', 'Agromyzidae of Economic Importance' and 'Diaspididae of Economic Importance'. Further work on Aleyrodidae and their natural enemies, and on the natural enemies of Agromyzidae is planned. The CD-ROM 'Eurasian Tortricidae of Economic Importance' will be demonstrated.

Index terms: Tortricidae, pests, identification key

[0789] NON-PARAMETRIC MODELLING AND EXPERIMENTAL TESTING OF BLOWFLY POPULATION DYNAMICS

S.J. Moe, Univ. of Oslo, Dep. of Biology, P.O. Box 1050 Blindern, 0316 OSLO, Norway. E-mail: imoe@bio.uio.no.

Periodic fluctuations in abundance is a characteristic feature of many insect populations. It is necessary to understand the underlying mechanisms in order to predict or regulate insect populations. A.J. Nicholson (1954) demonstrated that population-intrinsic factors produced sustained oscillations in experimental blowfly populations (Lucilia cuprina). Non-linearities and time-lags in density dependence are of particular importance because they can give rise to complicated population dynamics such as cycles or chaos. We used a non-parametric modelling method, GAM (generalised additive modelling), to estimate density dependences in time-series data from experimental populations of Lucilia sericata. This method makes minimal assumptions about density-dependent functions and is therefore very useful for describing stage-specific density dependences, in particular for identifying non-linear relationships. The model indicated that 1) larval survival was nonlinearly dependent on larval density (highest survival at intermediate densities), 2) adult survival was density-independent, and 3) reproduction was dependent on adult density. These predictions were tested experimentally in order to evaluate the model. The experimental results confirmed both the non-linear relationship between larval density and survival and the density independence of adult survival. The humped larval survival function is probably a result of faciliation by group feeding at low densities and competition for food at high densities. The reproductive rate was dependent on past larval density rather than on present adult density, which demonstrates delayed density dependence. Because adult density at any time is correlated with larval density of the same individuals their effects can not be separated by time-series analysis, only by experimental testing. The accordance between the model predictions and the experimental results shows that the non-parametric modelling method can be a powerful tool for analysing ecological time series and for generating new hypotheses. Index terms: Calliphoridae, Lucilia sericata, density dependence, larval competition,

ecotoxicology

[0790] SPECIES, SPECIMENS AND SOCIETY: CONTRIBUTIONS FROM BIOLOGICAL COLLECTIONS

S. O. Shattuck, CSIRO Entomology, P. O. Box 1700, Canberra, ACT, 2601, Australia

The millions of specimens held by biological collections form the corner stone of our understanding of global biological diversity. These specimens are also essential for the taxonomic research which transforms these individual data items into a rich picture of the world around us. Traditionally the results of taxonomic research have been published in paper-based journal articles and monographs. These journal articles and monographs are often the product of years of work and provide a snap-shot of our understanding of the taxa under study at a given time. While this time honoured and widely used publishing model has serviced us well in the past, the ever increasing rate of new knowledge acquisition, combined with electronic publishing, poses challenges to maintaining this model in the future. The problem is compounded by the fact that biological collections are constantly growing and changing as a result of new discoveries and taxonomic research. Existing taxonomic publications struggle to maintain their value and usefulness in the face of this rapidly changing world and competition from electronic information sources. To overcome these limitations a new publishing paradigm is needed. This new publishing process builds on well established taxonomic traditions and adds the flexibility and timeliness of electronic publishing. Publishing will continue to be based on a "monograph" model, but instead of these monographs remaining as static documents of years or decades, they are transferred to an "encyclopedia" model. They move from a static publication model to a living publication model, a model where "revisions" are updated regularly to better reflect current taxonomic understanding. For this new model to succeed, these new publishing methods need to be integrated into routine collection management practices and everyday taxonomic research activities. In this way information will flow freely from collections and research into publications which are made available without the delays normally associated with the paper-based publishing process. As a first step towards this total-taxonomic-information-management system, the Australian National Insect Collection has developed BioLink, a software package which manages both taxon- and specimen-based information. BioLink offers not only information management and reporting tools, but also analytical tools including build-in GIS capabilities and geographic modeling tools. BioLink offers a complete package for the collection, maintenance, analysis and dissemination of a wide range of biodiversity information

Index terms: BioLink, taxon databases, specimen databases, taxonomic publishing

[791] DEVELOPING ELECTRONIC FIELD GUIDES: FIRST RESULTS USING COSTA RICAN BUTTERFLIES AND MASSACHUSETTS AQUATIC MACROINVERTEBRATES

<u>R. D. Stevenson¹</u>, F. SaintOurs¹, R. A. Morris², M. Passell² & W. A. Haber³, ¹Dept. of Biology and ²Dept. of Math and Computer Science, Univ. of Massachusetts, Boston, MA, USA and ³Missouri Botanical Garden P.O. Box 299 St. Louis, MO 63166 USA; E-mail robert.stevenson@umb.edu

Field guides are important tools for people to learn about and enjoy biodiversity and natural history. They are also used in pest management and public health monitoring. Among insects, the most common field guides are for butterflies. Following the lead of the birding community, there are now an increasing number of citizens groups monitoring butterfly populations, based on the species they have learned using field guides. Despite their clear value, economic and technological barriers have prevented the publication of a much wider array of guides for insects. Now the digital revolution is rapidly relaxing these constraints. Digital devices, graphical software tools and the connectivity of the WWW are making it relatively cheap to produce Electronic Field Guides (EFGs) that have several advantages over dichotomous keys and traditional paper field guides. EFGs can be tailored for specific user groups and local coverage, incorporate more information, especially images, and are easier to update. We have a project to produce software tools (http://www.cs.umb.edu/efg) that will help biologists to make there own EFGs. Output of the guides is generated dynamically from an objected oriented database using Java. Information is displayed in HTML (but we have started the process of using XML for output). The guides store information about species in taxonomic trees, the leaves of which are "species pages", that describe life stages, ecological interactions, spatiotemporal distribution, and provide links to other species and bibliographic information. Inclusion of a variety of data types including text, images, movies, and sounds is possible. The keys are broad, shallow acyclic graph structures that use high quality images and context sensitive help. Examples of EFGs for Ithomid butterflies from Costa Rica and the aquatic macroinvertebrates from coastal Massachusetts will be shown. Issues for EFG authors, such as the type and amount of information that can be included, controlling the user output and intellectual property rights, are discussed.

Index terms: Bioinformatics, field guides, technology, butterflies, aquatic insects.

[0793] BIOSYSTEMATIC DATABASE OF WORLD DIPTERA. NAMES: KEYS TO INFORMATION

F. C. Thompson¹ & N. L. Evenhuis², ¹Systematic Entomology Lab., ARS, USDA, Washington, D.C. 20560-0169, USA, e-mail: cthompso@sel.barc.usda.gov; ²Bishop Museum, 1525 Bernice St., Honolulu, Hawai¹i 96817-0916 USA, e-mail: neale@bishopmuseum.org

The BioSystematic Database of World Diptera (BDWD) is a cooperative effort of the World's leading dipterists to provide a comprehensive index to the names of flies (Order Diptera). The database is disseminated annually on CD-ROM (on the Diptera Data Dissemination Disk) and is available on the World-Wide-Web with quarterly updates at USDA Entomology Laboratory Systematic Diptera the site (http://www.sel.barc.usda.gov/Diptera). All the nomenclatural details (name, author, year, page, type, current status, valid name, valid author, family) are included. For valid names, abbreviated distributional data are provided. While the database is still being constructed, all name records are available. Those that have been checked by specialists and have been peer-reviewed are identified and dated. Currently the fruit flies and a number of small families have been completed. Altogether, there are more than 160,000 names, including all family-(4,324) and genus-group names (21,000) and about half of the species-group names (130,000K). The reference file includes little more than 7,000 citations. Ultimately the database will contain more than 250,000 names and 25,000 references. Currently more than 100,000 different kinds of flies are known to Science, with some 2,000 new ones being described annually. The BDWD has participated with the Species 2000 program and Integrated Taxonomic Information System (ITIS) since their initiation. Likewise, the BDWD will contribute to the Global Biodiversity Information Facility, Electronic Catalog of Names of Known Organisms. The BDWD is endorsed by the Council for the International Congresses of Dipterology, a scientific member of the International Union of Biological Sciences. The BDWD is sponsored by the Systematic Entomology Laboratory, Plant Sciences Institute, Beltsville Agricultural Research Center, Agricultural Research Service, USDA, Washington, D.C. and the Bishop Museum, Honolulu, Hawai'i. Index Terms: Flies, Nomenclature

[0792] SPECIES INFORMATION DATABASE KONCHU ON JAPANESE, EAST ASIAN AND PACIFIC INSECTS, SPIDERS AND MITES ON INTERNET

O. Tadauchi⁴, H. Inoue², Y. Takematsu³ & H. L. Xu¹, ¹Entomological Laboratory, Faculty of Agriculture, Kyushu University, Fukuoka, 812-8581 Japan, E-mail tadauchi@agr.kyushu-u.ac.jp; ²Computation Center, Kyushu University, Fukuoka, 812-8581 Japan; ³Department of Applied Biology, Faculty of Textile Science, Kyoto Institute of Technology, Matsugasaki Sakyo-ku, Kyoto 606, Japan.

A publically available entomology database KONCHU is a general database name, which includes various files of bibliographical and images. The former is a taxon-based entomology database based on main Japanese entomological journals (16 journals (16 journals (16 ifles) at present). Therefore it includes many East Asian and Pacific insects as well as Japanese ones. It has a taxonomical feature as well as a bibliographical one because it treats one taxon, e.g. species, genus, family, as one record. The records of KONCHU are written mainly in English and in Japanese with katakana and kanji characters. Each record of the database is composed of 13 items, such as bibliographical (author, title, journal, volume, page and year), taxonomical (order, family, synonymy), distributions, key words (taxonomy, morphology, ecology, biology, etc) and notes including useful information such as type locality, type depository of new species, host record of parasite. The other database is an image one including various figures taken by digital camera and microscope. Images of some groups of Japan are constructed, such as wild bees. The KONCHU is managed by a text database management system SIGMA. It has been opened to the public on INTERNET as well as at Computer Center of Kyushu University, Fukuoka, Japan. A user can access to the KONCHU by retrieving the following URL: http://konchudb.agr.agr.kyushu-u.ac.jp/. Outline, usage and ex-amples of use of the KONCHU are presented.

Index terms: entomology database, species information, East Asia, bibliography, images.

[0794] REPRESENTATION AND DISSEMINATION OF MIGRATION DATA FROM AUTOMATIC INSECT-MONITORING RADARS

II.K. Wang & <u>V.A. Drake</u>, School of Physics, University College, The University of New South Wales, Australian Defence Force Academy, Canberra, ACT 2600, Australia. E-mail: haikou.wang@adfa.edu.au.

Insect-Monitoring Radars (IMRs) installed at two locations in inland eastern Australia have been making automatic observations of nocturnal insect migration since mid-1998 and mid-1999 respectively. Each IMR is controlled by a microcomputer that both acquires the radar data and analyses it. The microcomputers are also linked to an adjoining Automatic Weather Station (AWS) and, via a modem and telephone connection, to the project's base laboratory in Canberra. An automatic system has been developed to analyse downloaded IMR and AWS data files and generate daily statistical summaries and graphical representations of the migrations observed by the two radars during the previous night. The summaries and graphs show the intensity, altitude, speed, and displacement direction of the migrations, and the orientation, size, and shape of the migrants, together with the surface weather conditions, at each site. Automatic processing using Dynamic Hypertext Mark-up Language (DHTML) and scripts allows these summaries to be posted on a server (http://www.imr.ph.adfa.edu.au) for dissemination via standard internet and World-Wide-Web (WWW) protocols by mid-day of the following day. A higher-quality printed output can also be provided if required, using automátically generated PostScript print files.



A summary of the observations from each IMR is presented on a WWW "front page" which incorporates miniature histograms of the principal migration parameters, a time series of migration intensities over the the previous month, and graphs of the surface temperature and wind through the might. More detailed tables and graphs showing how the migration varied with height and time-of-night can be called up with single mouse-clicks. The summaries and graphs, in both their WWW and printed forms, are illustrated with examples from nights when Australian plague locusts *Chortoicctes terminifera* or native budworms *Helicoverpa punctigera* were amongst the migrants.

Index terms: Chortoicetes, Helicoverpa, forecast, internet, World Wide Web.

[0795] WEB-BASED INTELLIGENT INSECT MANAGEMENT INFORMATION SYSTEM FOR BETTER DECISION-MAKING SUPPORT

Y. L. Xin & J. Baumgärtner, Dept. of Population Ecology and Ecosystem Science, International Centre of Insect Physiology and Ecology (ICIPE), P. O. Box 30772, Nairobi, Kenya, E-mail: yxia@icipe.org

At the International Centre of Insect Physiology and Ecology (ICIPE) a Web-based Intelligent Insect Management Information System (WIIMIS) is being developed. The objective is to assist different users in decision-making support. The users range from policy-makers, NARES scientists, extension workers, decision-makers to grass-root smallholders. WIIMIS is designed according to the needs and interests of these users and consists of four main parts: 1) Web-based Graphical User Interface (GUI), which uses Open GIS approach, 2) System Master Control, 3) Decision-making Function, and 4) Meta-database Management Function which manages data and information. The Decisionmaking Function is based on empirical knowledge and on explanatory simulation models representing crop yield formation as affected by biotic (pests) and abiotic (water availability, soil quality) constraints. Moreover, the Function will be associated with time and space-specific socio-economic factors. Onion crop management in Kenya highlands has been included as a WIIMIS case study. Remote sensing data (climate parameters, soil parameters and NVDI), soil quality ground data and weather station recordings are used to drive the simulation models which predict onion production at different locations and at different times. The results are applied to map the geographical suitability for onion production. WIIMIS can also be developed for the strategic planning of other African agricultural commodities, for natural resource management, as well as for integrated pest management. For users without Internet access, we plan to disseminate the results through other relevant media such as CD-ROM, brochures, leaflets or posters.

Index terms: decision-making, remote sensing, meta-database, model, open GIS, ICIPE

[0796] TOWARDS A DATABASE FOR THE TRICHOGRAMMA SPECIES, THEIR HOSTS AND PLANT ASSOCIATIONS IN THE SOUTH AMERICA

R. A. Zucchi & R. B. Querino, Dep. de Entomologia, Fitopatologia e Zoologia Agrícola, Univ. de São Paulo, ESALQ, Av. Pádua Dias 11, 13418-900 Piracicaba, São Paulo, Brasil. E-mail razucchi@carpa.ciagri.usp.br

Trichogramma is the largest genus of the family Trichogrammatidae, with approximately 180 species worldwide. However, according to the most recent catalogue of the South American Trichogramma species published in 1997, only 24 species were recorded. Probably this small number of Trichogramma species in South America is because the surveys are carried out mostly in agricultural areas. For this reason, the known Trichogramma hosts are mostly lepidopterous pests. Consequently, little is known on the species which occur in natural habitats and their hosts in these areas. Except to some surveys which are being conducted in a Brazilian natural reserve (Querino's thesis in progress), the data for the South American countries have been related to collect in agricultural areas. Since 1997, some new records of Trichogramma were found in Argentina by Botto, Chile by Pintureau, Peru by Whu and Valdivieso and Uruguay by Basso, besides the data from Brazil and Uruguay (T. lasallei) obtained by us. The objective of this paper is to update the 1997 Trichogramma Catalogue with the records published in the last three years in order to place it into a database. Only the papers with taxonomic procedures were included herein, as follows: Argentina. T. nerudai (introduced species, E. Botto, per. comm.). Brazil. (1) T. lasallei from Anticarsia gemmatalis on soybean (first record by Querino); (2) T. bruni from Heliconius phyllis on Passiflora sp. fruits (first record by Querino). Chile. T. nerudai from Rhyacionia buoliana on Pinus radiata and on Tuta absoluta (latter record by RBQ). Peru. (1) T. exiguum from Argyrotaenia sphaleropa; (2) T. pintoi (introduced species) from Helicoverpa zea; (3) T. pretiosum from Erinnyis ello on cassava, Heraclides thoas on citrus and Hypsipyla grandella on cedar; (4) T. rojasi (host unknown). Uruguy. (1) T. exiguum from Argyrotaenia sphaleropa and Bonagota cranaodes on vine; (2) T. lasallei from Diatraea sacchuralis on sugar cane (first record by RBQ). Two previous records had not been included in the 1997 Catalogue: (1) T. distinctum Zucchi recorded by Basso and Morey in Uruguay. (2) T. exiguum (according to De Santis and Fidalgo's 1994 catalogue) in Argentina and Guiana. Therefore, three species of Trichogramma (T. lasallei, T. nerudai and T. pintoi), 11 new hosts and 8 plant associations were found in South America lately. Currently 27 Trichogramma species are recorded in South America. Index terms. Egg parasitoids, hosts, plant association.
[0797] PROBLEMS AND STATUS OF TAXONOMIC RELATIONSHIPS AMONG CEPHIDAE

M. Ivie

ABSTRACT NOT RECEIVED

[0799] ASPECTS OF THE ECOLOGY OF THE WHEAT STEM SAWFLY (HYMENOPTERA: CEPHIDAE) IN NORTH AMERICA

D.K. Weaver¹, W. L. Morrill¹, R. J. Bartelt², A. A. Coss², M. J. D. Grieshop¹ & G. D. Johnson¹, ¹Dept. of Entomology, Montana State Univ., Bozeman, MT 59717 USA, Email weaver@montana.edu; ²National Center for Agricultural Utilization Research, USDA-ARS, 1815 N. University Ave., Peoria, IL 61604 USA.

Cephus cinctus, the wheat stem sawfly, is a major pest of wheat and other cereals the northern Great Plains of North America. It occurs throughout much of North America, but in regions away from the northern Great Plains populations are confined to feral grasses. It is likely that the host plants in the crop and grassland habitats differ in their developmental phenology, thus resulting in cereal cropland being an unused host reservoir in regions away from the areas of economic loss. Recently, Montana populations of this insect have moved into the earlier maturing wheter wheat crop from spring wheat, indicating the pest is adapting to cultural practices. The wheat stem sawfly has an obligatory diapause, and it is suspected that geographically diverse populations in North America have differing requirements to break prepupal diapause. After diapause is broken, metamorphosis is completed, and adult males emerge several days before females. Mature females will lay unfertilized eggs, resulting in male offspring, if they do not mate. The mating system of this insect is quite complicated. In cereal crop systems, abundant newly emerged individuals will occasionally mate immediately in the fallow crop residue, but the majority of the mating occurs at the border of the current year's crop. Here, small groups of males form spatially discreet leks that serve to influence receptivity and mating with nearby females perched on vegetation. Lek events are short-lived and recurring, but appear to be triggered by a combination of favorable temperature and bright insolation. Males in a lek area do not appear to relocate, but mated females appear to move into the standing crop to oviposit. This lek-driven mating system utilizes a powerful, nearinstantaneous release of pheromone compounds to facilitate mating. A number of compounds have been identified as having a behavioral and sensory role in this pheromone blend. The lek system appears unusual in a large, continuous acreage of cultivated suitable hosts, but may have developed to facilitate reproduction in relatively arid ancestral grasslands where bunchgrasses and small patches of suitable hosts predominated.

Index terms: Cephus cinctus, pheromone, chemical ecology, lek

[0798] DO HOST-PLANT INTERACTIONS AND SUSCEPTIBILITY TO SOIL CULTIVATION DETERMINE THE ABUNDANCE OF GRAMINIVOROUS SAWFLIES ON BRITISH FARMLAND?

<u>A.M. Barker</u> & C.J.M. Reynolds, The Game Conservancy Trust, Burgate Manor, Fordingbridge, Hants, SP6 1EF, U.K. E-mail: abarker@game-conservancy.org.uk

Relatively little is known about the graminivorous sawflies of the two genera Dolerus and Pachynematus, which feed on cereals and grasses in farmland habitats. Dolerus species are univoltine with spring flying adults and larvae present in the field from May to July; Pachynematus species are bivoltine with spring and summer generations. Both overwinter as pupae underground. In Britain these sawflies are not economic pests but they have an important role in the wider ecology of agricultural ecosystems as important sources of food for birds. In a four-year farm survey, we found that larvae of these two sawfly genera were over six times more abundant in fields of sown perennial rye-grass Lolium perenne than in winter wheat and spring barley crops or long-established grazing pastures. To investigate the factors behind this distribution, we conducted oviposition and rearing trials and experimentally investigated the effect of ploughing on overwintering survival. We found that the three most common Dolerus species and one of the two common Pachynematus species generally preferred perennial rye-grass to winter wheat (Triticum aestivum) and spring barley (Hordeum vulgare) as oviposition hosts. Growth and survival of larvae of five Dolerus species and one out of two Pachvnematus species tested were also significantly higher on rve-grass than on winter wheat or spring barley. Subsequent trials have identified a range of grasses that make more suitable hosts than either cereal. Differences were sufficiently marked to have had a strong influence on the distribution of larvae between crops in the field. In addition, in trials in which we used emergence traps on cultivated and uncultivated areas of the same fields we found that in some years the soil disturbance caused up to 50% extra overwintering mortality, although the extent of this mortality varied from year to year, possibly as a result of variation in the severity of winter weather. This mortality will reinforce the effects of host-plant requirements in leading to decreasing abundance in ploughed cereal habitats. Shifts in patterns of crop rotation towards intensive cereal production with yearly cultivation and also more 'efficient' farming with fewer wildlife-friendly grassy field boundaries may account for recorded decreases in graminivorous sawfly abundance on British farmland.

Index terms: Dolerus, Pachynematus, winter wheat, spring barley, perennial rye-grass

[0800] ACOUSTIC DETECTION AND MONITORING OF CEPHUS CINCTUS SAWFLY LARVAE IN WHEAT STEMS

R. W. Mankin¹ & D. K. Weaver², ¹USDA-ARS-CMAVE, P. O. Box 14565, Gainesville, FL 32604, USA, E-mail rmankin@gainesville.usda.ufi.edu; ²Dept. of Entomology, Montana State Univ., P.O. Box 173020, Bozeman, MT 59717-3020, USA.

The behavior of *Cephus cinctus* Norton larvae in wheat is difficult to study because they are hidden from view inside the stems. We tested the feasibility of using acoustic techniques to nondestructively identify infested stems and monitor larval activity. Adult females were allowed to oviposit in small pots of wheat. After three weeks, a small accelerometer was clamped to the base of each stem and sounds were recorded for -3 minutes. Infested stems and uninfested stems in motion produced short clicks -0.5 msec in duration. The clicks could be detected in the moderate background noise of a research laboratory without using an insulated room or anechoic chamber. No clicks were recorded for from stationary, uninfested stems. After recording, the stems were cut and the locations and weights of any larvae were noted. The signals were analyzed using custom-written digital signal processing software. Methods were developed to distinguish larval movement and feeding activity from background noises. In the initial study, we identified putative larval sounds from 17 of the stems tested. All were infested with larvae (mean weight = $5.25 + 4 \cdot 0.77$ mg). The mean rate of clicks produced by larvae in the infested stems was 1.41 + 4 - 0.26 clicks per minute. Our experience in the initial study led to development of an improved device for clamping the accelerometer to the wheat stem. The use of nondestructive techniques will enable the future monitoring of long-term activity patterns.

Index terms: sound, behavior, activity pattern.

[0801] IMPACT OF CULTURAL PRACTICES ON POPULATIONS OF THE WHEAT STEM SAWFLY (HYMENOPTERA: CEPHIDAE) AND ITS ASSOCIATED PARASITOIDS

W. L. Morrill, S. E. Sing, J. B. Runyon & D. K. Weaver, Dept. of Entomology, Montana State Univ., Bozeman, MT 59717 USA E-mail: wmorrill@montana.edu

The wheat stem sawfly, Cephus cinctus, is an important pest the northern Great Plains of North America. Records indicate that sawflies first occurred in native prairie grasses and were held in check by parasitoids. Wheat was infested when tillage began about a century ago. Many farmers established narrow "strip" fields to minimize soil erosion and also used alternate-year, or "summer fallow" to conserve moisture from 2 years for one crop. These practices affect pest insect and weed populations. *Cephus cinctus* larvae overwinter in lower stem sections, or "stubs". Wasps emerge in June and disperse to standing crops. Although several eggs may be laid in each stem, only one larva survives to maturity due to cannibalism. Larvae complete their development while enclosed within the stems. Infested stems yield less, and usually break or "lodge", before harvest. Insecticide application and other traditional control practices are not effective, therefore a biological control program should be developed. Bracon cephi and B. lissogaster (Hymenoptera: Braconidae) are larval parasitoids that commonly attack C. cinctus in Montana. Levels of parasitism in fields are affected by wheat production practices, and range 5 - 90%. We compared sawfly larval population densities and percent larval parasitism in different winter wheat production systems. The variables were field size (narrow strip fields vs larger block fields) and weed control methodology (herbicide vs tillage). Data indicate that sawfly damage is higher in field borders, therefore overall losses decrease as field size increase. Intensive spring soil tillage of fallow fields suppresses parasitoid populations. In another study, we intensively sampled spring wheat fields to document the spatial pattern and abundance of wheat, wild oat (Avena fatua), sawflies, and parasitoids. Sawfly wasps are more prevalent at the field edges, but larval infestations extend across fields. Wild oat influences the patchiness of larval infestation in wheat. Sawfly wasps readily oviposit in wild oat, but the resulting larvae do not survive.

Index terms: Cephus cinctus, Bracon, IPM, biological control, Avena fatua

[0802] SAWFLIES IN EUROPE: DAMAGE AND CONTROL STRATEGIES

A. Harris

ABSTRACT NOT RECEIVED

[0803] BIOLOGICAL CONTROL OF WHEAT STEM SAWFLIES: PAST AND FUTURE

T. G. Shanower¹, ¹USDA-Agricultural Research Service, 1500 N. Central Ave., Sidney, MT 59270, USA; E-mail: tshanowe@sidney.ars.usda.gov

Several species of grass-feeding stem sawflies (Hymenoptera: Cephidae) are important pests of wheat and other grain crops in the northern hemisphere. At least six species have been reported as pests including Cephus fumipennis in China, C. cultratus in central Asia, and C. pygmaeus and Trachelus tabidus in the Mediterranean region. The latter two species are also widespread in Europe and were introduced into eastern North America more than 100 years ago. A third species, C. cinctus, attacks wheat in western North America though its origin is uncertain. The biology of these species is similar. Females oviposit in cereal or grass stems and larvae feed within the stem. The larva moves to the base of the plant as it matures and cut a groove around the inside of the stem. The lumen of the stem is plugged below the groove, forming a chamber for the diapausing larva during the winter or dry season. The weakened stem breaks at the groove leaving a stub. Increased temperatures, moisture and/or photoperiod terminate diapause. Pupation occurs within the stub and adults emerge several weeks later. Stem feeding by sawfly larvae reduce grain weight up to 30%. Fallen, unharvested grain is an additional and unquantified loss. Yield losses of up to 35% have been reported from several countries. Annual losses due to C. cinctus in North America are estimated at approximately US\$100 million. Biological control efforts were first initiated against C. cinctus. Three parasitoids were released in western Canada from 1930-40: two were imported from England and the third came from the eastern US. A second biological control attempt was undertaken in the western US from 1952-55, using parasitoids imported from France. No exotic natural enemies have been established against *C. cinctus*. Biological control efforts against *C.* pygmaeus were carried out 1935-38 in the US and 1937-40 in Canada. Three species were imported from Europe but only Collyria coxator (Hymenoptera: Ichneumonidae) has been established in North America. It appears to play an important role in regulating C. pygmaeus populations, parasitizing up to 80% of C. pygmaeus larvae. The USDA-ARS has initiated a project to find and import effective, new biological control agents for C. cinctus in the western US. Analysis of the failed attempts against this species, and the successful effort against C. pygmaeus, provide insight and important lessons for this new program. This paper reviews previous biological control efforts against wheat stem sawflies, discusses possible reasons for the earlier failures, and outlines the approach and progress of the new project.

Key words: Cephus spp., Collyria spp., parasitoids

[0804] FOREIGN EXPLORATION FOR SAWFLY NATURAL ENEMIES

K. Hoelmer, USDA-ARS, European Biological Control Laboratory, Campus International de Baillarguet, CS-90013 Montferrier-sur-Lez, 34988 St. Gély du Fesc Cedex, France, E-mail khoelmer@wanadoo.fr.

Sawflies (Hymenoptera: Cephidae: Cephini) which feed and develop within the stems of small grain crops are widespread throughout the the northern hemisphere, particularly in the Palearctic region. Wheat is the primary crop impacted, but these sawflies also attack rye, barley and timothy, as well as various native, non-crop grasses. Cephid species causing significant damage to crops occur in North America, Europe, Asia and north Africa. However, relatively little is known regarding their ecology in wild grass hosts, including the occurrence and impact of natural enemics. Following the successful introduction and establishment of European parasitoids against Cephus pygmaeus in North America, several unsuccessful attempts were made during the early to mid-twentieth century to establish new parasitoids, also originating from Europe, against Cephus cinctus in North America. The failures were attributed to a lack of adaptation to C. cinctus or to the lack of proper synchronization with suitable host stages. Further collections and introductions were not pursued at that time. However, taxonomic uncertainty exists regarding the identity and relationship of various species of Cephus. Important natural enemy taxa are also in need of revision. Further field collections and biological studies are warranted, especially for species in central and eastern Asia for which information is particularly sparse. Such collections would provide new study material for taxonomic revisions, and possibly new populations and/or species of natural enemies for biological control evaluations. Thus, new opportunities exist for the discovery and collection of better-adapted parasitoid populations in regions with climates that are very similar to those of the desired areas of introduction. Greater success in evaluations and releases may also result from faster delivery and better handling of overseas shipments, and from improved knowledge of natural enemy biology, behavior, and ecology. Index terms: Cephus, Trachelus, parasitoids.

[0805] CONDITIONAL MUTUALISMS IN ANT-PLANT-HERBIVORES INTERACTION IN TROPICAL SAVANNA

K. Del-Claro, Univ. Fed. Uberlândia, InBio, CP593, Cep 38400-902, Uberlândia, MG, Brazil. delclaro@ufu.br

The outcomes of mutualistic interactions are dependent upon the ecological settings in which they occur. In this directions we will show results of two studies conduced in Brazilian cerrados. Controlled ant-exclusion experiments in a system involving an extrafloral bearing Malpighiaceae, *Peixotoa tomentosa*, revealed that herbivory and fruit production are dependent on ant associated species behavior. Also the interaction between herbivore-ant behavior and herbivore-ant-plant morphologies can change the meaning of each relationship. In the association between the honeydew-producing membracid *Guayaquila xiphias* and its ants attendants, two years of controlled ant-exclusion experiments showed that ant effects on treehopper survival and fecundity were conditioned by time, and varied with shifts in the abundance of natural enemies. In both studies the results also revealed that plants and herbivores are positively or negatively affected depending on ant presence and species.

Index terms: Guayaquila xiphias, Camponotus, Thysanoptera, Malpighiaceae, Araliaceae,

[0807] ANT-WHITEFLY INTERACTION IN A NEOTROPICAL FOREST: ANT ATTENDANCE REDUCES FUNGAL AND PARASITOID ATTACK

<u>I. M. Queiroz</u> & P. S. Oliveira, Departamento de Zoologia, Universidade Estadual de Campinas, C.P. 6109, 13083-970 Campinas SP, Brasil. E-mail: jqueiroz@obelix.unicamp.br.

Sap-feeding whiteflies (Aleyrodidae) have increasingly attracted the attention of applied entomologists due to the severe damage that these homopteran insects may cause to economically important crop plants. Whitefly damage to plant results mainly from colonization by sooty mold encouraged by honeydew build-up, which markedly depreciates the commercial value of plant-derived food products. Continuous collection of honeydew by tending ants can confer a range of benefits to homopterans such as aphids, scales, and treehoppers. Surprisingly, however, despite the widespread ocurrence of anthomopteran associations in temperate and tropical regions, there is no experimental study on ant-whitefly interaction. We investigated the interaction between the honeydewproducing whitefly Aleurothrixus aepim (Hom: Aleyrodidae) and tending ants on shrubs of Croton floribundus in a forest reserve in SE Brazil. Ovipositions of A. aepim were randomly divided in two experimental groups: control (ants present) and treatment (ants excluded). Adults emerged in significantly greater numbers from control than from treatment aggregations, the latter being heavily attacked by fungi due to accumulation of honeydew. Decimation by fungi due to honeydew build-up was 3 times more frequent at ant-excluded than at ant-tended groups. Control aggregations with low levels of ant attendance produced significantly fewer adults than those more frequently tended by ants. Parasitoid wasps were more frequent on ant-excluded than on control whitefly aggregations. This is the first demonstration of an ant-derived benefit to honeydewproducing whiteflies. Given that aleyrodid honeydew causes severe damage to several crop plants in tropical and temperate areas, our results suggest that the honeydew-gathering activity by tending ants can be relevant for the management of agroecosystems. Index terms: Aleurothrixus aepim, Aleyrodidae, Homoptera, honeydew, mutualism

[0806] ONTOGENY FO DEFENSE IN THE TEMPERATE ANT-PLANT SYSTEM INVOLVING CHAMAECRISTA FASCICULATA

R. J. Marquis

ABSTRACT NOT RECEIVED

[0808] CONSEQUENCES OF MAMMALIAN HERBIVORY ON MULTITHROPHIC INTERACTIONS: INSECTS, PLANTS AND NATURAL ENEMIES

R. Dirzo

ABSTRACT NOT RECEIVED

[0809] PATTERNS OF SPECIALIZATION AMONG LEPIDOPTERAN HERBIVORES OF *INGA* (FABACEAE: MIMOSOIDEAE) AND THEIR PARASITOIDS

<u>S. Koptur</u>, Dept. of Biological Sciences, Florida International Univ., Miami, FL 33199, USA, E-mail kopturs@fiu.edu.

Lepidopteran eggs and caterpillars encountered on five common species of montane Costa Rican Inga over a two-year period were reared for identification and parasitization information. Fifty species in sixteen families of Lepidoptera were reared: eleven spp. of microleps (Oecophoridae, Gelechiidae, Torticidae); 32 spp. of moths in eleven families (Limacodidae, Megalopygidae, Pyralidae, Percephoridae, Saturniidae, Geometridae, Eupterotidae, Noctuidae, Notodontidae, Arctiidae, Ctenuchidae); 2 skipper spp. (Hesperiidae) and 5 butterfly spp. (Pieridae). All Inga spp. have extrafloral nectaries that serve to attract both ants (more common at lower elevations) and parasitoids (more frequent at higher elevations where ants are scarce). Several parasitoid species reared from herbivores were also collected at nectaries. Egg parasites included species of Many caterpillars were killed by Cecidomylidae, Encyrtidae, and Scelionidae. parasitoids, primarily flies (Tachinidae) and wasps (Braconidae, Eulophidae, Ichneumonidae), though some were consumed by entomophagous fungi. Eight of the herbivore species occurred on most of the *lnga* spp., while most were restricted to one or two species. Herbivore species that were found on more than two species of Inga were parasitized more frequently than those species found on only one hostplant species. Index terms: Pieridae, Megalopygidae, Hesperiidae, Braconidae, Tachinidae.

Symposium and Poster Session

[0811] MOVEMENT OF ORGANISMS IN THE BIOSPHERE: A PERSPECTIVE ON SATIAL AND TEMPORAL SCALES

S.H. Gage

ABSTRACT NOT RECEIVED

[0810] A FRAMEWORK FOR INSECT MIGRATION STUDIES – AND SOME RECENT ADVANCES

H. Dingle, Dept of Entomology, Univ. of California, Davis, One Shields Ave., Davis, CA 95616, USA. Email: rdhdingle@ucdavis.edu.

Following Drake et al. (1995), we can think of a migration system as consisting of an arena in which migration takes place, a population trajectory, and a behavioral syndrome based in the genes and molded by natural selection. Habitat duration in the arena influences the frequency and occurrence of migration, and this is often determined by climate. A clear example occurs in Australian butterflies where climate variables such as soil moisture levels profoundly affect the proportion of migrants among butterfly regional faunas. Population trajectories are often wind guided, but in robust flyers like butterflies may be under the control of the individual insect and involve well-developed orientation mechanisms. Examples of orientation will be presented for both Australian and North American butterflies. Migration syndromes involve not only flight itself but also a variety of correlated traits from life history characters to flight muscle enzyme properties. These are revealed by studies of migratory and flight polymorphisms, and I shall provide examples from rapidly evolving species of seed bug (Henniptera). Finally, I shall demonstrate that the syndromes are based in the genes. Throughout I shall stress important gaps in our knowledge and suggest some directions future studies might take. Index terms: Flight, butterflies, Henniptera, polymorphisms, climate

[0812] SPATIAL ANALYSIS OF PEST MOTH POPULATIONS IN THE UK AND EUROPE

I. P. Woiwood

ABSTRATC NOT RECEIVED

[0813] INSECT MIGRATION AND POPULATION PROCESSES IN INLAND AUSTRALIA OBSERVED WITH MONITORING RADARS

V.A. Drake & H.K. Wang, School of Physics, University College, The University of New South Wales, Australian Defence Force Academy, Canberra, ACT 2600, Australia. E-mail: a.drake@adfa.edu.au.

In the semiarid environments of inland Australia, erratic rainfall leads to highly variable and essentially unpredictable spatial and temporal patterns of vegetation growth. These regions host a number of species of migratory insects that are well adapted to exploiting ephemeral vegetation flushes, and which can develop very large populations when conditions remain favourable for several generations. Some of these species are pests and cause major economic impacts when population growth is followed by migration into adjoining or distant dryland and irrigated cropping areas. A current study of the movements of these populations aims to relate them to the changing distribution of resources, with the twin objectives of developing understanding of how the species' migratory adaptations function and of improving pest-forecasting capabilities. Data acquisition for the study is centred around a pair of automatic monitoring radars that quantify the intensity, direction, speed, and altitude of nocturnal migration at two locations within the study area. The direct observations of insect movement that these radars provide are supplemented by satellite data on vegetation state and rain-producing clouds, and by a limited program of surveys (of both hosts and pests) and light trapping. Wind-borne transport opportunities are identified from regional meteorological analyses, and the various observations are integrated within a Geographic Information System. The potential of this suite of observing and analysis techniques is illustrated with data on spring



novements of Helicoverpa punctigera and other moths, and summer movements of Australian plague locusts Chortoicetes terminifera. Index terms: Chortoicetes, Helicoverpa, moth, locust, forecast.

[0814] INVESTIGATING OPTIMAL MIGRATION STRATEGIES IN BUTTERFLIES: THE USE OF LOCAL AND CELESTIAL CUES TO ADJUST COURSE AND FLIGHT SPEED

<u>E. G. Oliveira</u>¹, R. B. Srygley² & R. Dudley³, ¹Depto. Biologia Geral, Inst. Ciências Biológicas, Univ. Federal de Minas Gerais, 30161-970, Belo Horizonte, MG, Brazil, Email evandro@mono.icb.ufmg.br; ²Dept. Zoology, South Parks Road, Univ. of Oxford, Oxford OX1 3PS; ³Section of Integrative Biology, Univ. of Texas, Austin, TX, 78712, U.S.A.

Butterfly migrations occur worldwide and are particularly common in the tropics, where distribution of rainfall appears to underlie both the phenology and direction of movements. In such cases, migration may require butterflies to discriminate favorable meteorological conditions in order to initiate light and to be equipped with orientation and navigation mechanisms to reach particular geographical destinations. In addition, migration may involve high energetic expenditure, and butterflies may be required to adopt optimal or more efficient migratory strategies in order to minimize costs. Over the last several years, we have investigated these questions on a multi-species migration system in Panama and Colombia. Results from clock-shift experiments performed with two butterfly species (Aphrissa statira and Phoebis argante) supported the hypothesis that a time-compensated sun compass is used for migratory orientation. Vector analysis of butterfly airspeed, track direction, wind speed, and wind direction to estimate butterfly heading and drift showed that butterflies (A. statira, Phoebis argante, and Marpesia chiron) change their headings to compensate for crosswind drift. This result suggests use of a sun compass in coordination with directional information obtained from local landmarks. Butterflies were less likely to compensate for crosswind drift when local landmarks were absent. In contrast, no evidence for wind drift compensation was found in the day-flying uraniid moth Urania fulgens. Also as predicted from optimal migration theory, butterflies (P. sennae) adjusted their airspeed according to wind direction, flying at a lower speed with tailwinds. However, the two sexes seem to adopt different migratory strategies, as only females exhibited this last behavior. Males may minimize migration time to destination in order to increase their chances to fertilize newly emerging females. Finally, as suggested by aerodynamic theory, flight speed of U. fulgens decreased as endogenous energy reserves were gradually depleted. Together, these findings support the general notion that insect migration comprises specialized behavioral and physiological processes, and that insects approximate an optimal migratory strategy. Research on behavioral mechanisms may provide the basis for understanding the adaptive significance of butterfly migrations and for planning their conservation.

Index terms: Lepidoptera, migration, sun-compass, airspeed, optimal behavior

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[0815] SHORT-RANGE MIGRATION BY BEMISIA WHITEFLIES

D. Byme

ABSTRACT NOT RECEIVED

[0816] THE RELATION OF ATMOSPHERIC FACTORS AND THE DISTRIBUITION OF APHIDS AND OTHER SMALL INSECTS IN THE AIR

M. E. Irwin

ABSTRACT NOT RECEIVED

ABSTRACT BOOK I – XXI-International Congress of Entomology, Brazil, August 20-26, 2000

[0817] RAPID EVOLUTION OF FLIGHT POTENTIAL IN LEPIDOPTERA

K. Wilson¹, J.K. Hill^{2,3}, C.D. Thomas² & O.T. Lewis², ¹Institute of Biological Sciences, University of Stirling, Stirling FK9 4LA, UK, E-mail kw2@stir.ac.uk; ²Centre for Biodiversity & Conservation, School of Biology, University of Leeds, Leeds LS2 9JT, UK; ³Environmental Research Centre, Department of Biological Sciences, University of Durham, Durham DH1 3LE, UK.

Many studies have investigated changes in flight-related traits in insects over evolutionary time (e.g reduced dispersal on true oceanic islands, evolution of migration syndromes in heterogeneous habitats). Here we produce evidence of rapid evolutionary changes in flight traits in ecological time. We present data showing evolutionary changes in flight-related traits in Lepidoptera in response to changes in availability of breeding habitat (due to rainfall, habitat fragmentation, climate change etc) occurring on an ecological time scale. We discuss implications of these rapid changes for insects persisting in modern Index terms: Spodoptera exempta, Pararge aegeria, Hesperia comma, phenotypic

plasticity.

[0819] MODELLING OF INSECT MOVEMENT AND RELATED BEHAVIOUR IN 3D SPACE: NEW TOOLS, OLD QUESTIONS, BETTER SOLUTIONS?

J. Hanan

ABSTRACT NOT RECEIVED

[0818] MOVEMENT OF APHID PARASITOIDS OVER DIFFERENT SPATIAL SCALES STUDIED USING MOLECULAR MARKERS

H. D. Loxdale¹, C. P. Brookes² & W. Powell³, ^{1, 2, 3}. Entomology and Nematology Dept., IACR-Rothamsted, Harpenden, Herts, AL5 2JQ, U.K. E-mail: hugh.loxdale@bbsrc.ac.uk

There is considerable interest in the use of primary Hymenopterous parasitoids as biological control agents in IPM strategies to combat aphids. Within agro-ecosystems, such strategies could involve the manipulation of extant parasitoid populations, encouraging them to move between crop and alternative or 'reservoir' hosts in nearby uncultivated land. For these approaches to succeed, knowledge of the population structure and dynamics of the parasitoid/s concerned is highly desirable, along with information about host specificity, i.e. 'generalism' or 'specialism'. Recently, we have demonstrated that morphologically similar primary parasitoids Aphidius ervi sensu lato attacking sympatric populations of pea aphid (Acyrthosiphon pisum) and nettle aphid (Microlophium carnosum) appear to display host specificity and reproductive isolation. Whilst host forms of the parasitoids will readily cross and produce viable offspring in culture, field collected samples showed fixed allelic differences at the phosphoglucose mutase locus. The result emphasises the importance of thoroughly studying the population structure of 'parasitoid species' before assuming them to be 'generalist'. Besides such fundamental concerns about host specificity, if parasitoids are to be mass released or natural populations manipulated, it is important to understand 1, how far particular genotypes or strains travel; 2, how long particular genotypes/strains persist in the field; 3, whether there is gene flow between populations attacking different hosts or occupying different habitat patches and 4, how many times individual female parasitoids attack particular host colonies, as reflected in patterns of genetic variability. Detailed information on these various aspects is scarce. A major problem is the haplo-diploid reproductive system of parasitoids, which can result in populations becoming homozygous at isozyme loci. Because of this tendency, we have designed a suite of microsatellite DNA markers and are presently using these to investigate spatio-temporal parameters in the primary parasitoid, Diaeretiella rapae attacking the cabbage aphid, Brevicoryne brassicae infesting oilseed rape, Brassica napus in southern England. In this talk, I shall describe how the use of a range of polymorphic microsatellites is providing insights into the population structure and dynamics of D. rapae, including behaviour, attack strategy and breeding systems, at spatial scales ranging from single leaf through to farm scale. It is hoped that the information gained can aid the design of IPM strategies as well as contributing to simulation models of parasitoid population spread and effectiveness

Index terms: Hymenoptera, Aphidius spp., Diaeretiella rapae, isozymes, microsatellites

[0820] INTERSPECIFIC INTERACTIONS, POPULATION DYNAMICS & COMMUNITY STRUCTURE

W. W. Murdoch¹ & S. L. Swarbrick², 1, 2. Dept. of Ecology, Evolution & Marine Biology, Univ. of California, Santa Barbara, CA, 93106-9610, USA

Entomologists have discussed for decades whether, and under what circumstances, it is better to release multiple natural enemies rather than the single "best" enemy to achieve biological control. Population dynamics theory provides some guidance, but no single answer. In practice, release of several to many species is common, and apparently competing species of natural enemies coexist in many cases of successful biological We will discuss the results of a field experiment in a citrus grove where control. California red scale, Aonidiella aurantii, is under control, putatively by the parasitoid Aphytis melinus, but other enemies are also present. Red scale density was increased experimentally and the responses of two parasitoid species and a number of predators are being measured.

Index terms: Aonidiella aurantii, Aphytis melinus, biological control

[0821] LIFE HISTORY AND ITS ROLE IN INTERSPECIFIC INTERACTIONS

<u>G. H. Walter</u>, Department of Zoology and Entomology, The University of Queensland, Brisbane Qld 4072, Australia. E-mail: g.walter@mailbox.uq.edu.au.

Interspecific interactions dictate a great deal of what we observe in ecological systems. The most significant interactions in "structuring" these systems are those that have a functional basis, and it is around these that we need to develop realistic generalisations for theoretical purposes. Functional interactions are mediated by specific mechanisms that evolved to serve a particular "purpose" or function, and they can be contrasted with those interactions that take place incidentally (mainly interspecific competition). The latter have no such mechanistic basis. They are consequently variable in process as well as outcome, and the course they follow is influenced even by small variations in numerous contingent environmental circumstances. The life history properties of organisms that are relevant to developing realistic generalisations about interspecific interactions are those that mediate functional interactions. These proximate mechanisms lead to the observable patterns of resource use, host specificity, and so on. They are stage-specific and are governed by the physiological state of the organism. How do such interactions evolve? Two answers are available, with these being dependent upon the underlying interpretation of natural selection. One view sees evolution progressing competitively, through selection working to increase or optimise "efficiency". The alternative view does not involve intraspecific competition as a primary driver of evolutionary change. Selection works primarily on the proximate mechanisms and their effective functioning within particular environmental contexts. Such functional interactions are "complex and co-ordinated" in being made up of a sequence of subsidiary steps, each inconsequential in itself, but which together and in sequence achieve a particular end point (the function). Such a structure implies that adaptive change does not take place under "everyday" ecological conditions (as accepted under optimality theory), but occurs only when change is imposed by consistently altered environmental and biotic conditions. Complex mechanisms are therefore stable under the usual conditions occupied by individuals of particular species, and are species-wide in distribution. These alternative views clearly have different implications from one another for the interpretation of local diversity ("community structure") and the use of organisms in population management.

Index terms: life history, interspecific interactions, evolution

[0823] INTERSPECIFIC INTERACTIONS AMONG PARASITOIDS IN AGROECOSYSTEMS

C.E. Bográn¹ & K.M. Heinz¹, ¹Department of Entomology, Texas A&M Univ., College Station, TX 77845-2475, USA. Email: cabo@tamu.edu.

Even though there is evidence to suggest a significant role of interspecific interactions among parasitoids on host population suppression, few studies have addressed this issue experimentally. Agroecosystems offer unique advantages to manipulative studies on interspecific interactions among parasitoids. In these systems, host plant variation is minimized by planting dates, cultivars and agronomic practices. Plant variation can influence the second trophic level (the herbivores), which in turn is a major determinant of the third trophic level (the parasitoids). The inherent control of variability at the lower trophic levels in agroecosystems, simplifies comparisons at the higher trophic levels. Bemisia whitefly (Hompotera: Aleyrodidae) and three of its parasitoids were used as models to 1) evaluate the occurrence and dynamics of interspecific interactions among parasitoids in a cotton agroecosystem; 2) assess the impact of interspecific interactions on the biological control of Bemisia argentifolii; and 3) examine the potential role of interactions on the composition of parasitoid communities. Encarsia pergandiella, a heteronomous hyperparasitoid (males develop as secondary parasitoids and females develop on 3^{sd} and 4^{sh} instar *B*. argentifolic) and two primary parasitoids, *Eremocerus* mundus, (males and females develop on 2^{sd} and 3^{rd} instars) and *Encarsia formosa* (a uniparental species that develops on 3^{rd} and 4^{th} instars) were the parasitoids included in our studies. Field manipulations were performed using large inclusion cages (3 x 3 x 2 m) that enclosed whitefly infested cotton plants. Parasitoids were released into cages in all species combinations or under different initial densities and conditions (simultaneously or in sequence). In each experiment, parasitoid and host populations were sampled periodically to compare population growth rates of parasitoids and host suppression levels among parasitoid combinations. Results showed asymmetrical competitive interactions and coexistence among the three parasitoids. The presence of competitors reduced population growth rate of E. formosa and E. pergandiella but not the population growth rate of E. mundus. Initial population density affected the outcome of competitive interactions among E. mundus and E. pergandiella. In most cases competitive interactions did not affect host population suppression. However, releases of E. formosa together with E. pergandiella showed lower levels of host suppression than those expected in the absence of competitive interactions. Differences in the distribution of parasitism along the vertical axis of cotton plants suggest that host utilization patterns may promote coexistence. Our studies demonstrate the potential impact of interspecific interactions on the dynamics of parasitoid and host populations and their role in parasitoid community composition. Index terms: Bemisia, Encarsia, Eretmocerus, competitive interactions.

[0822] HYPERPARASITISM AND ECTOPARASITISM: THE IMPACT OF OMNIVOROUS INTERACTIONS ON POPULATION MANAGEMENT

N. J. Mills, Insect Biology, Wellman Hall, Univ. of California, Berkeley, CA 94720-3112, USA, E-mail nmills@nature.berekeley.edu

Interspecific interactions between insect parasitoids can take a variety of forms, but the two most frequent direct interactions are hyperparasitism and ectoparasitism. The parasitoids of codling moth (Cydia pomonella, Lep.: Tortricidae) serve as a model to illustrate the generality of omnivory in capturing the functional significance of such interactions. Ascogaster quadridentata (Hym.: Braconidae) is a primary parasitoid of the codling moth attacking the egg stage of its host and developing as an endoparasitoid to kill the host as a prepupa within its cocoon. Although some hyperparasitoids have obligate relationships, developing only on primary parasitoids, the more frequent case is facultative hyperparasitism in which the parasitoid can also develop as a primary parasitoid of a phytophagous insect host. Dibrachys cavus (Hym.: Pteromalidae) is an important facultative parasitoid of the codling moth developing as a gregarious ectoparasitoid of codling moth cocoons and as a hyperparasitoid of the cocoons of several parasitoids, including A. quadridentata. Larval ectoparasitism is generally considered a form of primary parasitism. However, under some circumstances, by virtue of their more rapid development, larval ectoparasitoids develop at the expense of co-occurring endoparasitoids and are functionally equivalent to facultative hyperparasitoids. Hyssopus pallidus (Hym.: Eulophidae) is a gregarious ectoparasitoid of codling moth larvae that not only develops at the expense of A. quadridentata when they co-occur on the same host, but also experiences a substantial fitness gain by producing twice as many normal-size adult progeny from clutches laid on host larvae previously parasitized by A. quadridentata. These interactions are captured by a discrete-time, one host - two parasitoid model in which the facultative nature of hyperparasitism and ectoparasitism are represented by omnivory. Although hyperparasitism and the fitness advantage of ectoparasitism might be considered antagonistic relationships that should be avoided in classical biological control, analysis of the model indicates that these omnivorous relationships can frequently lead to enhanced reduction in the abundance of a phytophagous host. Thus contrary to popular belief, omnivory at the third trophic level should be promoted in the management of insect pest populations.

Index terms: Cydia pomonella, Ascogaster quadridentata, Hyssopus pallidus, biological control

[0824] INTERSPECIFIC INTERACTIONS AMONG ENTOMOPHAGOUS INSECTS IN PROTECTED CULTURES

H. F. Brødsgaard & A. Enkegaard, Dept. Crop Protection, Danish Institute of Agricultural Science, Research Centre Flakkebjerg, DK-4200 Slagelse, Denmark.

Interspecific interactions among arthropods in protected crops has become increasingly important as the use of still more complex biological control programs have been implemented in to glasshouse crops. In many areas of Northern Europe, ornamental growers are trying to use biological control of pests by means of beneficial arthropods because the number of registered effective pesticides is decreasing. One of the many features in which ornamental crops differ from vegetables is the wide range of arthropod pest species that may attack an ornamental crop species. Many crops are attacked by six to ten different pest species that have to be controlled simultaneously by a set of beneficials. Due to the facts that many pest species are difficult to control, the damage thresholds are very low, and the cropping cycles often are very complex several beneficial species have to be introduced not only against the pest complex in general but against each pest species. Many of the presently used heneficial arthropods are not monophagous. Hence, intraguild predation among introduced predators or predators switching away from the target pests are likely to occur. Several examples from laboratory experiments document intraguild predation among biological control candidates. Fewer studies suggest intraguild predation in glasshouse crops. However, both control failures and control delays due to intraguild predation are reported and in such cases the outcome of the control programs may differ from what can be expected based on the experience that has been generated from the much simpler greenhouse vegetable systems. The positive and negative aspects of using polyphagous predators have been discussed for years and the use of monophagous beneficials in biological control programs have been emphasised by many authors. In the present paper we will discuss the role of intraguild predation with a system approach and with focus on system stability and end control results.

[0825] FACTORS INFLUENCING DISTRIBUTION AND ABUNDANCE OF DIPLOLEPIS (CYNIPIDAE) IN CANADA

J. D. Shorthouse, Dept. of Biology, Laurentian Univ., Sudbury, Ontario, P3E 2C6, Canada.

All 12 species of cynipid wasps of the genus Diplolepis induce galls on either the leaves or stems of wild roses in Canada. There are 10 species of wild rose in Canada and all are host to at least one species of Diplolepis. Some species of roses are widely distributed across Canada south of the tree line whereas others are narrowly distributed. Likewise, some species of Diplolepis are found across most of Canada whereas others have a restricted distribution. Some species of Diplolepis are found on one species of rose whereas others are found on 2-3 species. Roses are common in montane, grassland and forested regions of Canada where they are ephemeral shrubs with patches becoming established following disturbance. Patches in grasslands may persist for >40 years whereas patches in openings in forested regions usually persist for 15-20 years. *Diplolepis* and their galls are likewise ephemeral with their distribution and abundance determined by presence of their host shrub, weather conditions at the time of adult emergence and oviposition, ability of inducers to survive winter temperatures, attack by parasitoids and inquiline cynipids, and size and distance between host patches. Diplolepis inducing galls on leaves support a component community of parasitoids and inquilines whereas most species inducing galls on stems have only parasitoids associated with their galls. Comparing the distribution and complexity of associated component communities reveals important patterns in evolution of the Diplolepis complex.

Index terms: Diplolepis, galls, roses, community, zoogeography

[0827] HOW GALL WASPS BECAME GALL WASPS

F. Ronquist¹ & J. L. Nieves Aldrey², ¹Dept. Systematic Zoology, Evolutionary Biology Centre, Uppsala Univ., Norbyv. 12, SE-752 36 Uppsala, SWEDEN, E-mail: fredrik.ronquist@ebc.uu.se; ²Museo Nacional de Ciencias Naturales, CSIC, José Gutierrez Abascal 2, ES-28006 Madrid, SPAIN.

Most gall-forming insects are considered to have evolved through a slow transition from phytophagous but not gall-inducing forms through forms making very simple galls to true gall inducers. The most cited scenario for the origin of gall wasps postulates such a slow transition from stem feeders on herbs in the family Asteraceae to species inducing true galls. However, recent phylogenetic studies suggest that the stem feeders on Asteraceae are not primitive but evolved from ancestors producing typical galls. Instead, the first gall wasps are likely to have induced conspicuous single-chambered galls in the seed capsules of Papaveraceae. Here, we present evidence that these early gall inducers evolved from parasites feeding internally on hymenopteran larvae that lived in, and perhaps induced, similar galls. These ancestral gall parasites lived more than 83 million years ago. The transition from insect parasites to gall inducers involved few morphological changes and left no surviving intermediate forms, which suggest that it was rapid. This indicates that the elusive gall-inducing principle of gall wasps may be a simple modification of a mechanism used by their insect-parasitic ancestors to control the development of the host larva. Furthermore, it means that none of the three traditional adaptive explanations for the origin of galling insects are likely to apply to gall wasps.

Index terms: Cynipidae, insect-plant relations, origin, evolution, phylogeny

[0826] MOLECULAR PHYLOGENETIC ANALYSIS OF GALL STRUCTURE AND EVOLUTION IN APHIDS

T. Fukatsu, Natl. Inst. Biosci. Human-Tech., Tsukuba, Ibaraki 305-8566, Japan, E-mail: fukatsu@aibh.go.jp

In aphids, there are two subfamilies, Hormaphidinae and Pemphiginae, almost all members of which form conspicuous galls on their primary host plant. They provide us with an opportunity to investigate the evolution of diversity in insect galls which are the product of intimate and sophisticated plant-insect interactions. The tribes Cerataphidini, Nipponaphidini and Fordini are particularly interesting groups in the subfamilies because (i) they embrace a considerable number of gall-forming species, (ii) their galls show a variety of shape, size and structure, (iii) gall formation in the respective groups can be assumed to be of a single evolutionary origin, and therefore (iv) independent phylogenetic analyses of these three groups allow us to conduct comparative evolutionary analyses. In this paper, we infer phylogenetic relationships in the respective groups based on mitochondrial rDNA sequences, and evolution of their galls are analyzed on the phylogeny. Evolutionary relationships between various gall-related characters are discussed such as gall formation site on the plant, basic structure of the gall, gall size, colony size, folds and projections on the gall wall, thickness and lignification of the gall wall, formation of the gall opening, defense by soldier individuals, etc.

Index terms: aphids; galls; evolution; molecular phylogenetic analysis; mitochondrial ribosomal RNA genes

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[0828] CIRCADIAN TEMPERATURE PATTERNS IN TWO CECIDOMYIID GALLS OF MACHILUS THUNBERGII (LAURACEAE)

Chi-Ming Yang¹, Wen-Yang Jen¹ & <u>M. M. Yang²</u>, ¹ Institute of Botany, Academia Sinica, Nankang, Taipei, Taiwan 115, R.O.C.; ² Dept. of Entomology, Nat. Chung Hsing Univ., 250 Kuo Kuang Rd., Taichung, Taiwan 402, R.O.C. E-mail: mmyang@dragon.nchu.edu.tw.

The temperature of two Daphnephia cecidomyiid galls of Machilus thunbergii leaf was recorded with a copper-thermocouple being plugged into the gall chamber and were compared with those of the air and soil, and relative humidity. They are oval-pointed and obovate galls and distributed in the northwestern and southeastern sides of Datun Mt. range in the Yangmingshan Mt. National Park at northern Taiwan. From the macroscopic view, the temperature of gall inside always follows that of the air outside. From the microscopic view, however, a general circadian temperature pattern was observed under whatever temperature condition. While the air temperature risen between midnight to midday, the gall temperature was always higher than the former until the maximal; then while the air temperature fell from midday to midnight, the gall temperature was always lower than the former until the minimal. In addition, the discrepancy between the gall and air temperature was gradually amplified during the rising period, and that gradually narrowed down during the falling period. Therefore, two circadian transition points existed at around midday and midnight each day. However, the above circadian rhythm disappeared during the cold wave period. In such weather condition, the temperature of the gall chamber is always lower than that of the air. It is apparent that the gall wall plays no role as a temperature insulator at all for the insect living inside. We propose that the circadian rhythm of gall chamber temperature is a function of the circadian behavior of the insect residing inside the gall. Further studies are necessary for identifying the behavior contributed to the gall temperature fluctuation.

Index terms: circadian rhythm, Daphnephia, Taiwan

[0829] SPECIATION IN GALL-INDUCING INSECTS

T.P. Craig¹, J. K. Itami¹ & J. D. Horner², ¹Department of Life Sciences, Arizona State Univ. West, P. O. Box 37100, Phoenix, AZ 85069, USA; ²Department of Biology, Box 298930, Texas Christian University, Fort Worth, TX 76129, USA

The characteristics of gall-inducing insects permit rapid speciation through a variety of modes including sympatric speciation. This will be illustrated by studies on the host races of a gall-inducing tephritid fly Eurosta solidaginis. Speciation mechanisms typically are divided into categories based on the degree of geographic isolation: allopatric, parapatric, and sympatric. The probability that speciation will occur by any of these modes depends on population characteristics including: dispersal ability, habitat specificity, mating behavior and relationship to natural enemies. Gall-inducing insects have several characteristics that favor sympatric speciation, which are direct consequences of the gallinducing habit. These same characteristics also increase the speed of speciation in allopatry. First, sympatric speciation models assume that there is strong disruptive selection for habitat use. Gall-inducers are highly host specific, so if a population of a species colonizes a new plant there will be strong disruptive selection for host use: that is each population performs best on its own host plant. Thus following a host shift there would be strong selection for the evolution of reproductive isolating mechanisms. A second critical assumption of sympatric speciation models is for the presence of strong habitat-based assortative mating. Sympatric speciation is favored when relatively few genes are involved in reproductive isolation. Habitat-based assortative mating lessens the number of loci involved because the same genes may control both habitat selection and assortative mating, Gall-inducing species commonly mate on their host plant. Gallinducers' extreme host specificity and strong host fidelity in mating site selection results in assortative mating and favors sympatric speciation. Third, fitness gains associated with the newly acquired host plant can also increase the probability of the successful establishment of a population as the result of a host shift. Since many natural enemies of gall-inducing insects locate their hosts by locating their host plants, a host shift can increase fitness through the colonization of enemy-free space. Finally, the small size of insects has several consequences that facilitate speciation. Small size, in general means that dispersal is relatively limited, and the strength of dispersal barriers is increased. Short generation time, and large population size means that new genotypes are rapidly generated. This increases the probability for genetic combinations permitting host shifts and speciation to occur. Index Terms: Eurosta solidaginis, gall, sympatric speciation, assortative mating.

[0830] THE GALL MIDGES (DIPTERA: CECIDOMYIDAE) FROM COASTAL SHRUB ZONE OF RIO DE JANEIRO STATE (BRAZIL)

V. C. Maia, Museu Nacional, Depto. Entomologia. Quinta da Boa Vista, São Cristóvão. 20940-040 Rio de Janeiro, R. J. Brazil. E-mail: maiavcid@acd.ufrj.br

The coastal shrub zone (restinga) is a very complex environment whose biodiversity is exceeded only by pluvial forests. Three restingas of Rio de Janeiro State - Restinga of Barra de Maricá, Itaipuaçu and Carapebus - were investigated: the first one from January to December, 1997; the second from November, 1997 to October, 1998 and the last one from May, 1998 to April, 1999. The flora is relatively well known in these restingas due to surveys developed by brazilian botanists. Data on Cecidomyiidae fauna are scarce. Collections of the galls were made monthly in the three areas. The geographic coordinates of the collection points were obtained using the Global Positioning System. Samples of host plants were pressed and later identified mainly by Profs. Andrea Costa and Rui Valka (Depto. Botânica, Museu Nacional). Samples of dried galls are incorporated in the Diptera collection of Museu Nacional. Larvae and pupae of the gall midges were obtained from the dissection of each kind of gall under a stereoscopic microscope. This procedure also enabled the determination of the gall dwellers' habits (inquilinous, predaceous, parasitoid or gall making). The exuviae and adults were obtained in the laboratory. Larvae, pupae, exuviae and adults of Cecidomyiidae were preserved in 70% alcohol and they were later mounted on slides. The gall midges were identified by the author and the other arthropods obtained from the galls - micro-Hymenoptera, Formicidae and Pseudoscorpiones - were identified by Dr. John La Salle (International Institute of Entomology, London); Dr. Antônio Mayhé Nunes (UFRRJ, Rio de Janeiro) and Dr. Mark Harvey (Western Australia Museum), respectively. One hundred and eigth species of gall midges were found in association with 53 species of plants distributed among 42 genera and 32 families. Ninety three gall midge species were eccidogenous, 4 predaceous, 5 inquilinous and 6 were free living. Galling species were associated with 47 plant species belonging to 36 genera and 28 families. The majority of the galls occurred on the leaves (N=63), 13 on bud, 9 on inflorescence, closed flower or flower peduncule, 3 on fruits and 1 on tendril. The Myrtaceae were the richest family in number of galls followed by Burseraceae and Nyctaginaceae. Seventy nine Cecidomyiinae species were found at Restinga of Barra de Maricá, 64 at Carapebus and 41 at Itaipuaçu. Sorensen's index revealed that the restingas of Barra de Maricá and Itaipuaçu are more similar in Cecidomylinae fauna, confirming a positive relation between geographical proximity and fauna similarity.

[0831] GALLING APHIDS AS PHYSICAL ECOSYSTEM ENGINEERS : THE VASCULAR SYSTEM IN APHID GALLS AS A MASS-FEEDING APPARATUS

D. Wool ¹ & R. Aloni ², Departments of Zoology ¹ and Plant Sciences ², Tel Aviv University, Tel Aviv 69978, ISRAEL.

Galling insects create a favorable environment for their descendants by modifying the developmental pathways of their host plants. The primary function of these modifications is to insure the food supply of the gall inhabitants. We study the development of the vascular system in different galls induced on Pistacia trees (Anacardiaceae) by gallforming aphids (Fordinae, Pemphigidae; Homoptera). Aphids feed from the phloem in the vascular system, and their galls contain the parthenogenetic offspring of single fundatrices. Each species galls a different site on the leaf and makes a gall of a specific shape. Clone sizes vary among species, from less than 100 to several thousand , all of which must obtain food in the gall. The plant vascular system is greatly modified to meet these needs. While in the vascular bundles of the ungalled leaf, the xylem differentiates towards the center and the phloem towards the periphery, in the gall new vascular bundles are formed in which the order is reversed, placing the phloem close to the gall cavity where the aphids are located . In closed, bag-like galls the vascular system is organized into an elaborate network of feeding tubes, enveloping the gall cavity a few cell layers beneath the surface. In the smaller, leaf-margin galls the structure is again different . The differences may be related to the structure of the meristematic tissues at the galling sites. The mechanisms by which these modifications are induced are unknown, but probably involve modifications of the balance between plant hormones (auxin/ cytokinin) at the galling site at the early stages of leaf differentiation. Our comparative study of the histological structure of galls of different species on the same host may give us some clues for the mechanism.

Index: galling aphids, Fordinae (pemphigidae), gall anatomy, vascular system

[0832] TEMPORAL VARIATION IN HOST-PLANT PREFERENCE AND OFFSPRING PERFORMANCE: CONSTRAINTS ON HOST-PLANT SPECIALIZATION

J. T. Cronin¹, W. G. Abrahamson² & T. P. Craig³, ¹Dept. of Biology, Univ. of North Dakota, P. O. Box 9019, Grand Forks, ND 58202, USA, E-mail jeronin@badlands.nodak.edu; ²Dept. of Biology, Bucknell Univ., Lewisburg, PA 17837, USA; ³Dept. of Life Sciences, Arizona State Univ. West, Phoenix, AZ, 85069-7100, USA.

Genotypes of the same plant species can have drastically different effects on the fitness of herbivorous insects. Under such circumstances, natural selection is expected to favor a preference by female herbivores for the plant genotypes that confer the highest fitness to their offspring. However, there are numerous possible constraints on the adaptation of herbivores to particular plant genotypes, or the occurrence of a positive correlation between preference and performance. One seldom-considered constraint is year-to-year variation in the acceptability or suitability of plant genotypes to an herbivore. In this study, we used 12 years of data from the same 20 clones of goldenrod (Solidago altissima) to examine the temporal variation in oviposition preference and offspring performance of a stem-galling fly, Eurosta solidaginis. Over the course of this study, correlations in preference between years, and performance between years, were positive in 90% and 60% of the comparisons, respectively. Interestingly, a significant majority of the correlations between rank preference and performance were negative (84%). This unexpected result is apparently a consequence of stem-galling flics aggregating their attacks onto few, preferred, goldenrod clones. The relatively high density of offspring on these preferred clones precipitates intense intraspecific competition with a consequent reduction in per-capita performance. We also found that the magnitude of change in rank preference or performance of goldenrod clones between years was quite high. Each goldenrod clone changed in rank position by an average of 31% between successive years. We suggest that these consistently high year-to-year fluctuations in preference and performance by E. solidagins are likely due to significant genotype x environment interactions. For example, water availability, nutrient levels and the abundance of interspecific herbivores are known to affect the acceptability and suitability of goldenrod clones to E. solidaginis, and these effects are clone specific. Temporal fluctuations in these environmental variables are common; thus, they may be responsible for the fluctuations in ranks. These results are significant because such temporal fluctuations in preference and performance are likely to favor a more generalized diet by herbivorous insects.

Index terms: clonal variation, Eurosta solidaginis, gall insect, host specialization, preference-performance correlation, Solidago altissima

[0833] CONSEQUENCES OF HOST PLANT RESISTANCE AND SENESCENCE TO THE SURVIVORSHIP AND DEVELOPMENT OF A NEOTROPICAL GALLING INSECT

<u>M. M. Espírito-Santo¹</u> & G. W. Fernandes¹, ¹Lab. Ecologia Evolutiva de Herbívoros Tropicais, DBG/ICB, Universidade Federal de Minas Gerais, 486, 30161-970, Belo Horizonte-MG, Brazil, E-mail esanto@mono.icb.ufmg.br.

Plant traits usually have a great influence in the ability of gall-making insect to explore their resources, directly killing the developing gall or reducing its growth. In this study, the mortality factors of the gall-inducer *Neopelma baccharidis* (Homoptera: Psyllidae) directly caused by its host plant, Baccharis dracunculifolia (Asteraceae) were analyzed. Furthermore, the influence of plant growth, reproduction and water status in gall mortality and eclosion were evaluated. In March 1999, 984 galls of the same cohort were randomly marked on 109 individuals of B. dracunculifolia in the field. Galls were verified each month during their development, from April to August. Dead and ecloded galls were collected and analyzed for mortality factors caused by the plant. The major mortality factor of N. baccharidis was plant resistance after gall establishment (19% of the original cohort), which killed the galls mainly until the third month of development. Shoot senescence killed 9.5% of the galls, and is minimized in June and after by gall ability to accelerate the development and eclosion in senescent shoots. However, the size at eclosion of this galls tended to be smaller, possibly affecting future fitness of the adults. Egg retention/abortion accounted for 7.7% of the observed mortality. None of the plant traits analyzed affected the intensity of mortality or eclosion, which are probably affected by other factors not analyzed in this study. Mortality of N. baccharidis caused directly by B. dracunculifolia was very important in controlling the gall-maker population, killing 36.2% of the original cohort of galls, mainly in the two first months of development, which are critical to gall survivorship. These results highlight the importance of (1) plant resistance not only affecting gall formation, but all the development of established galls and (2) the ability of the gall-maker to minimize the impacts of plant phenological shifts, such as senescence during the dry season.

Index terms: Neopelma baccharidis, Baccharis dracunculifolia, plant traits, gall mortality, gall eclosion

[0834] ASPHONDYLIA SPECIES OF ITALIAN FAUNA (DIPTERA: CECIDOMYIIDAE)

<u>M. Solinas</u>, Dept. of Arboriculture and Plant Protection, Univ. of Perugia Borgo XX Giugno 06121 Perugia, Italy, E-mail msolinas@unipg.it.

Asphondylia is a cosmopolitan, very large genus of the Cecidomyiidae family, with over 250 described species, including many agricultural pests. Most species produce bud, flower, and/or fruit galls on a great many families of plants. The galls produced by Asphondylia species are called "ambrosia galls" for the inner wall of the gall chamber is normally covered with a symbiotic fungal mycelium on which the midge larva feeds and develops to maturity. Both for morphological and behavioural features, concerning adults and larvae, it is quite easy to recognise this genus, whereas not always it is the same with species identification, especially when different host-plant species are presumbly colonised by the same Asphondylia species. Comparing the list of Asphondylia species in the Catalogue of Palaearctic Diptera (Skuhravà, 1986) with the list of the Italian Asphondylia species of the genus, and four of them (i. e., A. gennadii, A. lupini, A. miki and A. pruniperda) are sometimes agricultural pests in Italy. General angects such as the species between the host-plant, the fungus, and the gall-maker midge, as well as the economic importance of the agricultural pests in Italy, will be discussed.

[0835] SYNCHRONIZATION OF GALLER'S APPEARANCE WITH HOST PLANT PHENOLOGY

M. Tokuda, S. Satou & J. Yukawa, Entomological Laboratory, Faculty of Agriculture Kyushu University, Fukuoka, 812-8581 Japan, E-mail: tokudam@agr.kyushu-u.ac.jp.

Pseudasphondylia neolitseae is univoltine, making galls on the leaves of Neolitsea sericea (Lauraceae). In 1999, the galls were surveyed at various heights of host trees using a vehicle with a 12m long crane in Fukuoka, northern Kyushu. Galls were found mainly in the canopy layer, the most vigorous and sunny part of trees. The leaf opening phenology on canopy branches was about 10 days later than that on lower branches less than 3m in height. In southern Kyushu, however, the galls were usually made on the leaves of lower branches, non-vigorous and shady part. The percentage of galls that failed to develop was higher at the sunny part than that at the shady part both in northern and in southern Kyushu. In addition, the canopy layer seems to be an unfavorable galling site for such a short lived, diurnal, and tiny gall midge as *P. neolitseae*, because much windier and drier conditions with direct sunlight have a bad influence on the activity of adult midges and larval survival. Nevertheless, the adults inevitably oviposited on the higher branches in northern Kyushu, since their emergences could not synchronize with leaf-opening phenology on the lower branches. These results suggest that the synchronization is one of the important factors regulating the population density of gallers.

Index terms: *Pseudasphondylia neolitseae*, Cecidomyiidae, canopy layer, plant vigor, *Neolitsea sericea*

[0836] RESOURCE ALLOCATION VERSUS SEASONAL VARIATIONS AND THE COMMUNITY OF GALLING-INSECTS ON THE TROPICAL DIOECIOUS SHRUB BACCHARIS CONCINNA (ASTERACEAE)

<u>E. S. A. Marques</u>¹, F. M. Caldeira Castro² & G. W. Fernandes², ¹ Dept. Biology/Health & Wellness, Miami-Dade Community College, 11011 S.W. 104th Street, Miami, FL 33155, USA, E-mail: sefraz@ix.netcom.com; ²Ecologia Evolutiva de Herbívoros Tropicais/DBG, CP 486, ICB/Universidade Federal de Minas Gerais, Belo Horizonte MG - Brazil - 30161.

The occurrence of dioecy in plants suggests the existence of differential patterns of resource allocation between the sexes. Baccharis concinna (Asteraceae) is an endemic, dioecious woody shrub that shows continuous production of growth and flower meristems throughout the year. It supports one of the richest communities of galling-insects known for the tropics totaling 15 morphospecies. Resource allocation studies on the tropical dioecious shrub B. concinna have shown that female plants have longer apical shoots, with greater biomass of leaves, stems and twice the biomass of flowers, while male plants have longer lateral shoots. Nevertheless, our first study found no differences on total biomass of vegetative parts between male and female plants, and as expected no differences were encountered in the richness and abundance of galling-insects on this host plant. A second study evaluated the growth rates of lateral shoots over 12 months and revealed that lateral shoot growth rates were on average 2cm greater on male plants, but contrary to our expectation, this differential growth did not result on male plants being more attacked by galling-insects than female plants. Galling-insect species attacked both male and female plants and with similar abundance throughout the year. Galling-insect richness was mainly affected (42%) by seasonal variations in plant quality/microhabitat condition and was independent of plant gender and shoot growth rates. Although male and female plants allocated resources differently to apical and lateral shoots, shoot growth rates and seasonal variations in plant quality/microhabitat conditions accounted for only 29% of the variation in galling-insect abundance. We concluded that the community of galling-insect species did not respond to gender differences in resource allocation but are mainly affected by seasonal variations in plant quality/microhabitat conditions. The sex-biased herbivory hypothesis will be discussed within the genus Baccharis in the tropics.

Index terms: Baccharis concinna, dioecy, galling-insects, resource allocation, and seasonal variations

[0837] TIMING OF GALL-FORMATION CAUSING DIFFERENTIAL PERFORMANCE OF A STEM MOTHER IN *NEOTHORACAPHIS YANONIS* (APHIDIDAF)

Y. Tosaka1, T. Nishida1 & N. Ohsaki, ILab. of Insect Ecology, Graduate School of Agriculture, Kyoto Univ., Kyoto, 606-8502, JAPAN, E-mail juza@kais.kyoto-u.ac.jp

We examined a hypothesis that equal sex allocation observed in a gall aphid, Neothoracaphid yanonis was secondarily derived from LMC in the ancestral state. N. yanonis has five generations a year, with the fundatrix, i.e., the overwintered generation, forming a gall on a leaf surface of Distylium racemosum. The first generation shift to Quercus serratu, the secondary host and there reproduce parthenogenetically for a few generations before the third generation return again to D. racemosum. The third generation produced male and female nymphs, which disperse, develop to adults, and then mate. The numerical sex ratio of the nymphs at birth was female biased (1:2), but the males were just twice larger than females, resulting in equal investment for either sex as predicted by Fisherian theory. Observations on the mating system suggested random mating to occur because (1) multiple mothers laid nymphs within a single leaf, (2) newly hatched nymphs, particularly female nymphs dispersed from the natal leaf, and (3) reproductive adults were also highly dispersing. In spite of the suggested random mating, dissection of mother aphids revealed that almost all (97%) mothers produced two sons though the clutch size varied from 2 to 10, with the average of 6. The constant male production has been traditionally regarded as the evidence of LMC under varying resource condition (Ymaguchi, 1985). However, we found that constant male production occurs even under random mating. This suggestion that LMC might be once common in the native habitat. Thus, we tentatively conclude that the present random mating in N. yanonis may have derived from LMC in the ancestral state.

Index terms: Fisherian theory, sex ratio, constant male production.

[0838] HOST PLANT DEFENSE INHIBITING SYNCHRONY WITH ITS FRUIT GALL MIDGE, ASPONDYLIA AUCUBAE

K. Imai¹ & N. Ohsaki¹, ¹Laboratory of Insect Ecology, Graduate School of Agriculture, Kyoto Univ., Kyoto, 606-8502, JAPAN, E-mail kensuke@kais.kyoto-u.ac.jp

Studies of plant-gall former interaction suggest that synchrony between the susceptible period of plants and gall formers is critical for fitness of gall formers, and that gall formers may have synchronized with their host plant susceptibility through adaptation over time. However, how the susceptible periods of plants are determined and how gall formers keep their synchrony with the limited susceptible period has not been studied so extensively to date. A fruit gall midge Asphondylia aucubae (Diptera, Cecidomyiidae) lays egg in the immature fruits of Aucuba japonica, a common understory tree species of temperate broad-leaved evergreen forests in Japan. Adult life spans are I day in duration, and the adult season of our study area is a period of 10 days in mid-June. However, immature fruits of A. Japonica don't largely change their shape and look available for egg-laying from early-May to early-August. Anatomical research in 1999 revealed that: (1) before mid-June the inner-seed-coat of fruits inhibit the insertion of female ovipositor, and (2) after mid-June the nucellus of immature fruits (material of gall) is atrophied and gall formation may be difficult. These mechanisms should force adult midges to emerge and egg-lay in a quite limited period; therefore their synchrony with plant susceptibility may be difficult. Such mechanisms should be a host plant defense inhibiting synchrony with A.aucubae. Existence of such a defense mechanism may suggest the existence of an arms race over synchrony between gall formers and host plants.

[0839] HOST ALTERNATION BY MULTIVOLTINE GALL MIDGES OF THE GENUS ASPHONDYLIA

N. Uechi, D. Yamaguchi & J. Yukawa, Entomological Laboratory, Faculty of Agriculture Kyushu University, Fukuoka, 812-8581 Japan, E-mail uechi@agr.kyushuu.ac.jp

At least 200 galling species of the genus *Asphondylia* have been recognized in the world. These species are morphologically quite similar to one another, and therefore species identifications have chiefly been based on host data, life history information, and the shape of galls. In Japan, some *Asphondylia* gallers on 20 plant species have been left unnamed. Most of them cannot complete their annual life history on a single host species, because plant organs available for oviposition do not exist in the emergence seasons of adults. Therefore, they have to find alternative host plants. However, the host alternation has not yet been evident in the genus *Asphondylia* except for a few species. We studied, in Kyushu, Japan, the life histories of several *Asphondylia* species on respective host plants, focusing on their emergence and host plant phenology. From these studies we found possible combinations of host plants with which some of *Asphondylia* species can complete their annual life cycles. Recently, some of our findings were confirmed by DNA analyses. The combination of field surveys and DNA analyses will clarify the taxonomic status and life history of further species of the genus including a serious crop pest like the soybean pod gall midge.

Index terms: Cecidomyiidae, plant phenology, life history, DNA analysis.

[0840] PLANT QUALITY AND TROPHIC CASCADES: THE EFFECTS OS PLANT STRESS AND VIGOR ON INSECT ASSEMBLAGES

M. Williams & J. Cronin

ABSTRACT NOT RECEIVED

[0841] RESPONSE OF *PHYTOLYMA LATA* (HOMPOTERA: PSYLLIDAE) TO VARYING HOST DENSITY IN GHANA, WEST AFRICA

M. R. Wagner¹ & J. R. Cobbinah², ¹School of Forestry, Box 15018, Northern Arizona Univ., Flagstaff, AZ 86011-5018, USA, E-mail Mike.Wagner@nau.edu; ² Forestry Research Institute of Ghana, UST PO 63, Kumasi, Ghana.

Phytolyma lata (Homoptera: Psyliidae) is a gall-forming psyllid that attacks two commercially important timber species, Milicia excelsa and Milicia regia, in West Africa. This insect has been exclusively responsible for the widespread failure of Milicia spp. grown in plantations in West Africa. A series of three field and screen house experiments was conducted to assess the relationship between the density of the host plant (Milicia) and its susceptibility to the psyllid. Replicated plantings of 11, 25, 50, and 100% Milicia in mixtures with Terminalia superba were established. Two months after planting gall numbers were significantly lower in the 11% Milicia mixture when compared to the control. A combination of experimental approaches was used to demonstrate that shading of Milicia not plants apparently modified host plant resistance but did not affect natural enemy regulation. These results suggest that mixed species plantations may be an effective management strategy of forest pests in tropical plantations.

Index terms: Milicia, companion planting, tropical plantations, pest management.

[0843] GENOTYPIC VARIATION IN PR-PROTEIN ACTIVITY IN WILLOW AND RESISTANCE TO A GALLING INSECT

O. Paulsson & <u>S. Larsson</u>, Dept. of Entomology, Swedish University of Agricultural Sciences, Box 7044, SE-750 07 Uppsala, Sweden, E-mail Stig.Larsson@entom.slu.se

Great genetic variation in resistance exists among genotypes of Salix viminalis to the cecidomytid Dasineura marginemtorquens. On resistant plant genotypes 95% of the newly hatched larvae die within 48 hours without being able to initiate galls. On susceptible genotypes >90% of the larvae successfully form galls and develop into pupe. We have found peroxidase activity to correlate with resistance. A resistant willow genotype exhibited five times higher peroxidase activity compared with a susceptible genotype. The midges themselves do not induce peroxidase activity. At present, we cannot say which environmental factor(s) that trigger increased peroxidase activity. We hypothesize that peroxidases suppress gall formation through catalysis of lignification of the cell wall, thereby making it more rigid to gall initiation, and/or by catabolism of auxins suggested to be essential components in gall formation. In addition, chitinase activity was also higher in resistant plant genotypes. Few other data exist on mechanisms of resistance at the molecular level against gall-forming insects. Interestingly, the interaction between the insect and the plant resembles a plant-pathogen interaction (i.e. peroxidases and chitinases are pathogenesis-related proteins).

Index terms: Dasineura marginemtorquens, Salix viminalis, peroxidases, induction

[0842] PLANT RESISTANCE AGAINST GALL-FORMING INSECTS: THE ROLE OF PLANT HYPERSENSITIVITY

T.G. Cornelissen¹, D.P. Negreiros¹, C. Saraiva¹ & G.W. Fernandes¹, ¹Univ. Federal de Minas Gerais, Lab. Ecologia Evolutiva de Herbívoros Tropicais, ICB, CP 486, 30161-970, Belo Horizonte, MG, Brazil. E-mail: tatiana@icb.ufmg.br.

Hypersensitive reaction (HR) is an important type of induced defense of plants against herbivores. Previously thought to be an exclusive type of defense against pathogens, HR is also a widespread mechanism whereby plants resist the attack by herbivores, particularly galling insects. In this long term study we evaluated the importance of this kind of resistance against the galling insect Contarinia sp. (Diptera: Cecidomyiidae) on Bauhinia brevipes (Leguminosae). We sampled more than 15,000 shoots and 17,000 galls during four consecutive years of study. We also provided first data on how widespread and important is HR against a wide range of gall-forming insects in eight different plant species in the Brazilian savannas. Over several consecutive years, this host-driven mortality factor killed more than 90.0% of the galls induced by *Contarinia* sp. (1995: 97.5% ± 2.4; 1996: 93.4% ± 2.2; 1997: 93.8% ± 2.4; 1998: 94.3% ± 2.1) on B. brevipes leaves. The response to this insect herbivore is not related to density of attack or even to the vigor (growth) of the host organ. Studies on other eight tropical savanna species corroborated the occurrence and importance of IIR on insect herbivores population dynamics. HR was found to be common in the plant kingdom, irrespective of plant phylogeny and growth forms. This cellular host plant defense mechanism might involve cell suicide, or apoptosis, and molecular studies of HR in B. brevipes have been already realized in our laboratory. We established a protocol to B. brevipes DNA extraction, and we obtained pure DNA samples, confirmed by eletrophoretic analysis.

Index terms: plant hypersensitivity, plant defenses, induced responses, Contarinia sp

[0844] LONG-TERM POPULATION DYNAMICS OF GALL MIDGES IN EVERGREEN FORESTS

J. Yukawa, Entomological Laboratory, Faculty of Agriculture Kyushu University, Fukuoka, 812-8581 Japan. E-mail: jyukawa@agr.kyushu-u.ac.jp.

Field populations of the following univoltine gall midges have been studied since 1970 in the forests of broad-leaved evergreen trees in southern Kyushu, Japan. *Pseudasphondylia neolitseae* leaf galls on *Neolitsea sericea* (Lauraceae); *Lasioptera camelliae* leaf vein galls on *Camellia japonica* (Theaceae); *Asphondylia sphaera* fruit galls on *Ligustrum japonicum* (Oleaceae); *Daphnephila machilicola* leaf galls on *Machilus thunbergii* (Lauraceae) and *Daphnephila machilicola* leaf galls on *Machilus thunbergii* (Lauraceae) and *Daphnephila* sp. leaf galls on *Machilus japonicus* (Lauraceae). The population fluctuations of the first two species were relatively stable for many years. The analyses of life table data indicated that these populations have been regulated well by density dependent bottom-up effects. In contrast, the population was strongly influenced by the alternation of a good and bad year for fruit production and by the abortion of a large number of flower buds. The *Daphnephila* species were attacked by four parasitoid species, of which a pteromalid acted as a key factor but was not a density dependent mortality factor. Thus, the gall midge populations fluctuated in different manners even though they coexist side by side in the same broad-leaved evergreen forest which have been considered to provide inhabitants with stable conditions to live.

Key words: Cecidomyiidae, life table, bottom-up effect, parasitoid, population density

108451 AN INOUILINE APHID. TAMALIA INOUILINUS N. SP., CO-OCCUPYING GALLS OF THE COMMUNAL APHID TAMALIA COWENI (HOMOPTERA: APHIDIDAE)

D. G. Miller III, Dept. of Biology, Trinity Univ., 715 Stadium Drive, San Antonio, TX 78212 USA E-mail: dmiller@trinity.edu.

Foundress females of the Manzanita Leaf-gall Aphid, Tamalia coweni, readily co-occupy galls on Arctostaphylos spp. (Ericaceae) without engaging in overt agonistic behavior. The recently described squatter aphid, Tamalia inquilinus, invades and occupies galls of T. coweni, thereby exploiting this communal aspect of the host species. I describe this unique form of social parasitism in galling aphids and show how the specialized squatter aphid may be adapted to withstand the hazards of predators and dessication, both of which are more prevalent in its opportunistic life history strategy relative to the host species T. coweni. I place squatting behavior into the context of social behavior and social parasitism, suggesting that the lack of discrimination by T. coweni foundresses may facilitate intrusion of galls by T. inquilinus.

Index terms: social parasitism, social, squatter

108471 NEOTYPHODIUM DIVERSITY IN GRASSES AND THE ISSUE OF INSECT RESISTANCE

Clement, U.S. Department of Agriculture, Agricultural Research Service, Washington State University, P.O. Box 646402, Pullman, WA 99164-6402, USA, E-mail: slclement@wsu.edu.

Genetic variation for herbivore resistance in natural plant populations and agricultural plants is often associated with intrinsic factors such as chemical and physical defense mechanisms. Apart from heritable genetic and environmental factors, other factors such as plant microbes mediate host plant-herbivore interactions. For example, the presence of endophytic Neotyphodium fungi in some C3 grasses confers resistance to phytophagous insects through the production of specific alkaloid compounds. However, Neotyphodium infection does not universally confer resistance to insects as revealed, for example, by the species-specific nature of aphid resistance in Neotyphodium-infected wild barley (perennial Hordeum spp.). Experimental data show: 1) that the reproduction and survival of Russian wheat aphid (Diuraphis noxia) and rose grass aphid (Metopolophium dirhodum) is adversely affected by some wild barley-Neotyphodium associations, and 2) that wild barley endophytes have no adverse effect on bird cherry-oat aphid, (*Rhopalosiphum padi*). The endophyte-infected wild barleys originated from the Asian areas of origin of D. noxia (ancestral range of M. dirhodum is unknown). In other experiments, R. padi exhibited differential survival on different tall fescue (Festuca arundinaceae)-Neotyphodium associations originating from non-agricultural settings in Tunisia. The Palearctic home ranges of R. padi and tall fescue overlap. The observed aphid responses were likely the result of variable alkaloid production by an experimental suite of diverse host grass (species, genotype)-Neotyphodium (species, strain) associations. This research documents wide variability in plant-endophyte-insect interactions involving wild host grasses and aphids with overlapping home ranges (D. noxia and wild barley in Asia; R. padi and tall fescue in the Mediterranean Basin), as well as the important role played by diverse Neotyphodium fungi in mediating plant-insect interactions.

Index terms: Diuraphis noxia, Metopolophium dirhodum, Rhopalosiphum padi, grass resistance, endophytic fungi.

[0846] HOST-PLANT ARCHITECTURE AND THE DYNAMICS OF GALL-INDUCING SPECIES

P. W. Price, Dept. of Biological Sciences, Northern Arizona Univ., Flagstaff, AZ 86011-5640, USA, E-mail: peter.price@nau.edu.

Gall-inducing insects respond to host plant modular structure in highly specific ways, especially when they utilize buds and shoots which provide highly heterogeneous resources. This strong specificity yields patterns of module utilization that highlight the importance of host plant architecture, enabling new insights to hypotheses on host plant aging and architectural complexity effects on insect herbivores. Responses of sawflies to the architecture of trees and shrubs are compared showing dramatically different population dynamics on each architectural type. Also, shrubs with strong and weak apical dominance on shoots result in different dynamics for cecidomyiid gall midges. Strong preference among gall-inducers for rapidly developing modules also reduces the importance of host plant architectural type in promoting herbivore community richness per host plant species. The study of gall-inducers refines our understanding of the precision of the ovipositional preference-larval performance linkage in relation to the details of plant architecture.

Index terms: gall-inducing insects, plant architecture, sawflies, Hymenoptera: Tenthredinidae, preference-performance linkage

[0848] ENDOPHYTIC FUNGI, HOST PLANT GENOTYPE AND INSECT HERBIVORES

K. Saikkonen & M. Helander, ¹Dept. of Biology, Univ. of Turku, FIN-20014 Turku, Finland, E-mail karisaik@utu.fi.

Interactions among endophytic fungi, host plants and herbivores are usually studied emphasizing fungal mediated plant-herbivore interactions. Some seed-borne grassendophytes, particularly in agronomic arena, have inevitably shown to negatively affect herbivores. Contrary, most studies with natural grass systems and especially with horizontally by spores transmitted tree-endophytes have shown more variable effects ranging from beneficial to deleterious on herbivores. This variability is likely related to variation in the number of types and concentrations of alkaloids produced by fungi. In a case of horizontally transmitted endophytes in woody plants, it may also indicate differences in plant quality for fungi and herbivores without causal relationship between fungal infection and herbivore performance. We have examined endophyte medicated plant-herbivore interactions in a series of field experiments using clones or half-sib progenies of host plants (both grasses and woody plants). For example, we have compared the performance of several insect herbivores with endophyte abundances of 10 half-sib progenies of matured mountain birch (Betula pubescens ssp. tortuosa) growing in two environments (river slope, tundra). This allows us to examine both phenotypic and genetic correlations between fungal endophyte frequencies and herbivore performance on these trees. Importance of type of endophyte infection (systemic vs. non-systemic), the mode transmission (vertical vs. horizontal) and environmental factors is discussed.

Index terms: herbivory, endophytic fungi, mode of transmission, environment, phenotypic and genetic correlations.

[0849] EFFECT OF ENDOPHYTES ON THE DICHOTOMY BETWEEN TOLERANCE AND DEFENSE IN FORAGES GRASSES

<u>T.L. Bultman</u>, Division of Science, Truman State University, Kirksville, MO, USA., Email: tbultman@truman.edu

Resistance by plants to herbivore attack is thought to take two fundamental forms. Plants may avoid attack through defense or escape; alternatively, plants may tolerate attack through regrowth following damage. A negative relationship between tolerance and defense might be expected if each strategy is associated with a metabolic cost to the plant. Effects of plant symbionts on the tradeoff between tolerance and defense has been little The purpose of my study was to investigate how a fungal symbiont studied. (Neotyphodium coenophialum) of tall fescue influences tolerance to and defense against bird cherry-oat aphids, Rhopalosiphum padi. Seeds infected and uninfected with N. coenophialum were planted individually into pots filled with potting soil and watered as needed. Plants were grown for 6 weeks and then were damaged by clipping at 3cm above the soil surface. After 2 weeks of regrowth, four aphids were placed within clip bags onto the newest fully expanded leaf blade for 4 days. Population growth rate of apterous aphids during the 4 day period was lower on infected plants ($F_{1,100}$ =01.4, p=0.001). Furthermore, the effect of damage on aphid population growth depended upon fungal infection (F1,100=6.8, p=0.01); damage induced susceptibility to aphids in uninfected plants, but induced resistance in infected plants. Rate of regrowth by plants between the time of damage and the bioassay (a 2 wk period) was higher for infected plants (T=3.28, df=51, p=0.002). Another experiment with similar design, except that it used perennial ryegrass and its endophyte, Neotyphodium lolii, showed no constitutive or inducible effect of the fungus on R, padi reproduction. We conclude that Neotyphodium can enhance both the defense (constitutive and induced) and tolerance of plants to R, padi, but the effects may depend upon plant and fungal species.

Index terms: defense, fungi, Rhopalosiphum padi, tolerance

[0850] INTERACTIONS BETWEEN ABOVE- AND BELOW-GROUND FUNGAL ENDOPHYTES: EFFECTS ON A LEPIDOPTERAN HERBIVORE

M. Vicari¹, P.E. Hatcher², M.F. Dutton³ & P.G. Ayres⁴, ¹Dept. of Biology, York Univ., 4700 Keele St., Toronto, ON M31 IP3, Canada; ²School of Plant Sciences, Univ. of Reading, Whiteknights, Reading RG6 6AS, UK; ³Dept. of Physiology, Univ. of Natal, Congella 4013, South Africa; ⁴I.E.N.S., Biological Sciences Div., Lancaster Univ., Lancaster LA1 4YQ, UK.

Neotyphodium endophytes infect the above-ground tissues of grasses, are widespread in natural grasslands, and are well known for their ability to deter feeding by insects. Arbuscular mycorrhizal (AM) fungi are also common in grasslands, but few studies have investigated the effects of dual infection of host plants on insects. The purpose of this investigation was to determine how infection of Lolium perenne by the AM fungus Glomus mosseae and the foliar endophyte N. lolii affects the performance of lepidopteran herbivores sensitive to the latter. Preliminary experiments were conducted to assess the suitability of three British lepidoptera. The graminivorous generalist Noctua pronuba was insensitive to N. *lolii*, while the generalist Arctia caja showed a tendency (p = 0.07) towards reduced growth on N. *lolii*-infected (+N) plants but could not complete its development even on uninfected (-N) plants. The generalist *Phlogophora meticulosa*, however, demonstrated both antibiosis and antixenosis on +N plants, and was able to complete its development on L. perenne; thus it was selected for further investigation. Experiments were conducted in which G. mosseae [present (+AM) or absent (-AM)] and *N. lolii* infection of *L. perenne* were factors. The growth and survivorship of 2^{nd} - to 5^{ch} -instar larvae feeding on excised leaves were monitored. Survivorship of 2^{nd} - and 3^{rd} -instar larvae was reduced by *N. lolii*; that of 2^{nd} - and 5^{ch} -instar larvae was reduced by *G.* mosseae. Effects of the two fungi on larval survivorship were additive. N. lolii mitigated a detrimental effect of limiting phosphorus (P) on survivorship of 5th-instar larvae. effects of *G. mosseae* on larval survivorship were P-independent, although there were weak AM^*P interactions with larval growth. The maximum dry weight of 6^{th} -instar larvae was reduced by both G. mosseae and N. lolii, but those feeding on +AM+N plants had similar dry weight and consumption to those feeding on +AM-N plants. N. lolii caused an increase in relative consumption rate (RCR) and a decrease in efficiency of conversion of ingested matter (ECI), while G. mossene had no effect on RCR or ECI. Larvae foraging among intact +N and -N plants inflicted more damage on the latter, but the difference was decreased when both plants were +AM. Neither fungus affected foliar Kjeldahl nitrogen concentration, and G. mosseae had little effect on foliar concentrations of the insect deterrent peramine. The implications of these findings for Neotyphodiuminsect interactions will be discussed.

Index terms: Phlogophora meticulosa, Neotyphodium lolii, Glomus mosseae

[0851] ENDOPHYTIES IN WOODY PLANTS AND GRASSES: DEFENDERS AGAINST, OR CONSPIRATORS WITH, INSECT HERBIVORES?

S. H. Faeth

ABSTRACT NOT RECEIVED

[0852] ROLE OF THE PHORBIA FLIES IN THE EVOLUTION PROCESS OF EPICHOLE TAXA

A..Leuchtmann

ABSTRACT NOT RECEIVED

ABSTRACT BOOK I - XXI-International Congress of Entomology, Brazil, August 20-26, 2000

[0853] ENDOPHYTES, TANNIS, AND HERBIVORES: THE INTERFACE IN A WOODY SHRUB

H. R. Mendes, F. H. Melo, B. G. Madeira, M.M. Espírito Santo, M.L. Faria, M. Fagundes & F. G. Wilson

ABSTRACT NOT RECEIVED

[0855] INTERACTIONS BETWEEN PREDATOR SPECIES, THEIR PREY AND THE HOST PLANT

S. D. Wratten & C. N. Merfield, Ecology & Entomology Group, Soil, Plant & Ecological Sciences Division, P.O. Box 84, Lincoln University, Canterbury, New Zealand.

Most studies on invertebrate predation concern single predator or parasitoid species and evaluate their behaviour and ecology with little consideration of other natural enemies in the same or different guild, or of tri-trophic-level effects between plant, prey/host and the natural enemy. In many agricultural habitats however, there may be hundreds of natural enemy species potentially interacting and the crop itself may respond to herbivore feeding via wound-induced changes in plant defences. The interaction between the plant, the herbivore and the predator can therefore involve "top down" (ie predator) and/or "bottom up" (ie plant) effects on the herbivore population. This paper will explore two systems in which these interactions have been recently studied. The first is a tomato/caterpillar/predatory carabid interaction while the second concerns commensal relationships between predatory arachnid species. Work on the lepitopteran Spodoptera litura on tomato (Lycospersicon esculentum) and the non-climbing carabid predator Megadromus antarcticus showed that the carabid increased S. litura mortality with a subsequent decrease in leaf damage. Leaf wounding produced a possible decrease in herbivory and there was a trend for the presence of the carabid on the soil to interact with wound-induced changes in the plant; the latter caused a higher proportion of lavae to move to the soil surface, where they were available to the epigeal predator. Using time-lapse video techniques in the field and in the laboratory showed that when some predatory mite species (whirlygig mites: Anystis spp. and mites in the super-family Erythracoidea) had pierced a dipteran egg, the latter was more likely to be predated by harvestmen (Arachnid: Opiliones). The latter type of commensal interaction, between predators in the same guild with similar feeding mechanisms, has been very rarely demonstrated in predator-prey systems and maybe more common among predators in cropping systems than previously assumed.

[0854] LONG-TERM, RESOURCE-BASED LIMITATION OF GALL-INDUCING SAWFLY POPULATIONS EXEMPLIFYING A COMMON PATTERN

<u>P. W. Price</u>, Dept. of Biological Sciences, Northern Arizona Univ., Flagstaff, AZ 86011-5640, USA, E-mail: peter. price@nau.edu

A Darwinian approach to population dynamics works from macroevolutionary patterns in morphology, life history, behavior and phylogenetic relationships, to macroecological patterns in distribution, abundance, and population dynamics. Using gall-inducing sawflies and relatives (Hymenoptera: Tenthredinidae) such patterns are illustrated showing common macroevolutionary patterns of a saw-like ovipositor, monophagy, strong female ovipositional preferences linked to high larval performance, and specialization on rapidly growing, vigorous shoots. The macroecological consequences involve species that are generally distributed very patchily over a landscape, they are uncommon or rare, and populations remain low and relatively stable, constrained by a low carrying capacity, dictated by a limiting resource of vigorous host plant modules. The mechanistic reasons for the macroevolutionary effects on macroecological patterns are explained. Thus there is a flow of influences from Phylogenetic Constraints to Adaptive Syndromes to the Emergent Properties, the last being the ecological features of distribution, abundance, and population dynamics. Given that the patterns are documented and the mechanistic explanation for patterns are understood, we have the basis for the theory on population dynamics of these sawflies. Such a theory has strong predictive power, it involves a broad comparative framework, and it allows a synthesis of population dynamics across many taxa involving both latent and eruptive species.

Index terms: macroevolution, macroecology, population dynamics, Hymenoptera: Tenthredinidae, sawflies

[0856] DO NATURAL ENEMIES PREVENT OUTBREAKS OF EPIRRITA AUTUMNATA IN SOUTHERN FENNOSCANDIA?

M. Tanhuanpää & K. Ruohomäki, Section of Ecology, Dept. of Biology, Univ. of Turku, FIN-20014 Turku, Finland.

Research on population dynamics of herbivorous insects has concentrated on outbreaking and cyclic species although most species are always present at low densities. The tendency of a species to reach high densities is often related to certain life history traits. However, all the populations of an outbreaking species do necessarily not have outbreaks. Within a species, impact of different life history traits can be largely climinated, making it easier to identify the ecological traits affecting population dynamics. Yet, there are few studies assessing factors affecting dynamics of outbreaking and nonoutbreaking populations within a species. Periodic outbreaks are frequently more pronounced in northern populations of herbivore species with wide distributions. *Epirrita autunnata* is a forest lepidopteran with a Holarctic distribution but outbreaks only in northern and mountainous Fennoscandia. Genetic differences between populations, e.g., in size and hence, fecundity, are apparently not associated with the occurrence of E. autumnata outbreaks. Thus, extrinsic factors must be involved. According to the generalist/specialist predation hypothesis, in southern Fennoscandia, there are numerous prey species for each predator and thus, most predators function as generalists. While, in the subarctic, alternative prey is scarce and predators often need to specialize on one or few prey species. This study evaluates the appropriateness of the generalist/specialist hypothesis in explaining the contrasting dynamics of E. autumnata populations in southern and northern Fennoscandia. The study focuses on nonoutbreaking populations with the purpose of revealing whether the lack of outbreaks in southern Fennoscandia is due to the higher number of generalist predators. The approach taken is to experimentally evaluate the impact of natural enemies on survival of E. autumnata in each life history stage. Mean survival rate of E. autumnata larvae in the southern Fennoscandia varied from 8 to 14 percent whereas year-specific pupal survival rate ranged from 15 to 50 percent. Pupal predation by small mammalian predators was temporally density dependent in the southern but not in the northern populations. Adult predation decreased the number of larvae produced for the next generation by 60-86 percent and egg mortality by 20-40 percent. Although some of the mortality rates may have been overestimated, such high density independent mortality combined with density dependent pupal predation offers a plausible explanation for the lack of *E. autumnata* outbreaks in southern Fennoscandia. The results of this study suggest that the lack of E. autumnata outbreaks in southern Fennoscandia is most likely due to regulation by natural enemies.

Index terms: Lepidoptera, Geometridae, stability, predation, parasitism

[0857] FACTORS INFLUENCING TOP-DOWN CONTROL OF INSECT POPULATIONS.

N. J. Mills, Insect Biology, Wellman Hall, Univ. of California, Berkeley, CA 94720-3112, USA, E-mail nmills@nature.berekeley.edu

There has been a tremendous amount of interest in tritrophic interactions between plants and natural enemies, driven both by the need to integrate host plant resistance and biological control in the management of arthropod pests, and to understand the relative importance of direct and indirect interactions in ecological communities. There have been many documented examples of the direct effects of physical, chemical and nutritional qualities of plants on the attack rate, survival and reproduction of natural enemies. In addition, it is well known that these same qualities of plants have an indirect effect on natural enemies by influencing the distribution, abundance and vulnerability of herbivores. Here we focus on two aspects of tritrophic interactions between plants and natural enemies. Firstly, we make a comparative analysis of the influence of plant variation on the different groups of natural enemies (parasitoids, predators, pathogens and nematodes), and secondly, we explore the influence of plant variation on interspecific interactions between natural enemies. A comparative approach identifies common patterns in the influence of plant traits on natural enemies and highlights those traits that differentially influence natural enemy groups. We document examples of the influence of plants on the interspecific interactions of natural enemies, and consider approaches needed to better identify these effects in plant-arthropod-natural enemy systems.

Index terms: plant variation, natural enemy, interspecific interactions

[0859] BOTTOM-UP AND TOP-DOWN REGULATION OF INSECT POPULATIONS

P. Gutierrez¹ & J. Baumgärtner², ¹Ecosystems Science, 151 Hilgard Hall, Univ. alifornia, Berkeley, CA, USA 94720, ²ICIPE, P.O. Box 30772, Nairobi, Kenya

Species dynamics are affected by intraspecific competition for resources (usually physical factors such as space, chemicals, sunlight, food, etc.), and by other species directly below, laterally (interspecific competition) or above it in the trophic chain (predation in a general sense). Bottom-up processes are those that act through the quantity and quality of resources acquired by individual organisms to affect population intrinsic parameters such as birth rates and resource related death and emigration rates. Lateral or competitive processes may be viewed as bottom-up because they affect the process of resource acquisition. Top-down processes, on the other hand, are those that act through predation, parasitism and disease. In a general sense, any population is a resource for a higher trophic level, and as such is engaged in a bottom-up process relative to its consumer. What has not been clear is how these processes should be incorporated into a food chain model that still maintain the necessary structural constraint that the same ecological principles should apoly to any trophic level. Here we answer this question viewed from the perspective of the consumer. "What proportion of the consumer's demand for each of its requisites are met, and how does the proportion affect consumer birth and death rates individually and collectively?" Ecological principles of supply and demand are used to solve this problem. These principles are applied to physiologically age- mass structured tritrophic local and metapopulation dynamics in a real world setting.

Index terms: Bottom-up top-down regulation, metabolic pool, number and mass dynamics, metapopulation dynamics.

[0858] WHEN AND WHY TOP-DOWN REGULATION FAILS

P. Kindlmann¹ & A.F.G. Dixon², ¹Fac. Biol. Sci., Univ. South Bohemia and Czech Acad. Branisovska 31, 37005 Ceske Budejovice, Czech Republic, E-mail pavel@entu.cas.cz; ²Sch. Biol. Sci., Univ. East Anglia, Norwich, NR4 7IJ, U.K.

The population dynamics of deciduous tree-dwelling aphids have been studied over long periods of time and in considerable detail. Within a year, the dynamics of these aphids are very complicated and in looking for the mechanism of regulation this needs to be taken into consideration. An initial dramatic increase in population size in spring is typically followed by a steep decline in abundance during summer and sometimes a further increase in autumn. During spring and summer all the generations are parthenogenetic, short lived (2-4 weeks) and fully winged. In autumn, sexuals are also produced, which mate and give rise to the overwintering eggs that hatch the following spring and give rise to fundatrices, the first parthenogenetic generation. Analysis of empirical data has revealed the regulatory mechanism that is responsible for the summer decline in numbers: migration. This increases linearly with density and declines with improving food quality. In contrast to most other groups, the empirical data do not lend support to a marked effect of natural enemies, or a severe scramble for resources by these aphids. Therefore, these factors do not seem to play a substantial role in regulating the abundance of these aphids. Food quality determines the rate of development and size of an individual more than intraspecific competition, and food quality is not affected by aphid numbers substantially. An explanation of the low effect of natural enemies on aphid dynamics is offered: Because of their high mobility, food availability seems to be much less restrictive for adults compared with juveniles, which are confined to one patch. Therefore functional response does not seem to play an important role for adults. Egg and larval cannibalism are common in insect predators. Thus a strong selection pressure on predators to lay their eggs only in patches in early stages of their development and avoid those containing conspecific larvae determines the strategies of predatory adults to much greater extent than availability of food in one prey patch. In addition, the potential fitness of an adult insect predator mainly depends on the future trends in resource availability throughout the period of development of its larvae, because they, unlike the adult, are confined to a patch. Thus, adult oviposition strategy is likely to be determined by the bottlenecks in resources that occur during the period of its offsprings' development. Therefore, the longer the developmental time of a predator, the smaller the degree of depletion of the patch by this predator species. As a consequence, the relative "efficiency" of predators as biological control agents is negatively correlated with their generation time relative to that of their prey (GTR).

Index terms: Aphids, ladybirds, aphidophagous predators, population regulation

[0860] TOP-DOWN REGULATION OF SPRUCE NEEDLEMINER AND OTHER FOREST LEPIDOPTERA

A. Berryman^a & M. Münster-Swendsen^b, ^aDept. Entomology, Wash. State Univ., A. A. Berryman^{*} & M. Münster-Swentsen, Dept. Entoniology, main out carry, Pullman WA 99164 USA, ^bDept. Population Ecology, Univ. Copenhagen, DK-2100 Copenhagen, Denmark

We outline an approach for detecting, from time series data, whether populations are being regulated by bottom-up or top-down forces, and then apply the approach to data on the spruce needleminer, Epinotia tedella, in Denmark. The results support the hypothesis that spruce needleminer populations are regulated by top-down interactions with a guild of larval parasitoids. We then show how these results may apply to a number of other forest Lepidoptera and comment on the reason for top-down regulation in this group of insects. Index terms: Epinotia tedella, population regulation, parasitoids, time series analysis

[0861] THE ACTIVE ROLE OF PLANTS IN ATTRACTING PARASITODDS: DOES IT BENEFIT THE PLANTS?

T. Turlings & M. E. Fritzsche-Hoballah, Inst. of Zoology, Univ. of Neuchâtel, Case Postale 2, CH-2007, Switzerland, Email: Ted.Turlings@zool.uninc.ch

Maize plants under caterpillar attack initiated the release of a blend of specific volatiles. Parasitoids use these volatiles as cues in search of caterpillars. It has been proposed that the volatiles specifically function as signals to attract parasitoids and other natural enemies of herbivores. However, it is not always evident that an individual plant benefits from the action of parasitoids. In most cases, parasitized caterpillars continue their development and in some cases may eat even more than if they were not parasitized. We will present evidence showing that the induced plant signals indeed help increase parasitism rates by two solitary larval endoparasitoids and that these parasitoids reduce herbivory to such an extent that they may increase the fitness of individual plants.

Index terms: tritrophic level interactions, plant synomones, plant fitness

[0863] PLANT SPATIAL HETEROGENEITY AND HERBIVORE-ENEMY INTERACTIONS: THE UNDERLYING MECHANISMS WHEN THE ENEMY IS A PLANT-FEEDING OMNIVORE

M. Coll & L. Shaltiel, Dept. of Entomology, Fac. of Agric, Food and Environ. Qual. Sci., The Hebrew Univ. of Jerusalem, P. O. Box i2, Rehovot 76100, ISRAEL E-mail: coll@agri.huji.ac.il.

Movement of organisms between habitats is of great importance in determining their abundance and population structure. Most models of predator movement are based on the chance of the predator to locate prey while the effect of vegetation characteristics on predator behavior bas been largely ignored. In recent years, it has become apparent that many species of natural enemies, once considered exclusively predaceous, also feed on plant resources. The interactions between omnivores and their plant habitat are thus characterized by decoupling of the dynamics between enemy and prey populations. Further complexity is added to the system by the fact that many omnivores utilize hoat plants not only as a food source, but for oviposition and shelter, as well. We examine these interactions through studies of two omnivorous anthocorid bugs: Orius insidiosus populations in intercropped agroecosystems and Anthocoris nemoralis on four tree species in the Meditermanan forest. The latter study is aimed at understanding the relative importance of host plants and psyllid prey to the spatial dynamics of the omnivore. Index terms: Anthocoris nemoralis, Orius insidiosus, omnivory

[0862] BEHAVIOUR AND INDIRECT INTERACTIONS IN FOOD WEBS OF PLANT-INHABITING ARTHROPODS

A. Janssen, A. Pallini, M. Venzon & <u>M.W. Sabelis</u>, Inst. of Biodiversity and Ecosystem Dynamics, Univ. of Amsterdam, PO Box 94084, 1098 SM Amsterdam, The Netherlands

With the increased use of biological control agents, artificial food webs are created in agricultural crops and the interactions among plants, herbivores, and natural enemies change from simple tritrophic interactions to more complex food web interactions. Therefore, herbivore densities will not only be determined by direct predator-prey interactions and direct and indirect defence of plants against herbivores, but also by other direct and indirect interactions such as apparent competition, intraguild predation, resource competition, etc. Although these interactions have received considerable attention in theory and experiments, little is known about their impact on biological control. We discuss experimental results on interactions in an artificial food web consisting of pests and natural enemies on greenhouse cucumber. The two pest species are the two-spotted spider mite Tetranychus urticae and the Western Flower Thrips Frankliniella occidentalis. Their natural enemies are the predatory mite Phytoseiulus persimilis that is commonly used for spider inite control, the predatory mites Neoseiulus cucumeris and Iphiseius degenerans and the predatory bug Orius laevigatus, all natural enemies of thrips. The possible interactions among these 7 species are analysed, and we continue by discussing how indirect functional interactions, particularly the behaviour of arthropods, may change the significance and impact of direct interactions and indirect numerical interactions. It was found that a simple food web of only 4 species already gives rise to some quite complicated combinations of interactions. Spider mites and thrips interact indirectly through resource competition, but thrips larvae are intraguild predators of spider mites. Some of the natural enemies used for control of the two herbivore species are also intraguild predators. Moreover, spider mites produce web that is subsequently used by thrips to hide from their predators. We discuss these and other results obtained so far, and we conclude with a discussion of the potential impact of indirect and direct functional interactions on food webs, and its significance for biological control.

[0864] PREDATORS, PARASITOIDS, PATHOGENS, AND POLYMORPHISM: ECOLOGICAL INTERACTIONS AND EVOLUTION IN AN AGROECOSYSTEM

J. E. Losey, Dept. of Entomology, Coinell University, Ithaca, NY 14853, USA

Natural enemies of pea aphids, Acyrthosiphon pisum, can have very complex relationships with each other and with their prey. In fields of alfalfa, many natural enemy species simultaneously exploit aphid populations and the actions of each natural enemy species can have a significant impact on the susceptibility of aphids to other natural enemy species. Individual aphids within a population can very widely in their susceptibility of aphid color morphs to predation and parasitism. Compared to green morph aphids, red morph aphids suffer higher predation rates by Coccinella septempunctata but lower parasitism rates by Aphiditus ervi. Under certain environmental conditions, these two genetically-determined color morphs can shift to a spectrum of other colors. The implications of the existence of these multiple color forms for aphid population dynamics and their potential to cause damage in forage and vegetable systems will be discussed.

[0865] DYNAMIC TROPHIC CASCADES CAUSED BY GENERALIST PREDATORS - FROM PARALLEL TO COUNTERACTIVE EFFECTS

W. E. Snyder, Dept. of Zoology, Univ. of Wisconsin, Madison, WI 53706, USA, Email: wesnyder@facstaff.wisc.edu.

It is difficult to predict whether generalist predators will be effective biological control agents because these predators feed both on herbivores and on other natural enemies. I will discuss the biocontrol effectiveness of carabid beetles in two crops - eucurbits and alfalfa. Working in gardens of squash, we examined whether intraguild predation weakens the ability of two taxa of generalist predators, carabid beetles (Coleoptera: Carabidae) and lycosid spiders (Araneae: Lycosidae), to control herbivore densities. We also measured fruit production to determine if intraguild prodation disrupts the ability of generalist predators to indirectly impact plants through trophic caseades. Carabids strongly reduced densities of squash bugs (Anasa tristis), the dominant herbivores in the system, and thus increased squash yields. However, lycosids had a markedly different impact, causing squash bug densities to increase, and squash yields to decrease. Lycosids increased squash bug densities by killing nabid bugs, which were important predators of squash bug nymphs. The beneficial impact of carabids was counteracted by the detrimental impact of lycosids, so that squash yields were unchanged in the treatment where both predators were present. In a second research project, conducted in alfalfa, we examined interactions between pea aphids (Acyrthosiphon pisum), a specialist parasitoid wasp (Aphidius ervi) that attacks the aphids, and a common generalist predator, carabid beetles (primarily Pterostichus melanarius). In two field experiments, we manipulated carabid densities to measure their direct (through predation) and indirect (through intraguild predation on A. ervi) impact on aphid population dynamics. We found that carabids preyed heavily on pea aphids immediately after harvest, when plants were very short. However, the direct effect of carabids on aphids quickly disappeared during plant re-growth, apparently because aphids gained a refuge from predation in the foliage. In contrast, the indirect effect of carabids due to intraguild predation on parasitoids was slower to develop, but persisted into re-growth. Carabids reduced parasitoid densities by preying on the immobile parasitoid pupae, which the awkwardly climbing carabids could still capture when plants were taller. Thus, despite initial strong predation on aphids, the net longer-term impact of carabids was to increase pea aphid densities by releasing them from control by parasitoids. Together, these studies demonstrate that carabid beetles can act either as biological control agents or, essentially, as pests, and can switch between these opposing ecological roles within a short time.

Index terms: carabid beetle, lycosid spider, generalist predator, intraguild predation

[0866] COMPLEXITY BEGETS STABILITY REVISITED: THE IMPORTANCE OF VARIATION IN TROPHIC INTERACTIONS TO THE MAINTENANCE OF BIODIVERSITY

M.D. Eubanks¹, Dept. of Entomology and Plant Pathology, Auburn Univ., 301 Funchess Hall, Auburn, AL 36849, USA, E-mail meubanks@acesag.auburn.edu

The idea that complexity promotes community stability was one of the fundamental principles of community ecology in the 1950's and 1960's. In models of communities, increased complexity usually refers to an increased number of species, more interactions or connectance between species, greater average strength of interactions, or some combination of these variables. For example, MacArthur (1955) suggested that the more pathways by which energy passed through a community, the less likely it was that the densities of constituent species would change in response to an abnormally raised or lowered density of one species. Elton (1958) compiled a database of observations to support this hypothesis and was a major proponent of the idea that "complexity begets May (1972) was one of the leading opponents of this idea. May's diversity". mathematical models suggested that increased numbers of species, increased connectance, or increased interaction strength all tended to increase instability, not stability. As a result of this and related work, for two decades the prevailing view among community ecologists tended to be that simple communities were more stable. However, in the past ten or so years, new proponents of the "complexity begets stability" idea have produced detailed analyses of communities and new heuristic and mathematical models suggesting that natural communities are often extremely complex and relatively stable. Most of these models rely on the same measures or concepts of complexity used 50 years ago: number of species, connectance, and mean or total interaction strength. I have develop a relatively simple heuristic and mathematical model suggesting that another related measure of complexity is important in the maintenance of diverse communities. I suggest that variation in the intensity of interaction strength (equivalent to variation in ßji) and not just the average or total interaction strength is an important and largely overlooked component of complexity. I also suggest that variation in interaction strength plays an important role in the maintenance of diverse, complex communities. Variation in interaction strength promotes stability because even in diverse communities with relatively high connectance, the strength of interactions among individual consumers and key resources often approach levels that can not support stable interactions and can ultimately lead to the local extinction of one or more species if not relieved. I argue that intrinsic temporal variation in the interaction strengths among members of a community allow species to coexist under these circumstances. Stability, therefore, is often enhanced in natural communities by this variation, without evoking changes in diversity, connectance, or the average or overall strength of interactions.

[0867] AFRICAN ARMYWORM OUTBREAKS FROM MOZAMBIQUE TO JORDAN

C. Dewhurst

ABSTRATC NOT RECEIVED

[0868] THE MALAGASY MIGRATORY LOCUST IN MADAGASCAR

A. Monard

ABSTRACT NOT RECEIVED

ABSTRACT BOOK I - XXI-International Congress of Entomology, Brazil, August 20-26, 2000

[0869] THE BROWN LOCUST IN SOUTH AFRICA, NAMIBIA, AND BOTSWANA

R. Price

ABSTRACT NOT RECEIVED

[0871] THE MIGRATORY LOCUST IN CHINA <u>W.C. Foozhou</u> ABSTRACT NOT RECEIVED

[0870] THE DESERT LOCUST FROM PAKISTAN TO MAURITANIA

<u>S. Krall</u>

ABSTRACT NOT RECEIVED

[0872] THE MIGRATORY LOCUST IN AFRICA <u>A. Schroeder</u> ABSTRACT NOT RECEIVED

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[0873] THE MIGRATORY LOCUST OF SOUTH AMERICA

ABSTRACT AND AUTHOR NOT RECEIVED

[0875] CHARACTERIZATION OF THE POPULATIONS OF FRUIT FLIES (DIPTERA: TEPHRITIDAE) COLLECTED IN SEROPEDICA CITY (RJ), BRAZIL BY THE FAUNISTIC ANALYSIS

E. L. Aguiar-Menezes¹ & E. B. Menezes², ¹Embrapa Agrobiologia, Caixa Postal 74505, Seropedica, FL 23890-000, Brazil, E-mail menezes@cnpab.com.br, ²CIMP "CRG" /UFRRJ, BR 465 - km 7, Seropedica, RJ 23890-000, Brazil, E-mail ebmen@zaz.com.br.

Fruit crops are one of the major agricultural activities in the state of Rio de Janeiro. In Seropedica city, several fruit species are commercially cultivated, and are frequently subjected to attack of tephritid fruit flies. In order to characterize the population of these insects, we surveyed species of tephritids by collections of infested fruits in the campus of UFRRJ and surroundings from January 1998 to December 1999. The samples of fruits infested by tephritid larvae were taken to the laboratory of CIMP "CRG"/UFRRJ where they were placed into cages for holding until the flies emerged. A total of 2,578 tephritid fruit flies were recovered. The faunistic indexes of frequency, constancy, abundance and dominance were used to characterize the populations of the fruit flies that belong to the fauna of the Seropedica. Five species were identified: Anastrepha obliqua, A. fraterculus, A. sororcula, A. distincta and Ceratitis capitata. They occurred with the frequency of 43.47%, 16.75%, 10.48%, 7.34%, and 21.95%, respectively. They were presented in all collections, with the exception of A. distincta, which was characterized as accessory species. A. obliqua was the most abundant species. A. fraterculus and C. capitata were common in the region, and A. distincta and A. sororcula were characterized as dispersible. All species were not dominant in the region. We also observed that the faunistic indexes varied according to the fruit host. A. fraterculus and A. sororcula were predominate on guava and Surinam cherry. C. capitata, on coffee and orange, A. obliqua on mango, and A. distincta on inga, were the predominant species.

Index terms: Tephritidae, Anastrepha spp., Ceratitis capitata, faunistic analysis.

[0874] ITALIAN LOCUST AND OTHER SPECIES OS THE EAST EUROPEAN STEPPE

A. Latchininsky

ABSTRACT NOT RECEIVED

[0876] PHANUROPSIS SEMIFLAVIVENTRIS (HYMENOPTERA, SCELIONIDAE), AN EGG PARASITOID OF THE STINK BUG ANTITHEUCUS SEPULCRALIS (HETEROPTERA, PENTATOMIDAE) IN SEROPEDICA CITY (RJ), BRAZIL

E. L. Aguiar-Menezes¹ & E. B. Menezes², ¹Embrapa Agrobiologia, Caixa Postal 74505, Seropedica, RJ 23890-000, Brazil, E-mail menezes@cnpab.embrapa.br; ²CIMP "CRG" / UFRRJ, BR 645 - km 7, Seropedica, RJ 23890-000, Brazil, E-mail ebmen@zaz.com.br.

In the complex of insects that are associated with *Clitoria fairchildiana*, a native shade tree commonly used on the roads, parks and parking lots in the state of Rio de Janeiro, we found the following tritrophic relationship: the stink bug *Antitheucus sepulcralis* feeds on leaves of *C. fairchildiana*, and its egg clusters were usually found parasitized by *Phanuropsis semiflaviventris*. This scelionid is a gregarious endoparasitoid, suggesting a closed relationship with its host. In order to evaluate the impact of this parasitized on the population of *A. sepulcralis*, we collected 5,817 eggs (clusters ranged of 17 to 31 eggs) from March 1998 to February 1999. They were taken to the laboratory of the CIMP "CRG"/UFRRJ where the leaves with the egg clusters were placed into the Petri dishes containing a moistened filter paper for holding until the emergence of the bugs and/or parasitoids. The parasitism percentage was defined as the number of emerged parasitoids divided by the sum of emerged parasitoids and bugs. The overall parasitism percentage was 51.7%, ranging from 3.57% to 100%. During the period of a year, we observed that the parasitism percentage for 86.1% in the fall (March to May/98) to a high of 75.4% in the summer (December/98 to February/99).

Index terms: Phanuropsis semiflaviventris, Anitheucus sepulcralis, Clitoria fairchildiana, parasitism, biological control.

[0877] DECAY OF LEAF LITTER BY AQUATIC INSECTS IN ANDEAN LOW ORDER STREAMS

R. J. Albariño & E. G. Balseiro, Lab. Limnología, Centro Regional Universitario Bariloche, Universidad Nacional del Comahue. Unidad Postal Universidad, 8400 Bariloche, Argentina. E-mail: ralbarin@crub.uncoma.edu.ar

In this study we stressed the importance of aquatic insects on the decay of leaf litter that enter Andean low order canopied streams. Two experiments were conducted in streams running across a forest of Nothofagus pumilio locally called "lenga". Experiment 1 was run in a second order stream during a fall-winter period (118 days). The two treatments consisted of bags with leaf litter of the native deciduous N. pumilio or with the exotic evergreen Pinus ponderosa (of regional forestry importance). Experiment 2 was run in a first order stream during a spring-summer period (135 days). The two treatments consisted of bags with different mesh size, in order to offer open bags for natural insect colonization and closed ones to avoid large insects. Aquatic insects accounted for a 89% of the benthic community. They were represented by five orders: Ephemeroptera, Plecoptera, Diptera, Trichoptera and Coleoptera) with different mean densitics (2.3, 16 0, 65.0, 3.5, 0.9 % respectively). Signs of shredding activity were registered in N. pumilio but were not observed in P. ponderosa. Feeding activities of Plecoptera (Austroperlidae, Gripopterygidae, Notonemouridae), Diptera (Tipulidae) and Trichoptera (Limnephilidae, Sericostomatidae) that gradually colonised litter bags, were responsible of the mass losses Series of N, pumilio leaves. In Experiment 1, N, pumilio decayed two fold faster than P, ponderosa (P<0.05). In Experiment 2, the leaf litter exposed to the whole size spectrum of insects decayed faster than those where large insects were avoided (P<0.05). Large shredders accounted for a 51% of leaf mass loss. Sluedders were more abundant in number and biomass when leaf mass loss was 50% of initial mass; while collectors increased towards the end in both experiments. Ecological aspects of benthic insect community-leaf litter interactions for Andean low order streams will be discussed. Index terms: Benthic detritivores, forested streams, lotic ecology,

[0878] THE LEPIDOPTERA OF THE GALAPAGOS ISLANDS, PATFERN OF DISTRIBUTION AND ECOLOGY

L. Roque Albelo¹, ¹ Invertebrate Program, Charles Darwin Research Station, A. P. 17-01-3891, Quito, Ecuador, lazaro@fcdarwin.org.ec

The Lepidoptera fauna of the Galapagos Islands is analyzed and the number of families, genera and species is summarized. Compared with the Nectropical fauna, the Galapagos fauna is disharmonic. All Galapagos Lepidoptera are of American origin except some species that are nearly cosmopolitan. The number of families, genera and species reported are, 18, 143, 195 respectively. Based on field and museum work it is estimated that there are at least 171 genera and 298 species present in the Archipelago. One genus and 61 species are endemic to the islands. At less 46 species have been accidentally introduced by humans in the last two centuries. The influence of humans on the fauna is analyzed. Endemicity, colonization, distribution patterns and species awarns are discussed. Index terms: Biogeography, dispersal, endemicity, hostplants, introduced species.

[0879] DENSITY DEPENDENT DISPERSAL OF A TEPHRITID FLY

B. R. Albrectsen, Department of Animal Ecology, Swedish Univ. Agri. Sci.; S - 901 38 Umeå, Sweden e-mail: benedicte.albrectsen@szooek.slu.se

Regulation is thought to occur in all biological systems. Few studies have, however, quantified the strength of regulation. Regulation should by definition be density dependent. Dispersal is one such process that in many models is suggested a source of regulation. The aim of this study was to quantify the density dependent element of dispersal in the specialist tephritid (ly *Paroxyna plantaginis*, which is the main seed predator on *Tripolium vulgare* (Asteraceae). Marked flies were released in artificial host plant patches at three different fly densities. I noted the disappearance characteristics as well as movement between patches and invasion of unmarked flies. The disappearance pattern indicated that the dispersal of these Tephritids *is* density dependent. Moreover it seemed to be sex biased, hence females may react more strongly to the local fly density compared to males.

Index terms: Paroxyna plantaginis; Tripolium vulgare; sex-biased dispersal

[0880] SPACE-SEASONAL DISTRIBUTION OF CERATITIS CAPITATA (DIPTERA: TEPHRITIDAE) IN A MASS TRAPPING EXPERIENCE IN A CITRUS ORCHARD IN MALLORCA (SPAIN)

<u>A. Alemany¹</u>, M.A. Miranda¹, R. Alonso¹ & C. Martín Escorza², ¹Univ. of Balearic Islands. Cra. Valldemossa km 7,5, CP: 07017, Palma de Mallorca, Spain, E- mail: analem@uib.es; ² Natural History Museum, CSIC, J. Gutiérrez Abascal 2, CP:28006, Madrid.

Mass trapping of *Ceratitis cupitata* females has been curried out in an isolated plot of orange trees in Mallorca. 125 traps baited with synthetic food attractants (putrescine, ammonium acetate and trimethylamine), and 10 traps baited with Trimedlure for male monitoring, were used. The experience was begun with the first emergence of adults at the beginning of summer and ended with the disappearance of the Mediterranean fruit fly population, which occurred with the arrival of the first cold spells in November. The values of the fortnightly catches estimated by kriging are represented in several three dimensional diagrams, showing the pest evolution. This begins to establish itself on the orchard periphery and to spread progressively inwards until it invades completely, at the time of greatest medfly population density. The influence of bietic and abiotic factors in the *C. capitata* population dynamics is discussed, as well as the presence of two very localised maximum spots, situated at two opposite extremes of the crop, to the west and east, respectively.

Index terms: Ceratitis capitata, insects population, kriging, mass trapping.

[0881] EFFECTS OF DIFFERENT DATES OF SOWING ON COMMON BEAN CULTIVATED ON TILLED AND NON-TILLED SOIL MANAGEMENT SYSTEMS ON THE SEASONAL OCCURRENCY OF PESTS IN PONTA GROSSA-PR

<u>B. Allconi</u>¹ & J. C. Havryluk², ¹Dept. of Agronomy, Ponta Grossa State Univ., Praça Santos Andrade s/n^o, Ponta Grossa, PR, 84.010-790, BR, E-mail balleoni@yahoo.com.² R. Paranaguá, 85, Ponta Grossa, PR, 84050-190, BR.

The trial was carried out in the school farm "Capão da Onça" of Ponta Grossa State University, Ponta Grossa-PR, on common bean (Phaseolus vulgaris), cultivar carioca, sowed on three dates in the season 96/97 (25/11/96; 16/12/96 and 25/01/97) and four dates in the season 97/98 (14/11/97; 21/12/97; 13/01/98 and 24/02/98), on two soil management systems (non-tilled and tilled). The fluctuation of the insects was evaluated with sweep net, each 7 days after the seeds germination. The experimental design was randomized blocs in the factorial system 2 x 3 or 2 x 4, with four replicates, being two soil management systems and three or four dates of sowing. The size of experimental units was 90 m², having each one 18 rows and 0,5 m between rows. The pests Diabrotica speciosa, Maecolaspis jolivetti and Empoasca kraemeri were more frequent in all dates of sowing in both of the soil management systems. The mean and the minimum temperatures correlated with the D. speciosa fluctuation in the season 96/97 and the mean and the maximum temperatures and relative humidity correlated with the pest fluctuation in the season 97/98. The populational fluctuation of M. jolivetti correlated with the maximum, mean and minimum temperatures and pluviometric precipitation in the season 96/97 and with relative humidity in the season 97/98. The dates of sowing influenced in the populational fluctuation of M. jolivetti and E. kraemeri in the season 96/97 and in the three species fluctuation in the season 97/98. The soil management systems and the dates of sowing influenced in the productivity of the common bean in the season 96/97 and the dates of sowing, in the productivity of the season 97/98. The productivities of the common bean were greater in the both, non-tilled and tilled systems in the senson 96/97, compared with that of season 97/98.

Index terms: Phaseolus vulgaris, Diabrotica speciosa, Maecolaspis jolivetti, Empoasca kraemeri, dates of sowing.

[0883] OVIPOSITION OF *HOMALODISCA* SPP. (IIEMIPTERA: CICADELLIDAE: CICADELLINAE) AND ASSOCIATED EGG PARASITISM ON CITRUS: SPATIAL DISTRIBUTION

<u>A. K. Al-Wahnibi</u>^{1,2} & J. G. Morse¹, ¹Dept. of Entomology, Univ. of California, Riverside, CA 92521, U.S.A., e-mail: aliwah99@hotmail.com; ²College of Agriculture, Sultan Qaboos Univ., Sultanate of Oman.

Several Homalodisca species (sharpshooters) in the U.S. have been implicated in the vectoring of strains of Xylella fastidiosa, to a number of important woody crops and ornamentals causing destructive diseases in grapevine (Pierce's disease), almond (almond leaf scorch), peach (phony peach), and cleander (cleander scorch). They could also be involved in the transmission of citrus variegated chlorosis (CVC), a devastating disease in Brazil, should the X. fastidiosa strain causing this disease be introduced into the U.S. In southern California, citrus serves as a major host plant for H. coagulata and H. lacerta, acting as both a feeding and an ovipositional host. In this study, we examined the spatial distribution of Homalodisca eggs and associated egg parasitism on citrus in terms of differences in vertical position (height), sun exposure (tree quadrant), and depth within the tree (shoot section). Ten lemon (Lisbon) trees were sampled by collecting 30 cm shoots from 3 heights (0.5, 1.5, and 2.5 m) and 4 quadrants (east, north, south, west). The shoots were processed in the lab by dividing each shoot into 3 sections of equal length and then separating old egg masses from new egg masses. New egg masses were incubated for emergence of egg parasitoids. No significant differences were observed between the 4 tree quadrants for all of the above variables. However, the highest positions on the tree (at 1.5 and 2.5 m) had lower egg densities than the low position of 0.5 m. Shoot sections were different statistically in egg density variables when new and old egg masses were considered separately. Higher egg density was recorded for the outer shoot section (0-10 cm) than for the inner shoot sections (10-20 and 20-30 cm) when only new egg masses were analyzed. However, the reverse was observed when old egg masses were considered. Egg parasitism rate (proportion of parasitized eggs) was not significant at p=0.05 for all of the main effects tested. We collected two species of mymarid parasitoids from the eggs of Homalodisca: Gonatocerus ashmeadi (93% of emerged parasitoids), and G. morrilli (7% of emerged parasitoids). When old and new egg masses were compared, egg density variables were not different, however egg parasitism rates were significantly higher in new egg masses than in old egg masses. Overall, the proportion of dead unemerged parasitoids was surprisingly high at 43% of all parasitoids in old egg masses. These results are discussed in terms of the behavior and biology of Homalodisca species and their egg parasitoids.

Index terms: Xylella fastidiosa, biological control, Mymaridae, Gonatocerus ashmeadi, Gonatocerus morrilli.

[0882] BIOCOENOTICS OF WILD BEES (HYMENOPTERA, APOIDEA) OF RESTRICTED AREAS OF "CERRADO" IN JAGUARIAÍVA, PARANÁ (SOUTHERN BRAZIL)

M. C. de Almeida & S. Laroca, Depto. de Zoologia, Univ. Federal de Paraná, Caixa Postal 19020, 81531-990 Curitiba, PR, Brazil, E-mail slaroca@netpar.com.br

Qualitative and numerical analysis of the biocoenosis of wild bees (Apoidea) of restricted areas of cerrado (the Brazilian savanna) in Jaguariaíva, PR, Brazil are performed. The areas of study (one of which already deeply modified) represent relicts of cerrado:1. In the Parque Estadual do Cerrado [marginated by the Jaguariaíva and Santo Antônio rivers, with altitudes of ca. of 850 m, 8 km to the north of the Jaguariaíva city], 2. In the place called Desvio [3 km to the east of Jaguariaíva city, in the margin of the highway Jaguariaíva-Sengés, in the exit for Sengés, today Industrial District], 3. In Fazenda Cachoeira [about 12 Km to west of Jaguariaíva, in the Diamante river margin]. The total area of each of the above sites is of about 100.000 m². Those area were chosen considering the following criteria: the similarity in relation to the biotopes of cerrado, the access easiness, as well as the level of human interference. The sampling methodology is that developed by Sakagami & Laroca (cf. SAKAGAMI, LAROCA & MOURE, 1967: J. Fac. Sci., Hokkaido Univ., Ser. Zool. 16: 253-291) and Laroca (LAROCA, 1972: MSc. thesis, UFPR, Curitiba, 61 pp; 1983, PhD thesis, KU, U.S.A, 194 pp.), which consists of capture of all the Apoidea in activities in the flowers, or in flight, without choice. Each specimen received labels with the following informations: place, hour and visited plant. Specimens of the following families were collected (number of genera and species): Colletidae (5, 13); Andrenidae (5, 11); Halictidae (17, 50); Megachilidae (8, 11); Anthophoridae (33, 84) and Apidae (15, 21). The bee specimens were collected on 120 species of plants belonging to 32 families. Given a presumably neighborhood among the vegetation of cerrado and the one of the Atlantic Forest (continental and insular biotopes) the data are focused comparatively. Aspects as relative abundance, diversity (Preston truncate log-normal distribution), phenology and flower preferences are analyzed, by means of soft-wares developed by the authors for that purpose. Special attention is given for parameters that enable inferences on the degree of *environmental health* (or level of the community) systemic disorder) attributed to the anthropic action).

Index terms: neotropical, community, melissocoenotics, bee-assemblage, Braziliansavanna.

[0884] AN ANALYSIS OF THERSHOLD TEMPERATURES FOR THE DEVELOPMENT OF CEREAL APHIDS, SCHIZAPHIS GRAMIMUM IN MIDDLE EGYPT

<u>A. A. H. Amin</u>, Plant Protection Res. Institute, ARC 7, Nadi El-Sayied Street, Dokki, Giza 12311, Egypt, E-mail: aahakaa@yahoo.com

Field studies conducted during three wheat growing season of (1997-1999) in Banie Swief Governorate, Middle Egypt to detect field population of Cereal Aphids, *Schizaphis* graminum, Field generation numbers, thermal heat units required and life table parameters were estimated. The Cereal Aphids, *Schizaphis graminum* was found to have 6 generations during wheat growing season that extended from December to April. Generations occurred at an average of 94.45 ± 1.272 The lower threshold was 8.88 °C. The intrinsic rate of increase was varied according to each generation and season.

[0885] LIFE HISTORY AND LIFE TABLES OF CITRUS LEAF MINERPHYLLOCNISTIS CITRELLA (LEPIDOPTERA: GRACILLARIIDAE)

<u>A.H.Amin</u>¹, G.B.El-Snadany⁴ & A.D.Shamson², 1 Dept. Plant Protec.; Fac. Agric. Ain Shams Univ., Egypt. 2 Dept. Plant Protec.; Fac. Agric. Sanaá Univ., Yemen.

Life history and life table of citrus leaf miner Phyllocnistis citrella was studied at four constant temperatures as well as under greenhouse conditions. The average of incubation period for egg stage was 7.9±0.22 days at 15°C while it was 3±0.0 days at 30°C and under greenhouse; the larval stage lasted for 28.6±0.6 days at 15°C while it was 4±0.0 days at 30°C and under greenhouse conditions; prepupal stage spent 4.50±0.17 days at 15°C while it was 1 ± 0.0 day at 30°C and under greenhouse; pupal stage was 34 ± 0.26 days at 15°C while while it was 5.2 ± 0.13 days at 30°C and 7.3 ± 0.5 days under greenhouse. Adult female longevity was the shortest at 30°C and the longest at 15°C, it lasted 52.1±0.72 days at 15°C while it was 8.6±0.26 days at 30°C and 11.8±1.5 days under greenhouse. Threshold (zero) of development and thermal units required (DD) for different developmental stages were estimated. Life table parameters under three degrees of constant temperature; i.e. 20, 25 and 30°C as well as under greenhouse conditions showed that net reproduction rates were 33.28, 32.23, 16.61 and 41.0 individuals/female/generation. Generation time (Gt) lasted for 42.7, 18.33, 18.0 and 20.1 days under the four tested temperatures, respectively. Intrinsic rates of increase (rm) were 0.388, 0.764, 0.518 and 0.499 individual/day. Fecundity (mx) was 34.2±1.2, 23.8±1.8, 19.3±1.9 and 45.1±5.6 eggs/female under the three tested temperatures and greenhouse conditions, respectively. These results indicate that 25-30°Cseem to be the most favorable weather conditions needed for citrus leaf miner reproduction. Population doubling time (Dt) showed that the population had the capacity to double every 2.230, 1.138, 1.670 and 1.740 days under the above mentioned conditions, respectively. Index terms: Phyllocnistis citrella, life table, life history, threshold of development, thermal units

[0886] IMPROVEMENT OF HONEY-BEE POLLINATION IN ACTINIDIA DELICIOSA

<u>E. Antognozzi¹, T. Gardi¹, S. Moscatello², A. Battistelli² & F. Famiani¹, ¹Dip. Arboricoltura e Protezione delle Piante, Università di Perugia, via Borgo XX Giugno, 06121 Perugia, Italy, E-mail antognoz@unipg.it, ²Istituto per l'Agroselvicoltura, CNR, Viale Marconi 2, 05010 Porano (PG), Italy.</u>

In Actinidia, honey-bees are primarily responsible for pollination. In Italy, in some areas, there are pollination problems due to the simultaneous flowering of other crops which are more attractive to honey-bees. Therefore, in 1998 and 1999 trials were carried out to evaluate the effects on fruit growth and quality of different treatments designed to: 1) measure the relative contribution of wind and insect pollination, 2) increase the attractiveness of honey-bees towards flowers, 3) improve pollination by artificial application of pollen, 4) overcome the negative consequences of inadequate pollination by using growth regulators. Before flowering some fruiting shoots were bagged with nets that only allowed for wind pollination. Moreover, some bee hives were fed with actinidia male pollen (induction feeding) to increase the attractiveness of the flowers. During flowering, pollen collected from flowers of male vines was used for artificial pollination of just-opened flowers by applying it with a "tennis ball" or, after suspension in water, with a hand sprayer. Untreated flowers were used as control. To better evaluate the effect of artificial pollination, immediately after pollen application part of the flowers were bagged with nets to prevent visits by insects. Fifteen days after full bloom, half of the fruits were treated (by dipping) with a solution of thidiazuron (20 ppm). Preventing insect pollination caused a marked fruit drop (= 30%), reduced fruit growth (- 50%), a rounder shape and a reduced number of seeds. Induction feeding of bees resulted in an increase in actinidia pollen gathered by the bees. Both the artificial pollination systems tested resulted in a tendency for greater fruit growth with respect to the control, regardless of the bagging of flowers with nets after the pollen application, whereas, a significant decrease in fruit growth was observed in the control when flowers were bagged with nets. Artificially pollinated flowers also gave fruits which had a higher length to diameter ratio and number of seeds. Moreover, they tended to have a higher soluble solids content and a lower flesh firmness at harvest. Thidiazuron treatment caused a significant increase in growth of all the treated fruits. However, care must be given in the use of such compound as it also tend to reduce the fruit length to diameter ratio. In conclusion, the results show good possibilities for reducing or eliminating pollination problems by introducing induction feeding of bce-hives and/or by applying artificial pollination and growth regulators.

[0887] DETERMINATION OF SPATIAL DISTRIBUTION PATTERN OF EGG AND LARVAL INSTARS OF ELM-LEAF BEETLE XANTHOGALEAROCELLA LUTEOLA (COL.; CHRYSOMELLIDAE)

A. Arbab, J. Jalali & A. Sahragard, Dept. of Plant Protection, College of Agriculture, Univ. of Guilan. IRAN, 41335-3179

Elm leaf beetle is one of the most injurious insects attacking elm trees, *Ulmus spp.*, in Iran. For studding the type of spatial distribution pattern of egg and larval instars, two methods, Taylor's power law and Iwa's regression, were used. The effect of host and geographical directions in changing of crowding indexes of egg and larval instars, were studied. The results indicate that spatial distribution of these stages are aggregative and Iwao's index (B) is affected more than Taylor's index (b) by host, stage of life and place. The knowledge on the spatial distribution patterns of this insect, can be provide essential information for planning a sequential sampling.

Key word: Xanthogalearocella luteola; Spatial distribution; Ulmus spp

[0888] SOME BIOLOGICAL AND ECOLOGICAL ASPECTS OF PSEUDODOROS CLAVATUS (DIPTERA:SYRPHIDAE)

E. Arcaya¹ & <u>F. A. Díaz¹, ¹</u>Univ. Centroccidental Lisandro Alvarado, Decanato de Agronomía, Depto. de Ciencias Biológicas, Tarabana 3023, Lara, Venezuela. Email:dbfrancis@hotmail.com.

Pseudodoros clavatus is the most important aphidophagous syrphid in cultivated plants in Venezuela. Besides, it can be found in some weeds and wild plants where aphids develop. Using Toxoptera citricida as larval food the life cycle of P. clavatus was: egg, 2 days; larvae, 9-10 days: pupae, 6-7 days. The larvae is able to devour 365 aphids during its developmental stage. The adults were kept in a 50 cm high x 30 cm width x 30 cm deep wooden cage with a sliding glass front door and a metallic mesh back cover and fed on polen of Tridax procumbens (Asteraceae) which was supplied placing entire flowers into a 8 dram glas vial containing water and replacing both them twice a week. P. clavatus larvae are able to feed in a variety of aphids including: T. citricida and T. aurantii in Citrus aurantifolia, Rhopalosiphum maydis in Zea mays, Myzus persicae in Sesamun indicum (Pedaliaceae) and Aphis neril in Nerium oleander (Apocynaceae), and in Calotropis procera and Sarcostemma glaucum (Asclepiadaceae). Other host plants which allow the development of aphids colonies that support P. clavatus larvae, are: Capsicum fratescens and Solanun nigrum (Solanaceae), Bidens pilosa (Asteraceae) and Polyscias guilfoylei (Araliaceae). The main natural enemies found in this study include the idiobiont pupal parasitoid Pachyneuron syrphiphagum (Hymenoptera:Pteromalidae).

Index terms: Aphidophagous, Toxoptera citricida, Tridax procumbens

[0889] INFLUENCE OF AGE OF BEAN PLANTS ON THE FECUNDITY AND LEAF CONSUMPTION OF *DIABROTICA SPECIOSA* (COLEOPTERA: CHRYSOMELIDAE)

C. J. Ávila¹ & J. R. P. Parra², ¹Embrapa-Agropecuária Oeste, Caixa Postal 661, 79.804-970- Dourados, MS, E-mail: crebio@cpao.embrapa.br; ²Depto. de Entomologia, Fitopatologia e Zoologia Agrícola-ESALQ/USP, Caixa. Postal 9, 13.418-900-Piracicaba,SP, E-mail: jrpparra@carpa.ciagri.usp.br

The physiological age of a host plant can affect the behavior, survival and reproduction rate of the insects that feed upon it. Studies of that sort can generate results of practical importance to entomological research, as well as to provide data which would help the understanding of the populational dynamics of insects under field conditions. Diabrotica speciosa (Coleoptera: Chrysomelidae) is an important bean plant pest in South America. The adult feeds on the top part of several plant species while the larvae, which live underground, damage the roots and tubers. The aim of this work was to determine the fecundity and leaf consumption by D. speciosa adults when fed on bean leaflets of different physiological ages. The research was conducted at the Insect Biology Laboratory of the Escola Superior de Agricultura "Luiz de Queiroz" (ESALQ), at 25 ± 2°C, 60 ± 10% RH and 14-hour photophase. The number of eggs/female and leaf consumption by D. speciosa under free choice and no choice tests were determined by offering bean leaflets collected from the upper third part of the plants to the adults. The egg-laying capacity and leaf consumption by the adult insects was influenced by the physiological age of the bean plant. The leaflets of younger plants were preferred by the insect for consumption, which also provided a higher fecundity in relationship to the leaflets from older plants. The chemical and/or physical changes that are likely to occur in the bean plant leaf along the development of the plant's phenology, as well as the bioecological implications related to the populational dynamics of the insect in the field are discussed in this paper. Index terms: Corn rootworn, bean, plant age, and preference.

[0891] HERBIVORES ASSOCIATED WITH THE REPRODUCTIVE PARTS OF OURATEA HEXASPERMA IN CENTRAL BRAZIL

B. Baker¹ & <u>H. C. Morais²</u>, ¹Master's Program in Ecology, Univ. of Brasília, Brasília, DF 70910-900, Brazil, E-mail bbaker@unb.br; ²Dept. of Ecology, Univ. of Brasília, Brasília, DF 70910-900, Brazil.

Ouratea hexasperma is a common shrub in the central area of the Brazilian cerrado that flowers and fruits mainly during the dry season. The insects associated with its reproductive parts were studied during the reproductive seasons of 1998 and 1999. In both years we collected inflorescences in Brasília National Park, Fazenda Água Limpa and the reserve of the Instituto Brasileiro de Geografia e Estatística to raise adults. We found at least 17 species of insect herbivores. There were three morphospecies of membracids and one coccoid (Homoptera) attached to most inflorescence stems, and a Scolytidae and another Coleoptera perforating the basal part of some stems. There were two species of Anthonomus (Curculionidae) and a Diptera associated with the buds, and a gall-forming hymenopteran in the ovaries. We also found two thrips morphospecies associated with buds and fruits, and raised one species of Cydia (Tortricidae) and one gelechiid from flowers and one of each from fruits. We raised a species of the genus Compsolechia (Gelechiidae) from both flowers and fruits, and another curculionid from the fruits. Between August and October of 1999 we collected around 30 inflorescences every three weeks in the Brasilia National Park and opened flower buds, flowers and fruits to verify for the presence of immature insects or any indication of previous infestation, such as holes or eaten material. One of the Anthonomus species attacked around 34% and 16% of the buds encountered on the two first dates, while there were galls in 15% and 44% of the buds, respectively. The thrips occupied buds in half of the inflorescences, as did caterpillars. Initially there was a very low number of buds without evidence of predation (25 and 15%), but right after flowering the number of unaffected structures was more than 36%. We observed a great loss of buds, which, combined with predation during fruit maturation, resulted in very low levels of fruit production. Ants were frequently observed visiting inflorescences, and their possible role in the reproductive fitness of *O. hexasperma* deserves further investigation. We also raised many hymenopteran species that are parasitoids of the herbivores encountered and may have an influence on the fitness of the plant.

Index terms: Anthonomus, Lepidoptera, cerrado, galls, Ochnaceae

[0890] INFLUENCE OF THE HOST PLANT ON THE LEAF CONSUMPTION BY ADULTS OF *DIABROTICA SPECIOSA* (COLEOPTERA: CHRYSOMELIDAE)

C. J. Ávila¹ & J. R. P. Parra², ¹Embrapa-Agropecuária Oeste, Caixa Postal 661, 79.804-970-Dourados, MS, E-mail: crebio@cpao.embrapa.br; ²Depto. de Entomologia, Fitopatologia e Zoologia Agrícola-ESALQ/USP, Caixa. Postal 9, 13.418-900- Piracicaba, SP

Diabrotica speciosa (Germar, 1824) (Coleoptera) is a multivoltine insect occurring in several countries in South America. The adult feeds on the top part of several plant species while the larvae damage the roots and tubers in a smaller number of hosts. Studies aimed at the determination of the influence of the host on the feeding behavior of D. speciosa can yield results that will help the understanding of factors which determine the populational dynamics of the pest in the field, providing condition for the improvement and development of strategies aimed at its control. The aim of this work was to determine the leaf consumption of D. speciosa adults in four hosts (bean, corn, soybean and potato) under free choice and no choice tests. The research was conducted at the Insect Biology Laboratory of the Department of Entomology, Plant Pathology and Agricultural Zoology of the Escola Superior de Agricultura "Luiz de Queiroz" (ESALQ), at Piracicaba, São Paulo, state Brazil. Under multiple-choice conditions, the leaf consumption was higher in bean than in soybean, potato and corn. At the double-choice test, in which the preference degree for potato, soybean and corn were evaluated in relation to the standard plant (bean), the leaf consumption was also higher in bean than in the other tested hosts. Under the no choice test, however, the insect had a higher leaf consumption in corn and lower in potato. The bioecological implications related to the feeding standard of D. speciosa adults in the studied hosts are discussed in this paper.

Index terms: Corn rootworm, host plant, and preference

[0892] RAINFALL AND RECENT OUTBREAKS OF THE AFRICAN MIGRATORY LOCUST IN THE LAKE CHAD BASIN

G. Balança, P.-E. Gay, T. Rachadi & <u>M. Lecoa</u>, CIRAD, Centre de coopération internationale en recherche agronomique pour le développement, B.P. 5035, 34032 Montpellier Cedex 1, France, E-mail: michel.lecoq@cirad.fr

Heavy outbreaks of migratory locusts, *Locusta migratoria migratorioides*, were observed in southwestern Chad and northern Cameroon from September to November 1997. For many years, similar outbreaks were a recurrent phenomenon in this region, with the last one occurring in 1989. An analysis of rainfall distribution from 1986 to 1997, was undertaken according to the ecological requirements of this locust. To assess the possibilities of good breeding and gregarisation, the monthly position of the areas receiving an optimal rainfall for this species (50 to 100 mm/month) was studied. The following parameters, assumed to be key factors, were considered: northern limit of the optimal area in May and June, northern limit of the area with excessive rainfall (>100 mm/month) in June, maximal northern limit of the optimal area during the rainy season, maximal northern limit of the area where the rainfall is excessive, duration of optimal pluviometric conditions around Lake Chad during the rainy season. This study showed that the outbreaks were strongly linked to the extent and distribution of rainfall during the 1986-1989 and the 1996-1997 periods. A simple index, calculated on the basis of rainfall data, was correlated with outbreak years. It appeared that two successive years of suitable conditions are necessary to induce an outbreak.

Index terms : Orthoptera, Acrididae, Locusta migratoria, Chad, Cameroun

[0893] DISTURBANCE EFFECTS ON INSECT COMMUNITIES ALONG A SUCCESSIONAL GRADIENT

M.F Barberena and T.M. Aide, Univ. of Puerto Rico, Dept. of Biology, PO Box 23360, San Juan, PR 00931-3360. E-mail: is970678@rrpac.upr.clu.edu.

Disturbances (anthropogenic or natural) differently affect the structure of ecosystems, depending on their frequency, intensity and area affected. Most studies have focused on the effect of either natural or anthropogenic disturbances, with an emphasis on vegetation, but few studies have examined the recovery of animal populations. The Caribbean island of Puerto Rico has been strongly modified by human activities and is affected by a severe hurricane approximately every 21 yr. In this study, we addressed the following questions: How do insect communities change along a successional gradient? Do hurricanes affect insect communities in a similar way, regardless of the successional stage of the site? To answer these questions, we located three sites in the Luquillo Experimental Forest, in Puerto Rico. The sites were pastures that have been abandoned for 4-5 yr, 30-32 yr, and >60 yr. In addition, these sites were recently disturbed by the passage of Hurricane Hugo (1989) and Hurricane Georges (1998). Each site was censused five times between June 1998 and October 1999. In each census we used four trapping methods: pitfall baited with human feces, malaise, interception and litter samples. The insects collected were sorted to family and morphospecies, and assigned to a guild according to it's morphology and natural history. The interception trap collected the highest number of morphospecies, and the pitfall trap the fewest. The total species richness in the sites varied from 195 in the 4-5 yr site, 136 in the 30-32 yr site and 131 in the >60 yr site. The high richness in the younger site was mainly due to a dominance of dipteran and homopteran species. Guilds that were present before Hurricane Georges, continue to be present after the hurricane, but the species composition has changed. In the census before Hurricane Georges, the 30-32 yr site had the highest richness, but after the hurricane the richness decreased by 50% in the 30-32 yr site, the richness in the 4-5 yr site increased 4-fold, and changed little in the >60 yr site. Before Hurricane Georges, the species composition of the 30-32 yr site and >60 yr site were similar, but after the hurricane the composition changed resulting in a greater similarity between the youngest and oldest sites. The similarity between these two sites was due to an increase in the dipteran fauna may be due to an increase in decomposing animal and plant material, and a change in structural complexity following the hurricane. Index terms: anthropogenic and natural disturbances, insect diversity, trophic guilds

[0895] RESEARCH REGARDING POPULATIONS DYNAMICS AND MARKING EUROPEAN CORN BORER (*OSTRINIA NUBILALIS*)

<u>A. Barbulescu¹ & L Rosca², ¹ Research Inst.</u> for Cereals and Industrial Crops, 8264 Fundulea, N. Titulescu Str., 1, Calarasi District, Romania, E-mail: fundulea@cons.incerc.ro; ² Univ. Agricultural Sciences and Veterinary Medicine, Av. Marasti 59, Bucharest, Romania.

There are few things known about field movement of Ostrinia nubilalis. In order to develop an insect release technique, a special attention was paid to the investigations on the European Corn Borer dynamics and the estimation of the natural population by means of pheromone traps and marking and releasing technique. Methodology. ECB moths were labeled after they are the sensity thetic diet in which were added Calco red dye, and ^{32}P as a colorless and transparent solution of NaH₃³²PO₄. The ^{32}P radioactivity's in the diet were 7.4 and 13 kBq/g.. It were registered: no. of pupae/box, no. of moths/box, egg batches/female and percentage of fertile eggs; radioactivity of pupae, moths and exuviae. It was used releasing of a large number of Ostrinia nubilalis males marked with Calco red dye, and recapture of a part of these moths, in pheromone traps situated at different distance in field. Results. Experiments made during 1994-1997 have shown that released tagged ECB moths have been recaptured in pheromone traps at a distance no more than 3000 m from the point of release (300 m/day), and probably this is the distance for which the moths are capable to fly. The flight of the moths was influenced by the wind speed and its direction. Both, 7.4 and 13 kBq/g diet reached our purpose for permanent moths labeling, the biggest part of radioactivity was contained by moths and smallest part by exuvies. The radioactivity of 7.4 and 13 kBq/g, has a slight obvious influence on the longevity of marked ECB. In average, for moths reared with 7.4 kBq/g diet, males exuvies have had 8.55% radioactivity, females exuvies 9.02% and for moths reared with 13 kBq/g diet, 6.85% males exuvies and 7.03% females exuvies in rapport with whole radioactivity in the emergence day. There is a slight difference between radioactivity of males and females. ³²P labeled moths by using 7.4 kBq/g and 13 kBq/g in the diet, could live as long as control moths; meanwhile, the radioactivity in each adult insect has decreased in time after a slope which depend on sex and diet used. Conclusions. ecb is a weak flyer, it seems that its flight is, in average, no longer than 300m/day Presented data indicates that rearing of ECB on radioactive diet affect biological parameters of obtained moths and that rearing medium with 7.4 kBq/g of diet is most suitable for obtaining labeling of moths.

Index terms: Ostrinia nubilalis, flight distance, isotopes, dye labeling.

[0894] COMPARISON OF THE MACROLEPIDOPTERAN ASSEMBLAGES OF SALIX NIGRA AND ACER NEGUNDO: A STORY OF CATERPILLARS, PLANTS, PARASITOIDS, AND PREDATORS

<u>P. Barbosa¹</u> & A. Caldas¹, ¹Dept. of Entomology, Univ. of Maryland, Plant Sciences Bldg., College Park, MD, 20742, USA, E-mail pb5@umail.umd.edu and ac182@umail.umd.edu.

Larval free-feeding macrolepidoptera of two riparian trees Salix nigra (black willow) and Acer negundo (box elder) were sampled and sorted by species and abundance. Data collected established that the majority of species in the assemblages in each tree species occurred at low abundance in each of the 5 years when larvae were sampled. On both trees, assemblages were dominated numerically by relatively few species, a pattern that has been observed for insect assemblages on plants in managed and unmanaged habitats. Absolute sampling of two macrolepidopteran assemblages on box elder and black willow was undertaken by fogging the canopy. Collections of larval Lepidoptera demonstrated that assemblages are numerically dominated by few species, i.e., scarce species constitute a large proportion of our samples. Specifically, the proportion of singleton species in these temperate habitat assemblages parallels that observed in fogging studies in tropical habitats. The similarity index calculated for the species in the two assemblages was relatively low. The latter results were compared to those obtained from absolute sampling (achieved by fogging). The patterns were the same regardless of the sampling approach. Patterns of larval parasitism among species in the macrolepidopteran assemblages also were examined.. Total parasitism of larvae on box elder was significantly higher than that of larvae on black willow. Comparisons of parasitism levels among lepidopteran families showed that in five of seven families larval parasitism on box elder was significantly higher than on black willow. For species whose larvae were found on both tree species, total parasitism was significantly higher when the larvae were on box elder than when larvae of the same species were on black willow. In comparisons of species found on both tree species, larvae in three of seven families suffered significantly higher levels of parasitism when on box elder than when on black willow. The roles of the functional/numerical responses of parasitoids, common and numerically dominant parasitoid species, and plant volatiles are considered as causal mechanisms underlying differential parasitism but are not supported by the data. Age based differential predation by birds on one of the more common macrolepidoptera species also has been observed. Behavioral observations further suggest that the ability of prey larvae to differentiate among predators and other herbivores in the habitat may serve as the basis for other examples of differential predation.

Index terms: Differential parasitism, box elder, black willow, insect assemblages scarce species.

[0896] EFFECT OF FOOD DEPRIVATION ON IMMATURE PHASE OF ASCIA MONUSTE

H. C. H. Barros-Bellanda¹ & F. S. Zucoloto¹, ¹ Dept. of Biology, FFCL – Ribeirão Preto, Univ. of São Paulo, CA 14040-900, Brasil, E-mail hbarros@usp.br.

In general, the lepidopterons are potentially powerful agents in the selection of oviposition places; however some mistakes were described, e.g. large egg-laying; egg-laying in small plant, on small leaf or in old plant, etc. An important consequence of these mistakes is the food deprivation on immature phase; it was observed in Ascia monuste (Lepidoptera, Pieridae), important consumer of Brassicaceae in neotropical region and cannibal on immature phase. The work reported here investigated the effect of food deprivation for 24h on second and fourth instars of *A. monuste*. What's period is more critical? The performance of three groups of caterpillars was compared: control group (C), deprivation on 2ª instar (E1) and deprivation on 4ª instar (E2). The parameters measured were: time for pupation, imago weight (male and female), total emergence, number of eggs per female, hatching and digestive indexes (AD, ECI and ECD) measured on fifth instar. Negative effect of food deprivation was obtained on performance of experimental groups. In E1 group, the principal difference was the high time for pupation, which exposes the individuals to negative biotic and abiotic conditions to survival. In E2 group, adults were less heavy, which has negative effect on reproduction. In conclusion, food deprivation has a direct effect on population survival (E1) or an indirect effect on survival (E2). So, we can say that both periods tested are critical. Furthermore, immatures can resist to food deprivation on 2^a and 4^a instar for 24h (low mortality), have a compensatory behaviour (high ingestion and biomass gained) on fifth instar and do not demonstrate cannibal behaviour during food deprivation.

Index terms: cannibalism, compensatory behaviour, food deprivation, insect, ovipositional mistakes

[0897] DISCRETE TIME MODEL OF POSTFEEDING LARVAL DISPERSAL IN BLOWFLIES

R. C. Bassanezi¹, M. R. Sanches¹ & <u>C. J. Von Zuben²</u>, ¹Dept. of Applied Mathematics, IMECC, UNICAMP, 13083-970, Campinas, SP, Brazil; ²Dept. of Zoology, UNESP, Ave. 24A, 1515, P.O. Box 199, Rio Claro, SP, 13506-900, Brazil, E-mail vonzuben@rc.unesp.br.

Dispersal is one of the most significant and complex aspects in the life history of organisms. The complexity of dispersal is further enhanced by the spatial scale in which it occurs. In blowflies, the postfeeding larvae that have already attained the minimum weight necessary for pupation begin dispersing outside the food substrate, in search of suitable sites for pupation. Some continuous time mathematical models have been proposed to explain the appearance of oscillations in the dispersal of larvae from the food source, specifically for calliphorids. These models emphasized diffusion equations and non-local interactions. The objective of the present study is to investigate the same process of larval dispersal, but utilizing difference equations incorporating probabilities associated with larval movements. Two initial equations represent the dynamics of larval movement: (1)

$$A_{i,j+1} = A_{i,j} + \alpha C_{i,j} \text{ and } (2) \quad C_{i,j} = \omega C_{i,j-1} + \beta C_{i-1,j-1} - \beta C_{i,j-1},$$

where $A_{i,\,j}$ represents the number of larvae buried in the position i at time j , $C_{i,\,j}$

is the number of larvae in the surface of the pupation substrate in the position i at time

 \dot{J} , α is the proportion of larvae that bury in one location, ω is the proportion of larvae that remain stagnant in the same position in an unit of time, and β is the proportion of

In a rotation and the position i to the position i+1 in an unit of time. The results of simulations performed to investigate the oscillations in the dispersal of larvae from the food source, applying expressions obtained through the expansion of the two above equations, are similar to those obtained from the continuous time models. The advantages of the utilization of a discrete model, compared with continuous models, are that the obtainment of explicit solutions and the comprehension of the dynamics of larval movement are both facilitated in a discrete model.

Index terms: difference equations, larval movement, Calliphoridae.

[0899] A SEASONAL CHANGE IN HOST USE OF THE BRAZIL NUT FAMILY CORRESPONDS WITH GENETIC DIVERGENCE IN WOOD-BORING PALAME (CERAMBYCIDAE)

A. C. Berkov, Cullman Molecular Systematics Lab, Dept. of Ornithology, American Museum of Natural History, Central Park West at 79th St., New York, NY 10024-5192, USA, E-mail berkov@amnh.org.

In French Guiana, cerambycid beetles in the genus Palame appear to reproduce exclusively in trees belonging to the Brazil nut family (Lecythidaceae). During a yearlong rearing project (1995-96) in the rain forest of central French Guiana, Palame anceps, Palame mimetica, and Palame crassimana accounted for almost half of the cerambycids reared. Palame anceps emerged exclusively from a single host species, Eschweilera coriacea, during both the dry and rainy seasons. Palame mimetica appeared to make a partial change in host affiliation, from Lecythis poiteaui during the dry season to E. coriacea during the rainy season. Palame crassimana currently includes at least three distinct morphological forms, two of which were reared during this experiment. The 'bicolor' form emerged from four of the five potential host species during the dry season, while the 'unicolor' form emerged solely from Eschweilera coriacea, almost exclusively during the rainy season. It was difficult to find diagnostic morphological characters to support the delimitation of these forms as species, and I hypothesized that they were host races in the process of diverging. This hypothesis has been addressed by sequencing mitochondrial DNA, a 1000 bp segment of the cytochrome oxidase subunit I (COI) gene, to detect potential genetic differentiation. Minimal uncorrected sequence divergence (0 -0.3%) was detected within forms, even among individuals reared from different host species. The 'bicolor' and 'unicolor' forms differed at 10.5% of the bases sequenced. This falls comfortably within the range of divergence detected between other species pairs (9.8 - 14.6%). It was particularly surprising to observe considerable sequence divergence (7.8%) between P. mimetica reared during the dry season and P. mimetica reared during the rainy season. This is high compared to COI sequence divergence among other complexes of closely related insect species. Contrary to what might be expected in a tropical forest with high plant diversity, for Palame, temporal differences in life history appear to present a more effective barrier to genetic exchange than host association. Index terms: *Eschweilera coriacea*, Lecythidaceae, plant-insect interactions, COI. sequence divergence

[0898] A FIVE YEAR STUDY OF MATING FREQUENCIES AND SIZE VARIATIONS IN WILD POPULATIONS OF THE GREEN-VEINED WHITE BUTTERFLY *PIERIS NAPI*

<u>I. Bergström¹</u>, C. Wiklund¹ & A. Knitala², ¹Department of Zoology, Univ. of Stockholm, S-106 91 Stockholm, Sweden. E-mail jonas.bergstrom@zoologi.su.se; ²Department of Biology, Univ. of Oulu, P.O. Box 3000, FIN - 90 014 Oulu, Finland.

Factors affecting female mating frequencies are well studied in the laboratory. However, very few studies of polyandry have been carried out on wild populations. In this study we have examined mating frequencies and size variations in relation to age and generation in bivoltine populations of the green-veined white butterfly (Pieris napi) between the years 1990-94. P. napi has two generations per year in Sweden. The first generation flies in May/June after having spent the winter in the pupal stage. The second generation develops directly and flies in July/August. In this species males transfer a large nutritious ejaculate to the female, this spermatophore is known to increase female lifetime fecundity. Previous laboratory studies have shown that large females have a higher fecundity and that female fecundity increases with number of matings. The results from this study showed a positive correlation between female size and mating frequency in the second generation but not in the first generation. Thus, at least in the second generation, large females seemed to have a double advantage over small females. Large females have both a higher reproductive output due to their size, and are also better to make use of a male's nuptial gift. This is in contradiction with earlier hypotheses that have predicted that male gifts might reduce the value of large size in polyandrous females. This study also showed that the size of the butterflies varied according to sex, generation and year. The interaction between sex and generation was also significant. Although both sexes were larger in the directly developing generation, male size increased more. Thus, sexual size dimorphism increased in the directly developing generation. Another difference between the generations was that females in the first generation mate slightly, although significantly, more times than females in the second generation. Male size has been shown to be positively correlated with a female's unreceptive period after a mating; hence, it is possible that the decreased polyandry in the second generation is a consequence of increased sexual size dimorphism. Index terms: polyandry, sexual size dimorphism, body size, bivoltine populations

[0900] ON THE BIOLOGY OF THREE NEW POLLINATING SPECIES (COLEOPTERA: CURCULIONIDAE: DERELOMINI) OF CAIAUÉ *ELAEIS OLEIFERA* (KUNTH) CORTÉS AND OF THE F1 HYBRID (*E. GUINEENSIS X E. OLEIFERA*) IN THE STATE OF AMAZONAS, BRAZIL

P. Beserra¹ G. Couturier² & M.V.B. Garcia¹, ¹Lab. de Entomologia - Embrapa Amazônia Ocidental, Rodovia AM 010, Km 29, C.P. 319, CEP: 69011-970, Manaus, AM, E-mail: paulo@cpaa.embrapa.br. ²Museum National d'Historie Naturelle - I.R.D., 45, rue Buffon, 75005, Paris, E-mail: couturie@cimrs1.mnhn.fr.

The pollination of the bunches of the oil palm Elaeis guineensis is done principally by species of Derelomini of the African genus Elneidobius. For caiaué Elaeis oleifera, three new species of Derelomini native to Amazonia exist, one belonging to the genus Grasidius n. sp. and the other two to a new genus. The F1 hybrid of E. guineensis with E. oleifera, which exhibits characteristics of high resistance to fatal yellowing disorder, attracts the three Derolomini genera. With the objective of estimating the length of the biological cycles of the new species, the male inflorescences of caiaué and of the F1 hybrid were collected during anthesis, previously isolated and put separately into entomological cages along with each new species of Derelomini. Each day spikelets were removed to verify the evolution of the immature forms of the new species. The three new species of Derelomini use the male inflorescences of caiaué and of the Fl hybrid as a reproductive niche and for the development of progeny. The two species of the new genus completed their biological cycle in 20 days (n=2), and the Grasidius n. sp. completed its biological cycle in 35 days (n=2). These new species of Derelomini have the potential for mass production and inundative colonization in plantations of the F1 hybrids. Index terms: pollination, oil plam, Grasidius

[0901] THREE NEW SPECIES OF COLEOPTERA (CURCULIONIDAE: DERELOMINI) POLLINATORS OF CAIAUÉ *ELAEIS OLEIFERA* (KUNTH) CORTÉS AND OF THE F1 HYBRID (*E. GUINEENSIS X E. OLEIFERA*) IN THE STATE OF AMAZONAS

P. Beserra¹, LP.de A. Miranda² & G. Couturier³, ¹Lab. de Entomologia - Embrapa Amazônia Ocidental, Rodovia AM 010, Km 29, C.P. 319, CEP: 69011-970, Manaus, AM, E-mail: paulo@cpaa.embrapa.br.²Instituto Nacional de Pesquisa da Amazônia, Manaus -AM, C.P. 478, CEP: 69011-970, Manaus, AM, E-mail: ires@inpa.gov.br. ³Museum National d'Historie Naturelle - I.R.D., 45, rue Buffon, 75005, Paris, E-mail: couturie@cimrs1.mnbn.fr.

Insect pollination is a factor in oil palm production. There is a specificity of the pollinating insect fauna of the oil palm *Elaeis guineensis* consisting of five species of Derelomini of the African genus Elaeidobius. This also occurs with the visiting insect fauna of caiaué *Elaeis oleifera* with three new species of Derelomini native to Amazonia, one of the genus *Grasidius* n. sp., and the other two of the new genus. The Fl hybrid *E. guineensis* x E oleifera, which demonstrates high resistance to fatal yellowing disorder, attracts the African and native Derelomini. With the objective of determining if the new species of Derelomini are pollinators of caiaué and of the Fl hybrid, the three new species were collected in the female inflorescences of caiaué and the Fl hybrid in their receptive period and taken to the laboratory, where the acetholysis method was used to verify the presence of pollen adhering to the body of the insects and to determine its botanical origin. The presence of caiaué and Fl hybrid pollen on the three new species of Derelomini was proven. The results indicate that these three new species are pollinators of caiaué and the Fl hybrid. With the potential to enter into a program of mass production and inundative colonization of pollinators in plantations of Fl hybrids. Index terms: pollinator, oil plam, *Grasidius*

[0902] IMPACT OF THE GENOTYPE OF A SYMBIOTIC BACTERIA ON THE FITNESS OF A PHYTOPHAGOUS INSECT

L.M. Birkle¹, C.R. Tosh², K.F.A. Walters² & A.E. Douglas¹, ¹Department of Biology, University of York, York, UK, YO10 5YW. ²Central Science Laboratory, Sand Hutton, York, UK, YO41 1LZ.

Plant phloem sap is utilized not by insects but by insect-bacterial symbioses. In this tritrophic interaction, the bacteria provide the insect with essential amino acids, complementing the unbalanced supply from the plant. Here we explore the dynamics of the three-way interaction by investigating the impact of genetic variation in the capacity of the bacteria (*Buchnera*) to provide the essential amino acid tryptophan on the fitness of the pea aphid (*Acyrthosiphon pisum*) on different plants. A large field-based experiment established the impacts of bacterial genotype, plant cultivar and season on aphid fitness. Further investigation of pea aphid phenotype (related to actual or potential acitivity in tryptophan production) in selected aphid lineages with a range of bacterial genotypes is capable of incorporating and integrating algorithms predicting aphid fitness. The combined datasets of pea aphid fitness, bacterial genotype, pea aphid phenotype and the application of the model engine will enable use to explore the impact of bacterial genotype on aphid fitness.

Index terms: Acyrthosiphon pisum, symbiosis, nutrition

[0903] A COMPARATIVE ANALYSIS OF THE FLIGHT BEHAVIOR OF LYGUS HESPERUS AND LYGUS LINEOLARIS (HEMIPTERA: MIRIDAE)

<u>**LL Blackmer¹**</u>, **S.E. Naranjo¹ & L.H. Williams III²**, ¹USDA-ARS, Western Cotton Res. Lab., 4135 E. Broadway Rd., Phoenix, AZ, 85040, USA, E-mail: blackmer@ix.netcom.com; ²USDA-ARS, Southern Insect Management Res. Unit, Experiment Station Rd., P.O. Box 346, Stoneville, MS, 38776, USA.

In the United States lygus bugs are serious pests of agricultural and horticultural crops, Their feeding causes abscission of reproductive structures, destroys plant terminals, and reduces plant quality and yield. Two of the most important species, Lygus hesperus and Lygus lineolaris, are highly polyphagous, and readily move between hosts as plant quality declines. The distribution of L. hesperus is confined to the western U.S. and southwestern Canada, whereas L. lineolaris is found throughout the U.S. and Canada. Little is known about either species with regards to the factors that influence their tendencies to disperse. A better understanding of the dispersal capabilities of these insects could facilitate the development of more effective control strategies. To such an end, we have been conducting comparative studies of these two species, using a vertical wind tunnel (untethered flight) and flight mills (tethered flight). Under laboratory conditions, males and females of both species initiated flights throughout the day and night (on flight mills). The majority (90-95%) of flights were less than 5 min in duration whether tethered or untethered lygus bugs were tested. Males and females of both species were capable of extended flights (X ± SE, L. hesperus 22.07 ± 10.3 min, L. lineolaris 17.3 ± 2.8 min in the vertical wind tunnel; L. hesperus 32.08 ± 8.2 , L. lineolaris 39.02 ± 11.4 min with flight mills), but flights of longest duration (466 min) were obtained with the flight mills and were 5 to 6 times longer than the longest flight (83 min) observed in the wind tunnel. Differences in cumulative flight duration was influenced by the number of flights that an individual made, those being approximately twice as many for tethered versus untethered fliers $(23.9 \pm 6.4 \text{ vs.} 12.2 \pm 4.8 \text{ flights})$. The initial rate of climb toward the skylight cue in the vertical wind tunnel was approximately 50 cm/s for both species. L. hespenis had a bimodal distribution in its phototactic orientation (or frequency of flights > 5 min for tethered flight) with peaks from 0500 to 0700 h and again from 1900 to 2100 h. The response of L. lineolaris was variable but could more accurately be described as unimodal, with peaks in flight activity between 0600 and 1000 h in the vertical wind tunnel, and between 1900 and 2000 h with the flight mills. For both species, extended flights were rarely observed before 6 days of age. Most of the long duration flights occurred between 1 and 3 wk of age. Additional factors (mating, reproduction and nutritional status, light intensity and wind speed) that might influence flight duration in these two species will be discussed, as well as the advantages and limitations of tethered versus untethered flight mills.

[0904] NUTRITIONAL AVALIATION OF PLANTS OF ERVA MATE ATTACKED AND NOT ATTACKED BY "BROCA" HEDYPATHES BETULINUS

G. A. Borsoi¹ & E. C. Costa², ¹ Programa de Pós-Graduação em Engenharia Florestal (Mestrado) – Universidade Federal de Santa Maria, Santa Maria, RS – Brasil; ² Depto. de Defesa Fitossanitária, Centro de Ciências Rurais – Universidade Federal de Santa Maria, Campus Universitário, prédio 42, 1º andar, 3225 – CEP 97105-900 – Santa Maria – RS – Brasil – e-mail: eccosta@cr.ufsm.br.

The research had purpose to evaluate the nutritional deficiency of erva-mate plants (Ilex paraguariesis St Hil.) attacked and not attacked by Hedypathes betulinus (Klug, 1825), (Col : Cerambycidae), and correlate nutrition variable of soil and leaves, for identify nutritionals instability possible among two parameters analyzed. The area is localized in Catanduvas, SC - Brazil, it is plane and has 20ha. The stand is homogeneous, with eight years old. The sample were submitted chemical analysis in Soil Analysis Laboratory, in Centro de Ciências Rurais, at Universidade Federal de Santa Maria. With the obtainment of medians of the chemicals levels, maked the test of comparisons mediuns "t" and "F, test of homogeny of variances, in the final analysis of simple linear correlation between chemical variables of soil and leaves for two kind of plants. Soil showed levels adequates of N and P, low levels of K, Ca Mg, and right to S, B, Fe, Mn, Zn, Cu, Na, Al, AL+H, Ph and SMP. In the foliar analysis, plants presented levels adequates of K, Ca, B, Zn, and Na, low levels of P, Mn and S and high level of N, Mn, Fe and Cu. This analysis, were expressive the high concentrations of N and low levels of S in the foliar tissue. The test "t"demonstated expressive difference to soil and leaf, between mediums of two kinds of plants. The test "f' demonstrated P of the soil, of leave and Fe of the soil like chemicals variables wich expressives differences in the level of error 5%. The test of homogeny of variances presented the P and Fe of the soil and the K, S and Mn of the leaves, like variables with expressive heterogeny of the variances. Of the variable studied, plants attacked showed the most variation between mediuns. Of the correlations analyzed, between two kind of plants, the most importance were one formed by N and S of leaf, and by K, S, Fe, Mn of soil, because they presented the biggest number of correlations formed with chemicals elements in plants attacked. In most cases plants attacked presented most instability between the nutrients. In attacked plants, the correlations formed didn't demonstrated similaries with majority of the elements chemicals analysed to plants not attacked.

Key Words:. insect; soil fertility; Cerambycidae

[0905] SURVEY AND IDENTIFICATION OF FRUIT FLY SPECIES IN THE REGION OF BAIXO JAGUARIBE, STATE OF CEARÁ, BRAZIL

 R. Braga Sobrinho¹
 A. C. F. Ometto², A. L. M. Mesquita¹ & V. E. Silva³

 ¹Embrapa/CNPAT-Cx.
 Postal 3761 - 60.511-110 Fortaleza - CE Brazil;Email:braga@cnpat.embrapa.br;
 ²FUNCAP/SEAGRI - Fortaleza - CE; E-mail: carinaometto@hotmail.com;

 ³COEX - Mossoró - RN, E-mail: coex_frutas@uol.com.br

Fruit flies belonging to species Ceratitis capitata and to genus Anastrepha are well known around the world as the most destructive pest in fruit producing areas. Being an important quarantine pest, its presence in fruit crops make them impossible for any effort to export. In northeast Brazil, the species that present a large geographic distribution are Anastrepha obligua, A. zenildae and C. capitata, this last one known as the Mediterranean fruit fly. The growing areas of tropical and subtropical fruit crops in the state of Ceará are increasing. Using high technology and irrigation systems, 35,000 hectares are being established in six new agroareas within the state, one of them being Baixo Jaguaribe, located in the eastern region. This study has been carried out to identify and quantify different species of fruit flies. Pheromone traps using Trimedlure to attract C. capitata flies and hydrolyzed protein traps for Anastrepha sp. have been distributed into irrigation producing areas, backyards and towns. Host fruits have also been collected to check the presence of eggs and larvae inside of them. The preliminary results have shown the presence of C. capitata in all areas. In the genus Anastrepha four major species have been detected: A. obliqua, A. zenildae, A. sororcula and A. fraterculus. Species distribution frequency and its population dynamic will be further discussed. Index terms. Fruit flies, Ceratitis capitata, Anastrepha sp., Trimedlure, pheromone trap.

[0907] COMMUNITIES OF SOIL COLLEMBOLA ON THE NORTH AND SOUTH FACING SLOPES OF A MEDITERRANEAN VALLEY

M. BROZA¹, D. POLIAKOV¹, M. GRULA² & G. BRETFELD³, ¹Univ. of Haifa at Oranim, Tivon 36006, Israel, E-mail: broza@research.haifa.ac.il ²Instit. de Speologie "Emil Racovitza", Bucharest, Romania ³Zoological Instit. Univ. of Kiel, Kiel, Germany

Comparison was made between the assemblage of collembolan species on the north- (N-) and south-facing (S-) slopes of Valley Oren, Mt. Carmel, Israel. Its slopes, only 100 m apart at the bottom, represent a dramatic biotic divergence due to the much higher solar radiation on the south-facing slope. Both slopes have the same geological history and structure, the same height above sea level, and more or less the same rainfall. As a result of a difference of up to 500% in the radiation load, the S- slope is much drier than the Nslope. This results in a lower biomass of vegetation cover and, as a consequence, more vulnerability to erosion and intensive wind, which further increase evaporation. Thus there are clearly two very distinct ecological microsites on the N- as opposed to the S- facing slopes. The assemblage of Collembola found, includes 50 Athropheona and 17 Symphypleona species. The list of 67 species includes 13 new taxa. Arthropleona species richness is very similar on both sides, 43 species on the N-slope and 41 on the S-slope. In contrast, we recorded a rich assemblage of Symphypicona on the N-slope (17 species) but only 5 species on the S-slope. Thirty-four out of 50 species of Arthropleona were found on both sides of the valley. Nine species were found only on the N- and 7 only on the S-. Some families showed a greater abundance of species on one slope than the other. Differences in species richness were found between and within slopes according to altitude zone and vegetation. The Sorensen Similarity Index (SSI) used to compare the inter- and intra-slope distribution, as well as plants association. Greater similarity was found between the two vegetation types within any altitude. However, some inter-slope SSI values were higher than the intra-slope similarities. Data on species abundance for Entomobryoidea (17 species) indicated that two species, *Pseudosinella octopunctata* and *Heteromurus major*, were very common (ca. 89%) and found in all altitudes. In contrast most other species were rare, found in only some altitudes. While the two most common species are cosmopolitan at least half of the rest of the list are endemic to the eastern Mediterranean. These data are related to one of the most pervasive patterns in ecology, claiming that locally abundant species tend to be widespread, whereas locally rare species tend to be narrowly distributed. It is suggested that the N- versus S-slope model may represent a micro-cosmos with diverse soil community ideal for experimental field tests of major ecological issues.

Keyword; Entomobryidae, microsite, Israel

[0906] SURVEY OF FRUIT FLIES (DIPTERA: TEPHRITIDAE) IN FOUR CITIES IN PARAÍBA

C.H. Brito¹, <u>I.A. Mezzomo¹</u>, E.L. Araújo² & M.G.A. Lima³, ¹Laboratory of Biological Control, Dept. of Pharmacy and Biology, Paraíba State Univ., Félix Araújo Square, 13B, 58101-450, Campina Grande, PB, Brazil, E-mail jamezzo@zaz.com.br; ²Dept. of Entomology, ESAM, P.O. Box 137, 59600-970, Mossoró, RN, Brazil, E-mail elaraujo@carpa.ciagri.usp.br; ³Dept. of Biology, Ceará State Univ., P.O. Box 1531, 60740-020, Fortaleza, CE, Brazil, E-mail goretti@uece.br

The registered occurences are fundamental for the implementation of integrated pest management of fruit flies, that cause great damages to fruit cultures in Brazil, where there are already more than 90 registered species. For this reason and also because of the lack of studies of this type in Parafba, this research had as its objective innitiate basic studies that will allow the development of a line of research about fruit flies in our state. Occasional collections were made from September 1998 to July 1999 in domestic orchards within the city limits of Campina Grande, Lagoa Seca, Alagoa Nova and Areia. Fruits of the plant and on the ground were collected, which were weighed and counted, being left for 10 days in closed recipients containing sterilized soil. After this period, the soil was sifted to separate the pupae and these were maintained in Petri dishes with humid cotton. Daily, the flies that emerged in the dishes were collected, counted and sexed. Of the 25 different fruit species collected, in 15 there were 1511 pupae and 922 flies, being 518 Ceratitis capitata (56,2%), 91 Anastrepha obliqua (9,9%), 62 A. fraterculus (6,7%), 6 A. antunesi (0,7%), 4 A. sororcula (0,4%), 227 Anastrepha spp. (24,6%) and 14 flies without economic importance (1,5%). Guava (Psidium guajava) was the fruit where the most quantity of pupae and fly species were obtained, however the highest percentage of infestation occured in castanhola (*Terminalia catappa*) (52,5%), umbu-cajá (*Spondias* sp.) (48,0%) and pitanga (*Eugenia uniflora*) (32,6%). The species C. capitata infested 10 fruit species. predominantly in C. Grande; Anastrepha spp. infested 9 fruit species and predominated in Areia; and in 4 fruit species both genera were present, in similar proportions as in L. Seca and A. Nova. The C. capitata, A. obliqua and A. fraterculus species are the most important in the surveyed places

Index terms: Insecta, Anastrepha, Ceratitis capitata, geographic distribution.

[0908] GENETIC AND SOIL NUTRIENT EFFECTS ON RESISTANCE OF COMMON REED TO A GALL-FORMER

Luc De Bruyn^{1,2} & T. Backeljau^{2,3}, ¹ Inst. Nature Conservation, Kliniekstr. 25, 1070 Brussel, Belgium; ² Dept. Biology, Univ. of Antwerpen, Groenenborgerlaan 171, 2020 Antwerpen, Belgium; ³ Dept. Entomology, RBINSc, Vautierstr. 29, 1000 Brussel, Belgium; E-mail : luc.de.bruyn@instnat.be.

The flies of the genus Lipara (Diptera; Chloropidae) induce typical galls on the shoots of the common reed, *Phragmites australis* (Poaceae). In previous studies it was shown that shoot diameter (a measure of shoot vigour) is the major factor determining resistance to herbivore attack. Shoot diameter in turn depends on the growing conditions. Shoots are thicker in moist, nutrient rich environments. The aim of the present study was to assess whether resistance also has a genetical component. Therefore, 6 reed clones were grown in a common garden experiment under two treatments (nutrient rich, nutrient poor) in three subsequent years. Plant resistance to gall induction differs significantly among clones. Resistance consists of two components, resistance to gall induction and increased laval mortality in the gall chamber. Resistance also depends on the nutrient level offered to the reed rhizomes. Shoots growing on a nutrient rich soil are more resistant to gall induction than galls growing on a nutrient poor soil.

[0909] HONEY ANTS ON THREE DIFFERENTS REWARDING ATTRACTANTS

L. M. Buffa & M. A. Delfino, Cat. de Entomología, Univ. Nac. de Córdoba, Av. Velez Sarsfield 299, 5000-Córdoba, Argentina, E-mail lbuffa@com.uncor.edu

Both homopteran-ant and extrafloral nectaries-ant associations are common mutualisms found in differents regions. Many Homoptera, such as aphids, excrete honeydew as they feed on phloem sap. Ants preferentially tend those herbivores that produce the most nutritionally rewarding attractants. Honeydew-producing insects may funtionally be considered as extrafloral nectaries exploited by ants, and this association is generally considered mutualistic. Extrafloral nectaries occur in a wide variety of plant taxa, the extrafloral nectar is a generalized food source eaten by ants, some species use a variety of nectar sources and may forage on two or more plants simultaneously. A wide variety of ant taxa are attracted to many different nectary-bearing plants, mainly Myrmicinae, Formicinae, Dolichoderinae and Pseudomyrmecinae. Existing information suggest that ants switch from visiting a plant extrafloral nectaries to visiting honeydew-producing homopterans. In order to known the ant fauna foraging on extrafloral nectaries of Croton sarcopetalus as well as two honeydew producing aphids: Dysaphis foeniculus on Foeniculum vulgare and Aphis spiraecola on Eupatorium hookerianum, a field work was carried out in an area of Córdoba (Argentina). Weekly samplings of ants were made from October, 1995 to May, 1998. Twenty-three ant species in 11 genera and 4 subfamilies were recorded. The subfamilies Formicinae and Myrmicinae dominated the ant fauna, comprising, together, 19 species of visiting ants. Extrafloral nectaries were visited by several ant species (15), whereas A. spiraecola and D. foeniculus by 12 each one. Camponotus, Linepithema, Crematogaster, Pheidole and Brachymyrnex were found at the three differents rewarding attractants. Pheidole was the genus most abundant and occurrent at extrafloral nectaries and colonies of A. spiraecola, being Camponotus the genus with high species richness. Brachymyrmex was the genus most abundant, occurrent and with high species richness on D. foeniculus colonizing F. vulgare. Pseudomyrmex acanthobius, Pseudomyrmex sp.1, Crematogaster brevispinosa, Zacryptocerus sp.1, Camponotus blandus and Camponotus personatus were registred only visiting extrafloral nectaries. Solenopsis sp.2, Prenolepis sp.2 and Camponotus rufipes only tending A. spiraecola. Pheidole sp.1, Wasmannia auropunctata and Brachymyrnex sp.3 only tending D. foeniculus. Other considerations about the ant fauna in this three differents rewarding attractants are discussed.

Index terms: interactions, ants, aphids, extrafloral nectaries.

[0910] PATTERNS AND PROCESSES OF ARTHROPOD COMMUNITY SUCCESSION AFTER A FIRE

J. C. Burger¹, M. A. Patten², <u>J. T. Rotenberry</u>^{2,3} & R. A. Redak^{1,3}, ¹Dept. Entomology, ²Dept. Biology, ³Center for Conservation Biology, Univ. California, Riverside, CA 92521 USA; E-mail rote@citrus.ucr.edu.

We surveyed arthropods after a fire in southern California coastal sage scrub to investigate (1) the degree to which arthropods recolonized burned sites, and (2) the pattern of post-fire succession across arthropod orders, families, and guilds. We sampled arthropods from burned and unburned sites beginning 2 1/2 years after a fire. Arthropods collected from pitfall traps and vacuum samples were counted and identified to family, morphospecies. and feeding guild. Burned sites contained more arthropods and a guild distribution skewed toward detritivores and herbivores. Psocoptera were significantly and Collembola and Homoptera were marginally more abundant in burned sites. Species richness of the six dominant orders did not differ across sites but arthropod assemblages at the family level did in relation to burn history and grass cover. This study suggests that arthropod recolonization follows a similar pattern that vegetational succession does, in that there is a predictable species turnover and a shift in importance of different functional groups at a site over time. Mid-successional burned areas did not, as expected by current theory, have higher arthropod biodiversity than mature sites. Interestingly, the larger arthropod community appeared to follow a different successional pattern than the Dipteran community at our study sites. Finally, there is cause for concern as to the effect of nonnative grasses on arthropod recolonization.

Index terms: arthropod community succession, recovery after disturbance, wildfire, impact of non-native grassses

[0911] DISPERSAL OF EUROPEAN AND SOUTHWESTERN CORN BORER MOTHS WITHIN AND BETWEEN CORNFIELDS

L. L. Buschman¹, P. E. Sloderbeck¹, R. L. Hellmich II², S. B. Ramaswamy¹ & R. A. Higgins¹, ¹Dept. of Entomology, Kansas State Univ., Manhattan KS, 66506-4004, USA, Email: Ibuschma@oz.oznet.ksu.edu; ²Corn Insects and Crop Genetics Res. Unit, USDA, ARS, Iowa State Univ., Ames, IA. 50011, USA.

Moth dispersal is an important parameter in evaluating the placement of a refuge for resistance management in Bt-corn. This study was designed to evaluate the dispersal of European and southwestern corn borers by evaluating the dispersal of native moths into two Bt-corn fields and by releasing marked moths and trapping for recapture. During the first season of the experiment, first flight European and southwestern corn borer moths were evenly distributed across both fields. Since these moths had to fly into the test fields from surrounding fields, this suggests both species fly extensively during the first flight. oil soluble red and blue dyes (Sudan Red TB and Solvent Blue 35) were added to larval diets to mark moths that were released into the two cornfields. Thirty-nine pairs of European and southwestern corn borer pheromone traps and 22 blacklight traps were installed in the two release fields. Another 3 pairs of pheromone traps were installed around neighboring cornfields. European corn borer moth recapture was 3 and 5% for the early season release and 10 and 6% for the late season release in the two fields. The southwestern corn borer moth recapture was 13 and 26 % for a late season release in the two fields. More males then females of both European and southwestern corn borer were recaptured and males were recaptured at the greater distances away from the release sites. The blacklight traps captured more European corn borer moths, but the pheromone traps caught more southwestern corn borer moths. Both European and southwestern corn borers were recaptured at 1200 ft and in the neighboring fields. During the first season of the experiment, the dispersal patterns for European and southwestern corn borers appeared to be similar, but the European corn borer moths appeared to have more affinity for areas with high moisture or humidity. The trapping locations with the high catches of European corn borers seldom had high catches of southwestern corn borers.

Index terms: Ostrinia nubilalis, Diatraea grandiosella, resistance management, Bt-corn, maize

[0912] BIOLOGY OF THE LEAF GALL MAKER NEOTRIOZA TAVARESI IN STRAWBERRY GUAVA TREE

C. A. Butignol¹ & J. H. Pedrosa-Macedo², ¹ Dep. Entomologia, CCA, UFSC, in course at Dep. Zoologia, SCB, UFPR. P. O. Box 19020, CEP 81531-990, Curitiba – PR – BR. Email: butignol@garoupa. bio.ufpr.br. ² Dep. de Ciências Florestais, SCA, UFPR. Ave. Pref. Lotário Meissner 3400, CEP 80210-170, Curitiba – PR – BR. E-mail: johpema@netoar.com.br

Biology studies of insect species are crucial for acquiring knowledge about the most important events of its life cycle. In Piraquara municipality, state of Paraná, in the south of Brazil, a field study was conducted to determine the life cycle of Neotrioza tavaresi Crawford, 1925 (Hemiptera: Psyllidae), a leaf gall maker in strawberry guava trees (Psidium cattleianum, Myrtaceae). Three (3) cycles were observed (1997, 1998, 1999) in regular field trips in which 50 infested leaves were sampled. Laboratory analyses (dissection) were performed in the galls. It is a univoltine cycle in which adult individuals are found inside the galls from the month August onwards. After month 1 the sexually mature insects with sex ratio 1, leave the galls as it cracks open. The gall cracking is caused by adult insects as they feed on its walls. The release starts in October and ends in the second half of December, having its peak in November. Copulation takes place as soon as they exit the gall and egglaying starts the next day. Females have more than 100 ovarioles containing 217.4 ± 47.5 (n=30) fully formed eggs. This indicates the short sexual adult life-span (aprox. 1 week) of the species, also characterized by a concentrated oviposition. Adult individuals feed and lay their eggs on the shoots of the plant. The bottom of the yellowish eggs are inserted into the leaf tissue, markedly on its adaxial edge. The nymphs hatch and, as they feed on the adaxial side of expanding leaves, change the cell growth. This process starts with the lyse and proceeds with the sinking of the nymphs towards the leaf blade and the round-shape galls develop on the adaxial side. The nymphs go through 5 instars, the first being inside the leaf blade, whereas the others within the gall. The exuviae are stuck on a ball of wax inside the gall. The findings suggest that insect and plant life cycles are closely connected and both shooting and gall opening seem to be triggered by the same conditions. The presence of large numbers of shoots in their early stages of growth favor insect performance as adult individuals can easily find an ideal place for feeding, copulation and laying eggs.

Index terms: Psyllidae, life cycle, Psidium cattleianum.

[0913] PREFERENCES OF LEAF GALL MAKER NEOTRIOZA TAVARESI IN DIFFERENT SHOOTING STAGES OF THE STRAWBERRY GUAVA TREE

C. A. Butignol¹ & J. H. Pedrosa-Macedo², ¹ Dep. Entomologia, CCA, UFSC, in course at Dep. Zoologia, SCB, UFPR. P. O. Box 19020, CEP 81531-990, Curitiba – PR – BR. E-mail: butignol@garoupa. bio.ufpr.br. ² Dep. de Ciências Florestais, SCA, UFPR. Ave. Pref. Lotário Meissner 3400, CEP 80210-170, Curitiba – PR – BR. E-mail: johpema@netpar.com.br

Gall makers require specific developmental stages of the host's tissue in order to succeed. A confinement test was used to determine the most favorable stages for Neotrioza tavaresi Crawford, 1925 (Hemiptera: Psyllidae), to establish itself in the leaf of strawberry guava (Psidium cattleianum Sabine, Myrtaceae) and to develop a gall. This test was conducted with 32 trees (1.5 - 2.5m high) in the municipality of Colombo, state of Paraná in the southern of Brazil (22°25'S, 49°14'W, 945m above sea level). The shoots were mapped and rated with the aid of a scale in wich 0 (zero) corresponds to swelling buds; Ito sprouting with the leaves attached to themselves; 2 to deployed leaves; 3 to internodal distance; 4 to attached apical leaves and 5 to opened young leaves. Twenty insects (10 males and 10 females) released by galls were placed in metalassé bags for 5 days on the branches of each tree in November 4^{th} and 11^{th} , 1997, respectively. The percentage of the different shooting stages and of infested shoots differed significantly as reflected by the Chi-square test (X2=51.8, n=4, P<0.0001), showing that the insects' offsprings chose the shoots in which to establish themselves. The number of branches containing galls was larger in stages 2 (0.31±0.127) and 3 (0.36±0.119), both being at the same statistical level, as demonstrated by the grouping of averages according to their confidence intervals. The number of galls and adult specimens per leaf was larger in the stage 3 (0.92±0.03), the most favorable to the development of psyllids. Stage 5 showed absence of such insects. Index terms: Psyllidae, Psidium cattleianum, stages for infestation.

[0914] PREDICTING MEAN DISPERSAL DISTANCE OF POPULATIONS USING CORRELATED RANDOM WALK EQUATIONS RESOLVED BY SIMULATION

J. A. Byers, Dept. Plant Protection, Swedish University of Agricultural, Sciences SE 230 53 Alnarp, Sweden.

Animal movement and dispersal can be described as a correlated random walk dependent on three parameters: number of steps, step size, and distribution of random turning angles. The mean dispersal distance (MDD) of a population from a source (e.g. bark beetles flying from a brood tree) can be predicted by simulations using the parameters with realistic values. Equations of Kareiva and Shigesada (1983) use the parameters to predict the mean square dispersal distance (MSDD). However, the MSDD is less meaningful than the MDD about which the population would be distributed. I found that the MDD can be estimated by multiplying the square root of the MSDD by a three-dimensional surface correction factor found from simulations. The correction factors ranged from 0.89 to 1 depending on the number of steps and the variation in random turns, expressed as the standard deviation (SD) of the turning angles about 0° (straight ahead). Another equation (Bovet and Benhamou 1988) finds the MDD directly, and this agreed with the MDD obtained by simulation at most SD of turning angles. However, their equation has a significant error that increases as a power function when the SD of turning angles becomes smaller (e.g. $< 6^{\circ}$ at 1000 steps, or $< 13^{\circ}$ at 250 steps). Solutions to the other three variables in their equation are presented. Predicted values of MDD for various organisms (butterflies, ants, and beetles from literature) and the nematode Steinementa carpocapsae (Weiser) are calculated. The coefficient of variation (CV) in the distribution of dispersal distances of a population varied from 0 to 51% as a sigmoidal logistic function of an increase in the variation of turning angles. The CV of dispersal distances also was related to the number of steps as non-sigmoidal Gompertz curves. Equivalent values of AMT (angle of maximum turn) in uniform random models and of SD in normal random models were found that allowed these two models to yield similar MDD values. The step size and turning angle variation of animal paths during dispersal and hostand mate searching are correlated, thus, use of different measured step sizes gives consistent estimates of the MDD.

Index terms: bark beetle, Scolytidae, Coleoptera, dispersion, host selection, mate search, nematode, Steinernema carpocapsae

[0915] DOES GALLING AND FOLIVOROUS INSECTS SUPPORT THE RESOURCE CONCENTRATION HYPOTHESIS? THE CASE OF SCHINUS POLYGAMUS (ANACARDIACEAE)

P.P. Caballero¹ & II. Lorini², ¹Laboratorio de Química Ecológica, Departamento de Ciencias Ecológicas Universidad de Chile, P.O. Box 653, Santiago, Chile. E-mail paulac@abulafia.ciencias.uchile.cl ²Universidad Mayor de San Andrés, La Paz, Bolivia.

The resource concentration hypothesis states that the concentration and/or dispersion of host resources has a direct influence on herbivore insect populations. Plant consumers tend to concentrate at places in which plant resources are abundant and easy to find. We studied the case of Schinus polygamus, a polymorphic evergreen shrub, with high to low aggregated distribution that shows high levels of attack by different herbivorous insects. In 21 patches with different levels of aggregation, we measured level of galling and folivory, height of a focal individual, height, coverage and number of neighbouring conspecifics, and distance between the focal individual an each of the conspecifics. Multiple regression results showed no correlation between folivory and any of the variables measured and significant relationships between galling level and variables related to aggregation of resources. These differences are discussed in relation to differences in biological features of galling and folivorous species involved, such as size, searching behaviour, flight capacity and different degrees of specialization.

Index terms: concentration of resources, gall makers, folivory insects, specialization

[0916] EFFECT OF LARVAL DIETS ON THE SENSIVITY OF ANAGASTA (LEPIDOPTERA, PYRALIDAE) TO MICROWAVES **KUEHNIELLA RADIATION (2.450 MHz)**

F. Cabral¹; G.G. Fagundes¹ & M. E. M. Habib², ¹Dept. of Parasitology, IB, University of Campinas (UNICAMP), SP, 13083-970. Brazil. E-mail fcabral@obelix.unicamp.br. ²Dept. of Zoology, IB, University of Campinas (UNICAMP), SP, 13083-970. Brazil.

The Mediterranean flour moth, Anagasta kuehniella (Zeller, 1879), a world wide distributed pyralid, is well known as one of the most important lepidopterous pests of stored products. Microwaves radiation is being investigated as a promising method for its control. The present study, therefore, was undertaken to evaluate the comparative sensitivity of *A. kuehniella* 3nd instar larvae in three different food treatments, all based on wheat grains, whole meal flour, grain germ and bran. Seven exposure times, to microwaves radiation, were established for each food treatment, and the median lethal exposure time (LET50), was calculated. For each exposition, 100 larvae were utilized and divided in 4 repetitions. A total number of 2100 larvae were utilized during the final tests. The LET₅₀ for larvae which fed on whole meal flour was calculated as 16.59 seconds, with a minimum of 12.37 and a maximum of 28.14 seconds. The grain germ treatment resulted in a LET₅₀ of 15.52 seconds, with an inferior limit of 13.51 and a superior one of 28.14 seconds, without significant differences in relation to those fed on whole meal flour. The larvae which fed on bran, however, showed to be extremely sensitive to the microwaves radiation, since the LET₅₀, in this case was calculated as 2.85 seconds, with an inferior limit of 2.51 and a superior one of 3.23 seconds. Obviously, the deficiency of the bran as a diet was the principal factor responsible for such an exaggerated sensitivity. Researchers of the same laboratory involved in the present study, revealed that the braconid parasite, Bracon hebetor, of the MFM, showed to be highly resistant to the same radiation, since the LET₅₀ was calculated as 106.57 seconds. These results indicate the high efficiency of the microwaves radiation against the 3rd instar larvae of the MFM. Its low cost and safety, could be added to reveal the high possibility to be considered as a and alternative method to control this pyralid pest.

Index terms: physical control, IPM, storage pest, nutrition

[0917] FORAGING ACTIVITY OF *HETEROTERMES TENUIS* (ISOPTERA: RHINOTERMITIDAE) IN SUGARCANE AREA ACCORDING TO YEAR SEASONS

M.B.S. Campos¹, <u>N. Macedo¹</u> & S. B. Alves², ¹Centro de Ciências Agrárias/UFSCar, Araras, SP. Cx.p.153, CEP 13600-970. E-mail: newmac@cca.ufscar.br.; ² Dep. Entomologia, ESALQ/USP, Piracicaba, SP.

Foraging activity of *Heterotermes tenuis* in sugarcane area during year seasons from Dez/94 to Dez/95 was studied using five types of baits: CF (corrugated fiberboard) + dry sugarcane bagasse ("in natura"); CF + ground maize; CF + dry cowdung; corrugated CF + shredded cellulose and CF (Temitrap^R). Baits were disposed in bundle, four points per local, in five locals previously chosen by termites occurrence, in one hectare area. Fortnightly baits were changed by new baits and the quantity of collected termites were evaluated by a note scale as follows: (0) = absence; (1) = one to ten termites; (2) = ten to hundred termites and (3) = plus than one hundred. Data of the collected insects were correlated with monthly pluviometric precipitation from de region in the studied period and analyzed by χ^2 test. The best baits collecting termites were CF + dry cowdung and CF + ground maize. There were significant differences among seasons in collecting termites and the biggest collects were obtained during de auturn.

Index terms: Heterotermes tenuis, foraging, sugarcane, baits

[0919] POPULATION ECOLOGY OF CORECORIS DENTIVENTRIS (HEMIPTERA; COREIDAE) IN AN EXPERIMENTAL PLOT OF NICOTIANA TABACUM (SOLANACEAE): SEASONAL FLUCTUATIONS, MORTALITY AND PARASITIZATION

C. R. Canto-Silva¹ & H. P. Romanowski¹, ¹Depart. de Zoologia, Inst. de Biociências, Univ. Federal do Rio Grande do Sul, Av. Paulo Gama, s/n, Porto Alegre, RS, Brasil, Cep. 90046-900. E-mail: coreco@zaz.com.br

The study of the population ecology of insects competitors with man is fundamental for the development of technics management and control for its populations. In addition, agroecosystems, with their lower level of complexity, provide appropriate sites for studies on predation and parasitism to be carried out. Nicotiana tabacum is a major crop to export in Rio Grande do Sul, Brazil. The tobacco-leaf-bug, Corecoris dentiventris (Hemiptera; Coreidae) is associated to tobacco crops, causing rolling and wilting of the leaves. Its temporal dynamics, mortality in the immature phases and egg parasitization were studied in an experimental plot of *N. tabacum* at Porto Alegre (30° 05'S and 51° 13'W), RS. Twenty plants were sampled in 31 sampling occasions, from November 1996 to March 1997. In each occasion, the number of individuals in each stadium was registered. Mortalitality per instar was estimated by the difference population peaks in successive instars. Parasitized eggs show a typical colour pattern: parasitization was assessed by their relative frequence. Two generations occurr during the cycle of the crop, there being overlap of the various developmental stages within each generation. Mean mortality rates were 93.6% on the first generation and 99.8% on the second. In both generations, mortality was more intense in 1^{m} to 3^{nd} instar nymphs and eggs. Intense attack by Reduviidae (Hemiptera) was observed in the field. Mean parasitization rate was lower in the first generation (8.9%) than in the second (36.2%). There was a marked variation in mortality and parasitization rates between plants, suggesting an important role for the spatial distribution of these populations on these processes.

Index terms: tobacco, tobacco-leaf-bug, population dynamics, immature mortality, egg parasitization.

[0918] EARLY-MID SUCCESSIONAL TROPHIC PATTERNS IN AN ARTHROPOD COMMUNITY OF SAVANNA ECOSYSTEMS

<u>R. Candia¹</u> & L. Bulla¹, ¹Instituto de Zoología Tropical, Facultad de Ciencias, Univ. Central de Venezuela. Apdo. Postal 47058, Los Chaguaramos 1041-A, Caracas, Venezuela. rcandia@strix.ciens.ucv.ve & Ibulla@strix.ciens.ucv.ve

Most of the central region of Venezuela between the coastal range and the Orinoco river is covered by Trachypogon spp. savannas. These areas are extensively used for agricultural purposes, specially the production of rice, maize, sorghum, and other industrial grains. Large areas are cultivated only for a short period (1-3 years) and left abandoned. The later evolution of these fields and the process of recovery of the original savanna have seldom been studied. In this study we analyzed the changes that took place both in the vegetation and its associated insect community during a 9-year period in old fields, formerly used for sorghum (Sorghum bicolor) production. In this paper we will present the changes in trophic structure of the arthropod community. Arthropods were divided into five groups (herbivores, predators, parasitoids, saprophytes, and omnivores) and their biomass, richness, and abundance were estimated in a sorghum plot, 4 fallow (successional) plots of 1, 3, 6, and 9 years old, and 4 natural savannas of T. plumosus used as a baseline for the estimation of the changes observed in the other areas. Arthropods were captured by 1000 sweeps in each plot. The relation between species number and abundance from a total of 776 species and 78,510 individuals, respectively, was herbivores 459:52,570, predators 120:11,524, parasitoids 140:5,261, saprophytes 46:1,139, and omnivores (all Formicidae) 11:8,016. In terms of biomass (dry weight), herbivores were dominant (85,3%), followed by predators (8,8%), saprophytes (2,7%), omnivores (2,4%), and parasitoids (0,8%). As a rule, successional areas had higher biomass, richness, and abundance in all trophic groups than the natural savannas. During the succession, these three attributes decreased only for parasitoids. Also, the richness of herbivores and predators increased up to the 6-year period, but abruptly decreased in the last period. However, their abundance and biomass decreased during the succession. Saprophyte richness, on the contrary, decreased during the succession but its abundance and biomass increased. Omnivore richness remained the same but its abundance and biomass increased up to the 6-year period and abruptly decreased in the last period. In general, and only if we consider the two extreme successional periods, all three attributes decreased as the succession advanced. All trophic groups (except omnivores) showed a significant positive correlation with vegetation cover, green biomass, richness, and percentage of annual plants. After 9 years of succession, the system seems to be far from complete recovery. Floristic and faunistic species composition still differs significantly from the natural area and we believe a much longer recovery time will be necessary to cancel the effects of human intervention in this system. Index terms: succession, savanna, fallow, trophic groups, Trachypogon sp.

[0920] INFLUENCE OF PHOSPHATE-POTASSIC FERTILIZATION ON THE OCCURRENCE THE NATURAL ENEMIES ASSOCIATED TO SOYBEAN

A.M.Cardoso¹, F.J. Cividanes¹ & W. Natale², ¹Depto. de Fitossanidade, ²Depto. de Solos e Adubos, FCAV-UNESP, Via de acesso Prof. Paulo Donato Castellane, s/n - CEP 14870-000, Jaboticabal, SP - Brasil. E-mail: <amcardoso@zaz.com.br>

This study was developed in the experimental area of the São Paulo State University, Jaboticabal Campus, SP, and its objective was to determine the effect of phosphate-potassium manuring on the occurrence of soybean natural enemies. The levels of phosphorus and potassium tested were, respectively: 0, 80, 120 and 160 kg/ ha of P2O3 and 0, 40, 60 and 80 kg/ ha of K2O. The insect population survey was carried out on a weekly, basis using sweep net and ground cloth as sampling tools. Nutritional aspect of the soil fertility was assessed through analysis of soil collected on harvest day. The highest abundance of natural enemies was observed in the following manuring conditions: Nabis sp., at the potassium level enlargement with absence of phosphate; Geocoris sp., in largest potassium level and intermediate phosphate level; Doru sp., in the largest potassium level and phosphate intermediate level; Cycloneda sanguinea in the potassium intermediate level with absence of phosphate. The lowest abundance of natural enemies occurred in the following manuring conditions: Nabis sp., at the increasing of potassium level and phosphate largest level; Geocoris sp., in the phosphate intermediate level and absence of potassium; Doru sp., in the lowest potassium level and intermediate phosphate level; C. sanguinea, in the largest phosphate level and intermediate potassium level. The occurrence of Lebia sp. did not show evident influence from the phosphate-potassium manuring. Lebia sp. and Doru sp. presented positive correlation's with magnesium and organic matter in the soil, respectively; C. sanguinea and Nabis sp., presented negative correlation's with potassium and phosphate levels in the soil, respectively.

Index terms: Nabis sp., Geocoris sp., Doru sp., Cycloneda sanguinea, Lebia sp; ecology.

[0921] BIOECOLOGICAL STUDIES OF RUSSIAN WHEAT APHID IN ARGENTINA AND CHILE

<u>A.M.Castrol</u>, A.A. Clúa¹, B.B. Bellone², L.B. Almaraz², D.O. Giménez¹ & H.O. Chidichimo², ³, ¹ Dept. of Biology and Ecology and ² Dept. of Production, Fac. of Agronomy, Univ. Nac. La Plata, CC 31, 1900-La Plata, Argentina,³ CICBA ameastro@isis.unlp.edu.ar

RWA (Diuraphis noxia, Morvk.) was first reported in Chile in 1988 close to the Pacific Ocean and in Mendoza, Argentina in 1990. Four years later the RWA reached the Atlantic coast and spread northward and eastward infesting barley, bread and pasta wheat. There was none further report of RWA distribution and population dynamics in both countries, information of great value in terms of pest management. Since 1995 five recollections have been made to determine the presence of RWA. In Argentina, RWA is distributed between 26° 50' SL to 43° 28' SL. The presence of that aphid is remarkable from the isothermal of 20-22°C and the isohiet of 400-600 mm to the isohiet of 2000 mm. In Chile, RWA was found from Osorno (38° 13') to Temuco (38° 20') in the isothermal of 8-10°C and from the isohiet of 1000 mm to the isohiet of 2000 mm. In later spring had a poor presence in the Central Valley and resulted abundant from the 1000 m of altitude compared to the sea level. The most austral RWA population was collected in Teka and the most meridional was found in Tucuman. Conversely to the distribution of this dangerous pest in USA, RWA was found in regions with 2000 mm of rainfall, meanwhile in North America it was not found farthest than the isohiet of 750-1000 mm. The aphids collected showed a wide range of host preference (rye, barley, poa, Bromus, Hordeum spp., wheat) . This pest was first found infesting oats and in low latitudes preferred Sorghum halepensis. Highly variability was found in five isozyme systems between and within populations. The RWA breeding system was studied under natural conditions in La Plata (36° 36' SL, 57° 44' WL). Aphid populations and 10 derived clones of every population were reared on susceptible hosts form March to December under uncontrolled conditions during four years. Only 20% of RWA clones induced sexuals irrespective of the host where they were collected, the period of the year or the region of collection. Probably the air temperature and the shortest daylength in La Plata are not enough extreme conditions for RWA requirements.

Index terms: RWA, *Diuraphis noxia*, distribution, host range, genetic variability, breeding system

[0922] INFLUENCE OF PHOSPHATE-POTASSIC FERTILIZATION ON THE OCCURRENCE OF SOYBEAN INSECT PESTS

<u>A.M.Cardosof</u>, FJ. Cividanes¹ & W. Natale², ¹Depto. de Fitossanidade, ²Depto. de Solos e Adubos, FCAV-UNESP, Via de acesso Prof. Paulo Donato Castellane, s/n - CEP 14870-000, Jaboticabal, SP - Brasil. E-mail: <ameardoso@zaz.com.br>

This study was developed in the experimental area of the São Paulo State University, Jaboticabal Campus, SP, and its objective was to determine the effect of phosphatepotassium manuring on the occurrence of soybean insect pests. The levels of phosphorus and potassium tested were, respectively: 0, 80, 120 and 160 kg/ ha of P2O3 and 0, 40, 60 and 80 kg/ ha of K_cO. The insect population survey was carried out on a weekly, basis using sweep net and ground cloth as sampling tools. Nutritional aspect of the soil fertility was assessed through analysis of soil collected on harvest day. The highest abundance of insect pest was observed in the following manuring conditions: Diabrotica speciosa, in the largest phosphate and potassium levels; Piezodorus guildinii, in the largest phosphate level and without potassium; Cerotoma sp., without potassium manuring and intermediate phosphate level; Anticarsia gemmatalis, in intermediate phosphate-potassium levels. The lowest abundance of insect pest occurred in the following manuring conditions: D. speciesa, in the largest phosphate level and lowest potassium level; P. guildinii, without phosphate-potassium manuring; Cerctoma sp., without phosphate-potassium manuring: A. gemmatalis, intermediate potassium dose and absence of phosphate. P. guildinii presented positive correlation's with calcium and phosphate levels in the soil while Cerotoma sp., presented positive correlation's with calcium levels.

Index terms: Diabrotica speciosa, Piezodorus guildinii, Cerotoma sp., Anticarsia gemmatalis, ecology.

[0923] GENERAL PRINCIPLES OF INSECT MORTALITY DYNAMICS

I. R. Carev, Department of Entomology, Univ. of California, Davis, CA 95616, USA. Email: ircarev@ucdavis.edu.

In this paper I will provide an overview of the mortality dynamics of insects focusing on: (1) principles derived from the results of large scale life table studies on the Mediterranean fruit fly (*Ceratitis capitata*) including slowing of mortality at older ages, mortality crossovers, costs of reproduction, density effects, two-mode aging rates, life span indeterminacy, and subdetectable mortality; and (2) comparative demography of adult insect longevity including between- and within-order comparisons and hypotheses on the environmental and social factors that favor the evolution of extended longevity—resourcebased factors (uncertainty and scarcity) and kin-based factors (parental care; monogamy and eusociality).

[0924] HOW THE NUTRITION OF SPRUCE BUDWORM PARENTS INFLUENCES THE OFFSPRING

N. Carisey & É. Bauce, Département des Sciences du Bois et de la Forêt, Faculté de Foresterie et de Géomatique, Université Laval, Ste-Foy, Québec, G1K 7P4 CANADA, Enail nathalie.carisey@sbf.ulaval.ca.

Spruce budworm (SBW), Choristoneura fumiferana is the most important defoliator of the boreal forest in North America. SBW feeding lasts from mid-May to carly July. In August, the newly-hatched first-instar larvae build an hibernaculum, moult into second instar and enters diapause which lasts eight months until the next Spring without any feeding activity. Energy reserves of diapausing larvae come exclusively from their parents and thus might be strongly influenced by the parent nutrition. In laboratory, SBW larvae were fed with four different diets - various nitrogen and total soluble sugar concentrations found in balsam fir foliages -, moths were mated and offspring performance was determined. Although females from the different diets had similar pupal weight, those fed diet poor in nitrogen and total soluble sugars (PNS) laid 22% less eggs than those fed diet with medium nitrogen and total soluble sugar concentrations (MNS). The hatching rate of eggs from MNS parents was 28% higher than that of eggs from PNS parents. The firstinstar mortality was much higher when parents were fed PNS. Quantities of energy reserves (triglycerids and glycogen) in offspring were similar whatever diet the parents ate and could not explain results on hatching and first-instar mortality. Some other autritional dependant factors have to be elucidated. Offspring mortality from second instar to pupae was higher when parents ate rich nutritive diet than when they ate poor quality food. These results suggest that food quality could induce a selective pressure that could allow spruce budworm to adapt its fitness as outbreak progresses and foliage quality decreases

Index terms : Choristoneura fumiferana, food quality, selective pressure

[0925] LOSS OF TENEBRIONID DIVERSITY IN MEDITERRANEAN ISLANDS AS INDICATOR OF ENVIROMENTAL DEGRADATION (COLEOPTERA TENEBRIONIDAE)

M. C. Cartagena & <u>E. Galante¹</u>, lCentro Iberoamericano de la Biodiversidad. Univ. of Alicante. P.O. Box 99. E-03080 Alicante, Spain. E-mail: galante@carn.ua.es.

The Mediterranean ecosystems, mainly coastal and insular areas, are suffering in the last decades an incessant human pressure that causes a great degradation of those environments. Arthropods are generally used to monitor environmental degradation or to be protected areas. The insular ecosystems have animal populations vanishing to extreme conditions. Moreover, factors such as the population density and demographic structure, and also distribution and abundance of resources, change dramatically when compared with continental situations. Islands are natural laboratories: small, isolated and with relatively simple processes compared to continental situations. Their study is also appropriate because their faunas appear to be more sensitive to environmental changes and more prone to extinction than continental ones. The study of the entomological fauna of these ecosystems, and specially the study of typical land insects as tenebrionid coleopterous, frequently wingless and with limited dispersal abilities, is very important in order to know the environmental conservation. Also this group of insects has a great value in the biogeographical studies, and also as indicators of faunistic relationships among many insular areas. The vulnerability of small insular ecosystems and the tourist pressure along the whole Mediterranean coast conducted us to undertake investigations for detecting their current conservation status and preservation of biodiversity. According to these subjects, we carried out the study of Coleoptera Tenebrionidae fauna, in insular environments from eastern Iberian Peninsula to evaluate the tenebrionid populations and to analyze the changes occurred in the last years.

Index terms: coleoptera, insular ecosystem, conservation

[0926] COMPARATIVE BIOLOGY OF URBANUS PROTEUS (LEPIDOPTERA: HESPERIIDAE) IN CENTROSEMA PUBESCENS, CLITORIA FAIRCHILDIANA, GLYCINE MAX AND PHASEOLUS VULGARIS (LEGUMINOSAE)

A. G. Carvalho¹ & M. R. Silva¹, ¹Depto. de Produtos Florestais, Univ. Fed. Rural do Rio de Janeiro, Seropédica, RJ 23851-970, Brasil. E-mail: acacio@ufrrj.br.

This work had as finality the comparative study of the major biological aspects of the Urbanus proteus defoliate species (Lepidoptera, Hesperiidae) through the use of natural feeding based on leaves of the following leguminosae: Centrosema pubescens, Clitoria fairchildiana, Glycine max and Phaseolus vulgaris, in laboratory. The period of the egg's incubation was of about five days. Through the taking of the cephalic capsules, it was verified the occurrence of five larval instars for each of the four kinds of feeding used. The caterpillars feeded with leaves of the C. pubescens presented the biggest average duration in the larval period followed by the ones feeded with C. fairchildiana, G. max and P. vulgaris, respectively. The leguninosae, which provided the biggest weight gain to the caterpillars in the respective larval instars, were: P. vulgaris, in the second and C. fairchildiana, in the third, fourth and fifth instars. The prepupas originating from the caterpillars feeded with leaves of C. pubescens presented higher average duration than the ones feeded with C. fairchildiana, P. vulgaris and G. max. The pupas arising from caterpillars which were feeded with leaves of C. fairchildiana presented higher average weight than the ones feeded with leaves of C. pubescens, G. max and P. vulgaris. The adults which presented bigger average longevity were the ones originating from caterpillars feeded on leaves of C. pubescens, followed by C. fairchildiana, P. vulgaris and G. max, respectively. The females originated from the caterpillars feeded with leaves of G. max presented bigger average number of ovules per virgin female, followed by the ones originated from the caterpillars feeded on leaves of C. fairchildiana, C. pubescens and P. vulgaris, respectively. The individuals feeded with leaves of C. pubescens presented average duration of the life cycle higher than the individuals feeded with leaves of C. fairchildiana, G. max and P. vulgaris. The preference test showed that the U. proteus caterpillars preferred the leaves of C. fairchildiana, followed by the ones of C. pubescens, P. vulgaris and G. max, respectively. The kind of feeding used did not influence in the number of larval instars. There was no mortality of the U. proteus caterpillars due to the kind of leguminosae used in the feeding. The U. proteus species completed the life cycle the four kinds of leguminosae used as food. Index term: Defoliate.

[0927] 2REVIEW OF *CHALCOLEPIDIUS* (ELATERIDAE, AGRYPNINAE, HEMIRHIPINI)

S.A. Casari, Museu de Zoologia da Universidade de São Paulo, Caixa Postal 42 694, 04299-970 São Paulo, SP, Brasil. E-mail: casari@pop.usp.br.

The tribe Hemirhipini includes 26 genera and about 400 species worldwide distributed. The generic revision, with a cladistic analysis, was published in 1994 (Casari-Chen). This work revealed that several species were not congeneric and the revision of some genera to specific level were required. The study of six genera were published, and that of Chalcolepidius Eschscholtz, 1829 is now presented. The Chalcolepidius are recognized especially by integument clothed with colorful scale-like setae, scutellum "triangular" or folded and borders of mesosternal cavity horizontal without suture at base. It was established for four species from Elater, E. porcatus F., E. striatus F., E. sulcatus F. and E. virens F., and three new species, C. limbatus, C. smaragdulus and C. zonatus. Next, several species were described, always based only on the coloration of scale-like setae and shapes of scutellum and 3rd antennal segment. The only revision of this genus is that of Candèze (1857), who presented also a catalogue in 1891 and published several new species. At that time the genus was formed by 33 species, but later many species were described, totalizing 88, with about 160 nominal species. During this work, 8,750 specimens belonging to 85 valid species, including 55 types, were studied. Three species were not examined because the types were not located and any material corresponding to original description was found. For each studied species, a colored picture was taken and the antennae of male and female, pronotum, scutellum, borders of mesosternal cavity, fore leg of male and genital segments and genitalia of male and female were illustrated. The analysis of these characters, together with the pubescence coloration were useful to define the species, now redescribed. The analysis revealed that three species, C. alici Pjatakowa, C. haroldi Candèze and C. unicus Fleutiaux, are not congeneric and should be tranferred to Alaus, 36 species are synonyms, one was revalidate and 11 new species are described. The genus is now composed by 64 species.

Index terms: Coleoptera, Elateridae, systematics.

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[0928] EFFECT OF TOMATO HAIRINESS IN SURVIVAL AND FECUNDITY OF T. URTICAE AND N. CALIFORNICUS [ACARI: TETRANYCHIDAE: PHYTOSEIIDAE]

C. Cédola¹ & N. Sánchez¹, Centro de Estudios Parasitológicos y Vectores (CEPAVE) -Universidad Nacional de La Plata – CONICET. Calle 2 nº 584 (1900) La Plata, Argentina

The tomato is one of the most representative crops in the surrounding areas of La Plata (Buenos Aires, Argentina). This crop is attacked by numerous pests, among which, spider mites, Tetranychus urticae Koch (Acari: Tetranychidae) induce the frequent use of acaricid and frequently place the consumer's health in danger. The predator mite Neoseiulus californicus (McGregor) (Acari: Phytoseiidae) is the most widespread phytoseiid mite associated with spider mites. The interaction between arthropod phytophagous and their natural enemies can be modified by the chemical and physical properties of the plants. The variety and quantity of hairs and glandular trichomes characterize the tomato plant. The objective of this work was to determine the effect of tomato hairiness on the survival and fecundity of Tetranychus urticae and Neoseiulus californicus. Survival and fecundity of both species were estimated on two tomato hybrids having different densities of glandular hairs: Parador (23.67 ± 4.77 hair / 19.63 mm 2) and Fortaleza (48.33 ± 8.21 hair / 19.63 mm2). Experiments were conducted in controlled conditions of temperature, relative humidity and photoperiod (25 ± 1 °, 50-75% and 14:10 (L:D) h, respectively). The survival of the immature stages and the adult of T. urticae was not affected by tomato hairiness but the fecundity was. Fecundity of Turticae was significantly lower in Fortaleza. The survival of the immature stages of N. californicus was negatively affected by the hairiness (56% of the cohort reached maturity on Fortaleza compared to 82% of the cohort on Parador). However, survival and fecundity of adults was not affected by the hairiness. Fecundity of *Turticae* and N.californicus on the tomato was lower than that observed in other hoticultural crops. The tomato plant seems to be a less favorable resource to the establishment of T. urticae - N. californicus system than other horticulture crops. An antibiosis process due to glandular hairs could be, at least in part, the cause of this effect, since it was most strongly seen in the Fortaleza hybrid. These results show the necessity to understand tritrophic interactions before implementing the pest management programs for the control of T. urticae, on the tomato

Index term: Tetranychus urticae, Neoseiulus californicus, tritrophic interactions, tomato.

[0929] LIFE HISTORY AND INUNDATIVE RELEASE OF GREEN LACEWING, MALLADA BASALIS

<u>C. P. Chang</u>, Miaoli District Agricultural Improvement Station, 261 Kuan-Nan Village, Kung-Kuan, 363 Miaoli County, Taiwan.

The Mallda basdlis is a well known natural enemy. A series studies on the life cycle of this insect had been done . The life cycle of this insect is observed in the laboratory. The results of these observations are summarized as follows. The insect completed 10 generation in a year averagedly. The duration of each generation varied with temperature. In average, larval stage and pupal stage look 4.38, 11.83 and 11.92 days, respectively. The life span of female and male adults lasted 70.80 and 76.94 days, respectively. The insect needed 28.13 days to complete a life cycle, In average, it laid 13.72 eggs per day and total of 736.34 eggs could be produced by a female adult. Present experiment was conducted to evaluate the effectiveness of using the predator. During strawberry growing season, the mites were controlled by releasing the eggs or larvae of green lacewing on every plant in a 3-week intervals. As a result, 60 to 90% of kanzawai spider mite population and 50 to 90% of two-spotted spider mite population were suppressed by the predators. This measure not only saved the cost of control to more than US \$233/ha, but also increased 15% of fruit production and 7.7% of first class fruit. Besides, the deformed fruit in the predatorreleasing plots was about 6.1% lower than that chemicals controlling plots. Index terms: life cycle, biological control, evaluation, effectiveness.

[0931] BIOLOGY AND REPRODUCTIVE BEHAVIOR OF CENTRIS RODOPHTHALMA (HYMENOPTERA: ANTHOPHORIDAE)¹

E. Chiappa², R. Bascuñán² & S. Rodriguez³, ¹ Supported by FONDECYT Grant 1971141; ² Fac. of Sciences. Univ. of Playa Ancha, 34-V, Valparaíso, Chile. E-mail echiappa @upa.cl; ³ Lab. of Zoology, Catholic Univ., Valparaíso. boxmail 4059, Valpso., Chile. E-mail srodrigu@ucv.cl.

The genus Centris is a widely distributed group of species of the American continent, largely found it in tropical areas but also in arid zones. Only meager information is available on the biology and reproductive behavior of chilean species of Centris. For three years we have been studying the nesting and reproductive behavior of Centris (Wagenknechtia) rodophthalma Pérez, an endemic bee of III and IV Region of Chile, oligolectic on Adesmia glutinosa, A. pedicellata and Geoffroea decorticans (Fabaceae). Observations was conducted in 3 localities of the IV Region of Chile: Varillar, Andacollito and Hurtado. The bees appeared on the first week of August and adult activity was at a high level until last days of October, the peak of daily activity, both females and males, was between 1100-1200. Females searched for nest sites by flying randomly over the floor, the nests were widely scattered, excavated in earth in horizontal surfaces. Nest entrances located under debris, without turrets, borrows unbranched, slighty round 13-15 mm diameter. entered the soil at 45° angle to a depth of 6-7 cm long, terminated in a 1-3 cells. The cells are similar and characteristic of ground-nesting Centris bees, near the center of the closure there was a spoutlike projection that rose from the center and then bent horizontally. The egg curved, was placed on the center of the provisions, the second instar emerged 14 days later, the predefecant larva commenced the cocoon construction 45 days later and completed it in 4 days, C. rodophthalma was protandreus, males searched for females patrolling at the bushes or they perched, but did not established territories. Without courtship the males quickly mount females; copulations lengh is 75"- 80"; females rejected males frequently. They spend the night in groups of 3-6 individuals in the center of the bushes. In a comparative way with, Thornhill & Alcock, (1983) the mating system of this bee can be classified as scramble competition polygyny. Index terms: Centridini bees, mating behavior, larvae, nests, Chile

[0930] VERTICAL-LOOKING RADAR: A POWERFUL NEW TOOL FOR MONITORING INSECT FLIGHT AT ALTITUDE

J. W. Chapman¹, <u>I. P. Woiwod¹</u>, A.M. Dewar², D. R. Reynolds³, A. D. Smith³ & J. R. Riley³, ¹ IACR Rothamsted, Harpenden, Herts., AL5 2JQ, UK, E-mail Ian.Woiwod@bbsrc.ac.uk; ² IACR Brooms Barn, Higham, Bury St Edmunds, Suffolk, IP28 6NP, UK; ³ NRI Radar Unit, Great Malvern, Worcs., WR14 1LL, UK.

Both current and long-term monitoring of migratory insect populations are desirable for a variety of reasons, including the management of pest species and assessment of the impacts of environmental change. Traditional monitoring strategies, such as the Rothamsted Insect Survey's suction-trap network in the UK, do not provide direct information about insect migration at altitudes greater than their sampling height. Therefore, to supplement the information provided by suction traps a means of remotesensing insects at greater altitudes is needed. The expensive and labour-intensive nature of scanning radar technology has previously constrained its use for long-term monitoring, but the recent development of an inexpensive vertical-looking radar (VLR) has now made routine and long-term radar monitoring a practical proposition. VLR equipment has been in operation on the roof of the Entomology & Nematology Department at Rothamsted, south-east England, since May 1999. Coverage extends vertically from 150 to 1200 m above the radar. The unique analysis capabilities of the VLR allows the body mass of over-flying insects to be estimated, as well as providing measurements of their altitude, aerial density, body alignment, speed and direction of movement. These data can be readily stored on a PC database for subsequent analysis. Comparative analysis of the radar data with insect samples routinely collected by the Rothamsted Insect Survey's suction and light-trap networks, and from balloon-suspended aerial nets, should allow identification of many of the larger insects recorded by the VLR. The operation and capability of the VLR, and also the aerial netting technique used for sampling insects at altitudes of more than 200 m are described. Examples of the results obtained by the VLR, such as patterns of diurnal activity and the effects of meteorological factors on insect flight behaviour are presented.

Index terms: VLR, remote-sensing, aerial density, aerial netting, Rothamsted Insect Survey

[0932] BIOLOGY OF THE GUAVA COTTONY SCALE, *CAPULINIA* SP. NEAR *JABOTICABAE* (HEMIPTERA: ERIOCOCCIDAE) AND PHYSICAL EFFECT OF BARK EXFOLIATIONS OF GUAVA PLANT

D. T. Chirinos⁽¹⁾, F. Geraud-Pouey⁽¹⁾ y G. Romay⁽¹⁾, ¹. Unidad Técnica Fitosanitaria, Facultad de Agronomía, La Universidad del Zulia Apartado 15205, Maracaibo 4005, Zulia, Venezuela. Telefax (58 61) 597113. E-mail: dtchirinos@hotmail.com.

The guava cottony scale, Capulinia sp. near jaboticabae (Hemiptera: Eriococcidae), apparently a new species to science or at least on guava (Psidium guajava) became the most destructive pest in Venezuela since its appearance in 1993. During January-August 1999 studies were conducted on biology of the insect and the physical effect of bark exfoliations on its establishment, survival and development under room conditions utilizing potted guava plants. Duration of development of life cycle stages, discriminated by sex, sex ratio, longevity of adults and fertility were determined. To evaluate the physical effect of bark exfoliations three conditions were included: plants with natural exfoliations, with exfoliations mechanically removed and substituted by artificial simulations (paper napkins) and plants without exfoliantions. Eggs hatched after 8 days. The female undergoes two and the male four nymphal instars. First instar nymphs for both sex lasted 8.48±0.03 days and the second instar took 6.05±0.03 y 4.57±0.02 days for female and males respectively. At the end of the second instar the male forms a cigarshaped cocoon of wax filaments where it remains until adult emergence after undergoing inactive third and fourth instars, lasting 2.04±0.01 and 3.66±0.02 days respectively. After the last moult the tenereal adult remains in the cocoon up to one day until forming a pair of waxy caudal filaments which protrude through the distal opening if the cocoon. Adult longevity was 46.67±0.61 y 1.10±0.01 days for the female and male respectively. The proportion female: Male resulted de 1: 1.27 and the fertility 2511.94±57.20 eggs/female. Due to its greater development and longer feeding time the female might cause most of the damage to the plant. The male only feeds during the first and part of the second nymphal instar. The female's high fertility explain the possibility for developing large populations such as those observed when the insect colonized new areas. The duration of development was little affected by bark exfoliations but survival of first instar nymphs was significantly increased when natural or artificial exfoliations existed (70%, P<0.05) as protected setting sites for feeding. As seen in the field lack of exfoliations could constitute a source of resistance, although insufficient by itself, susceptible to potentate its effect in combination with natural enemies in lowering Capulinia sp. populations. Key words: Coccoidea, host plant, survivorship, life hystory

[0933] LIFE HISTORY OF ACRONICTA RUMICIS REARED ON THE NATURALIZED PLANT, RUMEX OBTUSIFOLIUS AS A HOST PLANT

Y. H. Cho¹, O. S. Kwon² & <u>S. H. Nam¹</u>, ¹Dept. of Biology, Taejon University, 96-3, Yongwun-tong, Tong-gu, Taejon, 300-716, Republic of Korea; ²Dept. of Sericulture and Entomology, National Institute of Agricultural Science and Technology, 61, Seodun-tong, Kwonseon-gu, Suwon, 441-100, Republic of Korea.

This study was conducted to investigate the life history of Acronicta rumicis on its new host plant, Rumex obtusifolius which is a naturalized plant in Korea. Prunus yedoensis as an existing host plant was used for the comparison. The study was started on March 1998 and finished on September 1999. A total of 5 generations was reared in the laboratory. The life history was studied from July to September (65 days), using 100 eggs (second generation) for each host plant. The environmental condition was controlled at 27° C, 70% RH, and 14-hour daytime length. Survivorship of the insect showed no difference on both plants. The life cycle took 37.9 ± 0.57 days on R. obtusifolius, and 43.3 ± 0.82 on P. yedoensis. The larval weight of A. rumicis reared on R. obtusifolius was consistantly higher than those reared on P. yedoensis throughout the life stages. It is suggested that A. rumicis is successfully adapted to the new host plant, R. obtusifolius. Index terms: life cycle, survivorship, naturalized plant.

[0935] ESTIMATION OF THERMAL THRESHOLD AND DEGREE-DAY MODEL FOR PREDICTING THE OCCURRENCE OF THE CABBAGE APHID (HOMOPTERA: APHIDIDAE)

F. J. Cividanes, Depto. de Fitossanidade, UNESP/FCAV, Via de acesso Prof. Paulo D. Castellane, s/n, Jaboticabal, SP, CEP 14884-900, Brazil, E-mail fjcivida@fcav.unesp.br.

The cabbage aphid *Brevicoryne brassicae* (L.) had determined under field conditions the period of nymphal development using cabbage as host plant. It was done in experiments where the calculation of the developmental period for all cohorts were based on the time from larviposition to the date on which the first adults appeared. Hourly temperatures were recorded from the point of first larviposition, summed, and averaged up to the midpoint of the day on which the first adults appeared. Developmental thresholds (Tb) and thermal constants (K) were determined by regressing developmental rate against temperature. The threshold temperature was approximated by the intersection of the regression line with the X axis and the thermal constant was calculated as K = 1/b, the inverse of the line's slope. The thermal requirements and the method used to compute accumulated degree-day allowed realistic predictions of adult emergence.

Index terms: Hemiptera, temperature, Brassica oleracea

[0934] EXPERIMENTAL OBSERVATIONS ON THE OUTBREAK OF INFESTATION BY KNEMIDOKOPTES PILAE (ACARINA: KNEMIDOKOPTIDAE) IN PARROTS (MELOPSITTACUS UNDULATUS)

F.Cianficconi¹, M.Principato² & G.Spinelli¹, ¹ Dipartimento di Biologia Animale ed Ecologia, Università di Perugia, Via Elce di Sotto,06123 Perugia, ITALIA; ² Dipartimento di Scienze Biopatologiche Veterinarie, Via S.Costanzo,4,06100 Perugia,ITALIA.

The mange of parrots caused by Knemidokoptes pilae is a serious infestation, which though withslow course, can lead the bird to death for cachexia. Although it occurs frequently, the factors favouring its outbreak are not well known. The biological behaviour of K. pilae seems to be similar to that of other mites, such as Sarcoptes scabiei in mainmals which determines a deep mange, but contrarily of that mite, it does not seem to be infectious at all. In fact, if parrots affected with serious mange are kept for months in captivity with other healthy birds, the illness does not pass on these ones. On the other hand, it seems inexplicable how the infestation can suddenly rise up in groups of healthy birds. We effected therefore some experimental tests with the aim of trying to understand the factors favouring the outbreak of mange. Two couples of parrots, one of which affected with mange, were placed under conditions of high relative humidity (80% RH), maintained constant by a NaCl saturated liquid and two more couples, one of which affected with mange, were kept at a reduced level of RH (55%). In both cases the temperature was stabilized around 20°C. After 46 days, two of the parrots kept at 80% HR showed the first evident signs of infestation: two small holes in their beaks, under their nasal cavities. After 38 more days the infestation was evident on the limbs showing hyperkeratosis and a tiny hole containing a K. pilae female. Three months later the infestation was clinically evident and the first lesions began to rise up on the wings and on the perianal skin. After such period the experimental was stopped. Throughout the experiment, one of the parrots did not show any sign of illness. The birds kept at low RH (55%) were not infected. This simple experiment shows how the rate of environmental humidity is relevant for the infestation outbreak, though some subjects may turn up particularly resistant. We can also assume that the infestation is maintained quiescent for the presence of nymphal instar of the mite remaining among the feathers and penetrating into the skin only when the conditions of RH become favourable. Index terms: mange, mites, Relative Humidity.

[0936] INTERACTIONS BETWEEN CLIMATE, PASTURE GROWTH AND PARASITES IN DEVELOPMENT OF OUTBREAKS OF AN ACRIDID, PHAULACRIDIUM VITTATUM IN SOUTH-EAST AUSTRALIA

A.D. Clifft¹ & G.L. Baker², ¹ Department of Crop Sciences, University of Sydney, NSW 2006, Australia, E-mail clifta@agric.usyd.edu.au; ² Australian Museum, 6 College St., Sydney, NSW 2000, Australia

The Tablelands of south-castern Australia (600->1200 m) are periodically subject to outbreaks of a complex of acridids, dominated by Phaulacridium vittatum, which infest pasture and horticultural crops. Changes in abundance have been studied over a sequence of 15 seasons and key factors influencing abundance identified. Outbreaks are associated with seasons of below average rainfall which increase both survival and the extent of favourable habitat: survival because parasitism by mermithid nematodes is suppressed under dry conditions and the extent of favourable habitats because dry conditions reduce plant cover promoting establishment of broad leafed weeds, favoured food plants of P. vittation. Dispersal of the into newly created, parasite free, habitats results in a population explosion and consolidation of infestations. During the dry seasonal conditions under which outbreaks occur, competition between grasshoppers and stock for the limited available pasture is maximal. Outbreaks persist until either drought intensifies to the extent where it reduces food plant availability, lowering fecundity, or conversely above average rainfall increases mortality from mermithid nematode parasites. High rainfall also reduces the extent of favourable habitats by creating a thick sward, resulting in competitive displacement of broad leafed weeds by grasses. This physically restricts oviposition and disrupts the hatching of eggs. Chronic infestations persist between outbreaks in areas unfavourable for nematodes such as well drained ridges and disrupted habitats like recently established pastures: cultivation for cropping purposes or to establish pasture was more detrimental to mermithid survival than drought. Long term survival of mernuthids is dependent on maintaining the biodiversity of the acridid fauna where differing phenologies ensure turn-over within hosts under a wide range of seasonal conditions. An understanding of the interactions between climate, pasture and mermithid parasites in determining the abundance of acridids has enabled the prediction of both the onset and collapse of outbreaks, allowing the adoption by landholders of farm management practices that minimise the economic impact of outbreaks.

Index terms: Phaulacridium vittatum, mermithid nematode, weeds, cultivation, drought

[0967] DYNAMICS OF THERMOPREFERENCE IN TRIATOMA SORDIDA

<u>M.J. Corchs</u> & C.R. Lazzari, Lab. de Fisiología de Insectos, Dpto. Biología, Univ. de Buenos Aires, Ciudad Universitaria, 1428, Buenos Aires, Argentina. E-mail: yuli@bg.fcen.uba.ar. Supported by: UNDP/Work Bank/WHO (TDR); CONICET, Univ. de Buenos Aires (Argentina).

Although being ectothermic animals, insects can affect their body temperature and metabolism behaviorally. As a consequence, the active choice for places at particular temperatures can be affected by the physiological state of the animal. The comparison between different species and with the climate in natural habitats, help to comprehend the particular adaptation of a given species to certain ecotopes. Triatomines include more than one hundred species that occupy a diversity of habitats. T. sordida is endemic of the "Cerrado", in Central Brazil and now distributes also throughout the Chaco region and central Argentina. This species is found under bark and hollow trees, and acts as a secondary vector of Chagas disease. We studied the behavior of T. sordida in temperature gradients. Adult bugs were reared in the laboratory at 30°C and fed on live chickens. Two experimental arenas (40 cm length x 12 cm width x 3.5 cm heigth) rest over an aluminum plate. In each arena, a temperature gradient (24°C-32°C) was established by means of an electric heater and a cold-water bath, related to each end of the aluminum plate, respectively. Both, cold and warmth sources were thermostatized at 0.1°C. After feeding, male or female bugs were released inside one arena. The position of the insects was recorded at every 30 minutes during 12 days, by means of a computerized system that controlled a video recorder, connected to an IR-sensitive CCD camera. A LD regime of 12h/12h was superimposed over a constant illumination provided by IR-LEDs that is not perceived by bugs. Results evinced that the thermopreference of T. sordida is not a static phenomenon, but shows both a daily variation and a variation according to nutritional status. Recently fed bugs preferred to stay at 28.5°C. After 12 days without feeding, bugs moved towards ca. 25°C. A relative difference of 1°C in the preference of males and females was maintained along the whole experimental period, females staying at higher temperatures. Both sexes showed a daily rhythm of variation, which amplitude reached about 2-3°C, with a maximum occurring during the second half of the scotophase. Similar patterns have been observed in other triatomines, each species exhibiting a particular amplitude, phase and slope in these dynamic processes. The long-term variation can be ascribed to a mechanism of behavioral regulation of the metabolic rate. The daily pattern could be related with the circadian pattern of activity displayed by each species. Index terms: triatomines, temperature, behavior, Chagas

[0938] LIFE HISTORIES OF EPHEMEROPTERA IN COMECHINGONES MOUNTAIN STREAMS

<u>M. del C. Corigliano</u>,¹, A. Barbosa¹ & L. Belver¹, ¹Depto. de Ciencias Naturales, Universidad Nacional de Rio Cuarto, X5804-BYA Rio Cuarto, Argentina. E-mail: mcorigliano@exa.inrc.edu.ar.

The life histories of four species of Ephemeroptera in streams of the Comechingones mountains (Cordoba, Argentina) have been surveyed. The study area was localized in Piedra Blanca stream where monthly Surber net samples were taken in a stretch of runs and riffles, at 640 m.a.s.l. Hydrological conditions and environmental variables were registered. The first right femur of 30 individuals, from each sample, was measured to carry out a size frequency analysis. The studied species were Baetis sp., Camelobaetidius penai, Tricorythodes popayanicus and Leptohyphes sp. Baetidae species populations were bivoltine with two generations, and early spring emergent generation with slow growth in winter and a second generation with fast growth in summer. Leptohyphidae species populations were multivoltine with a longer winter generation and two or three fast generations in late spring and summer. There were observed differences in body sizes and estimated biomass among studied species. Baetidae species had longer developmental times and larger body sizes than Leptohyphidae species. Population densities were 20 times over the average density values reported in published data from streams of other biomes, while body sizes were smaller. Baetis sp. showed the maximal mean density of \overline{X} : 17629 ind. m ², maximum values were registered during summer. All species, except Camelobaetidius penai, were presented along the year in the study site. Torrential streamflow, with strong rainfalls and scouring floods concentrated in the summer, would determine the selection of species of small size, high density and short life cycles.

Key words: Baetis sp., Camelobaetidius penai, Trichorythodes popayanicus, Leptohyphes sp.

[0939] GROWTH PATTERNS OF INCIPIENT COLONIES OF *COPTOTERMES HAVILANDI* (ISOPTERA, RHINOTHERMITIDAE) INITIATED IN THE LABORATORY FROM SWARMING ALATES

A.M. Costa-Leonardo¹ & R.C. Barsotti¹, ¹Department of Biology, Universidade Estadual Paulista, Av. 24-A, 1515, 13506-900, Rio Claro-SP, Brazil. E-mail: amcl@rc.unesp.br. Financial support: CNPq

Knowledge of the subterranean termite biology is essential for their control in the present days. Biological studies of these termites, in particular those that involve entire colonies, are difficult because of their cryptic habits. In this research we report the analysis of incipient colonies which were initiated from alates of the pest termite Coptotermes havilandi. Fifty two colonies were set up in August of 1997 using alates collected from urban swarming of Rio Claro (22° 21' 49 S, 47° 31' 32 W), S.P., Brazil. A pair of mature alates was placed in each 6 cm diameter plastic Petri dish (22 ml), which contained a moistened matrix of decayed pine sawdust. After 6 months, the colonies were transferred to a 250ml plastic container with the same culturing matrix. After 24 months, it was possible to stablish colony growth patterns and caste investment with the entire census of these 52 colonies. At the time of the census each colony had a pair of live primary reproductives and a total population (workers + soldiers + imatures + reproductives) ranging from 64 to 1164 individuals, with a mean of 345 individuals. The number of workers ranged from 53 to 830, with a mean of 223 per colony. The number of soldiers ranged from 6 to 83 per colony with a mean of 25. The number of soldiers plus presoldiers ranged from 6 to 86, with a mean of 26. The present data show a higher population than our previous records for C. havilandi, which never before exceeded 100 individuals per colony. The results show no linear development in the incipient colonies and indicate the use of more adequate conditions than those from our previous study. We also chose at random, 12 transferred incipient colonies to compare their development with 12 colonies kept in 6 cm diameter Petri dishes. The results showed an influence of the container in the growth of the incipient colonies and a positive correlation between queen weights and nonulation size.

Index terms: termite, young colonies, colony population.

[0940] FORAGING POPULATION ESTIMATES FOR TWO COLONIES OF COPTOTERMES HAVILANDI (ISOPTERA, RHINOTERMITIDAE) USING MARK-RECAPTURE STUDIES

A. M. Costa-Leonardo¹, C. R. R. de Camargo-Dietrich¹, F. C. Leonardo¹ & J. T. Lima¹, ¹Department of Biology, Universidade Estadual Paulista, Av. 24-A, 1515, Bela Vista, Rio Ciaro-SP, 13506-900, Brazil. E-mail: amcl@rc.unesp.br. Financial support: CNPq

Most research of Coptotermes havilandi in Brazil has not focused its foraging ecology and population dynamics. The present study was conducted to provide informations about the foraging biology of this pest termite in an urban area of São Paulo state. A heavy infestation of C. havilandi was found in a building of the Universidade Estadual Paulista (UNESP) located in the town of Rio Claro, SP, Brazil (22°21'49S, 47°31'32W). A triple mark-recapture programe was developed to assess the number of colonies present in the area, their territories and foraging populations. Traps of rolled corrugated cardboard were placed in-ground (around the building), on trees (in front of the building) and above ground (inside the building) to determine the trap stations. Termites collected from these stations were fed with filter paper impregnated with Nile Blue and Neutral Red dyes. A weighted mean model was used to estimate the foraging populations and associated standard error. The results showed two colonies (A and B) in the study site with foraging populations of 575,721±9,330 and 737,545±14,834 respectively. The foraging territory of the colony A (red colony) covered an area of about $395m^2$ and involved two urban trees of Caesalpinia peltophoroides. The foraging territory of the colony B (blue colony) covered an area of approximately 10m2 involving only above ground stations inside the building. Marked termites from colony A were recaptured at a maximum linear distance of 30m from their release point while marked foragers from colony B were recaptured at a maximum linear distance of 6.4m only. The mean of individual worker biomass was calculated by weighing eleven groups of ten individuals each. The mean of worker biomass was 3.6mg in the colony A and 3.7mg in the colony B. Foraging biomass was determined multiplying the mean worker weight by the foraging population. The foraging biomass was estimated at 2.1 kg in the colony A and at 2.7 kg in the colony B. Index terms: subterranean termite, colony sizes, foraging territories.
[0941] CORRIDORS FOR MOVEMENT OF BARK BEETLES IN FOREST LANDSCAPE MOSAICS

<u>R. N. Coulson</u>, Dept. of Entomology, Texas A&M University, College Station, TX 77843-2475, e-mail: r-coulson@tamu.edu

Species movement in landscape mosaics is a topic central to the concept of metapopulation dynamics. It is also a subject of considerable importance to forest management practice directed to reducing impact of pest insects. Human-caused fragmentation and natural disturbances create mosaic patterns where the specific arrangement of component ecosystems can influence species movement thereby enhancing or inhibiting herbivory by insects. In this study our goal was to consider how the spatial arrangement of landscape elements influences species movement and hence impact of the southern pine beetle, *Dendroctonus frontalis* (Coleoptera: Scolytidae) on forests. Our specific objectives were (i) to examine southern pine behavior in a landscape ecological context and (ii) to propose a corridor structure that facilitates movement and serves to link habitat targets and spatially subdivided populations of the insect. We illustrate the relation of spatial heterogeneity and species movement through an examination of SPB behavior in pine forest landscape, a three-dimensional corridor structure is proposed. The rational for the structure is framed in the context of specific behaviors associated with the natural history of the insect: host selection, colonization, dispersal capabilities, and adult longevity.

TO ANTIHERBIVORY COMPOUNDS

C. E. Coviella^{1, 2} & <u>J. T. Trumble</u>¹, ⁽¹⁾Univ. California Riverside. Riverside CA. 92521, U.S.A. john.trumble@ucr.edu, ⁽²⁾Univ. Nacional de Lujan, Argentina.

[0942] EFFECT OF ELEVATED CARBON DIOXIDE ON PLANT ALLOCATION

Some recent papers have predicted that plants grown in elevated CO2 should allocate relatively more resources to carbon-based defenses when compared with plants grown in ambient CO2 levels. Conversely, concentrations of nitrogen-based defenses should decline. We tested this hypothesis using a novel system that allowed us to simultaneously assess allocation to carbon-based and nitrogen-based defenses, relating these results with potential impacts on herbivorous insects. We used transgenic cotton plants incorporating a Bacillus thuringiensis (Bt) gene as well as a near isogenic line without the Bt gene, grown in both ambient (370 ppm) and elevated (900 ppm) CO_2 levels. We selected a split-plot design with CO_2 level as whole plots, and including a 2 x 2 factorial analysis for two levels of nitrogen fertilization and two levels of nitrogen-based defenses. The nitrogenbased compound (the Bt toxin) and the carbon-based compounds in cotton (total phenolics, condensed tannins and gossypol) were analyzed and quantified. We also examined the response of the insect herbivore Spodoptera exigua (Hübner) using foliar bioassays. We found that in the elevated CO2 concentrations expected within the next few decades, cotton plants will allocate more resources to carbon-based defenses and less to nitrogen-based This reduction in nitrogen defenses could be partly compensated for if defenses. additional N is made available. However, use of additional N has both economic and environmental consequences. The performance of the hypothesis and the biological significance of the observed changes in defensive compounds are discussed.

Index terms: Spodoptera exigua, Bacillus thuringiensis, herbivory, carbon dioxide

[0943] INFERRING ACTIVITIES AND POPULATION DENSITY FROM INCIDENTAL SOILBORNE SOUNDS OF WHITE GRUBS

R. L. Crocker¹, **M. Zhang²**, **R. Mankin³**, **K. Flanders⁴**, **R. Hickling⁵**, **P. Lee⁶ & J. Brandhorst-Hubbard⁷**, ^{1, 2}Texas A&M Univ. Res. & Ext. Ctr., 17360 Coit Rd., Dallas, TX 75252-6599 USA; ³Ctr. for Med., Agric., and Vet. Entomol., USDA-ARS, 1700 S. W. 23rd Dr., Gainesville, FL 32608 USA; ^{4, 7}The Alabama Coop. Ext. Serv., 208A Extension Hall, Auburn Univ., Auburn University, AL 36849-5629 USA; ^{5, 6}Nat. Ctr. for Physical Acoustics, Univ. of Mississippi, Coliseum Dr., University, MS 38677 USA.

Studies of soil arthropods often are hampered because the "black-box" nature of the soil environment generally necessitates destructive sampling. This is not compatible with repeated sampling, such as is needed in most long-term studies. This research demonstrated that characteristic incidental sounds were produced in the 300-2000 Hz frequency range by the larval stages (white grubs) of rhizophagous scarabacids (Coleoptera). These sounds are classified as digging, positioning, feeding and internal body sounds, which usually can be separated by a practiced listener or by computerized analysis. The circadian distribution of *Phyllophaga crinita* larvae's sounds were monitored under constant and variable temperatures. Daily levels of activity increased with soil temperature under naturally fluctuating temperatures, but showed no pattern at a constant temperature. The spatial distributions of P. congrua, P. crassissima, P. crinita and *Cyclocephala lurida* larvae in the soil were mapped under field, greenhouse, and laboratory conditions. Single-microphone sound samples were compared with conventional soil-core sampling for measuring larval population densities in turfgrass. Paired-microphone analyses made it possible to estimate the total number and approximate location of larvae in a sampled area. Soil moisture influenced the sensitivity of measurements. Sounds could be detected at greater distances in dry soil. This approach promises to be of considerable value for non-destructive sampling of these and other cryptic organisms.

[0944] WHITEFLY *TRIALEURODES VAPORARIUM* (HEMIPTERA: HOMOPTERA: ALEYRODIADE) COMPARED BIOLOGY IN SOYBEAN AND IN FIVE BEAN CULTIVARS

W. B. Crocomo⁴ & O. R. Campos², ^{1,2} Dept. of Vegetable Production - FCA - UNESP -P. O. Box 237, Botucatu - SP - Brazil, 18603-970, E-mail <wcrocomo@fca.unesp.br >

With the development of the greenhouse crops, the whitefly *Trialeurodes vaporarim* has becoming one of the most important pest. With the objective to verify the host effect on the development of this species was studied its biology on bean cultivars IAC - Carioca Pyatã, IAPAR - 57, Jalo Precoce, IAC- Bico de Ouro, IAC - Maravilha and on soybean cultivar Cristalina. The essay was conducted on the Agriculture Entomology Laboratory - FCA-UNESP, under temperature of 25+/-3°C, relative humidity of 80+/-10% and photophase of 14 hours. The biological parameters assessed were duration, viability and instars number of ninphal stage; male and female longevity, oviposition period, egg number per each female and sex ratio; eggs viability and incubation period and total cycle. With the obtained data were constructed fertility life tables to permit a comparative analysis of the cultivars effects on the biological development and consequent populational growth of this species. The results allowed to conclude that bean cultivars IAC- Maravilha and Jalo Precoce influenced negatively *T. vaporarium* development, whereas, the other bean cultivars studied, as well as the soybean cultivar Cristalina, provided better conditions to this pest development.

Index Terms: whitefly, bean, soybean, Trialeurodes vaporarium

[0945] PRELIMIARY EVIDENCE OF GEOGRAPHIC VARATION IN SOCIAL BEHAVIOUR OF HALICTINE BEES FROM HOKKAIDO, JAPAN

A. L. Cronin & M. Hirata, Graduate School of Environmental Earth Science, Hokkaido University, Sapporo 060 Japan. Email: CroninA@ees.hokudai.ac.jp.

Halictine bees are known for the flexible nature of their social behaviour, such that a single species may exhibit different states of sociality depending on the population studied. Previous studies have elucidated examples of intraspecific variation between populations at different latitudes or altitudes. Studies in Japan have indicated that altitude may be important in governing social behaviour, but studies of geographic variation have been limited. In an ongoing study in Hokkaido, North Japan, the social behaviour of several species of halictine bee was studied at several different locations with differing climates. Initial results indicate that populations may vary between solitary and eusocial behaviour depending on locality. The colder climate in Eastern Hokkaido apparently constrains bees to a solitary lifecycle whereas southern and central populations are eusocial. There is also some suggestion that variation in habitat may be important in influencing some demographic factors in populations from similar regions. Index terms: halictine, geographic variation, social plasticity.

[0947] FLIGHT PERIODICITIES IN MIGRANT MOTHS

W. Danthanarayana¹ & H. Gu², ¹School of Biological Sciences, University of New England, Armidale, NSW 2351, Australia; ²Institute of Plant Sciences, Swiss Fed Inst of Technology, CH-8092 Zurich, Switzerland.

Actograph studies of flight periodicities of moths show that there are diel and lunar rhythms of flight activity. Epiphyas postvittana and Helicoverpa armigera exhibit a diel bimodal periodicity pattern with a primary flight peak 2-3 hours after sunset and a secondary peak 2-4 hours after sunsite. Biological significance of this behaviour is discussed based on visual observations on E. postvittana. Flights initiate at twilight. A number of activity periods follow during which moths are engaged in different behaviours, viz. feeding, calling, mating and oviposition. In individual moths each type of activity occurs in bouts separated by pauses, where the animal is resting or is involved in one of the other activities. During the early part of the night virgin moths are engaged in calling and mating. Much of the egg laying activity occurs from sunset to sunrise. Thus postsunset flights are associated with calling, mating and oviposition whereas post-sunrise flights are associated with feeding. There is a sexual dimorphism in feeding behaviour, possibly a time budgeting adaptation to accommodate oviposition and competing with males. The lunar rhythm of flight activity in E. postvittana has a periodicity of 27 days. The "full moon" peak that occurred one day prior to the exact day of full moon during the first lunar cycle shifted forward by 3-11 days in subsequent cycles, but a periodicity of 27 days was maintained over the next 5 lunar cycles. It is relevant to note that the period of the Moon's revolution around the Earth, referred to as the "siderial month", is 27.32 days. The time between successive full moons, referred to as "syzygies", is a little longer than the siderial period at 29.25 days, which is the duration of the synodic or the lunar month. These observations based on actograph studies of E. postvittana will be compared with those based on radar studies of Helicoverpa armigera.

Index terms: Epiphyas postvittana, Helicoverpa armigera, circadian rhythm, lunar neriodicity

[0946] ALLOMETRIC RELATIONSHIPS BETWEEN BIOMASS, VOLUME AND POPULATION SIZE IN COLONIES OF SOLENOPSIS (HYMENOPTERA: FORMICIDAE) INVICTA

C. G. Dall'Aglio-Holvorcem, P. B. Candiani & W. W. Benson, Departamento de Zoologia, IB, UNICAMP, C.P. 6109, Campinas, SP 13083-970, Brasil. E-mail: chris@obelix.unicamp.br

In population studies of the fire ant, Solenopsis invicta, it is important to be able to estimate the biomass, colony volume, and population size of given ant colonies from measures, such as nest height (h), length (l), and width (w), that can be easily made without disturbing the ants. To this end, we measured the aboveground dimensions of 28 undisturbed S. invicta nests and determined their volumes (V, in liters), ant biomass (M, in grams) and worker numbers (N) after excavation in colonies from Campinas, Brazil

(22°47' S, 47°05' W). Of these, 14 colonies were examined during the rainy season of 1996-7, and the remaining 14 during the rainy season of 1997-8. The quantities h, l, and w were combined into a "volume index" $v = (4\pi/3)h(l/2)(w/2)$ (transformed to liters), and relationships between v, V, M, N sought in pair-wise regressions. The main quantitative results are $V=2.13\nu^{0.86}$ (R^2 =0.93), $M=5.51\nu^{0.82}$ (R^2 =0.59),

 $N = 7710v^{0.79}$ ($R^2 = 0.47$), $N = 1110M^{1.05}$ ($R^2 = 0.95$), suggesting that good to excellent estiates of S. invicta colony parameters can be obtained from simple non-destructive nest measurements. The data show that ant biomass per unit volume (M/V) and the mean biomass per worker (M/N) are essentially independent of the size of the colony. In contrast, an analogous study carried out by W.R. Tschinkel found out that in the southern United States mean S. invicta worker biomass increased with colony size. Index terms: Solenopsis invicta, fire ant, colony size, population density

[0948] ARTHROPOD COLONIZATION RATES OF EXOTIC WOODY SPECIES

T.E. DeGomez¹ & M. R. Wagner¹, ¹School of Forestry, Northern AZ Univ., Box 15018, Flagstaff, AZ, USA, 86011, E-mail: ted3@dana.ucc.nau.edu

Commercial forestry worldwide depends upon the use of exotic tree species because of the benefits that can be gained from improved production. However, the use of exotic trees in plantations has been rife with misconceptions from both supporters and opponents of their use. Many foresters tend to discourage the use of exotics predicting that the exotics would have higher numbers of insect pest species than the native trees. However, there are many examples when exotics have had fewer insect pest problems than natives of similar taxon. This study was a comparison of arthropod species data sets for species of woody plants in their native and exotic range. Data sets comprised 26 pairs of arthropod species lists; the paired data sets consisted of the number of arthropod species in the native range of the plant and a corresponding data set from where the plant grows as an exotic. Plants in the study came from many genera such as: Pinus, Robinia, Abies, Chamaecyparis, Cupressus, Picea, Pseudotsuga, Thuja, Tsuga, Prosopis, Tamarisk, Cytisus, and Schinus. Preliminary results indicate that there is greater arthropod species colonization on woody plants in their native range. We further analyzed whether the number of arthropods are influenced by the time a plant species has been growing in a non-native range, and whether the area of plant cover influences arthropod colonization of the native and the exotic plant species. Index terms: novel, native, insect, tree, shrub,

[0949] REPRODUCTION OF *SITOPHILUS SPP.* (COLEOPTERA: CURCULIONIDAE) ON DIFFERENT WHEAT CULTIVARS

L.R. Descamps¹, M.E. Reviriego¹ & <u>A.A. Suarez</u>², ¹Univ. Nac. Del Sur, San Andrés S/N, (8000) Bahía Blanca, Argentina, e-mail descamps@criba.edu.ar; ²E.E.A.INTA Anguil, Ruta Nac. N°5 Km 580, C.C. 11, (6326) Anguil, La Pampa, Argentina; e-mail asuarez@anguil.inta.gov.ar.

Sitophilus spp. is an important stored-grain pest in the cereal growing aerea of Argentina. The objective of this study was to determine the influence of different wheat cultivars on the insect reproduction. The trial was conducted under controlled conditions of temperature ($25 \pm 2^{\circ}$ C) and relative humidity ($67 \pm 3\%$). The wheat cultivars were: Buck Arrayán, B. Arriero, Klein Cacique, Cooperacion Calquín, B. Candil, B. Catriel, K. Centauro, B. Charráa, K. Dragón, Prointa Federal, B. Guaraní, C. Liquén, C. Maipún, C. Millán, C. Nahuel, C. Nanihue, B. Panadero, Prointa Bonaerense Pericón, B. Poncho, P. Pigué and B. Topacio. A randomized complete block design with four replication was used. Total adults insect born on each cultivar were registered. The data obteined were analyzed using PROC ANOVA and means were compared by MEANS / LSD test (P=0.05) (SAS Institute, 1998). Sitophilus spp. reproduction was significantly affected by wheat cultivars. On wheat cultivars B. Arriero and P. Federal insect reproduction was higher than on C. Millán and C. Nanihue cultivars.

Index terms: Sitophilus spp, stored-grain, reproduction.

[0950] RICHNESS AND ABUNDANCE OF LEPIDOPTERAN CATERPILLARS ASSOCIATED WITH CERRADO PLANTS

I. R. Diniz¹ & H. C. Morais², ¹Depto, de Zoologia, E-mail: ivone@rudah.com.br ²Depto. de Ecologia, Universidade de Brasília, 70910-900, Brasília, DF, Brosil.. * Partial funding from CNPq and FAP-DF.

The cerrado, the savanna-like vegetation of Central Brazil, is characterized by an elevated richness of plant species belonging to a flora that is highly exclusive to this biome. The region also presents a great richness of lepidopteran species with an estimated 10,000 species. This study is being developed, since 1991, in preserved cerrado sensu stricto areas of the Federal District (Brazil) (15°30'S - 47°25 W). The climate is markedly seasonal with five months of dry season (May-Sep). The 4 ha study area was divided into quarters, surveyed in rotation. Fifteen to 20 unmarked plants from each species were examined every week, during at least one year. Each individual of a plant species examined on a particular date was considered to be a census, and the proportion of censuses with caterpillars was used as an indication of caterpillar abundance. All external folivorous caterpillars found were collected and reared to adult stage in the laboratory (450 species belonging to 36 families). We made 30,892 consuses of 40 plant species, yielding a low proportion of plants with caterpillar (10%), but this proportion varied from 0.7 to 34% among the plant species. An average of 19 (range 4 to 53) caterpillar species were found per host plant. The most common families (56% of the species) were Gelechiidae, Elachistidae, Pyralidae, Geometridae, Tortricidae and Arctlidae. Of these species, 80% were found on only one host plant family and 20% on two to 23 families. In general, caterpillars are most abundant at the end of the rainy season and the beginning of the dry season (Mar-June) and are very rare at the end of the dry season (Aug-Sep), when the relative humidity of the air falls to 15%, and at the beginning of the rainy season (Oct-Nov), when most plants sprout new leaves. The plants species vary in relation to their growth shape, foliar phenology, leaf pilosity, presence of latex and extra-floral nectaries, number of taxonomically proximate species and through their geographical distribution Variations in the richness and abundance of caterpillars were within the cerrado. examined in relation to these characteristics for 40 species (20 families) of host plants. The richness and abundance of caterpillars are positively and significantly correlated. The variation in the species richness is not explained by the plant characteristics when examined separately. Local richness of herbivorous insect species has been positively correlated with the size, abundance, number of taxonomically related, and geographical distribution of the host plants in temperate environments and, in some situations, in tropical environments. The preliminary results for the cerrado do not show either of these relationships.

Index terms: Elachistidae, Gelechiidae, Pyralidae, host plants, diet

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ABSTRACT BOOK I - XXI-International Congress of Entomology, Brazil, August 20-26, 2000

[0951] PATTERNS OF INSECT ABUNDANCE IN THE CERRADO OF BRASÍLIA AND THE EFFECT OF CLIMATE

I. R. Diniz¹ & F. Pinheiro², ¹Departamento de zoologia; ²departamento de ecologia, universidade de brasília, 70910 900, df, brazil e-mail: ivone@rudah.com.br. Partial funding from FAP-DF.

In the cerrado, insects present large fluctuations in numbers on a seasonal basis. This variability is primary driven by environmental factors such a rainfall, temperature and relative air humidity. The study was carried out in an area of cerrado (savanna like vegetation), in Central Brazil. The seasonal distribution of the relative diversity and abundance of different insect orders were investigated through systematic surveys with regular collections through the wet and dry seasons, employing the simultaneous use of four sampling techniques: Malaise tent, pit-fall trap, Window interception trap, and sweep net. The monthly averages of rainfall and relative humidity, as well as the maximum, minimum, and mean temperatures were used in four different manners: the month of collection, and delayed in one, two and three months totaling 16 variables. For all analyses, monthly averages of insects were used. Multiple regression analyses explained most of the insect abundance fluctuations by association with climatic parameters and insect numbers. More than 830,000 insects of 16 orders were collected during the one-year period. The results obtained showed large variability among, and within insect orders. However, it is possible to recognize four broad categories of insect order abundance patterns in the cerrado: (1) Greater insect abundance after the first rains: Coleoptera, Diptera, Homoptera, Hymenoptera, Lepidoptera, Orthoptera, and Psocoptera; (2) Greater abundance occurring from the mid-rainy season, until the beginning of the dry season for Collembola; (3) Greater occurrence of the end of the dry season, until the beginning of the rains for Hemiptera; and (4) Greater abundance and/or activity in the dry season for Isoptera and Thysanoptera. Among the more numerous insect orders, 10 presented aggregated temporal distributions, and only Hymenoptera was uniform, with a peak in abundance occurring in November. The number of insects begins to decrease well before the end of the rainy season, but there is an increase in the beginning of the dry season with a strong reduction as the dry season proceeds. In the beginning of the dry season hydric stress is not yet accentuated, the intense decreases in minimum temperatures have not yet occurred and there are young leaves available on some plant species. These facts appear to be important in supporting fauna of superior trophic levels in the region. However, the long dry season appears to be stressful for the majority of insect populations in the cerrado. In the wet season one or more climatic factors may act to trigger activity breaking diapause for the majority of species finding food resources quantitatively and qualitatively modified, thereby allowing for reproduction and survival of young. Index terms: central Brazil, dry season, insect orders, wet season

[0952] PHYLOGEOGRAPHY AND ECOLOGICAL DIVERSIFICATION OF CICINDELA LUSITANICA (CICINDELIDAE: COLEOPTERA)

A. C. Diogo¹, A. R. M. Serrano¹ & A. P. Vogler², ¹Depto. Zoologia e Antropologia and Centro de Biologia Ambiental, Fac. Ciências de Lisboa, Campo Grande, Lisboa, Portugal, E-mail adiogo@fc.ul.pt; ²Department of Entomology, The Natural History Museum, Cromwell Road, London, SW7 5BD, UK.

Cicindela lusitanica is the Portuguese component of C. hybrida Group, one of the most widespread and common taxon of the Palearctic Cicindela (s.str.). The C. hybrida group is represented in Portugal by two endemic subspecies whose distribution is restricted to the stabilised dunes of the Atlantic coastline. Both groups are morphologically different and show a markedly distinct North-South distribution. The goal of this work is to test the causes of this geographic patterns which could be due to selection in the face of ecological (habitat) differences or due to a long history of separation between northern and southern populations. To assess the historical context of these differentiated populations, we analysed the pattern of ntDNA distribution, as a way to reconstruct palaeogeographical events and gene flow in C. lusitanica. Four regions of the mtDNA genome (COI, COIII, 16S and Cytb) were sequenced for a total of 74 individuals belonging to 22 Portuguese populations, 8 representatives of other European populations of C. hybrida group and 4 outgroups. In total 13 haplotypes were detected. Although these haplotypes exhibited low levels of genetic divergence, phylogeographic structuring was apparent, clearly separating the populations in three distinct groups. However, these groups are not consistent with the taxonomic recognised entities. Further, we found that the Portuguese populations represent a group deeply separated from the remainder of the European samples, including populations in Central Europe, Russia and Italy. The phylogeographic patterns are interpreted in the light of hypothesis about past geological and climatic events which night have affected the flora and fauna of the Iberian Peninsula. The distributional range of C. lusitanica coincides with the postulated Pleistocene refugia and thus the analysis of these populations gives insight into the history of the colonization pathways in the Palearctic during the quaternary. A comparative analysis of populations existing under different geological conditions along the Portuguese coastline will permit to analyse the processes of ecological diversification in these populations which apparently have persisted over long time periods.

Index terms: mtDNA, speciation, refugia.

[0953] DEPOSITION OF CORN POLLEN ON MILKWEED AND EXPOSURE RISK TO MONARCH BUTTERFLY LARVAE

G.P. Dively¹, J.E. Foster², G.D. Jones³ & T.L. Clark², ¹Dept. of Entomology, Univ. of Maryland, College Park, MD 20742, USA, Email gd7@umail.umd.edu, ²Dept. of Entomology, Univ. of Nebraska, Lincoln, NE 68516-4729, ³USDA, ARS, APMRU, 2771 F&B Rd., College Station, TX 77845.

Exposure risk to the monarch butterfly depends on the amount of Bt corn pollen that falls on its host plant. To address this risk factor, studies were conducted in 1999 to quantify the pollen deposition on common milkweed associated with corn fields. In corn producing areas in Maryland and Nebraska, 1517 leaves at different strata were removed from 652 milkweed plants associated with 86 fields during full anthesis. Distance from each corn field, plant cluster size, and surrounding habitat type were recorded. Plants also were visually examined for monarch butterfly larvae and feeding injury. Pollen deposits were rinsed from leaves, processed, and counted. Pollen deposition was expressed as the number of pollen grains/cm² of leaf area. No monarch larvae were found feeding on any sampled plant. Only adult butterflies and eggs were seen at the end of the sampling period. This indicates that larval activity did not coincide with corn anthesis in the sampled areas. For the Maryland data, the exponential decay relationship of y=3.82 + 32.36*exp(-x/3.85) provided a significant nonlinear fit of the pollen levels (y) as a function of distance (x). The highest pollen level was found inside and at the edge of fields, where the number of pollen grains averaged 56.2/cm² of leaf area. Pollen deposition dropped 61% (21.8 grains/cm2) within the first 5m from the field edge. Pollen deposition averaged 12.7 grains/cm² within 6-10m from field edge. After 10m, pollen levels averaged 7 grains/cm2 or less, and 42% of the leaf samples had no pollen deposit at all. In the Nebraska study, pollen levels dropped rapidly from the field edge and were significantly less than those recorded in Maryland. The exponential decay relationship of $y=0.32 + 5.44^{4}exp(-x/3.03)$ predicted pollen levels of 6 grains/cm² at the field edge compared to 35 grains/cm² predicted by the Maryland data. Differences in pollen deposition due to weather conditions, wind direction, leaf strata, and patch size are discussed. Although wind can move pollen away from fields, these data clearly show that the relatively large pollen grains settled out very rapidly within a short distance. Given provisional "no effect" levels of <150 pollen grains/cm2 and the frequency of pollen deposits found on milkweed, the majority of leaves are safe to monarch larvae, even those that are found inside corn fields.

Index terms: Danaus plexippus, Asclepias syriaca, Bt corn, monarch butterfly, risk assessment

[0954] MIGRATION OF NORTH AMERICA MONARCHS, DANAUS PLEXIPPUS, TO CUBA

C. Dockx, Dept. of Zoology, University of Florida, 223 Bartram Hall, Fl 32611, USA, Email cdockx@zoo.ufl.edu.

The monarch butterfly from eastern North America is known by its annual migration from northern North America to the Oyamel forest located on the Transverse Neovolcanic Belt in Central Mexico. The migratory butterflies are mainly born in the United States and southern Canada where the host plant of the monarch larvae Asclepias sp. is abundant. After the adults emerge, they move southward as the Asclepias sp. decrease in abundance at the end of the summer. During their travel they feed on nectar that will be transformed in lipids. The migraat monarchs arrive in central Mexico, from October through November. During the approximately four months that these monarchs stay in Mexico, they are reproductivily dormant, living from their lipid reserves. In March these butterflies mate and recolonize the southern United States. In contrast with the extensive study of the migrant monarchs in Mexico alternative migration routes like Cuba, and resident populations of the Caribbean have been poorly studied. My research explores the possibility of a migration of North American monarchs to Cuba and the inclusion of their individuals and their genes into the Caribbean, specifically into the Cuban population. In order to adress this possibility, monarchs were collected in November during four years (93,95,96,97) in three different areas in Cuba. These areas were: San Antonio de los Banos, Zapata Swamp and Guanahacabibes Peninsula. In order to know if the butterflies were Cuban resident or migratory, two techniques were used: thin Layer Chromatography (TLC) and Stable Isotops (carbon and deuterio). The fat content of the butterflies as well their reproductive stage was analized too. The results show that some North American monarchs do not migrate to Mexico, and instead go to Cuba. This migration to Cuba occurred during all the four years of this project. The preliminary isotopic results show that North American monarchs that go to Cuba came from a broad geographical range (especially northern and southern United States), in contrast to the 50% of the monarchs that go to Mexico came from the Midwest. The fat content of the butterflies show that North American monarchs that arrive to Cuba, have only 18 mg of lipids in comparisson to 113 mg of the healthy overwintering monarchs in Mexico.Suggesting that the physiological condition of the butterfly can determine their migratory behavior. Some of these North American monarchs were reproductivily active, suggesting that they can hybridize with resident population and staying in the island without retourning to the United States.

Index terms: monarch butterfly, Caribbean, animal migration.

10955] GREEN LACEWINGS OCCURENCE ON WEEDS IN CROP CORN

H. O. S. Dória¹, N. M. M. S. de Albergaria², R. J. Forreira³, A. T. Murata³ & S. de Freitas¹, ¹²Dept. de Fitossanidade, Fac. Ciências Agrárias e Veterinárias, UNESP, Via de Acesso Prof. Paulo Donato Castellane, s/n, 14884-900, Jaboticabal, SP, Brasil, (¹CNPq Fellowship), (²FAPESP Fellowship), ³Dept. de Biologia, Fac. Filosofia, Ciências e Letras de Ribeirão Preto, Univ. de São Paulo, Av. dos Bandeirantes, 3900, 14040-901, Ribeirão Preto, SP, Brasil, E-mail: murataat@asbite.com.br (FAPESP Fellowship)

This work was carried out to evaluate the influence of weeds in the maintenance of green lacewings populations in the corn crop fields. The trial was led at the Research Farm located Universidade Estadual Paulista, Jaboticabal, SP, Brazil. The weed plants were sampled 16 times with intervals from 3 to 4 days. Each time was evaluated the number of eggs, larvae and pupae of green lacewings on 100 weed plants in a crop of corn field. The results showed that 13.4% of the weed sampled was found crisopids. The weeds sampled that presented insects were: Arachis hypogaea L. (60.28%), Acanthospenum hispidium D. C. (23.83%), Cenchrus echinates (2.34%), Ephorbia hetertophylla (2.34%), Amaranthus deflexus L. (1.87%), Bidens pilosa (1.87%), Portulaca oleracea L. (1.40%), Alternanthera tenellacolla (1.40%), Amaranthus spinosus L. (1.40%), Parthenium hysterophorus L. (0.93%), Amaranthus viridis L. (0.47%), Sida santaremnensis (0.47%), Senna obtusifolia L. (0.47%), Brachiaria plantaginea (0.47%) and Cyperus rotundus L. (0.47%). The iarvae occurence on the weeds was rare, representing just 1.46% and 1.15% in Arachis hypogae and Acanthospenum hispidium respectively. The percentage of plants with coccons was 3.7% and it was found 8.1% of parasitism in green lacewing eggs. Index Terms: Crisopids, Neuroptera, parasitsm.

[0956] BIOLOGICAL ASPECTS, POPULATION DENSITY, DAMAGE RATE AND BEHAVIOR OF THE FRUIT-BORER, CONOTRACHELUS SP. (COLEOPTERA: CURCULIONIDAE) ON CUPUAÇU TREE (THEOBROMA GRANDIFLORUM SCHUM.) IN AMAZONIAN REGION, BRAZIL

J.A.Duarte-Aguilar¹ & A.M.Tavares¹, ¹ Embrapa Amazônia Ocidental – CNPq/DCR, Lab. de Entomologia, Rodovia AM-010, Km 29, C.P. 319, CEP 69011-970, Manaus, AM. E-mail sac@cpaa.embrapa.br, ²Embrapa Amazônia Ocidental, Lab. de Entomologia, Rodovia AM 010, Km 29, C.P. 319, CEP 69011-970, Manaus, AM, E-mail adauto@cpaa.embrapa.br.

The fruit-borer (Conotrachelus sp.) has been causing severe economic damage in the cupuaçu tree plantations (Theobroma grandiflorum Schum.) in the Amazon region. In order to estimate the damage of this pest on fruits production, surveys were carried out in areas nearby Manaus, in plants age six years and over, collecting twenty fruits once a week. In each sample of fruit, the number of holes, where the larvae are going out, were counted, and then opened to quantify the larvae in fruits. Biological and behavioral parameters were studied in laboratory, putting the larvae recently emerged from fruits (last instar) into plastic boxes, using as substrate a mixture made of soil and vermiculite in the proportion of 2:1, sterilized at 160 °C and moistened with distilled water. The cultures were kept at room temperature (27 ± 2 °C), relative humidity (80 ± 10%) and photoperiod of 12:00. The intensity of insects on fruits during February to May 1998 and 1999 were 93% and 66%, respectively. Were also observed that 63%; 24% and 13% of the larvae built up their pupal chambers in the soil at depths of 10, 12 and 15 cm, respectively. The emergence time of adults from the soil was 49 to 80 days, with 81,6% of viability. In areas where the fallen fruits were regularly collected from the ground, the extraction process of the fruit pulp were made in an adequate local, including the destruction of the peels, were observed a notable reduction of the insect density to 27 %. The results show that the cultural control was efficient in the reduction of the population of Conotrachelus. Index terms: Tropical pests, cultural control, injury level

[0957] STUDY OF THE PEST OF AN ORGANIC ONION CROP: THEIR POPULATION'S FLUCTUATION, THEIR SPATIAL DISPERSAL AND THEIR NATURAL ENEMIES

<u>A. C. Dughetti</u>, National Institute Technology Agriculture (INTA), Agric. Hilario Ascasubi Exp. Station, Hilario Ascasubi, Bs. As.- 8142, Argentina, E-mail adughetti@inta.gov.ar

In the irrigation area of Colorado's River bonaerense valley, Province of Buenos Aires, Argentina, the organic onion crop is a new activity from five years ago. It is considered a new economic resource to satisfy the demand of the others markets. During the period 1998/1999 was made a list of pest an organic onion crop. In this field was studied the different pests, their densities, their spatial dispersion and their natural enemies. The field was situated in Espié Colony, Hilario Ascasubi, in the Colorado River bonaerense valley. The observations were made in the seed bed and then in the crop using absolutes and relatives methods of counting. The absolute methods were evaluated in 50 onion's plants at random and weekly. The natural enemies of the organic onion pests were made by direct observation of the plants, by the soil's trap (Barber's trap) and by the metal square (0.50m x 0.50m), also by observation weekly. The seed bed was attacked by Delia platura and Delia antiqua, but they weren't very important The onion thrips Thrips tabaci was the most important pest in the definitive crop, also attacked the beetle Conoderus sp. but they were less important. The onion thrips population was two peaks abundance. The first was 02/26/99 with 31.50 thrips/plant and the other was 03/25/99 with 41.6 thrips/plant. The onion thrips spatial dispersal was studied by different index. They were: variance/mean, Southwood and Elliot, David and Moore, Green, Mean Crowding, Patchiness and Morisita. Also was used Taylor's power law, by study the spatial disposition of this insect. Result of evaluation with different index and the Taylor's power law indicated an overdispersed population of *Thrips tabaci*. The main natural enemies were the predators. They were the beetle Eriopis connexa and the spiders.

Index terms: pest, organic onion, population fluctuation, spatial dispersal, natural enemies.

[0958] SPREAD OF A MIGRATORY LOCUST PLAGUE IN MADAGASCAR

J.-F. Duranton¹, A. Razafindratsima², A. Franc¹ & <u>M. Lecoq</u>¹, ¹ CIRAD, Centre de coopération internationale en recherche agronomique pour le développement, TA40/PS2, Boulevard de la Lironde, 34398 Montpellier cedex 5, France, E-mail : nuichel.lecoq@cirad.fr; ² Projet de lutte acridienne, B.P. 1042, Nanisana, Antananarivo 101, Madagascar.

Since 1997, Madagascar has been experiencing an outbreak of the Migratory Locust that is the most severe for about fifty years. In spite of vast control operations, both terrestrial and by air, over three years (with financial support from the international community), gregarious residual populations remain in various localities and control will need to continue for at least several months. This outbreak originated in the locust's gregarious area in the southwestern semi-arid zone, between Toliara and Ambovombe. The first outbreak resulted from a sequence of favorable rainfall events. This phenomenon is well known in Madagascar but, for various reasons, caught the authorities unprepared. The initial outbreak - at that time restricted to well defined and restricted zones in the gregarious area - had been diagnosed from the very start of 1996, but no control measures were undertaken. From this date, the gregarious populations (swarms, hopper bands) progressively invaded northwards and by 1998 the whole island was infested. Observations over the last several years make it possible to provide an outline of this northward progression. The invasion followed a traditional sequence and route, essentially reproducing those of preceding outbreaks - especially those during the periods 1921-29 and 1939-57 (which, however, are much less well documented). The recent data provide a much clearer understanding of how the progression, year by year, relates to the island's ecological zonation. In addition, it seems that recent environment changes have modified some of the invasion routes, with swarms progressing quickly along the east coast (a naturally forested region now subject to deforestation) for the first time. Index terms: Acrididae, Locusta, migration, swarms.

[0959] POPULATION DYNAMICS OF *BEMISIA* SPP. IN WILD HOSTS IN AGRICULTURAL SYSTEM

<u>E. D. Quintela</u>, Embrapa Arroz e Feijão, Caixa Postal 179, Santo Antônio de Goiás, GO, Brazil, 75375-000. E-mail: quintela@cnpaf.embrapa.br.

Many weeds and agricultural crops are colonized by Bemisia spp. Little work has been done on the importance of wild hosts to build up populations before they disperse to cultivated hosts and vice versa. Understanding the population dynamics of Bemisia in different host plants is very important for its management. The objective of this study was to measure relative population levels of Bemisia eggs and adults in wild hosts. From April 1999 through February 2000, plants were selected randomly in a field in Santo Antônio de Goiás GO, Brazil. Plants were also sampled on May and June 1999, in Santa Helena de Goiás, GO, Brazil. The number of eggs and nymphs were counted with a dissecting microscope on the lower surfaces of five top leaves and five lower leaves on main stem of each plant. The plants were sampled weekly or every two weeks. The species sampled were Commelina benghalensis, Ageratum conyzoides, Bidens pilosa, Waltheria indica, Alternanthera ficoidca, Amaranthus deflexus, Emilia sonchifolia, Acanthospermum hispidum, Sida spp., Ipomoea spp., Euphorbia brasiliensis, Cassia tora, Euphorbia heterophylla, Erigeron bonariensis, Sonchus oleraceus, Leonotis nepetaefolia, Acanthospernum australe, Blainvillea rhomboidea, Crotom glandulosus, Stachytarpheta cayennensis. The results showed that population dynamics of Bemisia eggs and nymphs were influenced by the host plant, the intraplant distribution and climate factors. Index terms: Silverleaf whitefly, Aleyrodidae, weed species

[0960] SEEDLINGS AS EPHEMERAL UNDERSTORY IN MANGROVES : IMPACT OF HERBIVORES AND WATER LEVEL ON SEEDLING SURVIVAL

<u>A. Eben, J. García-Franco, M. Martínez & J. López-Portillo,</u> Instituto de Ecología, A.C., Km 2.5 Antigua carretera a Coatepec, 91000 Xalapa, Veracruz, Mexico, E-mail : astrid@ecologia.edu.mx

The impact of herbivorous insects and water level on the establishment of Avicennia germinans and Laguncularia racemosa seedlings was evaluated in two mangrove communities at a coastal lagoon in Veracruz, Mexico. Seedlings of both species were marked along 10 transects in one site ("1"). Type of herbivory and percentage leaf area lost were recorded for each seedling throughout the rainy season. We compared nitrogen content and phenolics in leaves of both species. There was a significantly higher damage by herbivorous insects in A. germinans when compared to L. racemosa. Highest damage was found in transects with higher water level. Herbivore exclusion experiments were conducted at both sites. Seedlings were marked in separate exclusions for both mangrove species. Exclusions and controls were distributed at two locations with different water level at site "1". At site "2", an A. germinans monoculture stand, the same experimental design was used. Presence of herbivores, damage and seedling survival were recorded from the onset of propagules until their establishment. Each species was attacked by one particular herbivore: A. germinans by Junonia evarete (Lepidoptera : Nymphalidae), and L. racemosa by a Psyllidae (Homoptera) species. At site "1", herbivore exclusion did not reduce mortality of A. germinans seedlings, and mortality was significantly lower at locations with higher water level. Survival of L. racemosa seedlings was significantly higher inside herbivore exclusions independent from water level, but overall survival was higher at locations with lower water level. Leaf phenolics were significantly higher in L. racemosa than in A. germinans. Nitrogen content was higher in A. germinans than in L. racemosa. Patterns of herbivory, nitrogen and phenol content indicate that slow growing L. racemosa invest more resources in defenses than fast growing A. racemosa. At site "2", J. evarete larvae decapitated unprotected seedlings, which were able to sprout again. Survival was significantly higher inside exclusions, nevertheless, flooding caused the death of all seedlings at this site. At both sites, survival and establishment of seedlings for both mangrove species was affected by an interaction of herbivore pressure and water level.

Index terms: Avicennia germinans, Junonia evareta, Laguncularia racemosa

[0961] CAN PLANTS USE ENTOMOPATHOGENS AS BODYGUARDS?

<u>S.L. Elliof</u>¹, M.W. Sabelis¹, A. Janssen¹, L.P.S. van der Geest¹, E.A.M. Beerling^{1, 2} & J. Fransen², ¹Section Population Biology, Univ. of Amsterdam, Postbus 94084, 1090 GB Amsterdam, The Netherlands. E-mail elliot@bio.uva.nl. ²Research Station for Floriculture and Glasshouse Vegetables, Linnaeuslaan 2a, 1431 JV Aalsmeer, The Netherlands.

For nearly thirty years, ecologists have been gathering evidence in support of the hypothesis that plants can use insect natural enemies such as predators and parasitoids as bodyguards to protect themselves from herbivory, but entomopathogens have escaped this consideration. We extend the bodyguard hypothesis to ask whether plants can use entomopathogens as bodyguards. We first discuss the evolutionary context of such tritrophic interactions and then categorise possible mechanisms as: (1) maintaining a population of bodyguards on the plant surface, (2) increasing contact rates between insect host and pathogen and (3) increasing the susceptibility of the host. We explore these mechanisms further, examining published studies for evidence for the hypothesis. We then discuss potential costs to the plant of promoting pathogens as bodyguards which may include a reduction in the efficiency of other "bodyguard" species, the incidental promotion of plant pathogens and the risk of entomopathogens developing phytopathogenicity. Aside from our intention to stimulate the testing of the bodyguard hypothesis with entompathogens and to provide a conceptual framework for this, we hope to bring evolutionary ecology and insect pathology closer together.

Index terms: tri-trophic interactions, mutualisms, biological control, plant defence.

[0963] MUTUALISM GONE AWRY? LACK OF HERBIVORE RESISTANCE IN NEOTYPHODIUM INFECTED GRASSES

S. H. Faeth & T.J. Sullivan, Dept. of Biology. P.O. Box 871510, Arizona State Univ., Tempe, AZ 85287-1501, USA.

Systemic endophytic fungi are thought to interact mutualistically with their host grasses mainly by increasing resistance to herbivores, as well as by increasing drought resistance, germination success, competitive abilities and deterring seed predators. However, antiherbivore effects have been documented only for a relatively few grasses, mostly agronomic ones, and mostly on non-native herbivores. There are few studies of the interaction of endophytes in native grass populations and communities. We first show that relatively few native grasses infected with systemic endophytes have strong negative effects on either invertebrate or vertebrate herbivores. Second, our observational studies of Neotyphodium-infected Arizona fescue (Festuca arizonica), a widespread and native grass, show no pattern of increased infection frequency with increased vertebrate grazing as predicted by the mutualistic hypothesis. Third, in field and greenhouse experiments, the presence of the endophyte did not alter preference or mortality of native and non-native invertebrate herbivores, such as leaf-cutting ants (Acromyrmex versicolor) and grasshoppers (Melanoplus femurrubrum and Xanthippus corallipes). Generally, plant genotype swamped the effects of the endophyte on both herbivore and host performance. Since asexual, vertically-transmitted Neotyphodium infections are usually common in natural populations of Arizona fescue, as well as other native pooid grasses, we are testing alternative hypotheses to explain their consistently high, but variable, frequencies. Index terms: Acromyrmex versicolor, endophytes, Festuca arizonica, Melanoplus femurrubrum, Xanthippus corallipes

[0962] INVESTIGATION ON HOST PREFERENCE OF PSUEDODENDROTHRIPS MORI (THYS; THRIPIDAE) ON FOUR VARIETIES OF MULBERRY IN THE FIELD AND LABORATORY

K. Etebari¹, J. Jalali¹, M. Tak sokhan² & E. Hossini², 1.Department of Plant Protection, College of Agriculture, Univ. of Guilan. IRAN, 41335-3179, 2.Research unit of silkworm rearing Co. Rasht, IRAN, P.O.Box 41635-1538.

The mulberry thrips Psuedodendrothrips mori NIWA is introduced as dominant species in the insect fauna of mulberry field in the north of Iran. The insect sucks the sap of the plant and reduces the quality of the leaf fed by the silkworm. The host preference was conducted on a complete randomized plot with four treatments i.e. Kemochi (KM), Kairyo-Nezumigaeshi (KN), Ichinose (I) and Shin-Ichinose, which are improved varieties present in the area. For this purpose, the insects were collected three times with fifteen replications each time. Number of individuals in one cm2 of leaf area was calculated as a density index. The results of statistical analysis with Duncun's new multiple range test (DMRT) indicates that the KM bearing an average of 3.48? 0.3 insects is significantly different from the other treatments at %1 level. Ichinose, bearing 2.2?0.01 stands second while KN and SI varieties each with 1.31?0.06 and 1.07?0.02 insects respectively, stand third. Nonpreference of this insect to different varieties in laboratory with poly choice test was studied. The preference percent of this species in four varieties out of thirteen replications was 38.8, 29.38, 18.96, and 12.73 respectively. The results of statistical analysis in laboratory condition also indicate that the KM is the most preferred variety and stands first while SI with the least preference stands last and the other two varieties are intermediates. Considering combination of the laboratory and field results, the KM variety is the most susceptible one to mulberry thrips while SI shows a relative resistance to this insect species.

Index terms: Psuedodendrothrips mori ; Host preference; Mulberry thrips

[0694] PLANT QUALITY AND GALLING HERBIVORE POPULATION ECOLOGY ON BACCHARIS DRACUNCULIFOLIA

M. L. Faria¹, B.G. Madeira¹, M. Fagundes¹ & G.W. Fernandes¹, ¹Ecologia Evolutiva de Herbívoros Tropicais, DBG/ UFMG. Belo Horizonte, MG, CP 486, 30161-970, BRAZIL, E-mail mlfaria@mono.icb.ufmg.br.

Three-trophic level interactions has been the model that best explains the population We tested two hypotheses in the system Baccharis dynamics of herbivore insects. Neopelma baccharidis (Homoptera: Psyllidae)dracunculifolia (Asteraceae)-Psyllaephagus sp. (Hymenoptera: Encyrtidae). The plant stress hypothesis proposes that plants become physiologically more susceptible to attack by herbivores, while the harsh environment hypothesis predicts that in more stressed habitats galls would suffer smaller attack rates by natural enemies and plant resistance. We collected galls in mesic and xeric habitats, and measured host plant height, width of the crown, xylem water potential, distance between leaves of apical branches, and number of galls found on each plant (n = 60). A sub-sample of galls were collected, weighed and opened for the evaluation of the parasitism rate. In addition, soil humidity was measured in the surrounding of each plant. The abundance of galls was significantly higher on plants in the xeric site (p<0.05). The distance between leaves, taken as an index of plant growth, was negatively related with xylem water potential (r²=0.75, p<0.001), which was negatively related with water content in the soil (r²=0.76, p<0.001). The distance between leaves explained 37% of the variation in gall weight (p<0.001). A multiple model that includes the volume of the plant and distance between leaves explained 16% of the variation of total number of galls in each plant (p<0.05). An average of 1.45 ± 1.29 nymphs of N. baccharidis was found on 1,123 galls dissected. The mean number of nymphs per gall did not vary among habitats, in spite of galls being larger in the mesic habitat (p<0.001). The mean rate of parasitism was 36% and did not vary among habitats. Our results indicate that the nutritional status of the plant is an important factor that determines the attack rates by N. baccharidis and that parasitism in any given habitat can be the result of a combination between environmental stress and the period in which the galls remain vulnerable to the attack by parasites. Index terms: Insect-plant interactions, galling insects, plant stress hypothesis

[0965] THE AGONY OF A HONEYBEE COLONY PARASITIZED BY THE SARCOPHAGID FLY SENOTAINIA TRICUSPIS: TEMPERATURE AND HUMIDITY VARIATIONS

<u>A. Felicioli</u>¹, S. Franceschini² & M. Pinzauti¹, ¹Dept. C.D.S.L., Sect., Agricultural Entomology, Univ., of Pisa. Via S. Michele degli Scalzi n°2, 56124 Pisa Italy E-mail mpinzaut@agr.unipi.it; ² Consorzio Pisa Ricerche, P.zza D'Ancona 1, 56124, Pisa.

This investigation was carried out in a coastal area of central Tuscany, (Italy) during summer and autumn 1999 starting on the 1st August until end of October. Temperature and Humidity were recorded by means of dataloggers (TinyTalk Relative Humidity TK-0302 and TinyTalk Temperature Range H TK-0040) inside and outside a honeybee colony parasitized by the Sarcophagid fly Senotainia tricuspis. All the dataloggers were set in order to take measurements every hour. Senotainiosis diagnosis was outlined by cheking the number of diptera larvae emerging from a sample of 30 bees. 30 bees were captured at the hive entrance and set into a jar. 24 hours after death the emerged endoparasitoid larvae were counted. Samples were taken three times during the investigation period at the beginning of August, on the 15th of August and on the 15th of September. The colony died on the 5th of October. Temperature inside the nest was kept between 30 and 35C° while the external temperature varied between 15 to 40C° from the beginning of the investigation (5th August) to the 30th August then started to decline from 32 to 20C° with an increase of temperature range up to 10C° over a period of 36 days. After such period the external temperature suddenly fell down to 5C° and the colony died. The humidity pattern shows a layout which is the opposite of the temperature pattern. During the first period of investigation (5th August). Afterwords internal humidity was kept by the bees lower (average 50%RH with a range of 10%RH) than external humidity (average 70%RH with a range of 30%RH). Afterwords internal humidity increased up to 28%RH until the bees death.

Index terms: Apis meilifera ligustica, thermoregulation, endoparasitoid.

[0966] RESISTANCE MANAGEMENT OF TUTA ABSOLUTA (LEPIDOPTERA: GELECHIDAE) TO SPINOSAD

M.C. Fernandes¹ & S.A. De Bortoli², ¹Depto. de Biologia, Univ. de São Paulo, 14040-901, Ribeirão Preto, SP, Brasil. ²Depto. de Fitossanidade, Univ. Estadual Paulista, CEP 14870-000, Jaboticabal, SP, Brasil. E-mail: bortoli@fcav.unesp.br.

This work was aimed to evaluate bioassay techniques to show the susceptibility of *Tuta* absoluta to spinosad (Tracer). The trial was carried out in the Biology Lab at University of Sao Paulo State, Jaboticabal, SP, Brazil, under controlled conditions ($T = 25 \pm 3^{\circ}C$, 12:12 (L:D) and RH = $70 \pm 10\%$. The tomatose leaves used were from 'Santa Clara' cultivar and the larvae from a lab population. To the Bioassay 1, tomatoe leaves were treated with 0, 8:16, 25.7, 81.6 and 257 ppm of insecticide solutions, during 5 minutes, and they were left to dry in the air. Two hours later they were put it on Petri dishes with 10 3rd instar larvae. To the Bioassay 2, tomatoe leaves were instated with 10 3rd instar larvae and 10 days later were treated by the same spinosad solutions. The bioassays were evaluated by larvae mortality 24 and 48 hours after the treatments. By the results it is possible to conclude that: spinosad showed high larvae mortality; bioassay 2 was the best to make tests about resistance management to the pest.

Index terms: Susceptibility, Tracer, bioassay

[0967] THE ANNUAL LIFE CYCLE OF AN POPULATION OF *DERALLUS* ANGUSTUS (COLEOPTERA, HYDROPHILIDAE)

L. A. Fernández, Depto. Entomología, Facultad de Ciencias Naturales y Museo, Paseo del Bosque s/11, La Plata, 1900, Argentina, E-mail: liliafer@museo.fcnym.unlp.edu.ar

Derallus is a Neotropical genus with 14 species. Only inmature states of two these species have been described, Derallus rudis y Derallus angustus, but no poblational studies have been accomplished yet, which are significant to understand the functioning of water bodies. The purpose of this research was to study the population dynamics of the species by periodic sampling of a natural population during one year, considering only those stages developing in the water. Derallus angustus is widely distributed from Guatemala to Argentina. The site studied was a permanent water body, located near the locality of Punta Lara (34° 47' S, 58° 01' W; Ensenada, Buenos Aires, Argentina). Punta Lara is at the austral end of "gallery forest" and has a subtropical and tropical floristic composition. The permanent water body was covered by Salvinia rotundifolia, Pistia stratiotes, Spirodela intermedia, Lemna sp., Hydromystria laevigata and Hydrocotyle ranunculoides. Twenty seven samples were taken (approximately two per month). On each sampling date, 20 random sample units of 200 cm² of aquatic vegetation were taken with strainer. Two reproduction periods were observed in this population: the first one by the end of spring and the second by the end of summer. Individuals of third instar larvae and adults were observed during the entire study time, suggesting that didn't hibernate at Punta Lara; this could be related to the fact that the water body is located in the "gallery forest" where environmental conditions are stable. Adults number, disminishing by the end of spring, probably die after reproduction.

Index terms: Derallus angustus, aquatic insects, larvae.

[0968] A STUDY OF MACROINVERTEBRATES IN RIVES ECOSYSTEMS (NW IBERIAN PENINSULA), AFFECTED BY SMALL HYDROELECTRIC DAMS

M. Fernández¹, M. Vidal¹, <u>A. Alonso¹</u>, D. Cuadrado¹, F. Mariño² & J. Garrido¹, ¹Dept. of Ecology and Animal Biology, Univ. of Vigo. E-36200, Spain, E-mail jgarrido@uvigo.cs; ²Ingenieria y Ciencia Ambiental, S. L. Meléndez Valdés, 5, bajo. E-28015. Madrid. E-mail ica@retemail.es.

River ecosystems in Galicia provide habitats for rich and diverse communities of aquatic animals; these communities have an extremely high conservation value as they include endangered species listed in the IUCN Red List of Threatened Animals, some of which are also endemic. Another outstanding feature is the abundance of species of European concern like the otter or the dipper. Stream regulation is known to have considerable impacts on the ecology of catchments, and, in some cases, results in severe environmental consequences for river biota. In general, it provokes a fall of the fauna with evident changes in the composition of the communities. In this sense, this comunication studies the effect of the hydroelectric dams on populations with bentonic macroinvertebratres. Among some effects, these infrastructures mean a problem for the moving of a lot of species, modify the physicochemical features which certain water has, and can affect the hydrological conditions in the rivers. This study expect to increase our knowledge on the biological diversity in the rivers of Galicia through the study of the biology and ecology of animal species and communities, as well as their structure and function. Secondly, we will try to evaluate the response of aquatic animals to river damming, paying special attention to the array of ecological interactions involved. Equally important to our study is to check the suitability of some species for bioindication and monitoring as a proper way to evaluate mitigation and enhancement options. This work takes part in several Vigilance Programmes and Environmental Monitoring carried out by Hidroelectric firms interprises such as San Miguel, S.A. y Aprohiga, S.A., which took place in the Deva and Tuño rivers (Ourense), where there is one hidroelectric minicentral in the first named river and three in the second one.

Index terms: Bioindicators. Conservation. Hydroelectric dams. River ecosystems. River fauna. River regulation

[0969] DAILY AND SEASONAL ACTIVITY OF HORSE FLIES (DIPTERA: TABANIDAE) ATTACKING REPTILES: *CAIMAN CROCODILUS* (ALLIGATORIDAE) AND *EUNECTES MURINUS* (BOIDAE), IN AN ANTHROPOGENIC CLEARING IN CENTRAL AMAZON, BRAZIL

<u>R. L. M. Ferreira¹, A. L. Henriques¹ & J. A. Rafael¹, ¹Dept. of Entomology - Instituto Nacional de Pesquisas da Amazônia – INPA, Caixa Postal 478 CEP 69.011-970 Manaus-AM, Brazil, E-mail: ruth@inpa.gov.br</u>

Tabanid females are known as hematophages in man and animals, linked to possible mechanical transmission of parasites during interrupted blood sucking. The association between horse flies and reptiles was first known sporadically, but has been gaining more corraboration througt experiments and occasional observation in the tropics. The present study was conducted in a military base (CIGS/BI-2), situated 54 km from Manaus/AM, in an anthropogenic clearing (02º45'S;59º51'W). Observations were made monthly, during April'97 to March'98, during two consecutive days. At the same time, other animals were offered, including humans. However in this paper we will only discuss data obtained on alligator Caiman crocodilus and anaconda, Eunectes murinus, in diurnal observations from 5:30 to 18:30. A total of 254 specimens were collected, 40 from anaconda and 214 from alligator. On the two reptiles four tabanid species were record: Stenotabanus cretatus , S. bequaerti, Phaeotabanus nigriflavus and Tabanus occidentalis. Diurnal activities showed species-specific patterns. althougt the three first species reported above were only found in the second semester which is the season with less precipitation and higher temperatures. T. occidentalis, occured during the whole observation period, and with increased frequency at the end of dry season. Preference in local attack and related defense behavior of the victim are reported.

Index terms: alligator, anaconda, hematophagy.

[0971] SEX, BUTTERFLIES AND BATESIAN MIMICRY: COLOUR PATTERN FORMATION IN THE TIGER SWALLOWTAIL

<u>R.H. ffrench-Constant</u>¹: P. B. Koch & B. Behnecke²,¹ Department of Biology, University of Bath, BA2 7AY UK; ²Department of General Zoology and Endocrinology, University of Ulm, Ulm, D-89069 Germany.

Melanism in lepidoptera, either industrial melanism or melanism involved in mimicry, is one of the most commonly cited examples of natural selection. However, despite extensive studies on the frequency and maintenance of melanic genes in insect populations, there has been little work addressing the underlying molecular mechanisms involved. Nowhere is butterfly melanism more striking than in the Eastern Tigger Swallowtail (*Papilio glaucus*) of North America. In this species females can be either yellow (wild-type) or black (melanic). The melanic form is a Batesian mimic of the distasteful Pipevine Swallowtail (*Battus philenor*) which is also black in overall color. Melanism in *P. glaucus* is controlled by a single Y-linked (female) black gene. Melanic females therefore always have melanic daughters. Melanic females show a replacement of the background yellow with black melanin. Here we show that the key enzyme involved is N- \Box -alanyl-dopanine-synthase (BAS) which shunts dopamine from the melanin pathway into the production of the yellow color pigment papiliochrome and also provides products for cuticle sclerotization. In melanic females this enzyme is suppressed leading to abnormal melanisation of a formerly yellow area and wing scale development is also delayed in the same area. This raises the possibility that either reduced BAS activity itself is preventing scale sclerotization (maturation) or, in contrast, that the delay in scale development precludes expression of BAS at the correct stage. BAS is probably homologous to the product of the *ebony* gene of *Drosophila*, mutants of which show black bedy color.

[0970] PERFORMANCE OF UTETHEISA ORNATRIX (LEP.: ARCTIIDAE) IN TWO SPECIES OF CROTALARIA SP. (FABACEAE) HOST PLANTS

V. G. Ferro & J. R. Trigo, Departamento de Zoologia, UNICAMP, POBox 6109, 13083-970, Campinas, Brazil. E-mail: vgferro@yahoo.com; trigo@obelix.unicamp.br

The moth Utetheisa ornatrix is protected against predation by pyrrolizidine alkaloids (PAs), sequestered from its larval food plants. Larvae are found mainly inside green pods of Crotalaria, where it feed on the seeds. Seeds have the highest PA concentration in relation to the other parts of plant. The objective of this study is try to answer what selective pressure lead to the utilization of this resource (seeds into green pods) for the larvae. Perforate the seeds and feed on highest concentrations of PAs could represent a cost? Or this represent a benefit, since the larva would become mechanical and chemical protection against natural enemies? We try to assess the performance of larvae (larval survival percentage and development time, pupal weight on the day after pupation and the females fecundity during 15 days) in C. juncea and C. pallida. Larvae were submitted to different feeding treatments: leaves, flowers, mature pods with seeds, green pods with seeds, green pods without seeds, green pods with seeds opened, green seeds and mature seeds. The last 4 treatments vs green pods with seed will assess the mechanical cost of pod uses. All U. ormatrix caterpillars reared since the first instar on mature seeds and mature pods with seeds of both plant species died. Larvae reared on flowers and leaves of C. pallida had the highest percentage of survival and green pods without seeds had the lowest. On C. juncea, the percentage of survival was highest for larvae reared on leaves; all larvae submitted to flower and green pods without seeds treatments died. Larvae reared on flowers and green open pods without seeds of C. pallida had development time significantly higher than larvae submitted to all other treatments. On C. juncea, larval development time were not significant. On C. pallida, larvae reared at green seeds developed significantly heavier pupae in comparison to the other treatments. On C. juncea, pupae obtained from larvae reared on leaves had a lower weight when compared with green seeds and green pods with seeds treatments. Female fecundity did not differ significantly in both species. These data indicate that U. ornatrix performance was better on green seeds, green pods with seeds and leaves. In these plant parts (where caterpillars are more commonly find) the percentage of larval survival percentage and the pupal weight were higher and the larval development time was lower; the females fecundity did not was affecting. Between species, C. pallida looked to be better than C. juncea. Though fed of leaves offered highest larval survival, green pods would be utilized because offer higher protection against predators: mechanic due the pods and chemical due PAs. This hypothesis remain to be tested. Index terms: Crotalaria pallida, Crotalaria juncea and resource utilization.

[0972] NECTAR AND POLLEN COLLECTION PATTERNS OF *MELIPONA* BICOLOR BICOLOR (HYMENOPTERA, APIDAE, MELIPONINAE)

A. O. Fidalgo¹, S. D. Hilário², A. M. P. Kleinert¹ & V. L. Imperatriz-Fonseca¹, ¹Dept. de Ecologia, E-mail afidalgo@ib.usp.br; ²Dept. de Zoologia, Univ. de São Paulo, R. do Matão, Trav. 14, n. 321, São Paulo, SP 05508-900, Brazil, E-mail sedilar@.usp.br.

This study describes how the foraging activity of Melipona b. bicolor is influenced by the us study describes now the foraging activity of *Metipona v. bicotor* is influenced by the environment and/or colony state. This bec species, was studied at the Bees Laboratory (Universidade de São Paulo; 23°33'S, 46°43'W) from November/98 to February/99. We used two colonies from Cunha/SP (23°05'S, 44°55'W). These colonies were classified as strong (Colony 1) and intermediate (Colony 2) according to general conditions, population and combs sizes and number of food pots. Flight activity was evaluated by capture of bees at nest entrance. Only bees carrying pollen and/or nectar were considered for the analysis. The pollen loads were counted, removed and saved for further analysis. Nectar was collected with capillary tubes placed between the mandibles while the abdomen was pressed. The volume was noted and the solutes concentration was measured by a pocket refractometer (Atago, BRIX 0-32%). Bees from each colony were captured for 10 minutes every hour from 6am to 7pm. Air temperature and relative humidity were also registered. M. b. bicolor was active from sunrise to sunset. Bees collected more nectar loads than pollen loads all over the day. Daily patterns of nectar and pollen collection was similar. However the collection of pollen and nectar loads were maximum in the early morning, from 6 to 7am. In Colony 2 the collection of pollen loads in the early morning was three times larger than in other times of day. Another peak in nectar foraging activity was observed between 10 and 11 am. Pollen and nectar intake varied strongly among the days studied. In January/99 the number of pollen and nectar loads decreased in both colonies, especially at Colony 2. That may be a consequence of changes in rain pattern in the study area in November/98 and January/99. Temperature and relative humidity showed daily variation in the study area. Temperature was maximum at noon when relative humidity was minimum ($r_s = -0.621$; p < 0.0001). The number of loads increased as relative humidity rose, being maximum between 70-90%. High temperatures had a strong negative influence on the number of loads collected with maximum ranging between 19-22°C. The foraging patterns of M, b. bicolor must be affected by colony state and environmental factors such as temperature and relative humidity.

Index terms: Melipona bicolor, bee, daily foraging patterns, nectar, pollen.

[0973] MAPPING, SURVEYING AND MODELLING INSECTS USING GIS TOOLS. CASE STUDY: CERAMBYX CERDO AND CERAMBYX VELUTINUS (COLEOPTERA: CERAMBYCIDAE) IN ALQUEVA DAM- PORTUGAL

D. Figueiredo¹& <u>R. Raimundo</u>¹, ¹Centro de Ecologia Aplicada, Universidade de Évora, Largo dos Colegiais 7000 Évora, Portugal, E-mail ceaue@uevora.pt.

The purpose of this work is the mapping, surveying and modelling of Cerambyx cerdo L. and Cerambyx velutinus Br. (Coleoptera: Cerambycidae) in the area of influence of the Alqueva dam (Guadiana river, Alentejo, Portugal) using GIS tools. The GIS was built using vector and raster approaches. Analysis of the spectral information in satellite imagery (Landsat TM, July 1997) and aerial photography interpretation supply information about land use and vegetation and was used to produce a habitat classification. Preliminary information of insects was stored in a relational database and managed using SQL (Structure Query Language). This methodology was used to produce the graphic outputs presented in this work. The Alqueva dam is one of the biggest dams in the Iberian Peninsula, and is projected to support a water volume of 4150 millions m³ at maximum level of 152m. The total submersed area will be about 29.000 ha and will include Holm and Cork oak stands. The Guadiana River is an important landscape element of the eastern part of Alentejo. Cerambyx cerdo is a threatened species in Europe, whose population has been decreasing at the same level of their habitats (holm and cork oaks) witch have been replaced by others land uses. This species is often mistaken by a 'sibling' species Cerambyx velutinus. Bait traps are used to catch the insects. This work allowed us to compare the two populations of those species in this area and to conclude that Cerambyx velutinus is much more abundant than Cerambyx cerdo (only one was found in this area). This confirms that this species is still rare in this region and needed some protection. We also tried to find some variables that could provide useful information in order to maintain these sustainable populations. In other areas (this area will be submersed soon), this may be done by using or maintaining the traditional land-use systems or even create new areas with adequate management. Future developments will help to create a good predictive model of the distribution of the two species in Alentejo region.

Index terms: Cerambyx cerdo, Cerambyx velutinus, GIS, conservation.

0975] INTERACTIONS BETWEEN FEMALES OF MANUELIA POSTICA AND COMPARISONS OF ITS NESTS WITH THE NESTS OF MANUELIA GAYI (HYMENOPTERA: ANTHOPHORIDAE)

L. Flores¹, <u>E. Chiappa</u>² & A. Alviña¹, 1 Inst. of Entomology, mailbox 147, Santiago, Chile. 2 Fac. of Sciences. Univ. of Playa Ancha, 34-V, Valparaíso, Chile. E-mail echiappa @upa.cl.

In the framework of field studies of biology of the three species of chilean genus Manuelia, behavioral records on interactions between females of M. postica are provided, Females exhibit three kinds of owner- intruder interactions at the nest: a) owner - intruder at the nest entrance (frequency= 87.9%); b) intruder 1 - intruder 2 at the nest entrancy (frequency= 6%); c) intruder entering the nest - owner (frequency= 6%). In adding, the nest architecture of M. gayi and M. postica was compared. The cells of both species were urnshaped, that of the nests of M. postica were arranged linearly in stems of Chusquea sp., (Gramineae: Bambuseae) and the cells of M. gayi were most irregularly distributed in larger stems of Persea lingue (Lauraceae). The size of the cells of M. gayi is significantly higher than in M. postica, as much the lenght (t = 5.75 p < 0.01) as the maximum diameter (t= 3.25 p<0.01). In both species the completed cells were always closed by partitions, which are more compacted in M. gayi, the thickness of partitions of M. postica was significantly smaller than in M. gayi (t= 16 p< 0.01). The mean value of the number of individuals in the aggregation of nests of M. gayi was 241, and in M. postica the mean was 10 individuals / nest. Both species overwinter as adults, the sex allocation was different, 1.36 females : 1 males in M. gayi, 1,6 females : 1 male in M. postica, probably the difference is caused because the nests of M. gayi were collected in the month of June only with adults inside, and the nests of M. postica were collected in the month of december with larvae, pupae and adults. The high value of number of cells in the nest of M. gayi, the proximity of the nests entrances and the interactions observed between females of M. postica, suggests the possibility of primitively social behavior, that should be corroborated with experimental studies.

Index terms: nesting habits, Xylocopinae bees, Chile

0974] FLIES UNDER STRESS: A TEST OF FLUCTUATING ASYMMETRY AS A BIOMONITOR OF ENVIRONMENTAL QUALITY

K. D. Floate & A. S. Fox, Agriculture and Agri-Food Canada, Lethbridge Research Centre, P.O. Box 3000, Lethbridge, AB, Canada, T1J 4B1, E-mail: floatek@em.agr.ca.

Fluctuating asymmetry (FA) has been proposed as a measure of environmental quality. The premise is that increased levels of environmental stress (e.g., chemical pollutants) are reflected by increased levels of FA within populations of organisms developing at the site. We test this premise by examining the relationship between stress, fitness, and FA among laboratory populations of house fly (Musca domestica L.). Exposures from 0.00 to 1.00 ppm of the pesticide, ivermectin, during egg to pupal development caused up to 18-fold differences in levels of stress (measured as percent pupation), and up to 18-fold differences in levels of fitness (measured as the average number of first-instar larvae produced by each female in the starting population) among populations. However, no differences were detected among population levels of FA for five wing traits examined. Power analyses estimated that the accuracy of the image analysis method used to obtain measurements would have detected a 10% difference in average FA among populations 95% of the time. Hence, the results of this study do not support the use of FA as a method for monitoring changes in environmental quality. The absence of a treatment effect on levels of FA may reflect the development of surviving flies in 'refuges', thereby minimizing or avoiding their contact with ivermectin (the 'refuge' hypothesis). Alternatively, flies surviving exposure to ivermectin may represent a 'robust' subset of the starting population whose symmetries are relatively unaffected by the effects of stress (the 'differential mortality' hypothesis). These two hypotheses have received little attention in the literature, yet may have important implications for interpreting the effect of environmental stress on FA.

Index terms: Musca domestica, bioassay, ivermectin, image analysis, environmental contamination

[0976] EFFECT OF TEMPERATURE ON THE SEX RATIO AND WEIGHT OF CHRYSOPERLA EXTERNA ADULTS OBTAINED FROM LARVAE FED ON SCHIZAPHIS GRAMINUM

<u>A.R. Fonseca¹</u>, C.F. Carvalho¹, B. Souza¹ & C.C. Ecole¹, ¹Dept. of Entomology, Federal Univ. of Lavras, Caixa Postal 37,CEP. 37200-000, MG, Brazil, E-mail rsjorge@ufla.br

The aphid Schizaphis graminum is one of the main pests of the sorghum culture, damaging the plant by the suction of the sap, injection of toxins and viroses transmission. Among the enemies of this aphid, Chrysoperla externa stands out, which is of natural occurrence in that Gramineae. Due to its great potencial in the biological control of that aphid, this work aimed to study the effect of temperature on the sex ratio and the weight of C. externa adults, recently emerged, originating from larvae fed on S. graminum, in growth chambers, at 15, 18, 21, 24, 27 and 30 °C, UR of 70 \pm 10 % and photophase of 12 hours. The experimental design was entirely randomized, with six treatments and fifteen replications. It was observed that adults coming from the temperatures of 18, 21, 24 and 27 °C presented the highest weights (6.62; 5.86; 6.31 and 5.84 mg, respectively), in relation to those obtained at 15 °C (5.22 mg), which presented intermediate weight. Adults kept at 30 °C presented lower weight (3.97 mg). Between 18 to 27 °C, C. externa adults presented higher performance in relation to weight. The sex ratio obtained in the six tested conditions were 44.1; 50.0; 45.4; 46.1; 54.5 and 57.1 %, respectively. Index terms: green lacewing, aphid, sorghum, predator.

[0977] PHENOTYPIC PLASTICITY IN *DEOIS FLAVOPICTA* - VARIATION IN THE DRY SEASON DORMANCY AMONG FAMILIES AND AMONG GEOGRAPHICALLY ISOLATED POPULATIONS

E. M. G. Fontes¹, E. R. Sujii¹ & C. S. S. Pires¹, ¹Embrapa Recursos Genéticos e Biotecnologia, PqEB, Final Av. W3 Norte, C.P. 02372, 70849.970 Brasilia, DF, Brazil.

The grass feeding spittlebug Deois flavopicta (Hom.: Cercopidae) is the most abundant species in cultivated pastures, in Brazil. In the Central-west and Southeast regions, populations of this insect are widely distributed; moreover, they consistently differ in abundance and in some traits such as adult coloration and markings, and voltinism. The display of phenotypic variability in physiological traits is expressed by the ability to enter egg diapause. With a gradual increase in the fraction of offspring entering diapause and varying the degree of diapause among a family of progeny to promote hatching variation, D. flavopicta performs a phenotypic plasticity by diversifying its offspring to survive in variable environments. We raised the question whether these variations were genetically related. To examine whether the two traits vary among families within populations we observed the hatching pattern of individual, field collected females from each of the three annual generations. Different hatching patterns and duration of diapause were observed among families from the same generation, and among the three generations. Some females laid nondiapause eggs only, others laid only diapause eggs and others laid a mix of diapause and nondiapause eggs. Moreover, diapause eggs of the same family displayed wariable hatching patterns. The variation in the proportion of diapause eggs among geographically isolated populations was examined by observing the patterns of egg hatching in the progeny of third (April) generation females collected along an East-West transect in parallels 15[°] and 20[°] S. Sample locations were established at each 2.5[°] from longitudes 40 to 50[°] W. A third transect followed the Northern direction on longitude 47[°] W from parallel 16 to 7[°] S. A total of 24 locations were sampled. Females were collected and placed in cages for oviposition. The eggs were transferred to plastic dishes and hatching was recorded each two-three days. D. flavopicta was the predominant species of pasture spittlebug along transects 20'S and 47' W but it was not found in the locations sampled along parallel 15°S. It was observed great variability in the proportion of diapause eggs, as well as in the duration of diapause in eggs laid by females from the different populations. We concluded: 1. traits associated with the diapause syndrome in D. flavopicta are probably genetically related; 2. There probably has three different genotypes underlying the proportion of diapause eggs; and 3. the two traits studied are probably genetically correlated.

Index terms: genetic of diapause, Cercopidae, spittlebug, phenology

[0978] VELVETBEAN CATERPILLAR PREFERENCE TO SOYBEAN AND PENUTS VARIETIES

<u>P. Fortes¹</u>, L. Vieira¹, G. Bissolli¹, S. A. De Bortoli¹ & A.T. Murata², ¹Dept. de Fitossanidade, Univ. Estadual Paulista, CEP 14884-900, Jaboticabal, SP, Brasil. ²Dept. de Biologia, Univ. de São Paulo, CEP 14040-901, Ribeirão Preto, SP, Brasil (FAPESP Fellowship), E-mail: murataat@asbyte.com.br.

Lately it has been increasing the reports about the attack of velvetbean caterpillar, Anticarsia germatalis in peanut crops causing economic damage. This work was carried out to study the preference of caterpillars to soybean (cv. Foscarin and Br 37) and peanut (cv. Tatu), under laboratory conditions $(25 \pm 2 \,^{\circ}\text{C}, 40 \pm 10\% \,\text{RH}, 12$ hours photophase). The trials used 5th instar larvae and multiple and two choicetests with 20 replications and 10 insects per replication, in arenas of 60 cm diameter. Around the arenas were placed pots with 2 plants of each variety (dual and multiple tests). It was evaluated the number of larvae per plant and the time expend to the larvae reach the plants. By the results could be verified that cv. Foscarin was the favorite substrate with 3.95 caterpillar followed by BR 37 (2.7) and peanut (1:15). The caterpillar took an average of 38", 1' 27" and 1' 15" to reach the cultivars Foscarin, BR 37 and Tatu, respectively. It can be conclude that larvae of A. gemnatalis showed preference to soybean, being cv. Foscarin the most attractive.

Index terms: Anticarsia gemmatalis, choice tests, attractively

[0979] BEETLE ASSEMBLAGES (COLEOPTERA) IN THE PARQUE ESTADUAL XIXOVÁ-JAPUI, SÃO VICENTE-PRAIA GRANDE, SÃO PAULO

<u>R. B. Francini</u>¹, I. B. Francini¹, R. G. Cedro², E. C. Francisco² & H. E. Alves², ¹ Museu de História Natural, FAFIS, Univ. Católica de Santos, Rua Euclides da Cunha, 247, 11065-902, Santos, SP, Brasil, E-Mail francini@unisantos.com.br, ² Curso de Licenciatura em Ciências Biológicas, FAFIS, UniSantos. Financial support: IPEC-UniSantos.

The Parque Estadual Xixová-Japui is an area of hills between the cities of São Vicente and Praia Grande (24°00' S - 46°24' W). These hills are formed by Precambrian rocks isolated by coastal plain Quaternary sediments. The park includes an area of approximately 900 ha. with the hills of Japuí, Xixová and Itaipú and the beaches of Itaquitanduva, Paranapuã, Prainha and Battalion, and rocky shores facing Atlantic Ocean. The original vegetation was rain forest (Atlantic forest core area), almost all substituted today by secondary forest in various regeneration phases including edges. The study area we inside the Fortaleza do Itaipú (of the Brazilian Army). Beetle samples were collected along a quasi-linear transect marked every 10 m interval unchanged during all the study period. Techniques included manual collecting, standardized litter samples (1 m², 10 samples each 20 m; Winkler extraction) and two Flight Intercept Traps (FIT). The data from June to December 1999 showed the presence of 420 morphospecies of beetles belonging the 46 families. Curculionidae represented 23.6% of the species followed by Staphylinidae (18.6%), Nitidulidae (6.0%), Scarabaeidae (5.7%), Chrysomelidae (5.5%), Cerambycidae (4.3%) and Carabidae (3.8%). Other families totaled 32.5% with 8.8% not identified. In the standardized 60 litter samples 102 morphospecies were collected with the most abundant, appearing in 20 samples; 55 morphospecies appeared in only one sample. The species accumulation curves for 60 standardized litter samples showed no stabilization after the sixth month of sampling. Beetle richness versus 6 habitat characteristics (mass, volume and moisture content of litter, terrain inclination, degree of canopy cover using fish-eye photography and relative level of illumination) in each point (60 samples) was relatively low (beetles x volume; Spearman R=0.559868;t=5.14594; p<0.000003). The data on beetle diversity was compared with the data from habitat diversity calculated using Brillouin's equitability index for each sample. The results showed a weak correlation between the two series of diversity estimates. A PCA made on the joint matrix (beetles + habitat) showed that the factors mass and volume of litter were important in the determination of the variance species diversity.

Index terms: species richness, winkler samples, flight intercept trap.

[0980] BIOLOGICAL AND ECOLOGICAL STUDIES ON OMASPIDES TRICOLORATA (COLEOPTERA: CHRYSOMELIDAE: CASSIDINAE)

F. A. Frieiro-Costa¹ & <u>J. Vasconcellos-Neto</u>², ¹ Curso de Pós-Graduação em Ecologia.Universidade Estadual de Campinas - Inst. Biologia - Depto. Zoologia. Campinas, SP, Brazil, 13083-970.² Universidade Estadual de Campinas - Inst. Biologia - Depto. Zoologia. Campinas, SP, Brazil, 13083-970. E-mail: jvascont@obelix.unicamp.br.

We studied a population of Omaspides tricolorata Boh. 1854, a species with maternal care at Serra do Japi, Jundiaí, São Paulo state, Brazil (23º 11' S; 46º 52' W) during almost three years (1988-1990). The life cycle of this species is closed tied to seasons and the fenology of its host plant, Ipomoea alba (Convolvulaceae). Adults appeared in October (spring) and remained active until April, when entered diapause, and remained hidden during the dry winter season; and the next reproductive cyle started again in the next spring. The first egg cluttches were found in October (1988) or November (1989), showing two peaks of egg-clutches abundance, one in December and other in February. The last egg clutches were observed in April (1989) and March (1990), and the females and theirs offsprings need at least two months to complet their life cycle. At this time (May) starts the cold dry season and the host plant shows old leaves, wich fall during the winter. The egg-clutch size varied form 28 to 80 egss with an average of 55.1 ± 12.2 eggs (n = 56 clutches). The incubation period of the egg stage was $15.5 \pm 4.4 \text{ days} (n = 120 \text{ clutches})$; the mean duration of larval stage, containing five instars, was $28.0 \pm 5.2 \text{ days} (n$ = 86 larval groups) and the pupal stage lasted 13.7 ± 5.3 days (n = 48 pupal groups). The imature life cyle lasted 57.3 \pm 5.7 days (n =48) and during these two months the female take care its offspring. All these biological dates were obtained in field conditions The females fed only during larval development of theirs offsprings or before laid eggs. One female can take care only two generations each reproductive period. Maternal care and cycloalexy are important behavior against natural enemies.

[0981] NEST DYNAMICS OF POLYGYNE COLONIES OF THE SOUTHEASTERN YELLOWJACKET

G. N. Fritz, S. Stewart & A. J. Deets, Dept. of Biological Sciences, Eastern Illinois Univ., 600 Lincoln Ave., Charleston, IL, 61920, E-mail: cfgnf@eiu.edu.

The yellowjacket, Vespula squamosa, is the only ensocial wasp that commonly has two social forms, has annual and perennial nests, facultatively usurps the nests of conspecifics, and parasitizes other vespine species. Thus, V. squamosa is ideally suited to study ecological determinants of social behavior and kin selection dynamics. Twenty annual and perennial nests of V. squamosa were collected from counties in Georgia and Florida. USA. All perennial nests had multiple gynes (12 - 46) whereas annual nests had single queens. Gyne number varied between perennial nests and nearly all individuals had spermatazoa and mature eggs (n = 143). The number of workers in perennial nests varied from 675 to over 65,000 individuals. Single queens had significantly more mature eggs per ovariole than gynes from perennial nests (7.0 ± 1.0 eggs/ovariole versus 2.0 ± 1.1 , respectively; p < 0.001). Gynes from perennial nests (p < 0.02), but workers were significantly larger eggs than those in single queens from annual nests (p < 0.02), but workers were significantly larger eggs that the latter nests (n = 268, p < 0.001). Data suggest that perennial nests are truly multiple queen colonies. Furthermore, supernumerary eggs and larvae suggest that cell number is a limiting resource in multiple queen colonies. Index terms: Vespula squamosa, polygyne, mongyne, kin selection

[0983] SOURCE-SINK RE-COLONISATION: A POSSIBLE STRATEGY OF INSECTS LIVING IN TEMPORARILY SUITABLE HABITATS

J. Frouz¹, P. Kindlman², II. H. Tulke³ & K. Frank³, ¹Inst. Soil Biology ASCR, Na sadkach 7, Ceske Budejovice, CZ-37005, Czech Republic, E-mail: frouz@upb.cas.cz; ²South Bohemian Univ. Fac. Biol. Branisovska 31, CZ-37005, Czech Republic; ³UFZ, Dept. Ecosyst. Modelling, Permostigerstr. 15, D-04318 Leipzig, Germany.

Continual colonisation and re-colonisation is critical for survival of species living in temporarily suitable habitats. Habitats included in this re-colonisation process are usually assumed to be self-sustainable in terms of species survival. However, some animals may occur also in sub-optimal habitats where population density is maintained by immigration from more suitable (source) habitats and is going extinct when this immigration is stopped (sink habitat). In this study the hypothesis that re-colonisation of permanent sink habitats from a temporary source habitat can increase the probability of metapopulation persistence was tested using a simple mathematical model. Two groups of source habitats recolonising each other were compared, each source habitat being either alone or accompanied by a sink habitat. Inclusion of a sink habitat increased the probability of metapopulation persistence in situations when availability of sources was synchronised or when colonisers were poor migrants or both. This effect depends on the relation between source and sink habitat growth rates and is well pronounced in high growth rates. When growth rates are low, survival probability strongly depends on the proportion of source to sink and sink to source migration rates and in some proportion of migration rated results in a decrease of survival probability. Field data about terrestrial chironomid species, Smittia aterrima, were used to test the model predictions for one patch source-sink system similar to those described above. S. aterrima is specialised in pioneer open habitats in initial stages of succession, which provide good quality food for the larvae and most of offspring are produced here. The optimal habitat, however, is sensitive to summer desiccation, which often results in almost complete extinction of the summer larval population in a large area. It is shown that re-colonisation from less suitable, but more stable "sink" habitats in the surrounding landscape enables population persistence in landscape. The field data correspond well with model outputs, which indicates that re-colonisation of source habitats from sink habitats is one of the reasons for persistence of the latter. Index terms: population ecology, modelling, metapopulation

[0982] SURVEY OF INSECTS IN WEEDS DURING THE OFF-SEASON OF CORN CULTURE

M.R. Frizzas¹, S. Silveira Neto¹ & N.M. Martinelli², ¹Dept. de Entomologia, Fitopatologia e Zoologia Agrícola, Univ. de São Paulo (ESALQ/USP), C. Postal 9, CEP 13.418-900, Piracicaba, SP, Brasil, E-mail mrfrizza@carpa.ciagri.usp.br; ²Dept. de Defesa Fitossanitária, Univ. Estadual Paulista (UNESP), CEP 14.870-000, Jaboticabal, SP, Brasil.

Weeds are considered undesirable plants because they can compete with cultivated crops as well as host insect pests and pathogens. Furthermore, they can also serve as refuges for insect pest during a crop off-season period. Therefore, the management of the abundance and compositions of weeds during the crop off-season period can greatly influence the pest infestation in a cultivated crop mainly in tropical regions. Based on these facts, the objective of this work was to study the insect species associated with weeds during the corn off-season period. The experiment was conducted at Experimental Station of Universidade Estadual Paulista in Jaboticabal, SP, Brazil, during the period between May to September of 1997 and 1998. Insect sampling on weeds were performed weekly by using light traps, Malaise traps and colored trays. After screening the samples, data were subjected to an faunistic analysis. The following index were estimated: constancy, dominance, abundance and frequency. Ninety nine different insect species were collected during the experimental period. Fourteen species were considered predominants: Aphodius sp.; Diabrotica speciosa; Epitragus similis; Paederus sp.; Condylostylus sp.; Alydus sp.; Pangaeus sp., Ophion sp., Anticarsia gemmatalis, Cirphis latiuscula, Elasmopalpus Ignosellus; Leucania humidicola; Spodoptera frugiperda and Chrysoperla externa. From the predominant species, the most frequent ones were E. lignosellus and Aphodius sp. Among the insects collected during the corn off-season period, most of them were insect pests and some of them with a great relevance in corn. A few natural enemies were also collected during this period.

Index terms: faunistic analysis, Zea mays, traps, ecology

[0984] THERMOREGULATION OF NEST OF WOOD ANT FORMICA POLYCTENA

J. Frouz, Inst. Soil Biology, ASCR, Na sadkach 7, Ceske Budejovice, CZ-37005, Czech Republic, E-mail: frouz@upb.cas.cz.

The factors affecting daily a seasonally pattern of temparature fluctuations and thermal loss from ant nest were studied. Patterns of temperature fluctuation and mechanisms of Two extreme thermoregulation change substantially along nest moisture gradient. situations can be distinguished. In dry nest (moisture of nest material c, 10 %) daily temperature fluctuation is characterized by slow decrease of internal nest temperature during night and increase during daytime. Seasonal changes are characterized by slow The thermal loss of these nests, increase of internal nest temperature during spring. during period of activity, is low (about 2w per nest) and the thermal flow is less homogeneous over the nest surface. In contrast the daily fluctuation of moist nest (moisture 35% and more) is characterized by increase of nest temperature during night and lower temperature during day. Seasonal fluctuation is characterized by step increase if temperature during spring. The thermal loss is higher in comparison with dry nest (c. 35w) and concentrated mostly to top part of the nest. The thermal loss of moist nest is so high that it can not be explained by ant metabolic heat production. In moist nest microbial activity increase and thus microbial metabolic activity may serve as additional source of heating in wet nest. The implications of this shift in thermoregulation for ecology of wood ants are discussed.

Index terms: Formicidae, social insects, thermoregulation, energetic

[0985] CONNECTIVITY AND HABITAT PREFERENCE OF SPASSALUS CRENATUS (COLEOPTERA: PASSALIDAE) IN THE LUQUILLO EXPERIMENTAL FOREST, PUERTO RICO

A. Galindo-Cardona & A. Sabat, Dept. of Biology, Univ. of Puerto Rico, P.O.Box 23360, San Juan, PR 00931-3360, E-mail: is973083@rrpac.upr.clu.edu

Connectivity between patches, in metapopulations, influences their demographic and genetic structure. Other factors influencing population dynamics, in metapopulations are local extinction rates and anthropogenic or stochastic disturbances. Animals inhabiting ephemeral patches, such as fallen tree trunks and ponds, have characteristics that match the assumptions of a classical metapopulation model: low vagility, few generations per patch, and reproduction in one or few patches during the adult lifespan. Bees-beetles (Coleoptera: Passalidae) inhabit fallen tree trunks where they establish a colony and spend their entire life cycle, which includes some parental care during egg and larval development. After attaining sexual maturity, adults disperse and colonize new trunks. In this study I addressed the following questions: 1) What is the colonization rate of the patches? 2) What is the effect of dispersal distance, trunk species and state of decomposition on colonization rate? To answer these questions an experiment was performed at El Verde Field Station (Luquillo Experimental Forest, Puerto Rico). Four 20 m x 1.5 m experimental plots were constructed by enclosing them with a 0.7 m barrier. In each plot, four stems were placed at 2 m, 6 m, 12 m and 18 m from the edge of the plot, for total of 16 trunks per plot. The trunks ranged from 60-70 cm in longitude, and 20-30 cm in diameter. The trunk species were Cecropia spp. and Ormosia krugii fallen down by Hurricane Georges (October 1998), and Swietenia macrophylla fallen down by hurricanes Hugo (September 1989) and Georges. Groups consisting of 3 or 4 bees-beetles individuals were released at the corner of each plot. The individuals were permanently marked by cutting small pieces of elytra. Trunks were checked after 24 hrs, 8 days, and then weekly for three months. Preliminary results indicate that of the 16-groups released on October 1999, three successfully established a colony, and two solitary individuals were found after 14 weeks. All three colonies were established in decomposed stems of S. macrophylla fallen down by Hugo, and located at 6 m from the release point.

Index terms: Colonization, dispersion, wood density, and decomposition level.

[0986] IMPLICATIONS OF HOST-PLANT CARBON UPTAKE PATTERNS AND LEAF SIZE ON THE PERFORMANCE AND ABUNDANCE OF A CYNIPID GALLFORMER

<u>P.S.Galusky</u>, J.R.Ott & R.J.Reynolds, Southwest Texas State Univ., San Marcos, TX, USA, 78666-4615, E-mail: pg34960@swt.edu.

Gallformers ovinosit at the site of larval development thus promoting selection for linkage between oviposition preference and larval performance. The host vigor hypothesis (HVH) predicts linkage on host tissues that attain relatively large size as a result of high growth rates. We examined preference-performance linkage and tested the HVH by documenting the within-canopy distribution of leaf galls induced by Belonocnema treatae (Cynipidae: Hynemoptera) on its host plant, Quercus fusiformis. Over 2 consecutive gallformer generations, 16 trees were sampled according to previously documented within canopy patterns of carbon uptake (upper > mid > lower and SE > SW = NE > NW) which, along with abiotic correlates, are known to influence phytophage habitat suitability. At each of the 12 strata x direction sites/tree, ovipuncture density, initiated gall density, gall size, and gall-former performance (# mature galls/ovipunclure) were estimated from a random sample of 100 leaves (total 1200 leaves per tree). Three-way ANOVA was used to test for main and interaction effects of direction, strata, and host plant on ovipuncture density, initiated gall density, gall size, and performance. Leaf area was estimated for all second year leaves attacked by B. treatae and correlated with gallformer performance and abundance to test the HVH. Gall and ovipuncture densities were highest in the low stratum. Conversely, performance was highest in the upper stratum. Tissue level performance and abundance were not consistently correlated with each other or leaf size. These results suggest that larval performance is enhanced on more physiologically active regions within host canopies, but preferred oviposition sites are not linked to larval performance and neither is influenced by tissue size. Observed patterns may result from spatially constrained gallformer attack strategies.

Index terms: *Belonocnema treatae* (Cynipidae: Hymenoptera), within-plant distribution, host vigor, preference-performance linkage

[0987] APHIDS: NOT ONLY A PEST INSECT

S.Ganassi¹, <u>A.M.Pagliai¹</u>, A. Moretti², A. Logrieco², B.Fratello¹& M.A. Sabatini¹, ¹Dept. Biologia Animale, Univ. Modena e Reggio Emilia, 41100 Modena, Italy, E-mail: sabatini@unimo.it ²Inst. Tossine Micotossine, CNR, Bari, Italy.

Aphids are considered major pests of crops, as they are sap sucking insects that can induce great damage by nutrient drain or other mechanisms, including virus transmission. Of the organisms proposed for biocontrol of pest insects, fungi producing bioactive metabolites are considered promising candidates, and aphids are considered a very good organism for testing their insecticidal properties. Aphids have parthenogenetic reproduction and short generation times that allow rapid increase in population size, and their colonies have numerous individuals that are closely related genetically. Moreover, due to heteromorphism, with wingless and winged morphs, they represent pest insects with different ecological value. Some fungal species produce toxins, and aphids present characteristics that make them excellent test organisms for verifying the toxic activity against target and non-target organisms. The sap-sucking behaviour allows them to be used to evaluate crops contaminated by toxigenic fungi. Furthermore, due to the peculiar feature of "telescopic generations" it is possible to treat and observe the effects of mycotoxins on two-or-three generations at a time. Aphids are in symbiotic mutualistic association with intracellular prokaryotes, permitting the simultaneous treatment of eukaryotic and prokaryotic organisms and identification of toxic effects on both of them. We used Schizaphis graminum, a cereal pest, as organism to test the effects of two formulations of the fungus Fusarium proliferatum and the effects of two toxins (fusaproliferin and beauvericin) from the same fungus. Treatment of aphids with the two mycotoxins, assumed via feeding on plants, affected their reproductive fitness, in particular with a significant decrease in newborns and increase in aborted embryos and newborns found dead. The large amounts of DAPI and Feulgen positive material in the symbionts of some bacteriocytes in third generation treated aphids suggests an interaction between toxins or their metabolites and nucleic acids. This interaction might affect the numerous exchanges between prokaryotes and their host, leading to anomalies in the aphid life cycle, particularly in reproduction and development. We hypothesise that toxin effects, starting from the first treated generation might also extend to the second and third generation due to telescopic generations. The outcome is an additive pathogenic activity most evident in the third generation. Another possibility is that the target embryos were in a developmental phase particularly sensitive to the bioactive metabolites applied. Second generation embryos, already present in newborns at treatment time, might have passed through the most sensitive phases before treatment and thus be less influenced by the metabolite. Instead, third generation embryos could be submitted to the toxic activity at an earlier developmental stage, and thus possibly be more sensitive.

Index terms: Schizaphis graminum, test organism, mycotoxin, bacteriocytes

[0988] INTRAGUILD PREDATION BETWEEN APHIDOPHAGOUS PREDATORS AND ERIGONID SPIDERS IN CEREALS

A. Gathmann & H.-M. Poehling, Inst. of Plant Diseases and Plant Protection, Univ. of Hannover, Herrenhäuser Str. 2, D-30419 Hannover, Germany, E-mail gathmann@mbox.ipp.uni-hannover.de,

In cereals, polyphagous predators are among the most numerous predators of insect pests. One of the most abundant predators in cereals are erigonid spiders. They can reach abundance of hundred or more individuals per square meter. However, most polyphagous predators can also feed on beneficial arthropods, which may affect the population dynamics of insect pests. Field studies in cotton revealed that intraguild predation (IGP) by hemipteran bugs can reduce the predation rate of lacewing larvae on aphids, but less is known about interactions between aphidophagous and polyphagous predators in cereals. In microcosm experiments we examine the intraguild predation between *Erigone atra*, *Chrysoperla carnea*, *Coccinella septempunctata*- and *Episyrphus balteaus*-larvae. 15 oneweek old wheat seedlings were infested with 20 alatiforme fourth instar larvae of the cereal aphid *Sitobion avenae* and 1 female or male of *Erigone atra* or the other mentioned aphidophagous predators were added, single or in combination. First results showed that spiders could reduce population size of aphids, but are less effective than coccinellid or syrphid larvae. Intraguild predation between spiders and the other predators occured but not very frequently.

Index terms: Chrysopidae, Erigone, Coccinellidae, Syrphidae, competition, predation

Symposium and Poster Session

$\left[0989\right]$ TRAP-NESTING BEES AND WASPS AND THEIR NATURAL ENEMIES AS BIOINDICATORS

A. Gathmann¹ & T. Tscharntke², ¹Inst. of Plant Diseases and Plant Protection, Univ. of Hannover, Herrenhäuser Str. 2, D-30419 Hannover, Germany, E-mail gathmanu[@]mbox.ipp.uni-hannover.de, ²Inst. of Agroecology, Univ. of Göttingen, Waldweg 26, D-37073 Göttingen, Germany, E-mail ttschar@gwdg.de.

Results from our field studies show that communities of trap-nesting bees and wasps and their natural enemies are promising bioindicators for ecological change or habitat quality. These small and easy to handle communities can be analyzed with respect to (i) species richness and related parameters, and (ii) ecological functions or interactions. The communities comprise Hymenoptera (Apidae, Sphccidae, Eumeninae, Pompilidae) and natural enemies belonging to many insect taxa. Traps consisted of 150-200, 15-20 cm long reed internodes, put into tins or plastic tubes of 13-15 cm diameter and wooden posts with 2-10 of such reed-filled tins were exposed in the target habitat. The sensitivity of this bioindicator system profits from the fact that evaluations rely not only on presence or absence of species, descriptive population attributes or diversity indices, but also on interactions or ecological functions. Monitoring ecological responses or multitrophic interactions, and their relationship to species diversity is rarely done but much needed. Ecological functions include e.g. the percentage mortality of trap-nesting bees and wasps due to parasitcids and predators, which was correlated with species richness of these natural enemies, seed set of allogamous plants due to successful pollination by trapinstitute the second se be easily characterized by simple parameters. Taxonomy and biology are well known and quick evaluations can be done using the close correlation between the number of occupied nests and species richness. Species richness of trap-nesting bees and wasps was closely correlated with that sampled by sweep nets. Further criteria of the indicator method are (i) sampling over the whole vegetation period (ii) reproduction and not presence or absence of a species, thereby excluding short term visitors or tourists (iii) possibility of experimental manipulation of parameters such as orientation of nests and diameter of nest holes.

Index terms: Trap nests, Apidae, Sphecidae, Eumeninae, monitoring, diversity, interactions, bioindication

[0991] THE NESTING BIOLOGY OF EUFRIESEA VIOLACEA (HYMENOPTERA: APIDAE) IN TRAP-NES'TS

A. L. Gazola¹ & C. A. Garófulo², Faculdade de Filosofia Ciências e Letras de Ribeirão Preto – USP, Dept. de Biologia, Av: Bandeirantes 3900, CEP: 14040-901, São Paulo, Brasil, E-mail: ¹algazola@usp.br ²garofalo@ffclrp.usp.br

The nesting behavior of Eufriesea violacea was studied on the campus of the University of São Paulo, Ribeirão Preto, SP, Brazil, from October to December 1998. Trap-nests consisted of bamboo canes, which were cut so that the nodal septum closed one end of the cane. The canes were placed horizontally along two shelves in a shelter built near the laboratory. The bees (n=16) nested in bamboo canes ranging from 14.8 to 25.9 cm in length and from 0.9 to 1.8 cm in diameter. Space occupied by the nest within the trap was filled with small pieces of barks, firmly fused to one another with resin, and the cells were moulded within this substrate. The trips to collect construction material (barks + resin) lasted 2 to 45 min (n = 127), and the time spent by the female to deposit the material within the cavity ranged from 0.6 to 3.0 min (n=37). After the cell is built the female collects resin which is used to line the inner cell wall. Larval food (pollen + nectar) collecting trips lasted 50 to 160 min (n=41), and the food discharge into the cell lasted 0.9 to 3.5 min (n=69). The duration of cell provisioning ranged from 4 to 15 days (n=29), but 59% of cells were provisioned from 4 to 8 days. After finishing the provisioning, the female oviposits and immediately seals the cell by constructing the cell partition. After finishing the construction of the cell partition, the female repeats the same procedure until all the brood cells are built. The period in which a female remained nesting in the area ranged from 13 to 54 days and it was significantly correlated with the number of cells built (r=0.638; P< 0.05; n=15). The number of brood cells in each nest ranged from 1 (n=5) to 6 (n=1) arranged in a linear serie. Of the 16 nests obtained, 4 nests produced only females, 4 nests had only males, 3 nests both sexes, and in 1 nest the inimature was dead. Of the 4 remaining nests, dead immatures were found in nests that produced females (n=2), males (n=1) and both sexes (n=1). Of the 33 brood cells built in the 16 nests, 28 produced adult bees and 5 contained dead immatures from unknown causes. The sex ratio of 28 individuals emerging from the nests was 35.7% female to 64.3% male which is not significantly different from a 1:1 sex ratio ($x^2 = 1.75$; P> 0.05) In the nests that produced both sexes, males always emerged before females. The egg-to-adult period ranged from 311 to 345days for females (n=9) and from 303 to 341 days for males (n=16) indicating the occurrence of a single generation per year.

Index terms: Euglossini, bee, behavior.

[0990] MORPHOLOGICAL CHARACTERIZATION OF TWO PASSIFLORA SUBEROSA FORMS AND INFLUENCE ON HOST PLANT SELECTION BY HELICONIUS ERATO

<u>E. A. B. Gauer</u> & G. R. P. Moreira, PPG Biologia Animal, Depto de Zoologia, Inst. de Biociências, Univ. Federal do Rio Grande do Sul. Av. Paulo Gama, 40. Porto Alegre, RS, Brasil, Cep. 90.046-900, E-mail grpm@if.ufrgs.br

In South Brazil, there is a strong phenotypic variation within populations of Passiflora suberosa (Passifloraceae), as for example on leaf color, trichome density, toughness and shoot growth rates. Contrary to plants located under shade situation, which are green, those established in open areas are violet, grow slower and have tougher leaves, and greater trichome density. The latter form is apparently avoided for oviposition by females of Heliconius erato phyllis (Lepidoptera: Nymphalidae), to whose larvae P. suberosa is one of the preferred host. Thus, phenotypic variation in this passion vine populations could be caused at least in part by local changes in light intensity, and be associated with herbivory exclusion by H. erato phyllis, which are examined in this study. We grow P. suberosa under two light regimes (light and shadow), characterize the resulted phenotypic forms, and test the corresponding response by H. erato phyllis. The study was conducted under laboratory and insectary conditions with field collected adults of H. erato phyllis and transplanted plants of P. suberosa from populations of Porto Alegre County, Rio Grande do Sul State. To produce the shadow condition, potted plants were individually covered with a 50% plastic screen. Every 14 days during the summer, plants under light and shadow situations were compared regarding growth rates of shoots, and variation on leaf color, size, toughness, and on trichome density. Sequential and simultaneous choice experiments were performed under insectary conditions to determine the oviposition preference regarding the two P. suberosa forms. Under laboratory conditions, larvae were reared on green and violet shoots to evaluate the corresponding feeding consequences on growth rates and adult size. We confirmed field observations concerning the effects of light intensity on changes of P. suberosa phenotype from a typic green to a violet form. Also, H. erato phyllis females preferred to oviposit on green to violet shoots on both sequential and simultaneous choice trails. However, there was no effect on larval performance. Thus, the ultimate causes for the corresponding oviposition choice remain undetermined. Additional studies indicate there is no significant differences among these forms regarding their nutritional value for H. erato phyllis larvae. Also, that females select the two forms according to color, within the human visible spectrum, and that the violet aspect of leaves is related to presence of antocionins.

Index terms: phenotypic plasticity, host plant selection, oviposition preference

[0992] CHANGES IN THE DEVELOPMENT OF MOSQUITOES OF THE CULEX PIPIENS COMPLEX CAUSED BY HORMONES, TEMPERATURE AND POPULATION DENSITY

I. Gelbic¹ & J. Olejnícek², ¹Institute of Entomology AS CR, ²Institute of Parasitology AS CR, Branišovská 31, 370 05 Ceské Budejovice, Czech Republic, E-mail: gelbic@entu.cas.cz

Developmental changes were found in the laboratory populations of mosquitoes of the *Culex pipiens* complex - autogenous *C. p. molestus* Forskal and anautogenous *C. p. quinquefasciatus* Say. In both species reared in the water containing different concentrations of analogs of insect hormones (methoprene, hydroxycedysone) exhibited dose dependent toxic effects , effects on the delevelopment of larvae and malformations of pupue and adults. Analog of juvenile hormone caused prolongation of larval development. In various strains of *C. p. quinquefasciatus* and *C. p. molestus* of various geographical origin different sensitivity to the action of tested compunds was found. Developmental changes caused by insect hormones were accompanied by changes in hemagglutination activity in gut., namely in the adults obtained after application of JHA on the larvae of *C. p. quinquefasciatus*. Various strains of the same subspecies can significantly differ in the response on various temperature and density during the preimaginal development. They can maintain these discaracters for several years even if they are reared for long time in constant laboratory conditions. That is why, we can teoretically have a situation when two different populations of the same species can coexist in the field in the same locality, adults of which need not meet.

Index terms: Culex molestus, Culex quinquefasciatus, toxicity, vector, autogeny, anautogeny, development, hemagglutination activity

[0993] LIVING AT THE EDGE OF ICE: CARABID BEETLES IN AN ALPINE GLACIER FORELAND

B.-A. Gereben-Krenn¹ & H.W. Krenn¹, ¹Institute of Zoology, Univ. of Vienna, Althanstr. 14, A-1090 Vienna, Austria, E-mail Barbara-Antina. Gereben@univie.ac.at

Based on the alternating periods of climatic cooling and warming over geological time, the attendant changes of glacial advances and retreats can be determined. Most glaciers in the European Alps have been retreating since the maximum postglacial extension in the middle of the 19th century, although occasionally interrupted by short advances. The dramatic retreat of glaciers in the last ten years has opened up new area for the colonization of animals and plants. Glacier forelands are suitable for the study of colonization in expanding high-altitude habitats, their primary succession and the underlying factors and mechanisms. In the Hornkees glacier foreland (Zillertal Alps/Austria) the first investigation of the succession of the arthropod fauna dates back to the middle of the 20th century. These studies showed that carabid beetles are one of the major epigean arthropods. In a second phase of investigation, between 1986 and 1988, distribution patterns of carabid beetles were assessed in more detail for this particular glacier foreland. Among the Carabidae, species of the genus Nebria are found to be the first colonizers of new alpine area after glacier retreat. The six Nebria-species, which were dominant within the ground beetle assemblage of the Hornkees glacier foreland in both the number of species, as well as in the number of trapped individuals, provided an excellent opportunity to investigate the co-existence of taxonomically closely related carabid beetles in the high-mountain region. The study focused on aspects of habitat and microhabitat use of the adults and larvae, phenology and diel activity. Each of the Nebria-species was most active, both as adults and larvae, in different areas within the glacier foreland characterized by distinct geomorphological and ecological conditions. The most recent investigation in the Hornkees glacier foreland were carried out in the year 1999. The glacier has retreated more than 100 m in the last ten years. The youngest ice-free area is limited by a characteristic end moraine. Five Nebria-species co-exist in an area immediately below this end moraine but only two Nebria-species were found in the newly exposed area above the end moraine. Comparative investigation of the distribution patterns and environmental factors in the various areas within the Hornkess glacier foreland allow us to conclude that habitat selection seems to be a major mechanism for the colonization and co-existence of carabid beetles of new alpine areas

Index terms: Nebria, Carabidac, co-existence, colonization

109941 AGE-SPECIFIC LIFE TABLE OF LIPAPHIS ERYSIMI (HOMOPTERA: APHIDIDAE) UNDER FIELD CONDITIONS

K. B. Godoy¹ & F. J. Cividanes¹, ¹ Dep. de Fitossanidade. Univ. Estadual Paulista, Via de Acesso Prof. Paulo Donato Castellane, s/n. Jaboticabal, São Paulo, Brazil. 14870-000, Email karlla@fcav.unesp.hr, CNPq Fellowship.

This work was developed in the experimental area of the Departamento de Horticultura, Faculdade de Ciências Agrárias e Veterinárias, Universidade Estadual Paulista, Jaboticabal, SP, Brazil, during the winter (August 13th, 1998 – February 22th, 1998) and summer (February 15th, 1999 – March 3th, 1999). The aphid *L. erysimi* was reared in kale, Brassica oleracea L. var. acephala, aiming the development of age-specific life tables, which are fundamental for to understanding the population dynamics of this insect pest. The results showed that the net reproductive rate (Ro) was larger in the winter (53.50) than in the summer (40.99), the same being observed with the mean generation time (T), which was 13.85 days for the winter and 7.57 days for the summer. The intrinsic rate of natural increase (r_m) and the finite rate of increase (λ) were 0.29/1.34 and 0.40/1.63 for winter and summer, respectively. The doubling time (DT) observed in the winter (2.39 days) was larger than the one observed in the summer (1.41 days).

Index terms: Insecta, ecology, population dynamics, Brassica oleracea

[0995] THERMAL REQUIREMENTS AND PREDICTION OF POPULATION PEAKS OF LIPAPHIS ERYSIMI (HOMOPTERA: APHIDIDAE)

K. B. Godoy¹ & <u>F. J. Cividanes¹</u>, ¹Dep. de Fitossanidade. Univ. Estadual Paulista, Via de Acesso Prof. Paulo Donato Castellane, s/n. Jaboticabal, São Paulo, Brazil. 14870-000, Email karlla@fcav.unesp.br, CNPq Fellowship.

The kale (Brassica oleracea L. var acephala) is attacked by several aphids species and Lipaphis erysimi is one of the most important of them. The determination of thermal requirements of pests provide a better understanding of the population dynamics of insects by allowing the prediction of population under field conditions. This work was developed at the laboratory of Insect Ecology of the Departamento de Fitossanidade and at the experimental area of the Departmento de Horticultura, Faculdade de Ciências Agrárias e Veterinárias, Universidade Estadual Paulista, Jaboticabal, SP, Brazil, during the period from October 1998 to August 1999. The aphid was reared in kale aiming to estimate its thermal requirements. For this, L. erysimi was studied under laboratory conditions, using incubators adjusted to 10, 15, 20, 25 and 30°C, 14 hours photophase and 70±10% RH. The lower developmental thermal threshold found was 3.04°C and the thermal constant 132.21 degree-day. The prediction of adult occurrence in the field was done using the triangulation method and the results showed that the predicted populational peak occurred 0-1 day before the observed dates in the field.

Index terms: Insecta, temperature, degree-day, thermal threshold, Brassica oleracea

[0996] INSECTS AS BATS' PREY: A CASE STUDY ON KUHL'S PIPISTRELLE (PIPISTRELLUS KUHLII)

U. Goiti, P. Vecín, I. Garin, J. R. Aihartza & M. I. Saloña, Dept. Zoología y Dinámica Celular Animal, Fac. Ciencias, Univ. País Vasco - Euskal Herriko Unibertsitatea, Apdo. 644 - Leioa, 48080 Bilbao, España, E-mail zopsabom@lg.ehu.es

Insects are known as basis of the diet of many bat species. Recently, several studies have pointed out specificity and seasonal changes of diet (Vaughan, 1996). This study has focused on *Pipistrellus kühlii*, a species of subtropical origin, which shows a southern distribution in Europe. This work was carried out from May to October 1999 on a breeding colony roosting in our university campus. Previous surveys of this species delimited 2 main activity areas for this colony: the campus itself and a reservoir close to the University. In both areas, we used Malaise traps every month during one night to collect insects and determine prey availability. The next day, faecal pellets were picked up on the floor beneath the nursery: 20 drops were selected randomly for analysis. Cuticle fragments found in them were compared with insects collected in the activity areas and identified, at least, to order level. Preliminary results of this research show that diet changes monthly and it seems to be not related with prey availability. Diptera are the most abundant insects collected by Malaise traps, especially Chironomidae, Cecidomyiidae and Psychodidae (moth flies mainly in May and June). Nevertheless the main groups identified in faceal pellets during the whole period were Lepidoptera and Diptera (mainly Culicidae). However, the presence of a species of a Coleoptera Scarabeidae (*Rhyzotragus* sp.) was remarkably predominant in May drops. Oth , taxa that appeared also, but in lower abundance, were Hymenoptera (Aphidiidac), Neuroptera (Hemerobiidae), Psocoptera (Stenopsocidae), Heteroptera (Acanthostomidae), Trichoptera (Beraeidae) and and Ephemeroptera. Other Arthropoda have been found although sporadically in bat drops such as isolated mites, probably parasites of fed diptera and of bats themselves ingested while grooming, and spiders.

Index terms: trophic, phenology, prey selection, Chiroptera

Symposium and Poster Session

[0997] DO INSECTS CONTRIBUTE TO LENGA (NOTHOFAGUS PUMILIO) DECLINE? A STUDY IN TIERRA DEL FUEGO, ARGENTINA

<u>C. A. Gomez</u>, Patagonian Andes Forest Research and Extension Center (CIEFAP), P.O. Box 14, 9200 Esquel, Chubut, Argentina, E- mail: cecilia@ciefap.cyt.edu.ar carabell@teletel.com.ar

Lenga is the most important ecological and economic native forest species in the patagonian region of Argentina. However, timber exploitation is mainly affected by the occurrence of white and brown rots in the heartwood that determine a poor sanitary condition as they decrease the stability of trees, their quality and wood value. Primary insects also contribute to the loss of vitality in trees. To improve the knowledge on the relationship between insects and fungi, the role of insects in diminishing the vitality of lenga was studied. 39 trees were selected, 18 of them unhealthy and 21 healthy, according to their external good commercial qualities. As no intense defoliations were registered in the study area, every branch were examined in detail looking for sapsuckers and phloem and wood horer insects. Sections of attacked branches were left in the field under caged conditions to report the emergence of adults. It was characterized the length, form, position and direction of the founded galleries just as colour, form and structure of the sawdust. Although primary insects and phloem borers were not registered on crowns, we could characterize aspects of the biology of Microplophorus magellanicus, a cerambycid boring beetle in rot wood, which was registered on 72% of studied crowns. The larvae of this species live within the brown rotted heartwood, following fungi in the colonization process. These rots define the extent of galleries that generally are related to dead branches and wounded bark, as it occurs with fungi.

Index terms: *Microplophorus magellanicus*, brown rot, fungus-insect relationship, loss of vitality.

[0999] DO HOST PLANT TRAITS AND GALLING INSECTS AFFECT THE ABUNDANCE OF ISSUS SP. ON COLLIGUAJA ODORIFERA ALONG AN ALTITUDINAL GRADIENT?

W. L. Gonzáles¹, R. Fernández² & H. M. Niemeyer¹, ¹Laboratorio de Química Ecológica, Departamento de Ciencias Ecológicas, Facultad de Ciencias, Univ. de Chile, Casilla 653, Santiago, Chile, willy@abulafia.ciencias.uchile.cl, ²Laboratorio de Ecofisiología, Area de Biodiversidad Animal, Facultad de Ciencias Naturales y Matemáticas, Univ. Nacional Federico Villarcal, Lima-Perú, rosariofi@hotmail.com

The common shrub Colliguaja odorifera is distributed between 600 and 1200 meters above sea level, and is scarcely attacked by folivorous insects but strongly attacked by gall makers. Previous work has focused on different aspects of the relationship between galling insects and C. odorifera, emphasizing the relevance of plant traits and the influence of altitudinal gradient. However, a common jumping hemiptera, Issus sp. closely associated to C. odorifera, has been poorly studied. In this work, the pattern of abundance of Issus sp. on C. odorifera growing at two contrasting sites was evaluated in relation to plant traits (fruits, flowers, buds, plant size and cover) and galling insect abundance. Two contrasting sites, at low (850 m.a.s.l.) and high (1150 m.a.s.l.) altitudes, were studied. At the low site, the number of fruits and buds, cover and plant size were larger (t-test, p < 0.05, for each trait) than in the high site. The number of galling insects and isids was higher in the low site. The ratio of isids to galls was not significantly different in low and high sites. The ratio of fruits to isids was significantly larger in the low site (t- test, p < 0.05) than in the high site. Using multivariate approaches to each site, plant cover was significantly (F2.97 =4,89, p<0.01) and positively associated with isid abundance in the low site, whilst at the high site the number of fruits was significantly ($F_{3,36}$ = 3.18, p < 0.05) and positively associated with isid abundance. The effects of plant phenology and presence of galls on isid abundance are discussed in terms of population dynamics of the insect species envolved.

Index term: Issus sp, Colliguaja odorifera, herbivores, altitudinal gradient

[0998] EFFECT OF CATERPILLARS AND DEFOLIATION IN OVIPOSICION OF PLUTELLA XYLOSTELLA

A.H.R. Gonring¹, M. Picanço¹, R.N.C. Guedes¹ & A.L.B. Crespo¹, ¹ Dept. de Biol. Animal, Univ. Fed. de Viçosa, CEP 36571-000, Viçosa, MG, Brazil, E-mail: gonring@alunos.ufv.br.

This greenhouse work was led in the Federal University of Viçosa, at Viçosa, State of Minas Gerais from May to June, 1999. During the experimental period the temperature ranged between 25.5 \pm 3.5°C, 75 \pm 5% of relative humidity and 10 hours photofase. Twenty four hours before the installation of the bioensay hybrid Astrus cabbage plants were infested with 2, 4, 8 and 16 caterpillars of Plutella xylostella (Lepidoptera: Yponomeutidae) of he fourth instar/leave, to produce different rates of defoliation. The experimental design was in blocks randomized with 10 treatments and four repetitions. The treatments were established in factorial outline 2 x 5 (caterpillars presence or not x defoliation levels). In leaves with three 4th instar caterpillar placed/leaf. Initial levels of defoliation ranger between 0 and about 1.60, 2.54, 4.61 and 7 cm²/leaf. The experimental portion was constituted by a glass of 200ml sealed with cotton and parafilm containing cabbage leaf with submerged peciole in water. Each block was constituted by wood cage 1.0 x 0.9 x 0.5m covered with organdy cloth. The portions were distributed equally distant from each other inside each cage. For the bioensay installation 300 non sexed adults of P. xylostella up to three days of life, raised in laboratory were released in the cage. The counting of P. xylostella eggs on cabbage leaves took place 24 hours after exposure to this insect. After the bioensay the contour of the defoliation was copied in paper white A4 of 72 g/m^2 density. Contours were cut out and their areas were measured three times in portable apparel of measurement of areas. The average of these evaluations was taken as the defoliated area. Experimental data was submitted to the covariance analysis and of regression p < 0.05. Larger number of eggs of P. xylostella cabbage leaves was verified with the increase of the rate of defoliation caused by this insect (p < 0.0001; $R^2 = 0.4335$; n = 40). The effect of caterpillars was not detected on the oviposicion of this species after 24 hour defoliation (F = 0.24; p = 0.6292).

Index terms: Insecta, behavior, diamondback, Brassica oleraceae var. capitata.

[1000] COMPARISON OF SENSITIVITY TO COLD IN SOUTH AMERICAN FRUIT FLY AND MEDFLY (DIPTERA: TEPHRITIDAE)

M.C.Gramajo¹, G.Gastaminza¹, <u>E.Willink¹</u>, A.R.Salvatore¹, M.B.Carrizo¹ & A.Macián¹, ¹Estación Experimental Agroindustrial Obispo Colombres, C.C.n^o 9, Las Talitas, (4101) Tucumán, Argentina. E-mail: saneeaoc@tucbbs.com.ar.

The presence of the South American fruit fly Anastrepha fraterculus and the medfly Ceratitis capitata in citrus groves in Argentina has imposed trade restrictions on the commercialization of fresh fruit to countries free of those pests. Such countries demand the implementation of measures to avoid the introduction of the fruit flies into their territory. Exposure to cold is one of postharvest treatments most often used to eliminate fruit fly immatures in citrus fruits. The USDA has determined the number of days at different low temperatures necessary to satisfy quarantine requirements for various fruit fly species. At a temperature of 1,66°C fourteen days are required to eliminate *C.capitata*, 22 days for A.ludens and 17 for other Anastrepha species. However, no cold sensitivity tests have been made for A. fraterculus. The objective of this research was to compare the cold sensitivity of A. fraterculus and C.capitata in oranges in northwestern Argentina. Third instar larvae were used in the tests because they are the life history stage which best tolerates low temperatures. The larvae were obtained by rearing in the laboratory. Each test included 10 different exposure time treatments of 8 inoculated fruits, and was repeated 3 times. Eighty eight Valencia Late orange fruits were inoculated with 35 larvae each, kept for 24 hours at 25°C, and then placed in a cold chamber at 2±0,5°C, to which 12 noninoculated fruits with sensors were added in order to verify the flesh core temperature. The cold treatment started when more than 6 sensors showed 2°C or less. Eight fruits were The cold from the cold chamber after 4,6,8,10,12,14,16,18,20 and 22 days, respectively. These were left for 48 hours at 25°C, and then were evaluated for live and dead fruit fly larvae. The mortality data were analysed using the Probit method, establishing the lethal time (LT) 50 and 99, with their respective confidence intervals. The overlap of the LT 50 confidence intervals shows that there is no significant difference in tolerance to cold between the 2 fruit fly species. The same occurs for the LT 99 confidence intervals. After 20 days exposure to cold no live larvae of either species were found. It is thus evident that the cold treatment currently used for C.capitata also guarantees total elimination of A fraterculus.

Index terms: Anastrepha fraterculus, Ceratitis capitata, quarantine.

[1001] PLANT PATCH SHAPE AND SURROUNDING VEGETATION AFFECT THE POPULATION DYNAMICS OF PREDATORY AND HERBIVOROUS INSECTS

A. A. Grez¹ & E. Prado², ¹Facultad de Ciencias Veterinarias y Pecuarias, Universidad de Chile, Casilla 2, Correo 15, La Granja, Santiago Chile, E-mail agrez@abello.dic.uchile.cl; ²INIA La Platina, Santiago, Chile, E-mail eprado@platina.inia.cl. Funded by FONDECYT 1970853

We assessed the effect of plant patch shape and surrounding vegetation on the density, emigration, and immigration of predatory coccinellids, and on the density of their prey, Brevicoryne brassicae. Between spring 1997 and fall 1999, we set up square and I-shaped patches of Brassica oleracea surrounded by Medicago sativa or Allium porrum. Medicago sativa was considered more permeable to coccinellids than A. porrum based on the former's greater use by coccinellids. We used a factorial (2 shapes x 2 surrounding vegetations) randomized block design, and evaluated the density of coccinellids and aphids every 10 d. We also evaluated emigration and immigration of adults coccinellids through mark-recapture experiments. We quantified the population increase of aphids, and the final weight of plants. All insects were more abundant in patches surrounded by A. porrum than in those surrounded by M. sativa, and coccinellids were occasionally more dense in square patches than in I-shaped ones. Coccinellids emigrated less from square patches, either surrounded by A. porrum or M. sativa, and immigrated more to patches surrounded by A. porrum, particularly square ones in the case of E. connexa. Aphids had a higher population increase, and plants of B. oleracea ended to be heavier in patches surrounded by A. porrum, particularly in I-shaped patches. Surrounding vegetation and plant patch shape seem to have a direct effect on the density of coccinellids by modifying their immigration and emigration patterns, but also seem to have an indirect effect resulting from changes in plant growth and its effect on herbivorous recruitment.

Index terms: Eriopis connexa, Hippodamia variegata, Brevicoryne brassicae, patch geometry, edge permeability.

[1002] RESPONSES OF AQUATIC INSECTS TO AN ENVIRONMENTAL STRESS GRADIENT

C. M. Gualdoni[†] & <u>M. del C. Corigliano[†]</u>, ¹Dpto. Ciencias Naturales, Universidad Nacional de Río Cuarto, Ag. Postal 3, X5804 BYA - Río Cuarto, Argentina. E-mail: mcorigliano@exa.unrc.edu.ar.

Lotic communities structure changes from the headwaters to the mouth of river systems in response to physical, chemical and hydraulic conditions of natural or anthropogenic origin. Organic pollution generally reduces insect diversity. However, since some species benefit from the increased supply of food, the numbers of macroinvertebrates may increase. The aim of this study was to analyze the benthic and drifting insects response to organic contamination, in a fluvial system which receives a sewage discharge. Along the Chocancharava river basin (Córdoba, Argentina) benthos and drift were sampled at 10 sites, for two years in high and low water level conditions. Application of the TWINSPAN program to the data set suggested that benthic and drifting fauna was distributed in characteristic groupings of rhithron, foothill and potamon reaches, where insects showed the higher densities and species richness. Baetis sp.1, Camelobaetidius penai, Paracloeodes sp., Leptohyphes sp., Tricorythodes sp. and other less frequent Ephemeroptera species contributed with more than the 75% of insect fauna. A gradual change in community structure and composition was observed until the sewage discharge site, where abrupt changes were produced. Immediately downstream from the release, the abundance of Chironomus sp., Nematoda, Nais variabilis and Limnodrilus hoffmeisteri increased, while non-Diptera insects were absent. Downstream of the polluted stretch Chironomidae was dominant in benthic community, the densities of Nematoda and Oligochaeta decreased and Ephemeroptera incremented again. Besides, in the drift fraction the contribution of non-insect groups continued being important. Abundance and composition of both fractions were similar in two flow conditions, except in the perturbed reach, where there were alterations during low water flow periods. The environmental stress produced by sewage effluent limited the insect densities and favored the population expansion of tolerant organisms to low oxygen concentrations. However, the disturbance only affects few kilometers. Although the abundance of insects drift decrease at the impact site, there is a fraction that surpassed it, demonstrating that drift would be an adequate mechanism to transpose ecological barriers such as polluted stretch. Recuperation of benthic community would be favored by the energy subsidy produced by the increment of organic material and by the recolonization mechanisms like drift and migrations from hyporreos.

Key-Words: Baetis sp.1, Camelobaetidius penai, Paracloeodes sp., Leptohyphes sp.

[1003] PHENOLOGICAL INTERACTIONS BETWEEN THE WEEVILS EXAPION SPP. AND LEPIDAPION SPP. AND THE GENISTEAE IN CENTRAL SPAIN (SW EUROPE)

<u>P.Gurrea¹</u>, M. J. Sanz² & Y. Jiménez¹, ¹Dept. de Biología, Univ. Autónoma de Madrid, Cantoblanco, 28049 Madrid, Spain, E-mail pilar.gurrea@uam.es; ²Fac. de Biología, Univ. Internacional SEK, c/. Cardenal Zúñiga, 12, 40003 Segovia, Spain.

Larvae and adults of weevils belonging to genus *Exapion* and *Lepidapion* (Coleoptera, Curculionoidea) feed on different parts of their host plants. Adults are leaf-eaters whereas larvae feed on seeds and flowers. In this work different behaviour patterns of eight weevils species (*Exapion compactum*, *E. fuscirostre*, *E., laufferi*, *E. putoni*, *Lepidapion argentatum*, *L. cretaceum*, *L. gallaecianum* and *L. squamidorsum*) are shown, which have been found on seven species of Genisteae in the Iberian Peninsula (*Genista florida*, *G. cinerascens*, *Adenocarpus complicatus*, *Echinospartum barnadessi*, *Retama sphaerocarpa*, *Cytisus scoparius* and *C. oromediterraneus*). By studing the insects phenology we have found that adults have two annual population maxima, one of them in spring time and the other one at the end of the summer. The species whose larvae are flower-eaters have the first population maxima at the beginning of the spring, whereas in the species whose larvae are seed-eaters this peak takes place in the middle of the spring. When we compare the insects phenology to their host plant phenology we find a narrow relationship between both. Index terms: Curculionoidea, seed-eaters, flower-eaters, host-plant

[1004] SPATIAL DISTRIBUTION OF INMATURE STAGES OF THE SWEETPOTATO WHITEFLY (BEMISIA TABACI) IN SESAME (SESAMUM INDICUM)

H. E. Laurentin¹ & <u>C.J. Pereira</u>², ^{1,2} Departamento de Ciencias Biológicas. Decanato de Agronomía. Universidad Centroccidental "Lisandro Alvarado". Apdo. 400. Barquisimeto, Lara, Venezuela. E-mail: helauren@yahoo.com entm96@hotmail.com

To estimate within plant distribution of eggs and nymphs of *B. tabaci* on six sesame genotypes, field studies in Turen, Portuguesa state, Venezuela were established in 1998 and 1999, using complete randomized block designs, four times replicated. Treatments consisted of all combinations of genotypes, three plant sampling strata (apical, medium, and basal), six sampling dates, and two years of evaluations. After natural infestations of experimental plot by *B. tabaci*, five leaves per stratum were weekly removed from each experimental plot during six consecutive weeks. Leaf area, number of eggs (H), and number of nymphs (N) were recorded for each leaf and transformed using a log transforming factor [In (x+1)] to conduct statistical analyses. A significant genotype x stratum interaction (P < 0.01) was detected for H and N, indicating differential variability of these forms in each stratum along genotypes. A three way significant interaction (genotype x stratum, likewise, in all combinations the basal stratum, showed greater values of N than the basal stratum, likewise, in all combinations the basal stratum showed greater values of this variable than the apical stratum on sesame plants, which indicates what leaves should be taken to estimate its population in sesame.

Index terms: Bemisia tabaci, Sesame, Within plant distribution.

[1005] COMPARATIVE BIOLOGY OF ANAGASTA KUEHNIELLA (LEPIDOPTERA, PYRALIDAE) FED ON THREE DIFFERENT DIETS BASED ON WHEAT GRAINS

M. E. M. Habib¹ & <u>F. Cabral²</u>, ¹ Dept. Zoology, IB, University of Campinas (UNICAMP), SP, 13083-970, Brazil; ² Dept. Parasitology, IB, University of Campinas (UNICAMP), SP, 13083-970. E-mail: fcabral@obelix.unicamp.br.

Biological informations about insect pests are necessary to develop successful IPM strategies. Like all the other animals, insect reproduction and development are directly influenced by the quality, as well as the quantity, of the available dict. The present study was conducted to, comparatively, study the biology of Anagasta kuehniella, reared on three distinct diets, all based on wheat grains: whole meal flour, grain germ and bran. The mated adult activities, investigated in 40 pairs per diet, included reproductive performance, longevity and duration time of its different phases. Concerning the unmated adults (n = 80), only longevity of both sexes was determined. The biology of the immature stages was undertaken investigating 250 individuals in each diet. The whole meal flour, utilizing the different biological indicators, showed to be the most adequate for the development of the immature stages. While the germ dict occupied an intermediate position, the bran one showed to be the worst. Under 25° C, 70% RH and 12 kr photo-period, the larval stage lasted an average of 29.41 ± 0.121; 37.38 ± 0.1.13 and 71.21 ± 1.72 days for whole meal flour, germ and bran diets, respectively. For these diets, and in the same sequence, the prepupal stage lasted 2.45 \pm 0.06; 1.86 \pm 0.06 and 7.16 \pm 0.25 days. The pupal one completed its development after an average of 11.35 \pm 1.16; 17. 40 \pm 0.63 and 17.30 \pm 0.07 days, respectively in the same sequenced diets. The natural mortality during the larval stage of the individuals reared on bran was more than 3 times higher than that of those reared on the other two diets, possibly due to its physical structure or hardness. In spite of its high energetic value, the bran inadequacy resulted also in the lightest pupae weight, in comparison with the other dists. The unmated adult longevity was shown to be higher that that of the mated ones, independently of sex or larval diet. In all cases, the male longevity showed to be higher than the female one. The number of eggs deposited per female, showed to be a good biological indicator to evaluate the efficiency of larval diets. While the adults, emerging from bran diet, deposited an average of 55.97 ± 7.68 eggs / female, those from the whole meal flour and germ diets produced an average of 175.9 ± 12.14 and 158.0 ± 3.96 eggs per female, respectively.

Index terms: nutrition, development, reproduction, insect

[1006] EL NINO, LA NINA AND BROWN LOCUST PLAGUES

<u>S.A. Hanrahan</u>, Dept. of Animal Plant & Environmental Sciences, Univ. of the Witwatersrand, WITS 2050, South Africa. E-mail shirley@gecko.biol.wits.ac.za

Rainfall is a key factor in the factor in the hatching of grasshopper and locust eggs. The brown locust, Locustana pardalina appears to have a regular cycle of swarming and nonswarming events. These have been recorded since 1910. The recording of actual locust numbers has never been attempted. The number of swarms destroyed have been recorded for each magisterial district. The records were kept to repay farmers and others for swarm control. The government provided the poison and paid for mileage. Swarming behaviour develops as the drought periods common to this country began to wane. L. pardalina is particularly well adapted for living in dry conditions. For example, females will lay eggs in dry soil where most other species require damp soil, the eggs can with stand high levels of desiccation and are capable of surviving long periods in a quiescent state. L. pardalina seems to be constantly ready to exploit favourable conditions. It has been shown that southern Africa has a rainfall pattern that is influenced by the Southern Oscillation . The central Karoo region, a semi-arid area where drought periods alternate with above average rainfall is the outbreak area of the brown locust. Southern Oscillation variations here are linked to El Nino cycles but the connections are tenuous. During the El Nino years southern Africa experiences drought or below average rainfall in the low phase of the Southern Oscillation. During the high phase above average rainfall would be expected . It yould seem intuitive that locust outbreaks or irruptions and recessions would link with La Nina and El Nino events. A simple comparison of locust outbreaks as measured by number of magisterial districts recording swarm destruction and lull periods with no locust activity shows a strong correlation with the timing of La Nina and El Nino events. Index terms: Locusta pardalina, brown locusts, swarming, El Nino,

[1007] ADAPTIVE CASTE MANIPULATION BY A POLEMBRYONIC PARASITOID WASP

<u>LA. Harvev^{1,2}</u>, Laura Corley¹ & M.R. Strand¹, ¹Department of Entomology, University of Wisconsin-Madison, Madison, WI 53706 USA; ²Centre for Terrestrial Ecology, Netherlands Institute of Ecology, P.O Box 40, 6666 ZG Heieren, The Netherlands, E-mail harvey@cto.nioo.knaw.nl

One of the most important transitions in insect life history evolution has been a shift from a solitary to a social lifestyle, where groups of specialized individuals (or castes) live together but perform different functions. Among caste forming insects, some individuals reproduce whereas other castes produce few or no offspring, but instead adopt worker functions, such as foraging and defense. Caste formation occurs in a diverse range of inzect groups, from ants and termites to thrips, aphids and polyembryonic wasps. The evolution of specialized castes is determined by natural selection acting at the both the level of the individual and the colony. Consequently, investment into different castes is predicted to be influenced by a range environmental factors, including resource availability, predation and competition. However, at present only limited evidence in the occurrence of adaptive shifts in caste ratios has been obtained. This is partly because it is difficult to manipulate factors influencing caste development, and also because workers of some eusocial species may switch tasks in response to short-term emergencies. Unlike other caste-forming species, the castes of polyembryonic wasps develop clonally, meaning that the increased production of one caste likely results in decreased production of the other. Because of their ability to manipulate the restricted host environment, combined with the absence of task switching, polyembryonic wasps make excellent subjects for studies of caste ratio evolution. Here, we report that the polyembryonic wasp, Copidosoma floridanum, is able to facultatively adjust caste ratios in response to competition by a solitary endoparasitoid, Microplitis demolitor. Our results reveal a classic trade-off between reproduction and defense, and further suggest that polyembryonic wasps like C. floridanum possess the ability to adaptively adjust caste ratios.

Index terms: Copidosoma floridanum, Microplitis demolitor, Pseudoplusia includens, parasitoid, caste induction

[1008] TOP-DOWN AND BOTTOM-UP CONTROL OF INSECT POPULATIONS: INTRODUCTION TO THE PROBLEM

B. A. Hawkins, Department of Ecology & Evolutionary Biology, University of California, Irvine, CA 92697, USA, E-mail: bhawkins@uci.edu

The issue of the relative impacts of foodplants and natural enemies on herbivorous insect populations has a long history in pest management. Biological control in particular is founded on the presumption that top-down effects are strong and widespread, and successes in biological control are commonly used to support the hypothesis that natural enemies are primarily responsible for the regulation of insect populations. However, this is true only if biological control and 'natural control' are synonymous. In this introduction to the symposium I will sketch a brief history of the problem and will assess the evidence that biological control actually reflects a reestablishment of the 'natural balance' that is thought to be lacking in pest situations.

Index terms: Biological control, natural enemies, natural control

[1009] DISPERSAL OF AN ERIOPHYID MITE, THE WHEAT CURL MITE, AND ITS IMPORTANCE IN DISEASE EPIDEMIOLOGY

G. L. Hein¹ & J. A. Thomas¹,¹Univ. of Nebraska, Panhandle Research & Eztension Center, 4502 Ave. I, Scottsbluff, NE 69361, USA, E-mail: GHEIN1@UNL.EDU.

The wheat curl mite Aceria tosichella transmits two viruses to wheat in the Great Plains of North America. These viruses, wheat streak mosaic virus and high plains virus, form a complex that is the most important disease problem to wheat in the western plains. The mites colonize winter wheat through most of the growing season. However, the key to disease epidemiology is the over summering period from wheat harvest in summer until emergence of the winter wheat in the fall. For disease problems to develop, mite populations must survive this period on over summering hosts. The most serious host for developing disease epidemics is volunteer wheat resulting from hailstorms. Hail shells out mature wheat from the heads, and it rapidly germinates and grows. This volunteer wheat provides a perfect 'green bridge' for the mites and virus to survive through the summer. Control of this volunteer is the major management objective in managing this disease. Other summer hosts are present in the region including crops such as corn, foxtail millet, spring wheat and barley and a number of grass hosts that include grass weeds and range and pastures grasses. Because of the tiny size of these mites, extensive study of their behavior and ecology has been limited. The objective of our research has been to try to understand the population dynamics of the wheat curl mite and its potential for dispersing into wheat from various over summering hosts. The mite has mostly been considered capable of dispersing only short distances (i.e. field to field). However, our recent surveys of virus diversity indicate virus variation between locations (counties) within a state is not great enough to detect differences in virus types, thus indicating population mixing. Host plant and genetic data indicate that regional (state to state) differences exist in mite populations. Studies on the survival of mites when held off the plant indicate relatively short survival (<24hrs), but at lower temperature and higher humidity conditions they can survive up to 3-4 days. These survival levels indicate potential for greater than field to field dispersal activity. Studies on the initiation of mite movement from wheat hosts show movement to be a function of the number of mites present rather than plant condition; however, as plant condition worsens the proportion of mites moving increases. The extent of movement from host plants depends on mite survival on the host plant, the growth patterns of the host plant, and the seasonal population dynamics of the mite in the agroecosystem. These factors make rotational and cropping systems important to the epidemiology of this disease complex.

Index terms: Aceria tosickella, wheat streak mosaic virus, high plains virus, movement

[1010] DISTRIBUTION OF THE HORSE-CHESTNUT LEAFMINER, CAMERARIA OHRIDELLA (LEPIDOPTERA, GRACILLARIIDAE) IN THE REGION SOUTH-TYROL – TRENTINO (NORTH EASTERN ITALY)

K. Hellrigl¹ & <u>P. Ambrosi</u>², 'Ripartizione Foreste Provincia Autonoma di Bolzano, Via Brennero 6 I-39100 Bolzano, Italy; 'Istituto Agrario di San Michele all'Adige, Via E. Mach 1 I-38010 S. Michele a/Adige (TN), Italy; E-mail: paolo.ambrosi@ismaa.it.

The horse chestnut leafmining moth (Cameraria ohridella Desch. & Dimic 1986), recently introduced in Central Europe, was observed for the first time in Italy in 1995 in South-Tyrol and Julian-Venctia. Over the last five years, this pest has invaded an area in north Italy about 50.000 Km². Its occurrence causes heavy defoliation on the main host, horse chestnut (Aesculus hippocastanum L.), with serious consequences on plant health and the environment. A survey on the present distribution of C. ohridella, in Italy and in Europe is shown. The progression of the distribution in the region of South Tyrol - Trentino is reported. In the province of Bozen-South Tyrol, between 1995 and 1999 the moth has spread in all three main valleys (Eisacktal, Pustertal, Etschtal). In Trentino province, local attacks began only in 1998, near Trento and Riva del Garda, but spread over the entire Etschtal/Adige Valley in 1999. While in South Tyrol C. ohridella was introduced from the north (North Tyrol), the introduction into Trentino occurred from the south (Verona). At present the attacks in Trentino have a relatively low impact and are serious only in the city of Trento and Riva del Garda. So far, the attacks are limited in a range of altitudes from 70 to 700 m a.s.l. In South Tyrol, attacks are more damaging in a range from 250 to 900 m a.s.l., while they decrease between 1,000 to 1,230 m. A survey was taken in the region and attack intensity and other parameters are given. The number of generations per year depends on climatic conditions: in lower altitudes, usually three generations develop in a year, but in higher altitudes, 800 to 1,100 m, only two generations; in the climatically favoured area around the Garda Lake a partial fourth generation appears possible. The question of host plants (Aesculus sp., Acer sp.) and the larval parasitism of C. ohridella is discussed. The parasitism of the larvae, principally by Eulophidae (Hym., Chalcidoidea), was ascertained already in the first years of attack. In South Tyrol, sixteen species of parasitodes are present, and eight in the Trentino, but only two species were dominant: Minotetrastichus sp. and Pnigalio sp. The level of parasitism reached was relatively low, comparable to other Central European countries.

Index terms: biology, Aesculus sp., parasitism.

[1011] SOUTHERN CORN ROOTWORM: BIOLOGY AND MANAGEMENT IN PEANUT

D. A. Herbert, Jr.¹ & R L. Brandenburg², 1Virginia Polytechnic Institute and State Univ. Tidewater Agric. Res & Ext. Ctr. 6321 Holland Rd. Suffolk, VA 23437 USA; 2North Carolina State Univ. Dept. of Entomol. Raleigh, NC 27695 USA

The southern corn rootworm (SCR), Diabrotica undecimpunctata howardi Barber, is a primary pest of peanut, Arachis hypogaea L., in the United States, especially in Virginia and North Carolina, and occasionally in South Carolina, Georgia, Alabama and Texas. Larvae injure peanut by feeding on developing pods causing direct yield loss, or cause indirect loss by allowing entry of secondary pathogens. Pod yield losses in Virginia have been reported to range from 100 to 500 kg/ha and exceed 1000 kg/ha (30% of total yield) been reported to range from two to so right and exceed two kgrint costs of total yield) in extreme cases. Current management is based on preventive application of soil insecticides (chlorpyrifos, phorate) against larval populations. The development of alternative management strategies has been difficult as SCR undergos several overlapping generations each year, adults feed on hundreds of different host plant species, and larvae which feed underground are difficult to detect and current soil sampling procedures are too labor intensive to be adopted by producers. Also, by the time large numbers are detected, it is essentially too late to apply remedial insecticide treatments. Therefore, producers must make insecticide treatments as 'preventives' with little knowledge of actual pest abundance or likelihood of crop loss. Efforts to monitor or control adults using traps baited with female sex pheromone (10-methyl-2-tridecanone), TIC (1,2,4-trimethoxybenzeae, indole and trans-cinnamaldehyde) or attractants impregnated with carbaryl as a toxicant have not proyen successful. Efficacy is poor and pod damage is unaffected compared with standard larval insecticide treatments. A risk index has been developed that predicts level of pod damage and the relative need for insecticide treatments using factors that affect SCR survival and ability to inflict pod damage: soil texture, soil drainage class, variety, planting date, and field history of crop damage. Field validations from 1989-1999 in producers' fields show that the index can reduce the need for insecticide without loss of vield.

Index terms: Diabrotica undecimpunctata howardi, Arachis hypogaea, IPM

[1012] CIRCADIAN RHYTHMS ON NECTAR AND POLLEN COLLECTION BY FORAGERS OF *MELIPONA BICOLOR BICOLOR* (HYMENOPTERA, APIDAE, MELIPONINAE)

S. D. Hilário¹, <u>A. O. Fidalgo²</u>, V. L. Imperatriz-Fonseca² & A. M. P. Kleinert², ¹Dept. de Zoologia, E-mail sedilar@.usp.br; ²Dept. de Ecologia, Univ. de São Paulo, R. do Matão, Trav. 14, n. 321, São Paulo, SP 05508-900, Brazil, E-mail afidalgo@ib.usp.br.

The aim of this study is to investigate an occurrence of rhythmic frequencies in nectar and pollen collection by Melipona bicolor bicolor. This species, was studied at the Bees Laboratory (Univ. de São Paulo; 23°33'S, 46°43'W) from November/98 to February/99. We used two colonies from Cunha (23°05'S, 44°55'W). These colonies were classified as strong (colony 1) and intermediate (colony 2) according to general condition, population and comb sizes and number of food pots. Nectar and pollen loads were counted for 10 minutes every hour from 6am to 7pm. The sixteen days of observation were separated in four groups of four days. This data were analyzed in chronological order to verify the occurrence of a circadian rhythm. Circadian rhythms were detected in pollen and nectar collection, except when pollen collection was scarce (Jan/99, for both colonies; Feb/99, for colony 2). Although pollen and nectar collection were more conspicuous in the early morning, pollen collection acrophases occurred earlier than nectar collection acrophases, except in Feb/99 - colony 1. The acrophases of nectar collection occurred earlier in the strong colony than in the intermediate one. Pollen collection not showed the same pattern. The results for nectar collection were expected, because foragers from strong colonies usually collect food earlier than bees from intermediate or weak colonies in the same species. In relation to pollen collection, our observations were strongly influenced by climatic changes.

Index terms: Melipona bicolor, bee, circadian rhythms, nectar, pollen.

[1013] MORTALITY ASSESSMENT OF PESTS WITH OVERLAPPING GENERATIONS: THE USE OF LIFE TABLES IN BIOLOGICAL CONTROL

M. S. Hoddle, Department of Entomology, Univ. of California, Riverside CA 92521, USA. E-mail: mark.hoddle@ucr.edu.

Assessing and quantifying the impact natural enemies have on target pest populations is essential if the success of a biological control program is to be determined. One method of assessing natural enemy efficacy against the pest of interest is through the use of life tables. Life tables tabulate pest numbers entering and dying in each life stage, and where possible assignment of mortality factors responsible for death in each stage is made. Multidecrement life tables partition total mortality observed in a stage amongst contemporaneous mortality agents and this approach is extremely powerful for determining which factors have the biggest impact on the target pest's population growth. Assessing the impact natural enemies have on specific life stages of pests with overlapping generations is difficult. Several techniques have been developed to quantify survivorship rates and advancement to subsequent life stages and these include: 1) stage frequency analysis, 2) recruitment analysis, 3) death rate analysis, and 4) growth rate analysis. Each of the preceding systems has its own set of particular shortcomings. One powerful technique that can be used for pests with overlapping generations to accurately quantify advancement to subsequent developmental stages is the use of artificially constructed pest cohorts. Individual survivorship and mortality within these cohorts is monitored over time. Construction of multi-decrement life tables from artificial cohorts can provide extremely useful insight into mechanisms regulating pest population growth. The use of a photographic technique for following artificial cohorts of whiteflies in the presence and absence of aphelinid parasitoids has been used to identify important factors affecting the success of biological control of Bemisia argentifolii on greenhouse grown poinsettias. The results of work assessing the efficacy of varying parasitoid release rates in greenhouses will be used to illustrate the usefulness of life tables in assessing the efficacy of biological control agents against pests with overlapping generations.

Index terms: Eretmocerus eremicus, Bemisia argentifolii, poinsettias, greenhouses

[1014] DENSITY-DEPENDENT GROWTH OF MONOCLONAL APHID COLONIES AND ITS CONSEQUENCES FOR CLONAL FITNESS

D.I. Hodgson¹, ¹Inst. of Virology and Environmental Microbiology, Mansfield Rd., Oxford OX1 3SR, United Kingdom. Email: djhod@ceh.ac.uk.

All aphid species undergo parthenogenetic multiplication for at least part of the clonal life cycle. Many species also have highly aggregated distributions. Aphis fabae forms large colonies on individual host plants: individual members of such colonies may compete for food resources. Density-dependent colony growth is implied by evidence for a dispersal response to crowding, but is difficult to prove empirically. Two experiments were performed to manipulate the dispersal of aphids from monoclonal colonies. The first demonstrated that few aphids dispersed from colonies before peak colony size was reached (early dispersers). Replacing the few aphids which did disperse early had no impact on the total number of dispersers produced over the entire lifespan of a colony. This demonstrated a growth-then-dispersal pattern of colony development. If colony growth is density-dependent, the release of early dispersers should relieve competition on the host plant and lead to greater longevity of the colony and increased total disperser-production over the colony's lifespan. Increased early dispersal was mimicked in the second experiment by harvesting adult aphids from growing colonies. The results confirmed the predictions for density-dependent colony growth. Disturbance controls in both experiments showed that differences in disperser-production were not due to alarm responses to manipulation. If natural aphid colonies are monoclonal and densitydependent, then natural selection should favour prudent resource use and early dispersal strategies. I discuss ecological explanations for the apparent sub-optimality of the unmanipulated aphid colony dispersal strategies in these experiments. Index words: Aphis fabae, dispersal, harvesting

[1015] BIOLOGICAL NOTES ON THE NEOTROPICAL MUD-DAUBER WASP, TRYPOXYLON MANNI (HYMENOPTERA: SPHECIDAE)

A.W. Hook, Dept. of Biology, St. Edward's Univ., Austin, TX, USA, 78704-6489

Trypoxylon, one of the largest sphecid genera, is most diverse in the neotropics with over 120 species recorded here. Unfortunately few species have been studied in this region even though many appear to nest communally. This report details results obtained from 46 nests collected in Trinidad, W.I. between 1996-1999. Most nests were found attached to exposed rootlets suspended under overhanging dirt banks that bordered sides of trails and roads. Nests contained up to 64 cells and as many as 10 females. There was a significant positive relationship between nest size and the number positive relationship between female size and its ovarian condition (r-squared = 0.38). Parasites reared from nests include members of the following groups: Ichneumonidae, Chalicidae, Chrysididae, Mutillidae, Sarcophagidae and Rhipiphoridae. Nest included members of these groups: Sphecidae, Megachilidae, Halicidae, Colletidae, Bethylidae and Lepidoptera. Nest Structure/contents, ovarian analysis, parasites

[1016] COMMUNITY OF INSECTS FROM PAEPALANTHUS BROMELIOIDES: A NEW PHYTOTELMATA PLANT

<u>M. A. P. Horta¹</u>, J. E. C. Figueira² & R. P. Martins¹, ¹Lab. of Ecology and Behaviour of insects, ICB, Univ. Federal de Minas Gerais, E- mail mahorta@mono.icb.ufmg.br; ²Lab. of Plant Population, ICB, Univ. Federal de Minas Gerais.

Phytotelmata are aquatic microecossistems formed by plants. These plants provide conditions to the accumulation of water and resources forming communities whose organisms develop and complete their lifecycles. Paepalanthus bromelioides is an Eriocaulaceae species from the highlands of Serra do Cip6, a chain of mountains located in the state of Minas Gerais, Brazil. The architecture of *P. bromelioides* is similar to that of bromeliads in its ability to impound water among the leaves. The aquatic contents is formed by water which comes from rainfall and a fluid secreted by the plant itself. Although the very dense medium and the acid nature of the liquid, individuals of the Culicidae (Diptera) and Helodidae (Coleoptra) families have been found inhabiting *P. bromelioides*. The reservoir contains a sediment rich in organic matter supplied by arthropod pieces and vegetal parts which are used by the inhabiting organisms. The reason by which these organisms are colonizing such habitats is still unknown. Although the low diversity found the nature of the aquatic medium appear not to be a limiting condition for some species, that might be using these ecossistems as an avoidance of competition or predation.

Index terms: Phytotelmata, Paepalanthus bromelioides

[1017] A POSSIBLE CASE OF MIMICRY BETWEEN AN INSECT AND A TADPOLE

M. A. P. Horta¹, A. L. Melo², J. Bertoloci³ & J. Cassimiro³, ¹Lab. of Ecology and Behaviour of Insects, ICB, Univ. Federal de Minas Gerais, E- mail mahorta@mono.icb.ufmg.br; ²Lab. of Taxonomy and Biology of Insects, ICB, Univ. Federal de Minas Gerais; ³Lab. of Herpetology, ICB, Univ. Federal de Minas Gerais.

Mimicry is a widespread phenomenon in which a palatable or unpalatable species dupe predators resembling an unpalatable species that often display aposematic colouration. This study presents a case where two immature species were found to have the same pattern of shape and colour and both were found in the same places. *Limnocoris* are heteroptera insects of the family Naucoridae that inhabits streams and are effective predators like all members of the family. *Scinax machadoi* is a treefrog of the family Hylidae whose tadpoles are also found in streams and obtain food by scraping stones and sediment of the stream. The observations took place in Serra do Cipó, a chain of mountains in the state of Minas Gerais, Brazil. Serra do Cipó presents a typical vegetation of highland savannas and a large number of rivers, streams and ponds. The naucorids and tadpoles are found in many streams of Serra do Cipó living close to each other in large numbers of individuals. Both present a rounded black body with a yellowish transversal stripe. Hypothesis about the processes involved are discussed.

Index terms: mimicry, Naucoridae, Hylidae, Serra do Cipó

[1019] FLIGHT PATTERNS OF AN ASIAN AMBROSIA BEETLE, XYLOSANDRUS CRASSIUSCULUS, IN TREE NURSERIES IN GEORGIA AND NORTH FLORIDA, USA

W. Hudson¹ & R. Mizell², ¹Dept. of Entomology, Univ. of Georgia, P.O. Box 1209, Tifton, Georgia, 31793, USA, E-mail wghudson@uga.edu; ²Univ. of Florida, NFREC-Monticello, Rt. 4 Box 4092 USA

The Asian ambrosia beetle (AAB), Xylosandrus crassiusculus, has become a serious pest for nurseries across the southern USA in recent years. While nurseries throughout the region have suffered losses each season, the number of locations experiencing severe problems has varied greatly from year to year. The beetles have proven difficult to control with the usual barrier sprays used in the industry for prevention of damage from other types of borers such as clearwing moths and long-horned beetles. Pesticide screening trials demonstrated that pyrethroid insecticides were more effective at controlling the beetles, but timing of the sprays was important for optimal results. Beginning in 1994, traps were operated at ornamental plant nurseries in north Florida and Georgia to gather data on beetle activity and attacks on nursery stock. Trap data provided some information about seasonal occurrence of adult females, but no clear pattern emerged that would allow prediction of where an outbreak would occur and how severe it night be. The patterns of flight activity were consistent among locations for a given year, but varied considerably from year to year. There was an effect of winter weather on both the number and timing of adults caught the following year, with colder winter temperatures followed by fewer beetles flying later in the season the following spring. There was no significant correlation between degree-day accumulation and date of first flight. Beetles were caught every month of the year (but not in all months every year), with two clear generational peaks in March and May. First activity was delayed by ca. 1-2 weeks in central Georgia compared to north Florida and south Georgia, a distance between traps of about 150 km to the north. Although a significant number of beetles were active in April and May, virtually no nursery stock was attacked after the spring flush of leaves was completely expanded. Attacks on stressed trees in landscape plantings, as well as pecan and peach orchards, can occur anytime from spring until cold weather arrives, sometime in November in these climates. Trapping data offer no explanation for this observation.

Index terms: integrated pest management, ornamental plant pests, beetle traps

[1018] PRELIMINARY STUDY OF LIFE HISTORY OF TORTOISE BEETLE, ASPIDOMORPH MILIARIS (COLEOPTERA: HRYSOMELIDAE)

W. F. Hsiao & H. J. Tsai, Department of Biological Resource, University of Chaiyi, Chiayi, Taiwan, 60083

Life history of Tortoise beetle, Aspidomorph miliaris (Fabicius) was conducted under laboratory in the incubator set at 25°C, 12L:12D. About 200 larvae and 100 adults were collected from sweet potato field ,20 km near Chiayi city and brought back and reared with the same food plant as the stock culture. Around 100 newly hatch larvae were randomly chosen to start the following experiment. Egg mass was laid on the undersurface of the leaf. Each brownish egg mass composed of 10-15 pieces sheath and each sheath contained 2-4 eggs. Eggs were longitudinal. The length of egg was 0.15cm with stage of 12.68 day. Larvae are oval, flat and bear two forked processes at posterior end of the body to which was attached cast skin, excrement, or debris. The color of larva was yellow and fringed with blackish spine. Larval stage has five instars, first two were colonized and started to disperse until fourth instar. The body length of five instars was in the following orders: 0.12, 0.26, 0.38, 0.57 and 0.75 cm, respectively. The duration of larvae was in the following orders: 4.26, 4.96, 5.2, 5.0, and 8.19 day, respectively. The survival rate of larvae were in the following orders: 100%, 100%, 100%, 99% and 99%, respectively. Larvae have been found devoured the leaves of sweet potato and wild morning glory that had caused a serious damage of this two host plant. The morphology of prepupae was similar to fifth instar larvae. The head of pupa and adult was largely and completely concealed from above. The duration of prepupa and pupae were 3.21 and 7.96 days, respectively. Adult was broadly oval, with body expanded and flattened, resembling a tiny turtle. It took several minutes to hours to complete the mating. Female has mated for several times throughout the life. The preovipotion period was ranged from 17-30 days. Female adults produced 1-2 egg mass per day. The life span of adults was ranged from two months to one year.

Index terms: Aspidomorph miliaris (Fabicius), life history. Sweet potato.

[1020] USE OF THE FUNGUS METARHIZIUM ANISOPLIAE TO CONTROL LOCUSTS IN AUSTRALIA

D. M. Hunter¹, R. J. Milner² & J. C. Scanlan³, ¹Australian Plague Locust Commission, AFFA, GPO Box 858, Canberra, ACT 2601, Australia. E-mail david.hunter@affa.gov.au ²Division of Entomology, CSIRO, GPO Box 1700, Canberra, ACT 2601, Australia. ³Robert Wicks Research Centre, Queensland Department of Natural Resources, P.O. Box 318, Towoomba, Queensland 4350, Australia.

In Australia, locusts are managed through a programme of preventive control where treatment begins with the small bands and swarms that form early in outbreaks. Such programmes have relied on the use of chemical insecticides but increasing constraints on insecticide use have led to the search for biological alternatives. Work by LUBILOSA in Africa and CSIRO in Australia has shown that the fungus Metarhizium anisopliae is a most promising candidate for the biocontrol of locusts. During intensive studies in the past two years, Metarhizium has been applied by aircraft to local infestations of the migratory locust, *Locusta migratoria* (L.) and the Australian plague locust, *Chortoicetes terminifera* (Walker). At a dose of 75-100 g/ha (3-4 x 10^{12} conidia/ha), there was >90% mortality of migratory locusts in treated sorghum crops or open grassland. Decline was less at lower doses. With the Australian plague locust, >90% mortality resulted even at a dose of 25 g/ha (1 x 1012 conidia/ha). Mortality was high both during the moderate temperatures of spring and during high summer when maximum temperatures were 36-42°C. Nymphs hatching a few days after treatment and bands invading treated areas also died suggesting Metarhizium persisted on the vegetation for some days. Persistence was confirmed by feeding locusts vegetation from the treated blocks: there was 50% mortality of locusts fed vegetation collected from the treated blocks 5-7 days after treatment. In areas where bands were treated with Metarhizium, mortality was evident in 7-10 days during the hot summer and in 10-14 days at moderate temperatures of spring. The efficacy of Metarhizium at quite low doses means that it is price competitive with chemical insecticides and will be used as part of programmes of preventive control in the coming vear.

Index terms: Biological control, Locusta migratoria, Chortoicetes terminifera

[1021] MAJOR PESTS OF SOURSOP (ANNONA MURICATA) IN BRAZILIAN CERRADOS REGION AND THEIR NATURAL ENEMIES

<u>I. M. Icuma¹</u>, M. A. S. Oliveira¹ & T. Asayama², ¹Embrapa/Centro de Pesquisa Agropeucária dos Cerrados (CPAC), Caixa Postal 08223 CEP 73301-970 Planaltina, DF, Brazil, E-mail icuma@cpac.embrapa.br; ² Kitahonjigahara-cho 2-143 Owariasahi-shi, 488-0043, Japan.

The soursop Annona muricata is a crop with a high economic potential in cerrados region, not only for its fresh fruit consumption but for its importance in the food processing market, because it has the exotic smell, flavor and consistence gives them an important role as source for industries of juice, ice-cream and consumption of fruits in natural. However, fruit production is limited by the attack of various insects and the phytosanitary problems, especially the pests have been discouraging the commercial plantations. The major insect pests were observed and collected in orchard of EMBRAPA-CPAC area, and the damage were registered. Insects and plant parts attacked were conducted to laboratory to be analyzed. The insects were mounted, identified and deposited in the CPAC Entomological Collection. Major insects pest observed in anonacean plants found in Brazilian Cerrados region were stem borer (Cratosomus bombina bombina and Eurypages pennatus (Coleoptera: Curculionidae)), stern base borer (Heilipus catagraphus (Coleoptera: Curculionidae)), fruit borer stem base borer (Heilipus catagraphus (Coleoptera: Curculionidae)), fruit borer (Cerconota anonella Lepidoptera: Oecophoridae: Stenomatinae)) and seed borer (Bephratelloides pomorum (Hymenoptera: Eurytomidae)). The fruit borer is the most serious pest of soursop. Damages caused by this pest may vary from 70 to 100% of the fruit production. It was observed that the larvae of C. anonella are parasitized by braconid Apanteles sp. and by ichneumonidae Xiphosomella sp., and the pupas are parasitized by chalcid Brachymeria annulata and by eulophid Trichospilus diatraeae.

Symposium and Poster Session

[1023] THREATENED JAPANESE BUTTERFLIES LISTED BY THE ENVIRONMENT AGENCY OF JAPAN IN 2000

<u>M. Ishii¹</u> & Y. Nakamura², ¹Entomol. Lab., Graduate School of Agr. and Biol. Sci., Osaka Pref. Univ., Sakai, Osaka 599-8531, Japan, E-mail ishii@plant.osakafu-u.ac.jp, ²Japan Wildlife Res. Center, 2-29-3 Yushima, Bunkyo-ku, Tokyo 113-0034, Japan, E-mail ynakamura@jwrc.or.jp.

Although none of circa 240 butterfly species distributed in Japan has become extinct so far, 2, 5 and 40 butterfly taxa were listed as endangered, vulnerable and rare, respectively, in the Red Data Book (RDB) published by the Environment Agency of Japan (EAJ) in 1991. Out of the total of 47 taxa listed, 13 and 14 occur in detached islands and high mountain regions, respectively, and of the rest 20 taxa, 3, 10 and 7 occur in evergreen and deciduous forests, and grasslands of mainlands, respectively. EAJ began to revise the list from 1996 on the basis of new Red List Categories of IUCN (1994), and prepared a revised list, which will be publish in the spring of 2000. In the revised list, the number of threatened butterfly taxa has increased to 74: 29 were added and 2 excluded. Out of the 74 taxa listed, 12, 21 and 41 were listed as (critically) endangered, vulnerable and near threatened, respectively. Numbers of taxa in detached islands (12) and high mountain regions (17) were almost similar, while those in mainlands (45) have largely increased as compared with RDB 1991. Especially, butterfly taxa inhabiting deciduous forests and grasslands have increased by 7 (70%) and 19 (270%), compared with RDB 1991. Main threats to these butterflies are considered to be the degradation and destruction of secondary forests and grasslands of earlier successional stages which have been maintained by human intervention through coppicing and grass-cutting for fuels, manure and other materials.

Index terms: threatened butterfly, Japan, Red Data Book, the Environment Agency of Japan.

[1022] *BELOSTOMA* (HETEROPTERA: BELOSTOMATIDAE) FROM THE STATE OF RIO DE JANEIRO, SE. BRAZIL

J. R. Inacio Ribeiro^{1,2,3} & J. L. Nessimian², ¹Depto Parasitologia, ICB, Universidade Federal de Minas Gerais, P. O. Box 486, 31270-901, Belo Horizonte, MG, Brasil, E-mail zribeiro@ig.com.br; ²Depto Zoologia, IB, CCS, Universidade Federal do Rio de Janeiro, P. O. Box 68044, 21994-970, Rio de Janeiro, RJ, Brasil, E-mail nessimia@acd.ufrj.br. ³Supported by CAPES, CNPq, FAPERJ, FUJB

During a revisional study of *Belostoma* from southeastern Brazil it was possible to record fourteen species from the State of Rio de Janeiro: *Belostoma anurum*, B. aurivillianum, B. candidulum, B. costalimai, B. dentatum, B. dilatatum, B. foveolatum, B. micantulum, B. oxyurum, B. plebejum, B. ribeiroi, B. sanctulum, B. stollii, and B. testaceopallidum. Of them, six species are newly recorded for the first time from this State: B. aurivillianum, B. candidulum, B. dilatatum, B. oxyurum, B. ribeiroi, and B. sanctulum. In this way, synonym lists, diagnosis, notes on the biology, and distribution maps are given. Index terms: *Belostoma*, Belostomatidae, taxonomy, Rio de Janeiro State, southeastern Brazil. [1024] POPULATION DYNAMICS OF COSMOCLOPIUS NIGROANNULATUS (HEMIPTERA, REDUVIDAE) IN NICOTIANA TABACUM

S. M. Jahnke, L. R. Redaelli & L. M. G. Diefenbach' Dep. Fitossanidade, Univ. Federal do Rio Grande do Sul, Av. Bento Gonçalves, 7712, Porto Alegre, CEP: 90046-900, Brasil, E-mail smjahnke@yahoo.com.

The effect of natural enemies upon phytophagous insects is important to keep their populations at low levels and so decrease the damage done to the cultures. Therefore, the knowledge about the bioecology of predators insects mainly population dynamics is essential to establish their role in biological control programs. The tobacco culture represents an important issue either in economical as in social terms in Rio Grande do Sul State. Previous studies in the same area registered the presence of a predator complex of the Reduviidae acting upon Corecoris dentiventris (Hem. Coreidae) population, a bug that cause the wilting of the tobacco leaves due to its sucking habit. The present work aimed to investigate the spatial distribution and population changes of Cosmoclopius nigroannulatus, a predaceous reduvid, along one cycle of the tobacco culture. The study was carried out in an experimental area of the Departamento de Fitossanidade, Universidade Federal do Rio Grande do Sul, in Porto Alegre (30°01'S; 51°13'W) with 270 tobacco plants (cult. Virginia, var. K 326). The sampling initiated in August, 1999, and 3 times a week all plants of the plot were inspected and the adults found were captured, marked, counted and liberated at the same place. Data was analyzed by the Fisher-Ford method. The beginning of the colonization of the experimental area was considered on September 19th when the first female was found on the tobacco culture. The second generation was registered approximately 76 days after this date. The sex ratio was 0,45 until the second generation, considering the number of adult individuals marked in the sampling occasions. Until the present moment, the adults daily survival rate is 96% and the population peak registered was 57 individuals in December 24th. The data fitting to Poisson and Positive Binomial distributions applying the dispersion index (I) resulted in 11,43% of occasions with random distribution, 50% with regular and 38,57% with clumped.

Index terms: Insecta, Spatial distribution, Predator, Tobacco

[1025] LIFE TABLE AND DEMOGRAPHIC PARAMETERS OF THE SOUTH AMERICAN FRUIT FLY (DIPTERA: TEPHRITIDAE)

H.E. Jaldo¹ & <u>E. Willink¹</u>, ¹Estación Experimental Agroindustrial Obispo Colombres, C.C.n^o 9, Las Talitas, (4101) Tucumán, Argentina. E-mail: saneeaoc@tucbbs.com.ar.

Anastrepha fraterculus, the South American fruit fly, is considered the second most important economical fruit fly species in Argentina. No life table or demographic analysis has been made for this species. Research of these parameters are useful to establish the baseline to plan action programmes to control or eradicate the pest. The objective of this tesearch was to study the life table of A. fraterculus under laboratory controlled conditions and analyse the most important population parameters that characterise this species. The material used came from the A. fraterculus rearing at the Estación Experimental Agroindustrial Obispo Colombres. The life cycle at a constant temperature of 24°C was: 2 days for the egg, 3 days for the first instar larvae, 3 days for the second instar larvae, 9 days for the third instar larvae, 14 days for the pupae, and 10 more days for the preoviposition period. The mortality was 8% for the eggs, 24% for the larvae, 32% for the pupae and 10% for the preoviposition period. The gross reproductive rate was 962.98 while the net reproductive rate was 313.12. The mean generation time was 61.7 days, the mean age of a stable population is 7.23 days and the time in which the population duplicates is 7.44 days. The intrinsic rate of increase was 0.093. The data obtained shows that the biotic potential of A. fraterculus is quite lower than Ceratitis capitata. Index terms: Anastrepha fraterculus, life cycle, demography

[1026] POPULATION DYNAMICS OF ADULTS CORECORIS DENTIVENTRIS (HEMIPTERA; COREIDAE) IN A TOBACCO EXPERIMENTAL PLOT

C. R. Jesus¹ & H. P. Romanowski², ¹Progr. Pós-grad. Biol. Animal, ² Depto. of Zoology, ^{1,2}Univ. Federal do Rio Grande do Sul, Av. Paulo Gama s/n⁰, Porto Alegre, CEP: 90046-900, Brazil, ¹E-mail crjesus@vortex.ufrgs.br.

To understand the processes shaping a population, knowledge on the yearly and seasonal fluctuations on its size, nad the movements and survival rates of its members are needed. Beyond its own theoretical importance, information on this aspects is crucial for management and control of "pest" species. The population dynamics of *Corecoris dentiventris* adults was investigated in a tobacco experimental plot in Porto Alegre, Brazil (30° 01'S 51° 13'WGR), using the mark-release-recapture method. In an area of ca. 300 m², 365 tobacco plants were grown; each plant was identified by alpha-numeric coordinates. From August/97 to February/98, all plants were inspected weekly. Adults were captured by hand, marked and released in the same plant they were caught. Data was analysed by the Fisher-Ford method. 273 bugs were marked in 45 sampling occasions. Recapture rates were about 41 and 40% for females and males respectively. Daily survival rate estimates were above 96%. Population size was about 200 individuals. Mean minimum longevity was 25.19 ± 2.21 and 22.9 ± 3.54 for females and males respectively. Dispersion indexes k and I were estimated: out of the 16 occasions in which sample sizes were large enough (n >= 10), 15 revealed an aggregated pattern of distribution. Index terms: grey-tobacco bug, mark-release-recapture, dispersion, distribution,

[1027] IS A LIMITED DISPERSAL PROPENSITY THE REASON FOR THE RARITY OF THE BEETLE OPLOCEPHALA INAEMORRHOIDALIS IN NORTHERN EUROPE?

M. Jonsson, M. Jonsell, & G. Nordlander, Dept. of Entomology, Swedish Univ. of Agricultural Sciences, P. O. Box 7044, SE-750 07 Uppsala, Sweden, E-mail: Mattias.Jonsson@entom.slu.se.

A large number of insect species are dependent on dead wood. In northern Europe many of them have become threatened due to human activities. One possible reason for this is that the dispersal propensity of the species limits colonisation of substrates that have become more sparsely distributed in the modern managed landscape. Knowledge about the dispersal propensity of wood-living insects is however very limited, and the data available primarily concerns pest species. It has been argued that rarity of insects is generally not due to a low dispersal propensity in managed boreal forests, but to an absence of suitable substrate. Comparing both the substrate demands and the dispersal propensities between rare and common wood-living insects with a similar biology could be one way to evaluate this. Fruiting bodies of wood-decaying fungi constitutes a well defined and species rich part of the dead wood. We have studied the two tenebrionid beetles Oplocephala haemorrhoidalis and Bolitophagus reticulatus, which both are monophagous on fruiting bodies of the wood-decaying fungus Fomes fomentarius. O. haemorrhoidalis is considered threatened in several European countries, whereas B. reticulatus is usually common where the host fungus is present. We studied the substrate demands of the species, the effects of forest history on the occurrence of them, as well as the genetic differentiation between their populations. O. haemorrhoidalis was strongly restricted to localities with a long continuity of dead wood, whereas *B. reticulatus* was not affected by this parameter. The substrate demands of *O. haemorrhoidalis* was somewhat narrower than those of *B.* reticulatus, but still broad enough to indicate that suitable substrate should be rather common at many localities where the species is absent. Populations of O. haemorrhoidalis showed a significant correlation between genetic and geographic distance, whereas no such correlation was found between populations of B. reticulatus. Based on these results we suggest that the main reason for the rarity of O. haemorrhoidalis in northern Europe is a weak dispersal propensity, which hinders colonisation of new patches although suitable substrate is abundant. To further evaluate this, a study of the duration of flight in flight mills is planned for the summer of 2000. Results from that study might be presented as well at the conference.

Index terms: conservation, saproxylic beetles, substrate demands, genetic differentiation, dispersal propensity

[1028] DIVERSITY AND TEMPORAL CHANGE IN THE EFFECTIVE POLLINATORS OF GERANIUM THUNBERGII

<u>L. Kandori¹</u>, ¹Laboratory of Entomology, Faculty of Agriculture, Kinki University, Nakamachi, Nara, 631-8505, JAPAN, E-mail kandori@nara.kindai.ac.jp.

Assessing the relative contribution to seed set for each of a plant species' floral visitors provides an indication of the relative influence of these visitors on the plant's reproductive success. This study examined pollinator activity and seed set in a population of Geranium thunbergii, an insect-pollinated perennial wild herb. This plant species was visited during the two years of the study by 41 insect taxa belonging to four orders. Of 21 main visitor taxa, 14 taxa consisting of eight bees, one wasp, one ant, two hoverflies, and two butterflies acted as effective pollinators. The main contributors to seed set changed largely between two year. The top five contributors in each of the first and second year were, 1: Coelioxys acuminata (bee), 2: Megachile tsurugensis (bee), 3: large Lasioglossum (bee), 4: Zizeeria maha (butterfly), 5: Ceratina spp. (bee) / Betasyrphus serarius (hoverfly), and 1: Apis cerana (honeybee), 2: M. tsurugensis (bee), 3: large Lasioglossum (bee), 4: Chalicodoma spissula (bee), 5: Sphaerophoria macrogaster (hoverfly), respectively. At the level of orders, Hymenoptera alone contributed to more than 80 % of seed set during the experiment, and the rest by Diptera and Lepidoptera. Meanwhile, the nectar/pollen robbers, which were defined as the frequent visitors with little seed set per one visit, were also mostly Hymenoptera (4 out of 5 robbers). Interestingly, smaller visitors were less efficient in setting seeds per one visit, and thus tended to act as the nectar/pollen robbers for this plant. The reason will be discussed from the point of behavioral difference in collecting nectar or pollen on the floral surface by different sized visitors. Seasonal visiting patterns of the main contributors were divided into four types, i.e., type 1: concentrated mass visits on the mid flowering season at its peak blooming (honeybee), type 2 and 3: concentrated visits in the early or late flowering season (one and two taxa, respectively), and type 4: normal visits throughout the flowering season (five taxa). Diurnal visiting patterns were divided into two types, i.e., type 1: one peak of visits around noon (five taxa), and type 2: two peaks of visits before and after noon (four taxa). In conclusion, G. thunbergli may well be considered as bee-pollinated. However, important pollinators, or contributors, among bee taxa could change largely year by year. Therefore, this plant is not specialized to a certain pollinator, though some specialization to mediumsized bees could occur in this study site. Since this plant has taxonomically diverse, potentially effective pollinators, it will successfully reproduce in spatio-temporally heterogeneous habitats.

Index terms: Geranium thunbergii, seed-set, pollination effectiveness, generalization, foraging behavior

[1029] THE DYNAMICS OF SEXUAL SELECTION AND THE EVOLUTION OF NOVEL ACOUSTICAL SIGNALING IN HAWAIIAN DROSOPHILA

<u>K.Y. Kaneshiro</u>, Center for Conservation Research & Training, Univ. of Hawaii, 3050 Maile Way, Gilmore 406, Honolulu, Hawaii 96822, USA, E-mail kykanesh@hawaii.edu.

It has been suggested that sexual selection and the dynamics of sexual selection have played a critical role in the evolution of the tremendous speciation of Drosophilidae in the Hawaiian Islands. During periods of small population size, there is strong selection for females that are less choosy in mate selection which results in an increased frequency of less choosy females in subsequent generations of small population size. It is suggested that such conditions result in a shift in gene frequencies toward the genotypes of the less choosy female. Perturbation of the balanced genetic system results in a destabilized genetic condition and the break-up of co-adapted genetic elements, which in turn, promotes the generation of novel genetic recombinants previously not present in the population. These novel genetic elements then provide the raw material upon which natural selection or sexual selection can operate in the population's ability to adapt to the new habitat or to changing environmental conditions. Some selection experiments involving morphological characters will be used to illustrate the pleiotropic effect of the sexual selection system and this model will be used to explain the four different mechanisms of acoustical signaling observed among the Hawaiian Drosophila species. While wing vibrations are known to produce acoustical signals among dipteran species, several species of Hawaiian Drosophila also produce sounds by vibrating two pairs of muscles that adjoin the thorax and abdomen. Other species produce a high frequency sound which is beyond the sensitivity level of the typical receptor found in Diptera, i.e. the arista. Still other species are able to modulate the frequency of their wing vibrations resulting in a much more complicated set of signals previously unknown for dipteran species. It is suggested that the novel acoustical signaling mechanisms in the Hawaiian Drosophila are pleiotropic results of shifts in the sexual selection system during founder events or during population bottlenecks.

Index terms: mate choice, small population size, speciation, founder event, genetics

[1031] BEHAVIORAL AND ECOLOGICAL FEATURES OF HOST PLANT SELECTION AND INFLUENCE ON LOCAL SPECIALIZATIONS BY HELICONIUS ERATO

S.M. Kernel¹ & G.R.P. Moreira², ¹PPG Ecologia, Univ. Federal do Rio Grande do Sul, Av. Bento Gonçalves 9500, 91540-000, Porto Alegre, RS, Brasil, E-mail solmk@bol.com.bt; ²Depto. de Zoologia, Instituto de Biociências, Univ. Federal do Rio Grande do Sul, Av. Paulo Gama 40, 90046-900, Porto Alegre, RS, Brasil. E-mail grpm@if.ufrgs.br

There is considerable interspecific variation in host plant (Passifloraceae) use among Heliconius erato phyllis (Lepidoptera: Nymphalidae) larval populations. The causes for the corresponding local differences are unkown. They could be based on either ecological or behavioral mechanisms that take part in their interaction with passion vines, regarding both larval and adult stages. The main objective of this study is, by adopting a behavioral ecology approach, to identify the mechanisms involved in *H. erato phyllis* local specializations concerning use of host plants. The study was conducted under laboratory or insectary conditions with a populations of H. erato phyllis of Porto Alegre County, Rio Grande do Sul State, using two preference host plants (Passiflora suberosa and Passiflora misera). Feeding preference and respective induction in relation to P. suberosa and P. misera were evaluated for all instars through choice tests using leaf disks. To evaluate Hopkins' effect, larvae were individually reared on either P. suberosa or P. misera. Under insectary conditions, females were tested for oviposition choice in relation to the two passion vine species. For testing conditioning of oviposition preference, field collected females were used. Shoots of either P. suberosa or P. misera were offered for these female during periods of 3, 7, 11 or 15 days (conditioning times). After, they were also tested for oviposition choice. To quantify density effects, intact shoots were offered for oviposition (six treatments), varying in number from zero to five. To the evaluate importance of presence of intact terminal bud on oviposition, field collected females were tested under four situations, which resulted from the possible combinations between presence of intact and/or damaged shoots of *P. suberosa* and *P. misera*. Both larvae and adult of *H. erato* phyllis showed preference for P. misera compared to P. suberosa, under laboratory and insectary experiments. Larval feeding preference could not be induced, the Hopkins' effect was not detected and oviposition choice could not be conditioned. Females alternated use of host plant species as a function of variation in either density or presence of terminal bud on shoots. Thus, data indicate host plant preference in H. erato phyllis is not learned but innate. Therefore, local use of host plant results in this butterfly from quali- and quantitative variation of passion vines, to which females respond.

Index terms: passion vines, induction of preference, Hopkins' effect, conditioning.

[1030] MIGRATORY SPECIES, INDIVIDUAL VARIATION IN MIGRATORY TENDENCY: CORRELATIONS WITH RESOURCE STORAGE AND MOBILIZATION

J. W. Kent Jr.¹, K. J. Min¹, J. L. Plunkett¹ & M. A. Rankin¹, ¹Integrative Biology Section, School of Biological Sciences, The Univ. of Texas at Austin, Austin, TX 78712 USA, E-mail: jwkent@mail.utexas.edu.

The North American migratory grasshopper Melanoplus sanguinipes exhibits heritable variation in migratory tendency. Although both migrants and non-migrants of this species are fully winged and capable of flight, some individuals are predisposed to make long flights in response to appropriate environmental cues. This predisposition can be measured on a tethered-flight apparatus in the laboratory, and the measure is repeatable. We are investigating the physiological differences between migrants and non-migrants, particularly with regard to mobilization of energy reserves. Migrants and non-migrants do not differ in magnitude of lipid reserves at rest, even though these reserves are used to fuel long flights. However, migrants mobilize more lipid than non-migrants in response to equal doses of adipokinetic hormone (AKH). Both migrants and non-migrants mobilize lipid when mounted on a tethered-flight apparatus, but the magnitude of adipokinesis is greater in migrants. Migrants have a greater content of total protein in the thorax, per unit of body size, than non-migrants. Thorax protein appears to be mobilized during flight, a phenomenon that has been indicated in migratory birds. Endocrine mechanisms of resource mobilization, and the physiological significance of protein mobilization, will be discussed.

Index terms: Melanoplus sanguinipes, migration, adipokinetic hormone, AKH

[1032] COMPARATIVE ANT SPECIES DIVERSITIES IN INTACT AND LOGGED AMAZONIAN RAINFORESTS

S. M. Ketelhut & A. Y. Haradn, ¹, ¹Museu Paraense Emílio Goeldi, Depto. Zoologia, Entomologia. Cxp 399 - 66040-170. Belém, PA, Brazil. E-mail: sktelhut@inpa.gov.br

A comparative study of ant fauna communities was made in a primary forest and in two kinds of logging systems (Managed and Traditional) located in a tropical rainforest area, near Paragominas, Pará state, Brazil. In each area, ants were sampled using pitfall traps during December 1997 and March 1998 on six 200 m transects, separated from each other by 100 m. Differences in ant fauna diversity among the sites were tested using diversity indexes (Shannon, Simpson and Fisher's Alpha) and richness estimates protocols (e. g. Colwell & Coddington 1994). Species composition was evaluated through affinity analysis (Scheiner 1992) and similarity indexes (Jaccard and Morisita-Horn). A total of 134 ant species belonging to seven subfamilies and 42 genera could be identified in the entire area. Of these, 90 species were found in primary forest, 90 in managed and 84 in the traditionally logged forest. Differences between habitats could be detected comparing diversity and similarity indices among different transects. There were no differences in indexes when absolute values were compared for each site. Results from richness estimates protocols also indicate that ant faunas were similar between sites and suggest that ant faunas were still underestimated. The richness and abundance of ants were different between the months, and it does not affect the diversity patterns in the areas as a whole. High mosaic diversity could be detected using affinity analysis, and it is suggested that the communities were composed by very complex gradients. Thus, differences in ant

composition would be due to heterogeneity at smaller scales. Index terms: Logged systems, Hymenoptera, Formicidae, Biodiversity, Amazon, Estimates.

[1033] STRUCTURE OF THE CROP IN THE ADULT QUEEN BLOWFLY, PHORMIA REGINA

J. Kinkorova¹. M. Jokes³, M. Carcupino³ & J. Stoffolano⁴, ¹Dept. of Zoology, Charles Univ., Prague-2, CZ 128 44, Czech Republic, E-mail kinkor@prfdec.natur.cuni.cz; ²Res. Inst. of Plant Prod., Prague-6, CZ 161 05, Czech Republic; ³Dept. of Zoology and Anthropology, Univ. of Sassari, Italy, E-mail carcupin@ssmain.uniss.it; ⁴Dept. of Entomology, Univ. of Massachusetts, USA, E-mail stoffolano@ent.umass.edu.

The majority of studies on the crop of adult dipterans focuses on the distribution of various nutrients fed upon and not on how it is regulated for intake or emptying. Evolution of the crop, a liquid storage organ in the adult queen blowfly, is essential for feeding on various nutrients, both proteins (for egg development) and carbohydrates (for energy), both of which are patchily distributed and often not readily available in the environment. The ability to store large quantities of liquid when encountered give adults greater dispersal capabilities. Thus, it is surprising that no known definitive study has been done on its structure, both at the SEM and TEM levels. The crop is a diverticulum connected to the esophagus by a duct and is a bilobed sac capable of considerable distention. Its ability to retain liquids for long periods of time following removal is attributed to sphincters that keep fluid from leaving the crop duct and also to its cuticular, impermeable lining. Circular and longitudinal, visceral muscles produce the contractions of the crop and crop duct. Recent studies show that these muscles are regulated by two peptides (one inhibitory and the other stimulatory). Fluorescent antibody probes reveal that the neurons releasing these peptides produce a net-like covering over the crop lobes and duct. TEM studies reveal a large number of trachea also cover and are located between the two muscle types. TEM studies also show that the neurons delivering these peptides usually follow the course of and are usually associated with the trachea. In addition to acting as a storage organ, the crop plays a significant role in terminating feeding once it reaches its maximum volume.

Index terms: Ultrastructure, diverticulim, Diptera

[1035] THE ROLE OF LEARNING AND MEMORY IN LEAF-CUTTING ANT FORAGING ECOLOGY

J. J. Knapp¹, T. Legg¹, L. Farnham¹ A. Shaw¹, A. Tonhasca Jr.² & Dr A. Eiras², ¹Division of Biodiversity and Ecology, School of Biological Sciences, Univ. of Southampton, Bassett Crescent East, Southampton SO16 7PX, UK. ²Crop Protection Laboratory, CCTA, Universidade Estadual do Norte Fluminense, Campos, RJ, Brazil. Email: jjk@soton.ac.uk.

Leaf-cutting ants of the genera Atta and Acromyrmex are known to cut and transport a wide range of fresh plant material as a substrate for their symbiotic fungus. The ants are selective. It has been shown that colonies harvest plant material which provide a suitable substrate for the growth of the fungus and avoid cutting plants which contain compounds that are deleterious to the fungus. Thus the relationship between the ants and the fungus is a close and complex one. It has been shown that the decisions involved in selecting plant material can involve a range of different behavioural responses some involving learning and memory. While some plant material is recognised upon first contact as unacceptable other plant material is not, it must first be harvested and only when negative consequences for the fungus result does the colony learn to reject the plant. This process has been termed delayed rejection and the negative conditioning involved has been shown to have long term consequences for substrate selection in laboratory and field colonies. The colony as a whole will continue to reject the deleterious material when presented even though only a few individual ants have been exposed to it in the first instance. Attempts to unravel how the ants first detect the deleterious effect, the mechanism by which they associate the correct plant with the effect and how this information is passed onto the other members of the colony have been difficult. Using fungicide baits made from a matrix of a normally highly acceptable plant species, citrus, we begin to illuminate the role of the different worker castes in making the decision to accept and/or reject a particular plant. Based on our results behavioural mechanisms which enable the 'message' to be spread throughout the foraging workforce are proposed. In addition the extent to which delayed rejection could be transferred from the bait to the plant itself was investigated in the lab and field. Results indicate that such transferral is possible. The significance of delayed rejection in the ecology of attine host-plant selection and the wider implications for control strategies will be discussed.

Index words: Atta, Acromyrme, x, ant behaviour, ant foraging

[1034] INVASION SUCCESS AND BREEDING SYSTEMS: A COMPARISON OF INBREEDING AND OUTBREEDING BARK BEETLES BREEDING IN PALM SFEDS (CURCULIONIDAE, SCOLYTINAE)

L. R. Kirkendall, Univ. Bergen Dept. Zool., Allégaten 41, N-5007 Bergen, Norway. Email: lawrence.kirkendall@zoo.uib.no.

On the Canary Islands, the endemic *Dactylotrypes longicollis* (outbreeding) and the cosmopolitan *Coccotrypes dactyliperda* (inbreeding) breed in palm seeds: 1 will present comparative data on their life histories and genetic variation (isozymes, mtDNA, cuticular hydrocarbon profiles), and discuss the phylogeography of populations of these two species, in the context of the role of genetic variability in colonizing success. I will also use the genetic data to attempt to disentangle the relative roles of historical vs. contemporary dispersal, in understanding current patterns of population subdivision. (See also the more general presentation in this same volume, for Session 21-Symp. Index terms: *Coccotrypes, Dactylotrypes*, biogeography, dispersal, Canary Islands

[1036] BEE-PLANT-RELATIONS OF MASS-FLOWERING TREES IN A SOUTH BRAZILIAN ARAUCARIA FOREST OF THE MATA ATLÂNTICA

A. Köhler^{1,2} & W. Engels^{1,2}, ¹LPB, PUCRS, 90619-900 Porto Alegre, RS, Brazil, e-mail: andreas@pucrs.br, ²Zool. Inst., Uni. Tübingen, 72076 Tübingen, Germany.

In contrast to the mostly anemogamous trees in temperate forests, zoogamous trees dominate tropical rain forests, with insects being the principal pollinators. We studied insects visiting mass-flowering trees in an Araucaria forest reserve of 4,500 ha, located at 900 m altitude on the Serra Geral of Rio Grande do Sul. In addition, the structure of inflorescences and the phenology of antheses were recorded for 51entomophilous tree species. About 2/3 of the flower visitors were bees. Syrphid flies were also frequently recorded in addition to other hymenopterans, coleopterans, dipterans and lepidopterans. The highest α -diversity was monitored for halictid bees. The most abundant foragers, however, were workers of stingless bees and the introduced Africanized honey bee. The pollen and nectar sources were quantified, including measurements of the sugar content. The period of tree blossom varied between 2 and 10 days. Of the melittophilous taxa, the family Myrtaceae contributed the maximum with 17 species, all exhibiting the massflowering syndrome, with anthesis occurring early in the morning. Pollen exploitation patterns and pollinator guilds are discussed regarding the impact of bees within the reproductive web of the subtropical Araucaria rain forest ecosystem. Index terms: Araucarian forest, flower visitors, bees, hoverflies, blooming time.

[1037] ABUNDANCE-REGIONAL DISTRIBUTION RELATIONSHIPS IN NORTHERN EUROPEAN CARABIDS (COLEOPTERA: CARABIDAE)

D. J. Kotze¹, J. Niemelä¹, H. Turin² & R.B. O'Hara¹, ¹ Dept. of Ecology and Systematics, PO Box 17, FIN-00014, Univ. of Helsinki, Finland. E-mail: johan.kotze@helsinki.fi² Esdoorndreef 29, 6871 LK RENKUM, The Netherlands.

Considered as one of the most basic patterns in ecology today, the abundance-range size relationship hypothesises that, for a given taxonomic assemblage, there is a positive interspecific relationship between abundance and range size. In other words, locally abundant species tend to be geographically widespread, while locally rare species tend to be geographically restricted. Although this relationship is well established in the ecological literature, little consensus exists on what causes it. For example, there are currently eight mechanisms that can explain this relationship, but none of these have unequivocal support. These mechanisms can be divided into two categories: artefactual (sampling artefact and phylogenetic non-independence), and biological (range position, resource breath, resource availability, habitat selection, metapopulation dynamics and vital rates). Using allas data, we investigated abundance-regional distribution relationships of ground beetles for Belgium, Denmark and the Netherlands. The aim here was to identify shared beetle characteristics along the abundance-range size distribution relationship in these three countries. For example, we investigated which set of characteristics make a species locally rare and narrowly distributed, and which set makes a species abundant and widespread. Three basic carabid beetle characteristics were investigated; wing form (macropterous, dimorphic, brachypterous), body size (a log2 gradient from < 3 mm to > 16.9 mm), and habitat specificity (a five-step gradient from stenotopic to eurytopic). A significant positive relationship was found between abundance and range size for all three data sets. There was, however, considerable scatter around the regression lines. Species with residuals greater than two standard deviations from the fitted lines were selected as outliers. In other words, carabid species narrowly distributed but locally abundant, and species widely distributed but locally rare were identified. Outlier species were not the same in different countries. The beetle characteristics; wing form, body size and habitat specificity, showed a significant relationship with beetle range, for the three countries investigated. For example, dimorphic beetles had a significantly larger range than either macropterous or brachypterous species, for all three countries investigated. Also, larger species, and eurytopic species were widespread, while smaller species, and stenotopic species tended to be more restricted. The results here are discussed in light of the eight proposed abundance-range size relationship mechanisms.

Index terms: ground beetles, wing morphs, body size, habit specificity

[1039] INCREASED INCIDENCE OF BOREAL FOREST PEST OUTBREAKS: HERALD OF GLOBAL CHANGE?

M. V. Kozlov¹ & A. V. Selikhovkin², ¹Sect. of Ecology, Univ. of Turku, Turku FIN-20014, Finland, E-mail mikoz@utu.fi; ²Dept. of Forest Protection, Forestry Academy, Institutskij 5, 184018 St. Petersburg, Russia, E-mail selichovkin@mailbox.alkor.ru.

We analyzed data on 133 forest pest outbreaks that have occurred during 1956-1998 in the Russian part of the Barents Sea region, approximately within the limits of 61-69°N and 31-57°E. Most of the records concern pests of Scots pine (74) and Norway spruce (31). The most extensive damage (average outbreak area >5,000 ha) was imposed by the European pine sawfly *Neodiprion sertifer* (12 outbreaks), the autumnal moth *Epirrita* autuninata (8), the larch bud moth Zeiraphera diniana (3) and the sawfly Cilpinia hercynae (3). The number of outbreaks reported in 1989-1998 was 3.5 times higher than in 1956-1965 ($\chi^2 = 9.20$, P = 0.002), and the intensity of forest damage increased by a factor of 2.1 ($\chi^2 = 6.89$, P = 0.009). Since the information on outbreaks collected during the past 20 years is less complete than the information for the period from 1956 to 1975, the true increase in outbreak frequency may be even higher than that reported here. Neither the annual nor the winter mean temperatures in our study region have demonstrated significant changes during 1955-1997. However, significant increase in winter precipitation may result in rarer inversions, and thus exclude low temperature extremes, which are dangerous for insects which overwinter above the snow cover. If these species are analyzed separately, both the annual number of outbreaks and the intensity of forest damage changed in species hibernating above the snow cover (r = 0.71, n = 43 years, P = 0.0001and r = 0.57, n = 28, P = 0.002, respectively) but not in species which overwinter beneath the snow (r = 0.23, n = 43, P = 0.13 and r = 0.04, n = 30, P = 0.83, respectively). The increase in the spatial extent of an outbreak was also much clearer in species directly exposed to short-term temperature fluctuations during the wintertime (r = 0.64, n = 43, P =0.0001) than in species protected by the snow cover (r = 0.35, n = 43, P = 0.02). Although our data point to an increase in low temperature extremes as a plausible explanation of the increased incidence of forest pests, the contribution of other factors (CO2, UVB, pollution) cannot be excluded, and the evaluation of causal links by means of our data set is therefore not really possible. Nevertheless, our findings indicate that forest protection measures should form an important part of strategies for the mitigation of and adaptation to Global Change impacts in the Barents region under the premise of achieving sustainable development in the European North.

Index terms: hibernation, minimum winter temperatures, Barents Sea region.

[1038] ECOLOGICAL ADAPTATIONS AND CONSERVATION OF THREE PAPILIONID SPECIES LIVING ON THE *ARISTOLOCHIA* SPECIES IN ULUDAG, BURSA, TURKEY

<u>B. Kovanci</u>¹, O.B. Kovanci¹ & N.S. Gencer¹, ¹ Uludag Univ., Fac. of Agriculture, 16384, Görükle, Bursa, TURKEY. E-mail: bkoruma@uu20.bim.uludag.edu.tr

There are three papilionid species, which feed on the Aristolochia spp. as larvae, in Mount Uludag located in Bursa. These species are Archon apollinus, Zerynthia polyxena and Allancastria cerisy. In IUCN Red Data Book, A. apollinus and Z. Polyxena is listed as vulnerable in Europe and A. cerisy is localised but common species in Turkey. In Uludag according to our studies, there are three landscapes where these species live. Two landscapes are small and one of these is modified for the agricultural production whereas the second is altered by urbanisation. The third one where all the three species live within an area of 2-3 km in diameter, have been disrupted by man's activities for the agricultural purposes. The studies were carried out essentially on this landscape where Aristolochia pallida and Aristolochia bodame, the larval foodplants, occur either side by side or mixed each other. The main aim of this study is to determine the landscape structure, composition, interactions and the characteristics of the ecological adaptations of three papilionid species and thus to obtain a sound data regarding their conservation. The study was based on the weekly counts and observations along the fragmented biotopes of the species in 1997 and 1998. Each of the species gives one generation in a year and overwinters as diapausing pupal stage. All species were monitored during the period from the first adult emergence in spring to the next pupal stage. Their behavioural ecology, lifehistory style and developmental stages were also examined. The first A. apollinus and Z. polyxena adults emerged on the same dates within April according to the climatic conditions. On the other hand, A. cerisy adults appeared 2-3 weeks later compared to the other species. Although the larvae of all species can feed on both foodplants as indicated above, Z. polyxena have a strong preference for A. pallida in nature whereas A. apollinus and A. cerisy feed primarily on A. bodame. A. apollinus lay eggs in groups but in other two species eggs are laid singly. In addition, A. apollinus larvae roll the upper leaves and feed inside them. In conclusion, it is possible to conserve these species by stopping the fragmentation and modification of the third landscape and by preserving hedgerows and as many biotopes as intact possible. Also of great importance are the restoration of some sites and sustainable utilisation of the landscape. In addition, beneficial aspects of insect conservation should be emphasized. Archon apollinus, Zerynthia polyxena, Allancastria cerisy

AND MAGNITUDE OF DENSITY FLUCTUATIONS IN SUBARCTIC FOREST MOTHS M. V. Kozlov¹, S. Koponen², J. Kouki³, P. Niemelä³ & P. W. Price⁴, ¹Sect. of Ecology,

[1040] LARVAL FOOD AND FEEDING HABIT CONTRIBUTE TO PERIODICITY

M. V. Kozlov', S. Koponen', J. Kouki', P. Niemelâ' & P. W. Price', 'Sect. of Leology, Univ. of Turku, FIN-20014 Turku, Finland, E-mail mikoz@utu.fi; ²Zoological Museum, Univ. of Turku, FIN-20014 Turku, Finland; ³Faculty of Forestry, Univ. of Joensuu, FIN-80101 Joensuu, Finland; ⁴Dept. of Biol. Sci., Northern Arizona Univ., Flagstaff, AZ 86011-5640, USA.

Density records of 232 species of Lepidoptera spanning 26 years (total catch amounts to ca 230,000 specimens), obtained by continuous light-trapping in Kevo, northernmost Finland, were used to quantify temporal variability of moth abundance's. Annual catches of 190 'rare' species fluctuated below or close to the doubled detection limit of our method (0.5 specimen/trap x year), and the maximum annual catches of 132 of these species never exceeded 1 specimen/trap x year. Catches of the remaining 42 'abundant' species accounted for ca 97 % of the total number of individuals, with mean densities ranging from 0.78 to 1716 specimen/trap x year. Moths with detritophagous or moss-feeding larvae, species hibernating in the larval stage, and species pupating during the first half of the growing season were over-represented among abundant species. Magnitude of density fluctuations in species whose larvae pupate early in the season (the character generally associated with hibernation in the larval stage) was 1.7 times higher than in species pupating late in the season. Magnitudes of density fluctuations in species with endophagous larvae were significantly higher than in species with exophagous larvae. Average coefficients of density variation were as follows: leaf onewers - 74 %, leaf rollers - 106 %, stem/root borers - 120 %, leaf miners - 188 %. Moths with herbivorous larvae generally demonstrated periodic density fluctuations whereas densities of species with larvae feeding on other substances usually fluctuated stochastically. Periodicity in density fluctuations was mostly recorded among species of Macrolepidoptera, whereas species from less advanced lepidopteran clades usually demonstrated stochastic density changes; however this conclusion presumably reflects size differences more than phylogenetic constraints. We concluded that some of life history traits are linked with temporal variability of moth abundance; quantitative approaches to population variability which forms a continuum from latent to eruptive species, rather than classification as 'outbreaking' and 'other' species, should be preferred in studies emphasizing an evolutionary perspective.

Index terms: Lepidoptera, life histories, population cycles, rarity, temporal variability.

[1041] SOCIAL EVOLUTION IN THRIPS: LACK OF REPRODUCTIVE SKEW IN A GALL FORMING THRIPS WITH 'SOLDIERS'

B. D. Kranz, T. E. Wills & <u>M. P. Schwarz.</u> School of Biological Sciences, Flinders University, GPO Box 2100, Adelaide S.A. 5001, Australia. Email: Michael.Schwarz@flinders.edu.au

One or two origins of eusociality have been inferred for the gall-inducing Australian thrips living on Acacia species in arid Australia. The existence of eusociality in these thrips was based on the coincidence of three traits: 'soldier-like' defensive armature in a micropteran non-dispersing generation, gall defence by these micropterans, and reproductive skew between the micropterans and their foundress mother. Recently, we have examined reproductive skew in a previously unstudied gall-inducing species, Oncothrips morrisi, with a micropteran generation. Micropterans in this species do not have smaller ovaries than their foundress mother and appear to be responsible for producing all, or virtually all, of the dispersing macropteran generation. This finding has two broad kinds of implications for studies of insect sociality: (i) it raises questions about how definitions of eusociality can be applied to the spectrum of social forms existing in insects; and (ii) it indicates that defensive adult morphology in group living species need not be linked to reproductive skew. O. morrisi exhibits larger gall volumes, and larger brood sizes, than occur in other described gall forming thrips with micropteran 'soldier-like' morphology. The lack of skew in O. morrisi may be linked to the inability of foundress mothers to fully exploit the resources of large galls. If this is the case, it may be that 'soldier-like' morphology of micropterans is more an adaptation of parental care (defence of offspring) and a lack of need for dispersal, than altruistic defence of collateral relatives. However, we have also studied reproductive skew in an undescribed species which is a sister species to O. morrisi. This has much smaller galls than O. morrisi, but also exhibits little or no reproductive skew, suggesting that gall size is not sufficient to explain the fully reproductive micropterans in O. morrisi. It is possible that O. morrisi and its undescribed sister species represent a plesiomorphic state in the evolution of thrips soldiers, rather than a proximate response to gall size.

Index terms: Oncothrips, thrips, eusociality, sociality, galls.

[1043] SPATIAL INTERACTION OF *PIRATA SUBPIRATICUS* (LYCOSIDAE) AND *PACHYGNATHA CLERKI* (TETRAGNATHIDAE) IN THE RICE FIELDS

<u>J.-H. Lee</u> & J.-A. Park, Entomology Program, School of Agricultural Biotechnology, Seoul National University, Suwon 441-744, Korea, E-mail jh7lee@plaza.snu.ac.kr.

This study was conducted to investigate the patterns of colonization and the spatial distribution of Pirata subpiraticus and Pachygnatha clerki in the rice ecosystem. investigate the interactions between P. subpiraticus and Pa. clerki, 10 rice hills were covered individually with transparent acryl plastic pipes and these spiders were introduced into each arena. In July, 1 individual : 1 individual and 3 individuals : 3 individuals ratios were tested. In October, 6 P. subpiraticus without Pa. clerki, and 6 Pa. clerki without P. subpiraticus were tested. The heights of vertical distribution and changes of densities of P. subpiraticus and Pa. clerki were investigated. Intraspecific competition was stronger than interspecific competition between two species. P. subpiraticus shared their shelter in the bottom of rice hill. Pa. clerki were far off each other and removed other individuals. The heights of location (mean ±SD) of P. subpiraticus and Pa. clerki were 1.9 ±2.65 and 9.4 ±5.72, respectively, at the 1:1 ratio. The heights of location of P. subpiraticus and Pa. clerki were 3.0 ±3.70□ and 19.6 ±11.34□ respectively, at the 3:3 ratio. The height of location of *P. subpiraticus* on the rice plant at an initial density of 6 individuals/plant was location of *P. subprattices* of the rice plane at all initial density of 6 individuals/plot was $22.7\pm12.97\Box$. The densities and distributions of rice spiders were examined in 100 (10×10) hills at three sites. Dominant families were Lycosidae, Erigoninae, Thridiidae, and the dominant specie was P. subpiraticus. Densities of spiders peaked on July and September. P. subpiraticus and Pa. clerki did not occur together in the same rice hill when densities were low in early season. However, after August when spider densities became higher, their coexistence in the same hill was common. The several individuals of the same spider species were also found during this period. The spatial distribution patterns of these spiders in the rice fields were analyzed.

[1042] DEFORESTATION, DROUGHT AND EXCEPTIONAL OUTBREAKS OF THE ORIENTAL MIGRATORY LOCUST, LOCUSTA MIGRATORIA MANILENSIS (MEYEN 1835) IN INDONESIA

M. Lecoq¹, Sukirno², M.H. Luong-Skovmand¹ & T. Rachadi¹, ¹CIRAD, Centre de coopération internationale en recherche agronomique pour le développement, B.P. 5035, 34032 Montpellier Cedex 1, France, E-mail : michel.lecoq@cirad.fr; ²Directorate General for Food Crops and Horticulture, Directorate of Crop Protection, JL Aup Pasar Minggu, Jakarta Selatan, Indonesia.

Serious outbreaks of oriental migratory locusts, Locusta migratoria manilensis, have been reported on different islands of the Indonesian archipelago during the rainy seasons 1997-98 and 1998-99. Sumatra, Java, Kalimantan, Sumba, Timor, Sulawesi and Flores were particularly affected. By far the most serious outbreaks were recorded in southern Sumatra, in Lampung province, in 1998. Such large outbreaks seems a new phenomenon. They were much larger than the small local upsurges recorded in the past. On the long term prospect these outbreaks are certainly caused by drastic environmental changes. The intensive deforestation that has been under way over the last 20 years is certainly partially responsible for these outbreaks. In many places, the natural forest has been replaced by large plantations: sugarcane, oil palm, natural rubber, cassava, etc. New biotopes were created, some of which seem to be very suitable for migratory locusts, especially in sugarcane plantations on light soils. These areas are certainly source areas (at least part of them) of the recent outbreaks, specially in Sumatra. On the short term, the drought that prevailed in Indonesia in 1997 also seems to be a major recent factor that prompted these outbreaks. Meteorological data analysis indicate that these outbreaks are likely to be linked to the frequency of droughts which prevailed more often in these areas during the last ten years, as the famous 1997 El Niño drought. We have indications that the problem might become recurrent in Indonesia and grow even worse in the future. Index terms : Orthoptera, Acrididae, El Niño

[1044] DAMAGE OF CUCUMBER, CUCUMIS SATIVUS CAUSED BY FEEDING OF THE COTTON APHID, APHIS GOSSYPII

S.-W. Lee & <u>J.-H. Lee</u>, Entomology Program, School of Agricultural Biotechnology, Seoul National University, Suwon 441-744, Korea, E-mail jh7lee@plaza.snu.ac.kr.

To assess the damage of cucumber, Cucumis sativus L. caused by feeding of the cotton aphid, Aphis gossypii Glover, its direct damage and indirect damage were assessed. Plant growth analysis and crop growth analysis was conducted. A. gossypii punctured in leaf cells and significantly reduced net photosynthetic rate and total chlorophyll content of the leaf. Ultimately, their damage caused loss of productivities of leaves, stems, and fruits and resulted in hindrance of plant growth. Aphid feeding caused significant collapse of epidermis cell and parenchyma cell of the leaf during reaching phloem sap. Results of quantification of aphid feeding for leaf damage showed that net photosynthetic rates were reduced by 70% by adult aphid feeding at 300 Aphid-days and total chlorophyll contents were reduced by 75% by adult aphid feeding at 600 Aphid-days. The relationship between the cotton aphid initial density levels (control, 5, 10, 20, 40 aphids per plant) and the cotton aprild finitial density revers (control, 5, 10, 40, 40 apriles per plan) and cucumber growth stages (vegetative stage, vegetative-reproductive stage \Box) and yield were determined to develop injury levels for the establishment of control times. In the vegetative stage, leaf area, total fresh and dry weights of cucumbers decreased significantly with increasing Aphid density. In vegetative-reproductive stage , low initial aphid density levels caused non significant damage compared with control plot, but significant damage occurred in initial density levels. In vegetative-reproductive stage [], these was no significant damage by any initial density levels. Plant growth analyses such as relative growth rate (RGR), unit leaf rate (ULR), leaf area ratio (LAR) showed the most damage occurred in the vegetative stage. Results of crop growth analyses with leaf area index (LAI) and crop growth rate (CGR) also showed heavier damage occurred in the vegetative stage than in any other stages.

[1045] EFFECTS OF TRICHOMES AND CRISTALIFEROUS IDIOBLASTS DENSITIES, CONCENTRATIONS OF MINERALS AND WEATHER ON THE BEMISIA ARGENTIFOLII IN TOMATO

<u>G. L. D. Leite¹, M. Picanço², M. D. Moreira², M. R. Gusmão² & G. N. Jhan³, ¹ Dept. de Fitotecnia, Univ. Fed. de Minas Gerais, CEP 39040-006, Montes Claros, MG, Brazil, E-mail gldleite@ig.com.br; ² Dept. de Biologia Animal, Univ. Fed. de Viçosa, ³. Dept. de Química, Univ. Fed. de Viçosa, CEP 36571-000, Viçosa, MG, Brazil.</u>

The objective of this study was to evaluate the factors that affect B. argentifolii in the tomato. Thus, the weather data, the natural enemies, the leaf minerals concentrations (N and K), as well as densities of trichomes and cristaliferous idioblasts in leaves of Lycopersicon esculentum cv. "Santa Clara" were determined and these parameters were correlated with B. argentifolii infestation. The largest trichomes density/mm² observed in the face abaxial (21.29 \pm 1.52) than in the adaxial (8.19 \pm 0.57), and these trichomes were mainly non-glandular (99.65%). Trichomes and cristaliferous idioblasts densities increased from the bottom to the apex of the plants ($R^2 = 0.91$ and 0.95, P <0.01; respectively) and decreased with age ($R^2 = 0.16$ and 0.26, P <0.01; respectively). The levels of N and of K decreased with plant age $(R^2 = 0.53 \text{ and } 0.12, P < 0.01;$ respectively), and an increase in leaf levels of N increased the trichomes $(R^2 = 0.14, P < 0.01;$ <0.01) and cristaliferous idioblasts densities ($R^2 = 0.17$, P <0.01). The number of nymphs $(R^2 = 0.85, P < 0.01)$ and adults $(R^2 = 0.94, P < 0.01)$ of *B. argentifolii* increased from the bottom to the apex of the plants. There was also an increased in the number of eggs ($R^2 = 0.53$, P<0.01), nymphs ($R^2 = 0.66$, P<0.01) and adults ($R^2 = 0.22$, P<0.01) with plant age. There was a decrease in number of nymphs and adults of this insect with increasing levels of N ($R^2 = 0.67$ and 0.12, P <0.01; respectively), and trichomes ($R^2 = 0.56$ and 0.32, P <0.01; respectively), and cristaliferous idioblasts densities ($R^2 = 0.36$ and 0.14, P <0.01; respectively) in the leaves. The increase in air temperature favored the adults of this insect $(R^2 = 0.17, P < 0.01)$. The density of trichomes and cristaliferous idioblasts were negatively correlated with eggs of B. argentifolii (R² = 0.80 and 0.36, P < 0.01; respectively). The natural enemies did not correlate with any of the studied factors. There was no nymph parasitism of B. argentifolii.

Index terms: Insecta, whitefly, Lycopersicon esculentum, population dynamic, fertilization levels

[1047] THE LYFE TABLE PARAMETERS FOR ZAGLOBA BEAUMONTI (COLEOPTERA: COCCINELLIDAE) AS A PREDATOR OF DIASPIS ECHINOCACTI (HEMIPTERA: DIASPIDIDAE)

I. M. de M. Lima¹, L. M. de Almeida² & G. V. de S. Barbosa³, ¹Dept. of Zoology, Univ. Fed. de Alagoas, Praça Afrânio Jorge s/n Centro, 57010-020, Maceió – Alagoas, Brasill. E-mail iralima@dialnet.com.br; ²Dept. of Zoology, Univ. Fed. do Paraná; Dept. Univ. Fed. De Alagoas.

This study shows the longevity and reproductive performance of Zagloba beaumonti Casey, 1899 (Scymninae: Scymnillini) a potential biological control agent for Diaspis echinocacti (Bouché, 1833) the unique pest of prickly-pear [Nopalea cochenillifera and Opuntia ficus-indica (Cactaceae)] - the main food sources for the survival of cattle and even people in semi-arid areas of Northeastern Region of Brazil. The bioessays were carried out under mean room conditions of 67,44% of relative humidity and 26.70 °C. The larvae were isolated in petri-dishes and the adults were reared in plastic glasses (one couple per recipient of 250 mL, covered with organdy fixed with rubber band). The prev were produced on "rackets" of the cactaceae. The base of each recipient was lined with filter paper. A sample of adults and larvae was deposited at the Coleção Entomológica Pe. Jesus Santiago Moure, Departamento de Zoologia da Unversidade Federal do Paraná. The pre-imaginal period was 22.55 days. The viability of eggs was 11.00% and the survival from neonate larvae to adult was 57.40%, wich represents a final survival of 51,00% from eggs. The sex ratio was 0.52 (1.082 females for each male) and the mean longevity, in days was 55.53 for adults, 56.63 for males and 54.42 for females. The female reproductive features were: 12.63, 36.11 and 5.68 respectively for the preovipositional ovipositional and post-ovipositional periods; 105.32 eggs (mean fecundity which represents an oviposition rate of 2.92 eggs/day distributed on 56.21 egg batches (1.55 batches/day and 1.88 eggs/batch). The mean level of ovipositon was 44,46 eggs on the 44th day of longevity. The populational statistics based on life table parameters were: 73.48 eggs/female (the gross reproductive rate, R), 25.21 net reproductive rate (R), 13.16 days (time to double the population, DT), 0.0666 (innate capacity for increase, r_c , by iteration), 0.059 (approximated value for the capacity of increase, r_m), 1.16 females per day (the finite rate of increase, λ), 5.81 generations per year, 22.00 as the mean length of a generation that means an addiction of with an annual reproduction potential of 252,157,643 females. The value of λ confirms the Ro value, showing an increase from a generation to another. The mean length of a generation (T), 21.23 days, means that the population of Z beaumonti will grow 25,21 (Ro) times in this period. The life expectancy table shows that the key-period for field releases is the 10^{th} day after emergence when the survival and egg production are in better levels.

Index terms: Scymninae, Scymnillini, biological control, prickly-pear, Cactaceae

[1046] *EPICHLOË* GRASS ENDOPHYTES AND THEIR INTERACTION WITH A SYMBIOTIC FLY

<u>A. Leuchtmann</u>¹, ¹Geobotanisches Institut, ETH Zürich, Zollikerstrasse 107, CH-8008 Zürich, Switzerland, E-mail leuchtmann@geobot.umnw.ethz.ch

Epichloë grass endophytes (Ascomycota) and related, asexual species form systemic associations with many poold grasses in temperate regions of the Northern hemisphere. During sexual reproduction the fungus produces spore forming structures (stromata) around aborted host inflorescence referred to as choke disease. Host specific fungal species are self incompatible (heterothallic) and need to be fertilized by spermatia of opposite mating type. The vectors for transferring spermatia are specialized flies of genus Botanophila which ingest spermatia and pass them through their gut. Female flies lay eggs on young fungal stromata and, by depositing faeces, fertilize them in the process. Hatching larvae feed on developing perithecia as their exclusive food source and thus maintain a symbiotic relationship with Epichloë fungi. As a consequence of sexual incompatibility of different Epichloë taxa, dependence on fertilized stromata as food source should promote specialization of flies to one compatible taxon. Investigations were made to examine whether flies are specialized on host grasses and their Epichloë fungi, and how flies could recognize different hosts. Distribution of fly genotypes collected from different hosts did not indicate host preference of flies. However, field observations and the absence of mating among different host strains in experimental field plots clearly suggested a high degree of specificity of flies. Volatile odours collected and analyzed from infected host plants revealed different patterns for each host association. Moreover, patterns of volatiles varied between day and night and during ageing of stromata. We hypothesize that volatiles could serve as specific attractants for Botanophila flies and may provide guidance for purposeful visits among compatible fungal stromata of the same species. Index terms: Botanophila, fungi, mutualism, volatile compounds.

[1048] ARTHROPOD DIVERSITY IN AN AGROFORESTRY SYSTEM OF BLACK WALNUT AND FORAGE CROPS

M.J. Linit, W.T. Stamps & T.L. Woods, Dept. of Entomology, Univ. of Missouri, 1-87 Agriculture Bldg., Columbia, MO 65211, USA, E-mail: linit@missouri.edu.

Alley cropping holds promise for increasing insect diversity and reducing pest problems by improving natural enemy complexes and adding competition to pest species. Arthropod diversity in an agroforestry system of walnut and forage crops was examined to determine the effects of the forage crops on walnut arthropod communities and the effects of walnut on forage crop insect communities. Eighteen blocks (12m x 36m) of 4 x 5 trees on 3m x 12m spacing were identified and three treatments were applied to six blocks each (randomized block design). The treatments were alfalfa (Medicago sativa), smooth brome (Bromis inermis), and chemical herbicide. Five 12m x 36m non-tree plots were selected to the immediate east of one area and incorporated two alfalfa plots, two brome plots and one herbicide plot. We sampled the plots with pitfall traps, sweep nets, and vacuuming prior to each cutting date for the forages. Comparisons were made between treatments and sampling dates. Approximately 2500 insect samples were examined over the two-year sampling period. The data analysis was consistent across both years of sampling. Alfalfa supported a greater number of taxa and individuals than did brome, and brome likewise supported more arthropods than bare earth plots. In alfalfa, significant differences in functional taxa groups (predators, herbivores and parasitic hymenoptera) were found between agroforestry plots and monocropped plots. Alfalfa intercropped with walnut supported twice as many predators and parasitic hymenoptera and half as many herbivores than did alfalfa alone. Apparently, the walnut trees provide a real benefit for the large numbers of predators and parasitic hymenoptera found in intercropped alfalfa. The results presented here bode well for pest management in an agroforestry setting and support the associational resistance" theory that multi-species plant associations have reduced insect damage compared to single species plant systems.

Index terms: Medicago sativa, Bromis inermis, alley cropping, natural enemies, associational resistance



[1049] DETERMINATION OF THE INFLUENCE OF THE MATURITY OF THE LEAVES OF CLITORIA FAIRCHILDIANA IN THE DEVELOPMENT OF URBANUS ACAWOIOS (LEPIDOPTERA: HESPERIIDAE)

A. M. Lunz¹, J. G. N. Wendt¹, J. of M. Pinto², F. A. A. Ferrara² & A. G. Carvalho¹, 1Depto. de Produtos Florestais, Univ. Fed. Rural do Rio de Janeiro, Seropédica, RJ 23851-970, Brasil. E-mail: amehl@zipmail.com.br; 2Depto. de Fitotecnia, Univ. Fed. Rural do Rio de Janeiro.

Urbanus acawoios has been causing big defoliate to the essence forest Clitoria fairchildiana (Leguminosae: Faboidae), the popular "sombreiro", used for arborization of parks, gardens and highways, since 1979, mainly in the southeast area of Brasil. Outbreaks of U. acawoios were verified in this essence in almost the whole country. This work had as main objective to determine the influence of the degree of maturity of the leaves of C. fairchildiana in the development of U. acawoios to the temperature it sets. The study was driven in the Laboratory of Forest Entomology of the Institute of Forests of the Universidade Federal Rural do Rio de Janeiro, in the period of March to April of 1999. The medium temperature during the conduction of the experiment was of $26,25 \text{ °C} \pm 1,59 \text{ °C}$, while the relative humidity of the air was of $69,49\% \pm 10,38\%$. The medium weight of the 1° and 5° instars were not verified. The leaves were classified as new, middlemen and old, being used thirteen caterpillars by treatment. The medium duration of the 1°, 2°, 3°, 4° and 5° larval instars, prepupa, pupa, the adult's longevity and cycle of total life of U. accavoios, in days, were of 2,1; 2,3; 3,1; 2,6; 2,6; 1,2; 2,0; 9,3 and 25,2 for new leaves; 2,3; 2,6: 2,5: 3,0: 3,1; 1,6; 1,8; 10,2 and 27,1 for the middlemen; and 2,1; 2,1; 2,3; 3,3; 3,1; 1,0; 2,0; 11,0; 26,9 for the old ones. The medium weight, in grams, of the 2°, 3° and 4° larval instars, prepupa and pupa of U. acawoios was of 0,0048; 0,0271; 0,1411; 0,3297 and 0,3227 in the new leaves; 0,0034; 0,0154; 0,1048; 0,3454 and 0,3311 in the middlemen; and 0,0062; 0,0187; 0,0975; 0,3197 and 0,3138 in the old ones. When compared by the Test of Tuckey to the level of 5% of probability, the medium duration of the life cycle and its phases, in days, they didn't differ significantly among the three degrees of maturity of the leaves of C. fairchildiana offered as food for U. acawoios. The comparison of the medium weight, in grams, for the three treatments, in the analyzed phases, they only showed statistical difference in two situations: in the second larval instar fed with smaller intermediary leaves than the treated ones with new and old leaves of the same instar; and in the third instar of treated caterpillars with new leaves obtained larger weight than the other types of leaves.

Index terms: Defoliate, Arborization, Outbreak.

[1051] TRITROPHIC EFFECTS OF A LEAFTYING LEPIDOPTERAN AS A KEYSTONE ECOSYSTEM ENGINEER

<u>R. J. Marquis</u>¹ & J. T. Lill¹, ¹Dept. of Biology, Univ. Missouri-St. Louis, 8001 Natural Bridge Rd., St. Louis, MO 63121-4499 EUA, E-mail robert_marquis@umsl.edu.

In addition to their trophic and competitive effects, shelter-building caterpillars can act as physical ecosystem engineers on their host plants by creating habitats that are subsequently colonized by an array of other organisms. We hypothesize that these engineering effects will influence the abundance and diversity of other herbivores (second trophic level), abundance and diversity of predators and parasitoids (third trophic level), and damage to the plant (first trophic level). In a temperate deciduous forest in the central United States (Missouri), approximately fifteen species of leaftying caterpillars are found on white oak (*Quercus alba*). We hypothesize that one species in the genus *Pseudotelphusa* acts as a "keystone" engineer, in that it creates the first wave of leafties in the early summer that are then preferentially colonized by a the remaining species. In order to examine the engineering effect of Pseudotelphusa sp., over and above its effect as a biotic interactant, we conducted a field experiment in the summer of 1999 in which we manipulated the density of leafties on individual white oak saplings and observed the effects on (1) the abundance and composition of the arthropod community, and (2) the amount of leaf damage accrued throughout the season. In order to separate the caterpillar's engineering effects from its trophic/competitive effects, we created artificial leafties both with and without caterpillars initially present. Compared to control trees, the treatments in which we clipped 10% of the leaves into leafties had twice the number of total arthropods and significantly greater species richness one month post-treatment. This difference persisted until the end of the growing season 3 months later. This pattern was largely due to recruitment of other leaftying caterpillars to trees containing artificial ties. The third trophic level, however, was also affected, as spiders and insect predators increased in the presence of artificial ties during the second half of the growing season. Finally, damage by leaftying caterpillars to artificial ties initially containing a single *Pseudotclphusa* caterpillar was twice that of initially empty ties, indicating a strong biotic effect in addition to the engineering effect (i.e., a colonization cue, such as damage, frass or feeding-related volatiles). These results suggest that in order to understand the impacts of shelter-building insect herbivores on associated arthropods and their host plant, we need to consider their role not only as herbivores, prey, and competitors, but also as engineers that create new habitats.

Index terms: Pseudotelphusa, insect herbivore, interspecific interactions, Quercus, biodiversity.

[1050] BIOECOLOGY OF URBANUS ACAWOIOS (LEPIDOPTERA, HESPERIIDAE) IN CLITORIA FAIRCHILDIANA IN CONTROLLED TEMPERATURE

M. C. Machado¹, S. R. S. Ventura¹ & <u>A. G. Carvalho¹</u>, ¹Depto, Produtos Florestais, Univ. Fed. Rural do Rio de Janeiro, Seropédica, RJ 23851-970, Brasil. E-mail: acacio@ufrrj.br.

The species forest Clitoria fairchildiana, the "sombreiro", is very used for to shade highways and for arborization of parks and gardens for the quality of its large crown. Native of the Amazon area, it was introduced in several Brazilian states for these purposes. Starting from the end of the seventies, population outbreaks of the defoliate Urbanus acawoios have been verified in this tree with more and more frequency, causing scrious damages. In this work, were obtained the parameters bioecologicals of U. acawoios in leaves of C. fairchildiana to the temperature of $29 \pm 2,1$ °C in stove. The experiment was accomplished in the Laboratory of Forest Entomology of the Universidade Federal Rural do Rio de Janeiro in the period of July 11 to September 5, 1999, with twenty repetitions. The medium duration, in days, of the five larval instars it was 3,1; 2,1; 2,1; 2,5 and 5,1, respectively. The medium duration so much for the prepupa stage as for the one of pupa it was of one day and the medium longevity for the adult it was of 15 days. The verified medium life cycle was of 35,8 days. The medium weight, in grams, of the third to the fifth instar was 0,0281; 0,1210 and 0,3217, respectively. For prepupa, the medium weight was of 0,3203 g, while for pupa it was of 0,3116 g.

Index terms: Defoliate, Arborization.

[1052] SEX RATIO IN THE ADULTS OF THE BUTTERFLY EUPHYDRYAS DESFONTAINH IN CENTRAL SPAIN

<u>J. Martín</u>¹ & J. M. Ferrín^{1, 1}Dept. de Biología, Univ. Autónoma de Madrid, Cantoblanco, 28049 Madrid, Spain.

The genus Euphydryas has some of the best known and studied butterfly species. In Europe it has two species: E. aurinia, a widespread and well known species and E. desfontainii, with a more restricted distribution and less studied. E. desfontainii can be considered the vicariant species of E. aurinia in areas with Mediterranean climate. It can be found in the Western Mediterranean: Spain, Portugal, Southern France and the North of Morocco and Argelia. As the other species of the genus it is univoltine and overwinters as larva. Adults fly in the Spring from the middle of May to mid June. Larvae are gregarious during their first instars and feed on Cephalaria leucantha. The habitat of both the butterfly and the plant consists on disturbed and marginal areas. During three years a population of the species was studied in Central Spain using mark-release-recapture (MRR) techniques. The study area was visited two or three times per week along the flight period. The captured specimens were given an individual mark, and the hour, sex, location of the capture, activity and relative wingwear were recorded for each butterfly. In the three years the total of captured and marked specimens was larger for the males in a proportion 2.5:1. The estimated number of individuals using the Poisson and the Jolly-Seber methods was also larger for the males than for the females. However, the sex-ratio obtained from laboratory cultures was not different from 1:1. There can be two possible explanations for the differences obtained between the results obtained in the laboratory and in the field. One is the different longevity of the sexes and the other differences in adult mobility. If the males live longer a larger number can be found flying in the site at a given moment. As far as differences in mobility is concerned, the males move longer distances than females. This produces more males from adjacent areas than females and results in an apparent larger number of males.

Index terms: lepidoptera, mark-release-recapture, longevity, mobility

[1053] THE SAND-FLEA HISTORY (TUNGA: SIPHONAPTERA)

<u>R. Mascarenhas</u>, Pós-Graduação Zoologia IB-UNESP-Botucatu, FAPESP Nº 98/02420-5 e-mail rita.mascarenhas@mailcity.com

The first record of sand-flea dates from 1526, when the Europeans arrived at American continent (Oviedo, 1526), but this animal was known much before by the Amerindians living from Brazil up to Mexico. The sand flea have many different common names in different languages as Maya, Aztec, Tupi and their derived languages. Brazil presents the greatest number of species of the genus *Tunga* all around the world, and an amount of folk records about the parasite-host interaction. Due to the long term relationship between this insect and humans, it is common to found many traces of it in the popular at as music and dance and even some therapies in the popular medicine to deal with the problems caused by this insect. Many of the former visitors which arrived in America as Hans Staden, De Lery, Wallace, MarcGrave and Saint Hilaire, reported their suffering with the infections and other illnesses caused by the sand flea. This insect was considered of African origin but nowadays its is known to be really Neotropical.

[1055] *DROSOPHILA* FAUNA (DIPTERA, DROSOPHILIDAE) IN THREE XEROPHYTIC AREAS OF SÃO PAULO STATE (BRAZIL)

R. P. Mateus & F. M. Sene, Dept. of Genetics, FMRP, Univ. São Paulo, Ave. Bandeirantes 3900, CEP 14049-900, Ribeirão Preto, SP, Brazil. Email: pincela@rgm.fmrp.usp.br. Financial Support: FAPESP, CNPq, FINEP, CAPES and USP.

The genus Drosophila (Diptera, Drosophilidae) includes more than 1700 described species. Some are endemic of certain regions, others are cosmopolitan due to their association with man. The majority of the Drosophila feed on microorganisms, mainly yeast, found in decaying fruits, vegetables, and cacti. We made a survey of Drosophila fauna in three cactus areas (Cereus hildemaniannus) in the state of São Paulo, comparing the frequencies of the species collected in these areas. In Serrana (SRN) we examined the temporal variation of the frequencies of the cactophilic species of the repleta group. Collections were made bimonthly in SRN from sept/98 to may/99 and in Itatiba (ITA) in april/99 and Sertãozinho (SRT) in oct/99. A total of 17894 flies were identified as belonging to 25 different species of Drosophila, 23 in Serrana, 17 in Sertāozinho and 16 in Itatiba. The species found were: D. annulimana, D. polymorpha, D. pallidipennis, D. coroica, D. mercatorum, Drosophila sp. D (formely D. serido "Type D"), D. simulans, D. sturtevanti and D. latifasciaeformis (SRN, SRT, ITA); D. immigrans, D. buzzatii, D. nigricruria, D. paranaensis, D. bandeirantorum and D. busckii (SRN, SRT); D. cardini, D. ornatifrons, D. mediostriata, D. malerkotliana, D. prosaltans and D. willistoni (SRN, ITA); D. meridionalis (SRT, ITA); D. nebulosa and D. fumipennis (SRN); and D. aldrichi (SRT). In Serrana, D. simulans was most frequent in september/98 (0.336), D. mercatorum in november/98 (0.302), D. sturtevanti in january/99 (0.754), D. willistoni in march/99 (0.413) and D. buzzatii in may/99. All Drosophila species of the repleta group were found at low frequencies in the dry season, increasing in the wet season, except D. paranaensis and D. mercatorum which showed an inverse pattern. In all areas some species simultaneously appeared at a greater frequency. D. simulans was most frequent in Sertãozinho (0.465) at the same time that it was in Serrana. In Itatiba, D. willistoni was most frequent (0.373) at the same time that it was in Serrana. D. aldrichi was collected in Sertãozinho for the first time. The high diversity found in Serrana could have been influenced by the numerous collections and because this area is of difficult access, diminishing anthropogenic action. The temporal variation found seems to be under a climatic influence.

Index terms: Biodiversity, ecology, populational temporal variation

[1054] SPECIATION AND DISPERSAL OF MARINE SHORE DOLICHOPODID FLIES IN EAST ASIA (DIPTERA: DOLICHOPODIDAE, HYDROPHORINAE)

<u>K. Masunaga</u>¹ & T. Saigusa², ¹Biosystematics Laboratory, Graduate School of Social and Cultural Studies, Kyushu Univ., Ropponmatsu, Fukuoka City 810-8560, Japan, E-mail: moaircb@mbox.nc.kyushu-u.ac.jp; ²Baikoen 2-7-1-402, Fukuoka City 810-0035, Japan.

In East Asia there are four hydrophorine dolichopodid genera, Acymatopus Takagi, Conchopus Takagi, Thambemyia Oldroyd and Cymatopus Kertész which exclusively inhabit rocky seashores. The former three are more closely related to each other than to the fourth, and appear to constitute a monophyletic group together with the Nearctic genus, Paraphrysylus Becker. In this paper, we compare the geographical distributions of species in the three genera with their ND5 gene tree, and discuss the mode and pattern of speciation and process of dispersal in this group. Most species of Continental China are either conspecific with or the sister species of a Japanese species. This suggests that speciation of the Continental species occurred relatively recently in the evolution of each genus. It is also considered that extant or ancestral species were widely distributed over the region when the Asian Continent was connected with the Japanese Archipelago during Quaternary glacial epochs. Ancestral species speciated after their ranges were isolated by higher sea levels during interglacial epochs. It has been frequently demonstrated that the Japanese fauna originated from the Asian Continent. But the present study also suggests that there are some cases in which species originated in Japan, and subsequently spread to the Continent. In other words, dispersal routes between the Asian Continent and Japan following speciation was in two directions. The present study also suggests that no long distance dispersal via ocean currents occurred in this group, at least between Japan and the Asian Continent.

Index terms: Acymatopus, Conchopus, Thambemyia, Phylogeography, ND5 gene

[1056] SAMPLING AND POPULATION DISTRIBUTION OF MITES FROM STIGMAEIDAE FAMILY IN CITRUS ORCHARDS IN SÃO PAULO STATE

<u>A. L. Matioli</u>¹ & C. A. L. Oliveira¹, ¹Dept. Fitossanidade, Univ. Est. Paulista/Câmpus Jaboticabal, Jaboticabal, SP, Brazil, 14.870-000, E-mail amatioli@fcav.unesp.br

This work was carried out in six municipalities of São Paulo State (Limeira, Araraquara, Itápolis, Jaboticabal, Bebedouro and Olímpia), during June 1998 until January 2000. It was sampled leaves, branches and fruits of citrus, variety "Péra-rio" (*Citrus sinensis*), over there more five frequently weed of each one sampled field. The sampling was realised monthly. The weather data (temperature, humidity and rain) was compared with population fluctuation curves of stigmeids species. We have found two species of stigmeids mites *Agistemus* aff. *bakeri* and *Zetzelia* aff. *yusti* or *mapuchina*, where *A*. aff. *bakeri* was the most abundant specie (97.5%). The stigmeids mites was found in Olímpia, Itápolis, Araraquara and Limeira municipalities, and in Limeira, SP, was the municipality that was found more number of stigmeids mites. The population distribution into the plant was studied and have verified that there are preference to fruits and leaves of citrus. The relationship between weather data and population distribution of stigmeids mites, the population had peaks during July until November, the same period of large occurrence of "leprosy mite" *Brevipalpus phoenicis* (Tenuipalpidae), the transmitter of virus plant disease. In the weeds sampled was found none stigmeids wates.

Index terms: Stigmeids, Citrus sinensis, biological control, Agistemus aff. bakeri, weeds.

[1057] FOOD PREFERENCE OF AGISTEMUS AFF. BAKERI (ACARI: STIGMAEIDAE)

<u>A. L. Matioli</u>¹ & C. A. L. Oliveira¹, ¹Dept. Fitossanidade, Univ. Est. Paulista/Câmpus Jaboticabal, Jaboticabal, SP, Brazil, 14.870-000, E-mail amatioli@fcav.unesp.br. Backing: FAPESP (Fundação de Âmparo à Pesquisa do Estado de São Paulo)

The biotest aimed to establish what the best food source to the stigmeids mites Agistemus aff. bakeri, towards was tested three food source, Brevipalpus phoenicis, Panonychus citri e Tetranychus urticae. It was used 10 stigmeids females of same age, to each one treatment, isolated into 10 cages, where was valued the daily posture per stigmeid female, during a week. The treatment that was tested P. citri, as food source, the stigmeid female was isolated in leaf citrus cage, with adaxial surface to up side and into each one cage were released 20 females of tetranychid, 48 hours before to release the stigmeid female. To the treatment that was tested B. phoenicis as food source, it was selected citrus fruits that have contained more than 100 mites per fruit, to release the stigmeid female into the cages. To test T. urticae as food source, it was utilized leaf citrus cages, supplying eggs and young stages of tetranychids to stigemeids females each 48 hours. The biotest was carried out into the climate room with temperature, relative humidity and light period from 25°C, 80% and 12 hours, respectively. The assessments were realized daily during seven days. The results have showed that the best food source was B. phoenicis, that produced 2.6 eggs per day, while the stigmeids females were fed with P. citri and T. urticae laid 2.1 and 0.44 eggs per day, respectively. The daily eggs laid per stigmeid female in function of the time, when the females were fed with P. citri, the curve showed unstable, perhaps did not have a large number of eggs laid per female but it was extended the period of lay eggs. The stigmeids female fed with B. phoenicis laid the most number of eggs four days after the initial of assessments. The T. urticae as food promoted a shorter daily lay of eggs and the lay of eggs period. In reason this results, we advice to rear A. bakery feeding with B. phoenicis and P.citri in labor because those specimens have showed the most efficient supply. Index terms: Stigmeids, tetranychids, B. phoenicis, biology, biological control, rearing labor.

[1059] UTILISATION OF UNIQUE ATTRIBUTES OF LARVAL WHITEFRINGED WEEVIL FOR BIOASSAYING TOXICITY OF PURE AND PLANT-DERIVED FUMIGANT COMPOUNDS

<u>J. N. Matthiessen</u>, CSIRO Entomology, Private Bag PO, Wembley, WA 6014, Australia. E-mail: johnm@ccmar.csiro.au.

The soil fumigant metham sodium, a methyl isothiocyanate precursor, has assumed a unique application as product-of-choice for control of whitefringed weevil, Naupactus leucoloma, the 'key' soil pest in potato production in parts of Australia. Its high cost is justified by the potentially devastating threat that this insect presents, together with spinoff benefits of enhanced tuber quality from suppression of noxious soil-borne microorganisms. Arising from concerns about the long-term sustainability of this pest management practice and its high cost, considerable interest in the potential of 'biofumigation' by isothiocyanate-releasing brassicas for suppression of soil-borne pests and diseases has developed. First instars of whitefringed weevil are a particularly good bioassay model for assessing and comparing the efficacy of volatile soil fumigants and biofumigants against an entomological target. Eggs are readily obtained in the thousands and, after providing appropriate conditions for embryogenesis, can be stored for long periods. The larvae remain in the egg and only hatch when stimulated by contact with water. Thus large numbers can be stockpiled and produced at will for experimental studies. Furthermore, the first instar is a non-feeding stage capable of many days' survival with neither food nor shelter. Longevity varies with temperature, but comfortably accommodates periods required to bioassay volatile compounds at a wide range of environmentally-realistic temperatures without appreciable mortality of untreated controls. Because of their unique attributes, first instar whitefringed weevil are proving highly valuable as an entomological bioassay tool for determining the toxicity of both pure isothiocyanates, and the wide variety of these compounds emitted by hydrolysis of various Brassica tissues. It also has high relevance because it is a soil pest organism. Tests, both in vitro and in vivo, sensitively reveal widely varying toxicity of tissues from different species and cultivars, and the influence of environmental factors such as temperature and contrasting soil types. This system is being used in conjunction with chemical analysis to indicate the potential of different biotoxic plants for biofumigation of soil-borne pest organisms, and to reveal the most potent isothiocyanates and combinations of those toxins. Index terms: Naupactus leucoloma, biofumigant, bioassay

[1058] ASYMMETRIC INTERSPECIFIC INTERACTION ON WING DIMORPHISM BETWEEN RICE PLANTHOPPERS, SOGATELLA FURCIFERA AND NILAPARVATA LUGENS

M. Matsumura & Y. Suzuki, Laboratory of Pest Management Systems, Kyushu National Agricultural Experiment Station, Nishigoshi, Kumamoto 861-1192, Japan, E-mail mmasa@knaes.affrc.go.jp

The whitebacked planthopper (WBPH) Sogatella furcifera and the brown planthopper (BPH) Nilaparvata lugens are two major pests of rice throughout Asia. Females of WBPH and both sexes of BPH exhibit density-dependent wing dimorphism and occur in two forms, macropters and brachypters. We found asymmetric interspecific interaction on wing dimorphism between the two sympatric species by a series of laboratory experiments. If the total number of planthopper nymphs per rearing tube was the same, the proportion of BPH macropterous adults was higher in a mixed population of BPH and WBPH than in a pure population of BPH. This suggests that interspecific effects on wing dimorphism are more than intraspecific ones for BPH. In contrast, for WBPH, interspecific effects were less than intraspecific ones. The proportion of macropterous adults of both species was higher on rice seedlings previously infested with WBPH nymphs than those infested with BPH nymphs or uninfested (control). This phenomenon was also observed on rice plants at tillering stage. Thus, interspecific interaction on wing dimorphism between the two planthoppers occurs not directly but indirectly through the feeding of rice plants. These results suggest that planthopper-induced changes in plant physiology in WBPH are greater than those in BPH, although the quantity of rice phloem sap consumed per insect is much less in WBPH than in BPH. Further evidence for the effect of interspecific interaction on population dynamics comes from a significantly negative correlation between the density of immigrant WBPH and the population growth rate of BPH.

Index terms: density, wing-form, BPH, WBPH, population dynamics

[1060] A REVIEW OF THE SOUTH AMERICAN NOTONECTA (PARANECTA), INCLUDING N. INCA NEW SPECIES FROM PERU (HETEROPTERA: NOTONECTIDAE)

<u>S. A. Mazzucconi</u>, Laboratorio de Entomología, Departamento de Ciencias Biológicas, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Ciudad Universitaria, (1428) Buenos Aires, Argentina. E-mail: mazzucco@bg.fcen.uba.ar

The South American Notonecta (Paranecta) are revised on the basis of morphological characters. Types of most of the species and large series of specimens were examined. At present 11 species are recognized: N. bifasciata from Argentina, Uruguay and Brasil; N. disturbata (= N. hungerfordi new synonymy) from Argentina, Brasil, Paraguay and Bolivia; N. fazi from Argentina, Chile and Perú; N. inca new species from Perú; N. indica from Colombia, Venezuela, Central and North America; N. peruviana from Argentina, Bolivia (herein first recorded) and Perú; N. polystolisma from Argentina and Brasil; N. pulchra from Argentina, Brasil and Paraguay; N. sellata from Argentina, Uruguay, Brasil, Paraguay and Bolivia; N. vereerbruggheni from Argentina, Uruguay, Brasil, Paraguay and Bolivia; N. vereerbruggheni from Argentina, Uruguay, Brasil, Paraguay and Bolivia; N. vereerbruggheni from Argentina, Chile and Perú, N. polystolisma from Argentina, Uruguay, Brasil, Paraguay and Bolivia; N. vereerbruggheni from Argentina, Chile and Perú, Previous descriptions are incomplete and most of the characters used to define the species are superfluous. In this regard, the genital capsule, the paramera, the aedeagus and the female urosternites are proposed to distinguish the South American species of Paranecta. In addition, three species groups are defined: (1) N. indica, (2) N. fazi and N. vereertbruggheni, and (3) the remaining eight South American species.

Index terms: Nepomorpha, backswimmers, new record, new synonymies, Neotropical Region.

Symposium and Poster Session

[1061] VELIIDAE FROM ARGENTINA (HETEROPTERA); A PRELIMINAR LIST

<u>S. A. Mazzucconi</u>, Laboratorio de Entomología, Departamento de Ciencias Biológicas, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Ciudad Universitaria, (1428) Buenos Aires, Argentina. E-mail: mazzucco@bg.fcen.uba.ar

Up to now 19 species of Veliidae were known from Argentina. The present work adds one new species and 14 new records, and establishes a new synonymy. Therefore, the following 33 species of Veliidae are known from Argentina: *Oiovelia cunucunumana* (= *Paravelia correntina* new synonymy), *O*. inedit species, *Paravelia anta* new species, *P. paxilla*, *P. platensis*, *Platyvelia brachialis* (first record), *Steinovelia virgata*, *Stridulivelia astralis*, *Rhagovelia boliviana*, *R. imatatrix* (first record), *R. janeira* (first record), *R. lucida* (first record), *R. ornata*, *R. paulana* (first record), *R. relicta* (first record), *R. versuta*, *R. zela* (first record), *M. thaumana* (first record), *R. trista* (first record), *M. hambletoni* (first record), *M. hinei*, *M. hungefordi*, *M. inannana*, *M. limaiana* (first record), *M. longipes*, *M. lujanana*, *M. minula*, *M. pulchella* and *M. venustatis* (first record). The purpose of the present work is to provide a key, distributional data, ecological preferences and comparative notes on the Veliidae from Argentina.

Index terms: Gerromorpha, new species, new records, new synonymy, Neotropical Region.

[1063] INFLUENCE OF WATER BALANCE ON THE POPULATION DYNAMICS OF THE BURROWING BUG ATARSOCORIS BRACHIARIAE (HEMIPTERA: CYDNIDAE)

M. O. Medeiros¹ & <u>O. Sales Jr.¹</u>, ¹Centro de Controle Biológico, Univ. Federal de Mato Grosso, Av. Fernando Corrêa, s/n, Cuiabá, MT 78060-900, BR, ceb@cpd.ufmt.br.

This research presents data on the population dynamics of Atarsocoris brachiariae. Comparisons are made against the water balance for the region of Rondonópolis, MT, Brazil. Population surveys were performed at Fazenda Guarita, in a 4-hectare, 8-year old Brachiaria decumbens rangeland highly infested with A. brachiariae, formerly an experimentation field owned by Empresa Mato-grossense de Pesquisa, Assistência e Extensão Rural S/A (EMPAER/MT). Weekly soil samples were taken at random from January, 1995 through December, 1997; sample size was 10 × 20 × 40 cm (width, length, depth). The number of eggs, nymphs and adults present in each sample was recorded. The highest population density for nymphs (7022/12915 - 54.37%) and for adults (1412/2318 -60.91%) was verified at the depth between 20 and 40 cm; for eggs, the highest population density (1159/1431 - 80.99%) was verified between 0 and 20 cm. The period from egg to death of the adult lasts about 11 to 12 months, with two generations per year, the first beginning in the water excess period and the second occurring during the water deficit in the soil. Eggs laid by A. brachiariae females from January through May have their population peak in February, producing first generation adults from May through October, with the population peak in June. Eggs laid between June and November have their population peak in August and produce the second adult generation between November and April, with their peak in January. Individuals from the first generation become adults during the water deficit period in the soil (drought) and do not swarm at that time, burrowing deep in the soil profile in search of more favorable humidity conditions. Conversely, second generation individuals become adults during the water excess period, in which dispersal swarms take place, beginning with the first rainfalls in October and ending with the last precipitation in May. For both generations mating occurs inside the soil; hence, swarms are for dispersal only and normally take place during the rainy season. During the soil water deficit season (drought), which happened between June through November/1995, April through October/1996, and March through May and July through October/1997, water deficit in the soil reached -1124 mm, with a monthly average of 59.15 mm for the three-year period. A total of 1012/1431 (70.72%) eggs, 7104/12915 (55.00%) nymphs and 855/2318 (36.88%) adults were observed in the period. Index terms: swarm, Brachiaria, dispersal, bioecology

[1062] IMPLICATIONS OF *DEPRESSARIA* (LEPIDOPTERA: OECOPIIORIDAE) AND HOST-PLANT PHYLOGENIES FOR *DEPRESSARIA* SPP. DISTRIBUTION, HOST-USAGE, ECOLOGY, AND SPECIATION

<u>D. D. McKenna</u>, University of Illinois Dept. of Entomology, 505 S. Goodwin Ave. Urbana, IL 61801 E-mail: mckenna@uiuc.edu

I have used methods of comparative phylogenetics to ask the question, "Have host-plant speciation events directed speciation in the 23 North American members of the genus *Depressaria* (Lepidoptera: Depressarinae) as evidenced by congruent cladogenesis?" Fifteen of the 80 species in the plant genus *Lomatium*, 6 other apiaccous taxa, and two Asteraceae are reported as hosts for these *Depressaria*. To assess patterns of cladogenesis in the genus, I compared and contrasted a morphological phylogeny I constructed for *Depressaria* and their host plants show similar patterns of cladogenesis. The resulting phylogenies for *Depressaria* and their host plants show similar patterns of cladogenesis. The results suggest that there is little temporal synchrony of speciation events in *Depressaria* compared with *Lomatium*; however, similarities between the groups with respect to distribution, ecological speciation in *Depressaria*, *Lomatium*, and allied taxa. Geographic isolation and host-use limitations based on chemistry, phenology, and morphology may account for many speciation events in North American *Depressaria*; thus future ecological study, as well as molecular study of *Depressaria* phylogeny, should be considered in future work. Comparative phylogenetics, *Lomatium*, Apiaceae

[1064] INFLUENCE OF PRECIPITATION VOLUME AND SOIL TEMPERATURE ON THE POPULATION DYNAMICS OF THE BURROWING BUG ATARSOCORIS BRACHIARIAE (HEMIPTERA: CYDNIDAE)

M. O. Medeiros¹ & <u>O. Sales Jr.</u>¹, ¹Centro de Controle Biológico, Univ. Federal de Mato Grosso, Av. Fernando Corrêa, s/n, Cuiabá, MT 78060-900, BR, ceb@epd.ufmt.br.

This research presents data on the population dynamics of Atarsocoris brachiariae. Comparisons are made against the precipitation volume and soil temperature for the region of Rondonópolis, MT, Brazil. Population surveys were performed at Fazenda Guarita, in a 4-hectare, 8-year old Brachiaria decumbens rangeland highly infested with A. brachiariae, formerly an experimentation field owned by Empresa Mato-grossense de Pesquisa, Assistência e Extensão Rural S/A (EMPAER/MT). Weekly soil samples were taken at random from January, 1995 through December, 1997; sample size was $10 \times 20 \times 40$ cm (width, length, depth). The number of eggs, nymphs and adults present in each sample was recorded. Nymphs and adults were also found within small chambers excavated in the soil in a sub-cylindrical or oval shape, showing a darker layer internally. It is suggested that these chambers are constructed as a protection during ecdysis and/or to withstand weather changes. Precipitation volumes indicated a positive correlation with number of nymphs (P > 0.05) and adults (P < 0.01), and were negatively correlated with number of eggs (P < 0.01). The greatest number of eggs (63.8%) was collected in the dry season; egg population density was highest in 1996, when the smallest rainfall amounts were verified. On the other hand, nymphs (57.17%) and adults (72.6%) were collected mainly in the rainy season. Soil temperature was negatively and not significantly (P > 0.05) correlated with number of nymphs and adults collected, whereas it was positively and significantly (P < 0.05) correlated with number of eggs. An increase in the population level of A. brachiariae in the order of 266.5% was observed from 1995 to 1997. This should serve as a warning for technicians and farmers to plan control measures for the pest, which is already expanding to other regions in the state of Mato Grosso.

Index terms: rainfall, ground, Brachiaria, pest

[1065] LIFE CYCLE OF MARTAREGA URUGUAYENSIS (HETEROPTERA: NOTONECTIDAE) UNDER LABORATORY CONDITIONS

<u>A. L. Melo</u> & M. R. V. Sant'Anna, Dept. of Parasitology, Federal University of Minas Gerais, P.O. Box 486, Belo Horizonte, 30161-970, MG, Brazil, E-mail: aldemelo@icb.ufmg.br. Support by CNPq.

Predation studies of invertebrates by aquatic Heteroptera, adults or nymphs, have been used mainly with species belonging to the family NOTONECTIDAE, which contains insects that are efficient predators of mosquito larvae implicated on the transmition of parasitic diseases. Martarega, a relatively small gender, is endemic in America, and M. uruguayensis is a common species in Belo Horizonte, Brazil. Aiming to determine the post-embryonic period and duration of the instars of M. uruguayensis individual were reared in laboratory and fed exclusively of C. quinquefasciatus, M. uruguayensis individual were reared in laboratory and fed exclusively of C. quinquefasciatus larvae. The photoperiod was of 12 D/E and temperature of 25,5 ± 0.8 °C. It was verified that the mean duration of the each instar was of $8,57 \pm 0.98$ days for the first instar, $8,75 \pm 1,55$ for the 2^{n4} , $12,45 \pm 1,23$ for the 3^{r4} , $12,79 \pm 1,47$ for the 4^{th} and $15,00 \pm 0,74$ for the fifty. During the nymphal period the predation average was $3,52 \pm 1,39$ for the 3^{r4} , 412, 46 ro the 3^{r4} , $3,28 \pm 1,31$ for the 4^{th} and $3,48 \pm 1,44$ for the fifty. The daily consumption of mosquito larvae by adults was $2,16 \pm 1,27$ larvae The mortality rate was restricted to the 2^{9} and 3^{9} instar, with rates of 8,69% and 4,35%, respectively, and adults of M. uruguayensis survived over six months in laboratory conditions. Those notonectids can be reared in large scale in laboratory for control of mosquito larvae population. Index terms: Aquatic insects, predation, biology.

[1067] AGONISTIC BEHAVIOR BETWEEN COLONIES OF THE FORMOSAN SUBTERRANEAN TERMITE, *COPTOTERMES FORMOSANUS* (ISOPTERA: RHINOTERMITIDAE), FROM LOUIS ARMSTRONG PARK, NEW ORLEANS, LOUISIANA

M. T. Messenger¹ & N-Y. Su², ¹City of New Orleans Mosquito and Termite Control Board, 6601 S. Shore Harbor Blvd., New Orleans, LA 70126-8012, USA; ²Ft. Lauderdale Research and Education Center, Univ. of Florida, 3205 College Ave., Ft. Lauderdale, FL 33314-7799, USA.

Intra- and intercolony interactions between Formosan subterranean termite (FST), Coptotermes formosanus Shiraki, colonies from New Orleans, Louisiana, were studied in the laboratory. In 1998, a field study was initiated in Louis Armstrong Park to identify and characterize each FST colony present in this 31-acre fenced-in park. By following a triple-mark recapture procedure, the foraging territory for each colony was defined and other characteristics such as wood consumption rate and mean body weight were calculated. Agonistic responses between each colony were studied after each colony had been characterized and their foraging territories defined in the field. Half of the termites collected from each colony were dyed with 0.1% Nile Blue A and the other half were undyed. Groups of dyed and undyed termites from each colony were then paired with termites from different colonies in a dish, in addition to being paired with termites from the same colony. Each pairing was videotaped and any form of agonistic behavior was recorded. Agonistic responses included mandible flares, mandible insertion, biting, fleeing, and chasing or no aggression. Agonistic behavior was observed from most colonies; however, a few intercolony pairings resulted in no aggression. The nonaggressive, intercolony pairings were further studied by placing groups of termites from each colony into two-dimensional foraging arenas to determine whether or not each colony would display any agonistic behavior. The data revealed that each colony displayed at least one type of agonistic behavior towards another colony. Some colonies tended to be more aggressive than others but some tended to be more submissive and flee from the aggressive colony. Intracolony pairings resulted in no aggression. The relationship between foraging territory sizes in the field and agonistic behavior in the laboratory will be discussed.

Index terms: intra- and intercolony aggression, territoriality, foraging territory

[1066] A NEW HYPOTHESIS FOR INSECT GALL-MAKER SPECIES RICHNESS: RESOURCE SYNCHRONISATION AND THE EFFECTS OF FIRE

<u>M. S. Mendonca Júnior.</u>¹, ¹Centre for Population Biology & Dept. of Biology, Imperial College at Silwood Park, Ascot, Berkshire, SL5 7PY, UK, E-mail: m.mendoncajr@ic.ac.uk.

I propose a new hypothesis to explain the insect gall-maker species richness pattern found by Price et al. (1998, Journal of Biogeography, 25:581-591). A hump-shaped latitudinal pattern was found, peaking at the warm temperate region (25°-45° in altitudinal-latitudinal equivalents). Xeric sites had higher gall-maker richness than more mesic sites, but xeric vegetation growing in mesic sites also had high gall-maker richness. This indicates that the correlation is to be found in the vegetation characteristics, and not in the climatic conditions per se. Host-shifts are believed to be the most likely way by which gall-makers can speciate. Since most galls are induced on young plant tissue, and mainly on leaves, the dynamics of leaf flushing in different vegetation types (i.e. how many plant species flush synchronously) can be of capital importance determining host-shifts for dispersing insect females. I suggest that vegetation types with synchronous leaf flushing facilitate gallmaker host-shifts and are therefore more likely to harbour higher insect gall-maker species richness. This is why the pattern found by Price et al. (1998) showed a low species richness of gallers for tropical rain forests and higher richness for other vegetation types in high latitudes. Additionally, perhaps more importantly, Mediterranean-like vegetation suffer seasonal influence of fires, and plants resprouting in response to this can provide further synchronous leaf flushes during which more host-shifts can occur. Plant species richness also underlies the host-shifting process in different biomes. Fire-prone areas of high plant richness like the South-African fynbos are expected to have even higher richness of insect gallers. Plant phylogeny is another important aspect of host-shifting, since barriers for host shifts between unrelated host plants (e.g. different families or genera) are probably stronger than for more closely related ones. Once an unrelated host type is colonised, host shifts can increase gall-maker species richness within this new plant group. This could be the reason why certain species-rich host plant taxa like Quercus or Eucalyptus have species-rich gall-maker communities: many members of these groups occur in fire-prone Mediterranean-like vegetation, and therefore could be more frequently subject to host shifting events. More information is needed to disentangle the ecological aspects promoting host-shifts, especially in relation to the relatively neglected question of the dynamics of the resources for gall induction, reactive plant tissues. Resprouting in response to fire is one of these ecological aspects, perhaps the most important. Index terms: host shift, host plant phylogeny, speciation.

[1068] ON SOME BEHAVIOURAL DECISIONS FOR POSTEMBRYONIC DEVELOPMENT AND FOR RESOURCE COMPETITION OBSERVED IN EULOPHID ECTOPARASITES (HYMENOPTERA: CHALCIDOIDEA)

<u>G. Minto</u>¹ & M.C. Rizzo², ^{1,2}Inst. of Agricultural Entomology, Univ. of Palermo, Viale delle Scienze 13, 90128 Palermo, Italy. E-mail: mineog@unipa.it.

Over the time in which the role of antagonists in the natural control of Phyllocnistis citrella has been studied, some little known and unknown behaviours looking at either the postembryonic development or the competition for resource were recorded in the following Eulophidae: Cirrospilus diallus, C. pictus, Ratzeburgiola incompleta and Semielacher petiolatus. Two of such behaviours realize the instruments permitting to the adult pharate stage an easier emergence from the pupal skin. The first one is made from the eonymph and its decision is related to danger of collapse of the mine onto the naked pupa. In order to prevent that, it voids the meconial pellets in a sort of pillars located between the roof and the floor of the mine and just at the points where the risk of collapse could eventually occur. The second one, observed in about all the individuals of the cited species, either in laboratory rearing or in the field, is realized from the young pupa when it slips off the integument of last instar larva from its body. Such a skin, by appropriate sequence of shakes of the body, is converted in a sort of ligament connecting the last abdominal sternite to the floor of the mine or to the meconium, with both ends welded by substances probably secreted from ileac tubes. The other behavioural decision refers to eventual competition for resource and involves the using of ovipositor as an instrument to prevent superparasitism and multiparasitism. In a series of observations made in laboratory submitting hosts previously parasitized from C. pictus or R. incompleta, the conspecific female, before a new deposition took place, proceeded to kill about all the eggs previously laid and in some cases also the new hatched larvae, stinging them with ovipositor. Such a behaviour has also been recorded in nature, where however the event is rather rare, perhaps due to the large amount of available unparasitized hosts.

Index terms: Cirrospilus spp., Ratzeburgiola incompleta, Semielacher petiolatus, emerging behaviour, ovipositor use

Symposium and Poster Session

[1069] LENGTH-MASS RELATIONSHIPS FOR AQUATIC INSECTS IN FRESHWATER ENVIRONMENTS OF PATAGONIA (ARGENTINA)

<u>M.L. Miserendino¹,</u> ¹Laboratorio de Ecología Acuática. Universidad Nacional de la Patagonia, Sede Esquel, Sarmiento 849, 9200 Esquel, Chubut, Argentina, E-mail lauram@teletel.com.ar

Ecological studies of aquatic insects often lack information on benthic biomass, although many ecological questions at the organism, population, community and ecosystem levels of organization can be understood using biomass data. Body mass relationships can be described by the general power equation DM=a. L^b, or after logarithmic transformation la $DM = \ln a + \ln b$ (where: a, b = regression constants, DM = dry mass and L = lengthparameters). The purpose of this work is to present length-mass relationships for insects of running waters from Patagonia. Aquatic insects were collected from 1991 to 1996 in different rivers found from 41° 53' S to 50° 25' W. Rivers were located in the mountains and in the Andean Patagonian plateau. Animals used were formalin-preserved (4 %). Body size of the animals was measured to the nearest 0.1 mm; body length included the distance between the anterior part of the head and the posterior part of the last abdominal segment. For dry mass determinations, the specimens were transferred into aluminum foils. Drying was performed at 105° C for up to 4 h. Animals were weighed on an electronic balance with 0.5 mg accuracy. In the procedure, 673 specimens were analyzed. Predictive equations for the conversion of length parameters into dry mass were obtained for 30 taxa. Regressions included the orders Plecoptera (10 species), Ephemeroptera (3 species, 3 genera), Trichoptera (4 species, 1 genus), Diptera (6 genera), Coleoptera (1 species, 1 genus) and Anisoptera (1 genus). Correlations were highly significant and explained a high proportion of variation of the dependent variable as expressed by the coefficient of determination (r^2 = 0.58-0.98). The predictive equations obtained may be used for biomass determinations of Patagonian running water insects, facilitating calculations of benthic standing cron and secondary production.

Index terms: length-mass regression, biomass, rivers, Patagonia.

[1070] RADE AND DISAPPEARING INSECT SPECIES (COLEOPTERA) IN THE NORTH-EAST OF UKRAINE

A.A. Mishchenko¹, V.L. Meshkova², l. Institute of Experimental and Clinical Veterinary Medicine under Ukrainian Academy of Agricultural Sciences. Pushkinskaja Str., 83. Kharkov, 310023, Ukraine, e-mail: admin@vet.kharkov.ua. 2. Ukrainian Research Institute of Forestry & Forest Melioration. Pushkinskaja Str., 86. Kharkov, 310024, Ukraine, e-mail: zahist@u-fri.kharkov.com.

In the East of Ukraine practically all natural biocenoses are under anthropogenic pressure which brought to insect fauna changes. There are the data not only on some species number but also on frequency of their occurrence. These are Staphylinidae: Emus hirtus L.; Scarabaeidae: Odontaeus armiger Soop., Ceratophyus policeros Scop., Geotrupes spiniger Marsh., Scarabaeus sacer L., S.affinis Brule., Amhicoma vulpes F., Chioneosoma pulvereum Knoch.; Tenebrionidae: Anatolica abbreviata Gebl., Pimelia sublobosa Pall., Prosodes obtusa F., Opatrum riparius Gerh. Recently the number of forest insects connected with dead wood or fungi decreased. These are Lucanudae: Lucanus servus L., Dorcus parallelopipedus L.; Scarabaeidae: Orictes nasicornis L., Trichius fasciatus L., Potosia aeruginosa Drury., P. lugubris Hbst.; Cerambicidae: Strangalia septempunctata F., Cerambyx cerdo L., Dorcadion carinatum Pall., D.fulvum Scop., D. holocericeum Kryn.; Carabidae: Calosoma sycophantha L., C. inquisitor L., Carabus violaceus L., C. corinatus L, Chaeres F.-W, Laemostenus terricola Hbst.; Staphylinidae: Oxyporus maxillosus F. Our observations in 1979-1995 showed that insect species composition changes with industrial cattle-breeding development, artificial pastures creation. The number of coprophages which utilize manure and predators of zoophilous and synanthropic flies has decreased. Ph. spinipes which was known from Japan and Manjury recently spread in Ukraine in the pastures in manure pellets of cattle, rarely under the decaying plants. It may be found more often in the cattle-breeding complexes in the fresh manure and in the stalls. It is one of the main regulators of synantropic and zoophilous flies number. Inspected area is located in the limits of two natural zones - Forest Steppe and Steppe. Here is the north limit of steppe species (Pentodon idiota Hbst., Monotropus nordmanni Blanch.), Mediterranean and Pontium (Aphodius conjugatus Pz., Psammobius laevipennis Costa., Anoxia villosa F.h.) and south limit of transpalearctic species (Cicindela maritima Latr., C. silvatica L.) and south holarct Tachyta nana Gyll. These species are rare, many of them are almost disappeared. To increase the protection of rare species, the more detail study of their ecology and anthropogenic factors influence is necessary. The sites of their preference must be protected too. Any species is a part of biocenosis, its destruction brings to important component loss.

[1071] DIVERSITY AND - FUNCTIONAL STRUCTURE OF INSECT COMMUNITIES UNDER GRAZING AND EXCLUSION REGIMES IN A MONTANE ARGENTINE GRASSLAND

S.I. Molina¹, L. Cagnolo¹ & <u>G.R. Valladares</u>¹, ¹Centro de Investigaciones Entomológicas, F.C.E.F.y N., U.N.C., Av. Vélez Sársfield 299, 5000-Córdoba, Argentina. E-mail: smolina@com.uncor.edu.

In the mountain grasslands of Central Argentina, a long history of cattle grazing has altered plant communities by increasing their diversity, while reducing their structural complexity and the frequency of tall grasses. The effects of grazing disturbance on the associated insect communities was examined in a grassland with two types of grazed habitats (intense and moderate grazing) and two cattle exclusions differing in age (7 and 20 years). Taxonomic and functional aspects of insect diversity and two levels of taxonomic resolution (family and species) were considered. Insects associated to the vegetation were sampled with a vacuum sucking device, and pit-fall traps were used for ground dwelling insects. Collected specimens were counted, identified to family (all insects) or species (Coleoptera) level, and allocated to trophic guilds. Intense grazing changed insect families and Coleoptera species composition both in vegetation associated and ground dwelling communities. Most groups were underrepresented or absent in the intensely grazed habitat but a few families and species seemed to be favoured by grazing. Abundance, richness, diversity and evenness of the insect communities had minimum values in the most intensely grazed habitat. Results of community functional analyses varied depending on taxonomic level. At species level no significant change was observed. At family level the functional structure of both ground and plant associated communities was modified under intense grazing. The former showed a relative increase of scavengers (which could be linked to alterations in the nutrient cycling in such habitats). In the latter community, the phytophagous guild was dominated by chewers at the intensely grazed habitat while suckers dominated the habitats with scarce or no grazing. According to these observations, intense grazing in montane grasslands in central Argentina would result in important taxonomic and functional changes in the associated insect communities, but such effects would not be noticeable with less intensive use. Conservation of a patch mosaic might allow conservation of a greater fraction of biodiversity, though the appropriate spatial arrangement and size should be studied. Moreover, the results suggest that higher (family) taxonomic level could be used in order to characterise insect communities in these habitats under varying disturbance regimes, thus allowing to evaluate biodiversity and human impact on them with less effort.

Index terms: Biodiversity, Colcoptera, feeding guilds

[1072] GEOGRAPHIC DISTRIBUTION OF CUPUAÇU FRUIT BORER CONOTRACHELUS HUMEROPICTUS ON CUPUAÇU IN THE STATE OF AMAZONAS, BRAZIL

C.M.D'A. Lopes¹ & N.M. Silva², IDAM, rua Paraíba, Conj. Celetrazon, rua 4, casa 5, Adrianópolis, CEP 69057-000, Manaus, AM, Brazil, E-mail consuelo@inpa.gov.br.² Fac. de Ciências Agrárias, Univ. do Amazonas, Campus Univ., CEP 69077-000, Manaus, AM, Brazil, E-mail neliton@argo.com.br.

The Cupuaçu fruit borer (Conotrachelus humeropictus) is the most important pest on cupuaçu plants in the state of Amazon. The insect is found in the states of Acre, Amazonas, Mato Grosso, Pará, and Rondônia. This study was conducted to evaluate the geographic distribution of *C. humeropictus* in the State of Amazonas during April and June of 1997 and 1998 in 15 counties: Apuf, Autazes, Careiro-Castanho, Fonte Boa, Humaitá, Iranduba, Itacoatiara, Manacapuru, Manaquiri, Manicoré, Maués, Manaus, Presidente Figueiredo, Rio Preto da Eva, and Urucará. Cupuaçu is predominately grown as a monoculture, though polycultures occur. The polyculture system includes several fruit and forest species. Ten fruit were collected per sampled site: five from the border and five from the middle, per hectare of cupuaçu cropping. The fruit were characterized as healthy or damaged. The number of larvae in each fruit were counted. The infestation level ranged from 100% at Manicoré, 80% at Manaquiri, 66% at Iranduba, 64% at Manacapuru, 60% at Castanho-Careiro, and 56% at Itacoatiara. We also found the borer damaging fruit from Autazes, Fonte Boa, Humaitá, and Rio Preto da Eva.

Index terms: Theobroma grandiflorum, Sterculiaceae, Curculionidae, Coleoptera

[1073] OCURRENCE AND FLUCTUATION IN POPULATION SIZE OF A RECENTLY INTRODUCED DROSOPHILIDAE SPECIES IN BRAZIL

E. M. Moraes; <u>R. P. Mnteus</u> & F. M. Sene, Dept. de Genetica, FMRP, Univ. São Paulo, Av. Bandeirantes 3900, CEP 14049-900, Ribeirão Preto, SP, Brasil. Email: emarsola@rgm.fmrp.usp.br. Financial Support: FAPESP, CNPq, FINEP, CAPES and USP.

Zaprionus indianus (Diptera, Drosophilidae), recently introduced in Brazil, is supposedly of African origin. Its discovery in Brazil in Santa Izabel, SP was first published by C. R. Vilela (Instituto de Biologia of Universidade de São Paulo, Brazil) in March 1999. This species is reaching major pest status in the main fig producing region in São Paulo State. We examined Z indianus occurrence in some areas of São Paulo state and studied shortterm fluctuations in population size. This species was collected in wild xerophytic vegetation areas in traps with orange and banana baits, along with other Drosophilidae species. It represented 25% of total collected flies in Itatiba, 22% in Serrana, 20% in Altinópolis, 19% in Itirapina, 14% in Santa Maria da Serra and 4% in Sertãozinho, being the main species in some sites. Three collections were made bimonthly in both Serrana and Altinópolis localities from January 1999 to June 1999. In Serrana Z. indianus represented only 0.07% of 4166 flies in January. In March there was a dramatic rise in population size, since it composed 20% among 8027 flies. This rate declined to 0.7% in May. In Altinópolis site the same kind of fluctuation was found, Z. indianus was collected at a rate of 2% in February, 20% in April and 3% in June. Several collections were made in these two sites beforehand and no specimens were collected. These preliminary data suggest that after the invasion of Z indianus in a wild area, there is an increase in population size, followed by a substantial fall. However, more extensive surveys are need to determine the impact on wild environments, of this introduced species.

Index terms: Zaprionus indianus; ecology; environmental impact

[1075] EFFECTS OF A PREDATORY ANT ON FLORAL VISITORS

H. C. Morais¹,³ & W. W. Benson², 1. Programa de Pós Graduação em Ecologia, Univ. Estadual de Campinas; 2. Depto. Zoologia, Univ. Estadual de Campinas, CP 6109, 13081 970 Campinas, SP; 3. endereço atual: Depto. Ecologia, Univ. de Brasília, Brasília, DF, email morais@unb.br.

Ants rarely pollinate plants and may interfere in the pollination process by reducing the pollen grain viability and nectar availability of flowers or even by impeding other insects from visiting flowers. Observations were made over the frequency of floral visitors to branches of a plant with and without Azteca cf. lanuginosa (Formicidae: Dolichoderinae) workers. This ant species builds carton nests in high trees of the cerrado, the savanna-like vegetation of central Brazil, and is predatory, with the workers capturing, in a cooperative manner, insects that land on the vegetation. The ants actively patrol the plant and some may remain in an alert position with their mandibles open, on the tips of branches and on Inflorescences, forming sit-and-wait groups. The study was conducted on the Fazenda Água Limpa experimental ranch (15° 30 ' S - 47° 25 ' W) of the University of Brasflia (DF, Brazil). Observations were made over two isolated branches of a legume (Stryphnodendron adstringens - Mimosoidae), one patrolled by the ants and the other not. The inflorescences are cylindrical (= 2 x 10 cm) with the flowers side by side, forming a cover of stamens. About 20 or more workers remained still among the stamens and attacked floral visitors. Observations were made on each branch for one hour, always in the morning, on eight different days from the 11th to 28th of September. During a total of 16 hours, 302 floral visitors were recorded, the majority being bees from the genus Apis. Azteca workers organized themselves into sit and wait groups and were present on 28 open These inflorescences received 21 visitors, during eight hours of inflorescences. observation, being that 15 (71%) were predated and 11 of them were Apis bees. The number of visitors per open inflorescence, on each date, was always greater on the branch not occupied by Azleca, despite having a lesser number of inflorescences present on that branch. During the observation period, there was a trend for reduction in the frequency of visits by bees to the branch with ants and an increase on the branch without ants. These results suggest that the bees learned to recognize the presence of the predators and began to avoid those inflorescences. In this case, a reduction in fruit production could be expected on plants having the presence of this species of Azteca. The area was accidentally burned on October 4th, impeding further observations.

Index terms: Azteca, Formicidae, cerrado, pollinization

[1074] CATERPILLARS ASSOCIATED WITH THE REPRODUCTIVE STRUCTURES OF PLANTS IN THE CERRADO

H. C. Morais¹ & L R. Diniz², ¹ Departamento de Ecologia; ² Departamento de Zoologia, Universidade de Brasília, 70910 900 Brasília, DF, Brazil. E- mail: morais@unb.br. * Partial funding from CNPq Proc. n° 5010225/92.

Flowers and fruits are more ephemeral and less predictable resources than leaves, but tend to be more nutritious and less protected against herbivores. Insects that attack the reproductive structures of plants tend to specialize on these resources, synchronizing their life cycles or utilizing these resources in a sequential fashion. This study presents the results of a preliminary inventory of Lepidoptera larvae associated with the buds, flowers and fruits of plant species of the cerrado, a savanna vegetation of central Brazil. The reproductive structures were collected and kept in plastic pots, in the laboratory, so as to obtain the adults. Forty-four species from 11 families of Lepidoptera were obtained from 28 species of 18 plant families. Three families included 77% of the total number of Lepidoptera species: Gelechtidae (18 spp.), Tortricidae (10 spp.) and Pyralidae (6 spp.). The results indicate three groups of lepidopterans: (1) specialists or oligophagus species, on one resource in the same genera of plants, representing 66% of the species; (2) polyphagus in relation to plant families and structures, representing 11% of the species; (3) oligophagus but opportunists on resources of the same plant, representing 23% of the The majority of species were found on only one species or genus of host plant. Only two of them have cryptic larvae on the petals of open flowers: Michaelus thordesa (Lycaenidae) on Jacaranda ulei (Bignoniaceae) and Fundella sp. (Pyralidae) on Senna rugosa (Leguminosae). Two species of Cydia (Tortricidae) were found attacking flowers and fruits of more than one family of plant and three species are highly generalist, attacking flowers and leaves on three or more plant families: Fregela semiluna (Arctiidae), Pleuroprucha asthenaria (Geometridae) and Phidotricha erigens (Pyralidae). Tem species were known as herbivores of leaves, restricted to host plants of one genus or one family in the study area, and were found to be feeding on flowers of the same plant. For example, Heliothis planaltina (Noctuidae) on Chamaecrista spp. (Leguminosae) and Cerconota achatina (Elachistidae) on Byrsoninna spp. (Malpighiaceae). This species group is not dependent on flowers as a food item, but use them in an opportunistic manner, enriching their diet.

Index terms: Gelechiidae, Lycaenidae, Pyralidae, Tortricidae

[1076] OCCURRENCE OF WEED PLANTS AS ALTERNATIVE HOSTS OF SILVERLEAF WHITEFLY (*BEMISIA ARGENTIFOLII*) (HEMIPTERA: ALEYRODIDAE), IN THE STATE OF RIO GRANDE DO NORTE, BRAZIL

M. A. B. Moreira¹, ¹Embrapa Roraima, Br 174, km 08, Distrito Industrial, Boa Vista -RR. Caixa Postal, 133. CEP 69.301.970. E-mail marcos@cpafrr.embrapa.br.

A study was carried out in field condition at Baixo-Açû region (state of Rio Grande do Norte, Northeastern Brazil) with the purpose of collecting native plants, that are alternative host of silverleaf whitefly, *Bemisia argenifolii*, and establish pest management strategies. The plants were collected on irrigated crops in thirty aleatory sample points, measuring 6 m² of effective area each and in twenty neighbouring sample points without irrigation, with the same dimension, between august and november of 1998. Plant leaves were analysed on the abaxial portion, to observe imatures forms of silverleaf whitefly. Twenty-three plants that are alternative host of the pest were identified, including weed plants, semi-shrubs and shrubs. The plants identified were *Amaranthus, Sida* and *Ipomea*, each with two species, and *Eufhorbia, Physalis, Acanthospermum, Caesalpinia, Phaseolus, Heliotropium, Waltheria, Croton, Sidastrum, Cassia, Cucumis, Cobretum, Bauhuinia, Terminalis, Minosa, Bearhavia and Phylanthus, each with one specie.*

[1077] POPULATIONS OF NECROPHAGOUS COLEOPTERA AS BIOLOGICAL INDICATORS OF PHYSIOGRAPHIC SUB-REGIONS IN THE TACHIRA'S MOUNTAIN PASS

O.I. Moros¹ & O. Tapias², ¹⁻²Parque Natural Paramillo. Univ. del Tachira. Av. Universidad. Paramillo. San Cristobal, Tachira. 5012-A. Venezuela.

The mountain pass of Tachira is a very particular physiographic region, which separates the Tovar-Uribante mountain range from the rest of the great Andes mountain range and communicates the flora and fauna from the Caribbean regions with the ones from the Amazon region. This area has the influence of a double wind front, conformed by the Alisian winds, coming from the northeast and the intertropical winds, which come from the southeast. This creates a big ecological hallway that has served as a bridge for human society, flora and fauna. Along the extension of the mountain pass, different physiographic sub-regions have been conformed, having a reasonable amount of animal and plant species, proportioned to the extension and climate of the sub-region. Plus each one of this sub-regions has a reasonable proportion of carnivorous and herbivorous. In this paper, the authors intend to determine the presence of necrophagous coleoptera in each sub-region of the mountain pass, as well as the influence of the Caribbean and Amazon regions in these populations. To achieve this objective, a set of traps was placed in twelve different locations along the 150 Km. of the mountain pass. As bait, these traps were provided with chicken skin. The samples were taken every 21 days, during the months of January, February and March. A total of 15 different species was obtained, represented by 370 specimens. Five species where present in just one determined subregion. These species where, Coprophaneus jasyus (in the passage woods); Dichotomius protector and Oxystenun conspicillatum (Pre-mountain woods); Dichotomius agenor and Ontherus sulcatur (Transition woods); and Canthon cyanellus (dry woods). Eleven species where present only in the area close to the Amazonian basin and only one species was found only in the area close to the Caribbean basin. This species was Canthon cyanellus. Three specific species, which are Canthidium sp., Canthon triangularis and Coprophanaeus telamon show that the mountain pass can be considered an ecological hallway, because they move free trough it, between the Caribbean and the Amazon.

[1078] BATFLIES OF THE FISHBAT NOCTILIO LEPORINUS (MAMMALIA: CHIROPTERA): EFFECTS OF HOST SEX, SIZE, DEVELOPMENTAL STAGE AND SEASON

M. O. Moura¹, <u>G. Graciolli¹</u> & M. O. Bordignon², ¹Curso de Pós-graduação em Entomologia, Depto. de Zoologia, Universidade Federal do Paraná. C. P. 19020, CEP: 81531-990. Curitiba, Paraná, Brasil. Laboratório de Sistemática, Ecologia e Evolução. ²Curso de Pós-graduação em Zoologia, Depto. de Zoologia, Universidade Federal do Paraná.

Among Diptera there are several families that have species with haematophagous feeding habits, but only three of them are exclusively ectoparasites; Streblidae, Nycteribiidae and Hippoboscidae. Bats are one of the most diverses mammals of neotropics, becaming a very interesting system to study population and community ecology of ectoparasites. Our sytem study comprises the fishbat Noctilio leporinus, a large (50-90g) psicivore species that is common in the Neotropics. Our aim is to describe the component batfly community of Noctilio leporinus rufipes, specifically trying to describe the temporal patterns of prevalence and intensity as well as to identify possible causal relationship between host sex, size, and developmental stage on prevalence and intensity. Field workes were done at Balneário Caiobá (PR) during january 1998 and february 1999. During the study, four ectoparasites species were recorded for the 56 (n) Noctilio leporinus. Two of them were streblids, Paradyschiria fusca and Noctiliostrebla aitkeni; one was a bedbug Latrocimex spectrans and one was an undescribed Acari. The prevalence showed to be independent between seasons and sex for *P. fusca* and *N. aitkeni* but not between reproductive, (*P.* fusca $\chi^2 = 8.50$, p=0.036 and N. aitkeni, $\chi^2 = 7.43$, p=0.059) and size classes (P. fusca $\chi^2 =$ 9.86, p= 0.019 and N. aitkeni, $\chi^2 = 14.21$, p=0.002). ANCOVA revealed that weight classes and sex of the host was not a source of variation to intensities of N. aitkeni ($F_{1.52}$ =2.264, p=0.138) as well as to *P. fusca* ($F_{1.52}$ =3.64, p=0.068). There were an effect of season on intensities of both batflies (*P. fusca* $F_{3.52}$ =2.85, p=0.046 and *N. aitkeni* $F_{3.52}$ = 4.97, p=0.004). For P. fusca, the effect was more pronounced on females ($F_{3.52}$ = 3.29, p=0.02) than on males ($F_{3.52} = 2.57$, p = 0.06). N. aitkeni intensity analysis showed that season influencied significatively both males ($F_{3.52} = 3.95$, p = 0.01) and females ($F_{3.52} =$ 5.5, p = 0.002). The reproductive stage did not show to be a source of variation for both species. Based on it, the population of these batflies should be regulated by other factor than host features, and probably by hyperparasitism and maybe grooming could be the main factors.

Index terms: Paradyschiria fusca, Noctiliostrebla aitkeni, ectoparasites, community ecology, parastism ecology

[1079] EFFECTS OF NATURAL ENEMIES AND RESOURCE QUALITY ON HERBIVORE ESABLISHMENT IN TWO HABITATS

C.B. Miiller & II.C.J. Godfray, Imperial College at Silwood Park, Dept. of Biology & NERC Centre for Population Biology, Ascot, Berkshire SL5 7PY, UK

In a field experiment, population development of Aphis jacobacae on Senecio jacobaca was followed. In a $2x^2$ factorial design, we manipulated simultaneously the density of natural enemies and the quality of the plant resource in two different habitats. The first habitat was diverse in other species of plants, herbivores and natural enemies, while the second habitat was species-poor in plants due to heavy rabbit grazing. Increased plant quality was achieved by adding fertiliser to the plants every week. Predator pressure was reduced by placing interception traps around the plants to protect the aphid colonies from flying and crawling predators. A. jacobaeae can be tended by mutualistic ants, and the occurrence of ant-attendance was treated as a site factor and left unmanipulated. The number of tended colonies was not different between sites and treatments, but in the species-poor site Lasius niger was predominantly tending the aphids while in the speciesrich site Myrmica ruginodis was the dominant ant species tending the colonies. During the initial phase of the experiments, all possible effects on colony development of the aphids were blurred by extremely unfavourable weather conditions in which aphid colonies did not grow much. Later on we show that the two opposing factors, effects of natural enemies and resource quality, act with differential strength on the probability of establishment and growth of the aphid populations. In both habitats the interactions with predators were stronger than effects of plant quality. In the species-rich habitat, the persistence of the aphid colonies was significantly shorter than in the species-poor habitat. This could either be caused by 'diffuse apparent competition' via predator populations that were maintained at high densities on other species of aphids or by the presence of the 'wrong' species of ants in this site. In the species-poor site, most colonies that were protected form natural enemies or consistently tended by ants persisted up to two months. This explains why A. jacobaeae is occurring at very low natural densities in the species-rich site. At the end of the experiments we measured various plant fitness traits, such as plant fresh weight, the weight of reproductive versus vegetative biomass and the number of flowers produced. The fertiliser treatment did not have a significant effect on these plant fitness traits in the species-rich site, presumably due to interspecific plant competition for nutrients, which would explain why the plant quality did not translate into colony performance in this kind of habitat. In the species-poor environment, we found a significant increase in total fresh weight and the number of flowers produced for the fertilised plants.

[1080] FEEDING RESPONSES AND GROWTH OF *HELICOVERPA ARMIGERA* (LEPIDOPTERA: NOCTUIDAE) LARVAE MAINTAINED ON CHICKPEA, COWPEA, BLACKGRAM AND PIGEONPEA DIETS

S. Mullick & A. K. Singh, Dept. of Zoology, Univ. of Delhi, Delhi-110007, India,

Studies on the feeding preferences and growth of last instar Helicoverpa armigera larvae on legume seed based synthetic diets were carried out in controlled laboratory conditions. The basic ingredients and their proportions were similar in all the test diets, save these differed in powdered seed materials, i.e. chickpea, cowpea, blackgram, and pigconpea-The larvae were tested in early last instar after rearing them on a particular diet upto the penultimate larval instar. Food intake of larvae in 24 hrs was minimum on pigeonpea diet (p<0.05). However, the consumption of chickpea diet by chickpea diet- reared last instar larvae, cowpea diet by cowpea diet- reared larvae, and blackgram diet by blackgram dietreared larvae, was statistically identical. Growth of the larvae was also observed significantly lower on pigeonpea diet in comparison with other test diets (p<0.05). The results indicated equal food value of chickpea, cowpea, and blackgram diets for the gram podborer larvae. Consumption of chickpea, cowpea and blackgram diets by chickpea dietreared larvae was statistically similar. However, consumption of chickpea diet by chickpea diet-reared larvae was significantly higher compared to consumption of pigeonpea diet. Growth of chickpea diet-reared larvae on chickpea diet was also significantly higher (p<0.05) as compared to growth of chickpea diet-reared larvae on pigeonpea diet, but this was statistically identical to growth of chickpea diet-reared larvae on cowpea and blackgram diet. Food consumption of cowpea diet- reared larvae on cowpea diet was statistically equal to consumption of chickpea and blackgram diets, but significatly lower as comapred to pigeonpea diet (p<0.05). However, growth of cowpea diet-reared larvae on cowpea, chickpea, pigeonpea, and blackgram diets was identical. Consumption of blackgram diet by blackgram diet-reared larvae was significantly higher than the consumption of chickpea and cowpea diets, but identical to consumption of pigeonpea diet. Growth of larvae reared on blackgram was significantly lower on pigeonpea diet compared to blackgram diet. Food consumption and growth of pigeonpea reared larvae on chickpea, cowpea, blackgram and pigeonpea diets was identical. The results indicated that pigeonpea seed kernels contain both antixenotic and antibiotic factors, which is reflected by lower food intake and lower growth rate of larvae. Also, induction of feeding preferences in terms of quantitative consumption were observed for blackgram diet reared last instar larvae for the blackgram diet. However, such preferences were not evident for the larvae reared on other diets.

Index terms: Food consumption, antixenosis, antibiosis, induction.

[1081] NUTRITIONAL AND BIOLOGICAL ASPECTS OF VELVETBEAN CATERPILLAR ON SOYBEAN GENOTYPES WITH AND WITHOUT INJURY

A.T. Murata¹, S. A. De Bortoli², O. A. Fernandes² & L.M.X. Lopes³, ¹Dept. de Biologia, Fac. Filosofia, Ciências e Letras de Ribeirão Preto, Univ. de São Paulo, Av. dos Bandeirantes, 3900, 14040-901, Ribeirão Preto, SP, Brasil (Bolsista Fapesp), E-mail: murataat@asbyte.com.br; ²Dept. de Fitossanidade, , Unv. Estadual Paulista, 14884-900, Jaboticabal, SP, Brasil; ³Dept. Química Orgânica, Instituto de Química, Unesp, Araraquara, SP, Brasil; FAPESP (96/10486-0)

The Anticarsia gemmatalis Hueb., 1818, is the major pest defoliator pest in Brazilian soybean crops. The relationship between defoliation and plant response is essential to understanding better the pest management. This work was carried out to analyze the consumption, food utilization and performance of velvetbeen caterpillar reared on soybean leaves (genotypes BR37 and Embrapa 4) with and without previous injury. This work was conducted in the Insects Biology Lab, under controlled conditions $(27 \pm 2^{\circ}C, 70 \pm 10\%$ RH and 10 hours photophase). Were used 4th instar caterpillars, being placed 15 larvae in Petri dishes with 15 cm of diameter. The larvae were fed twice a day (7:00 AM and 18:30 PM). The trial loads 6 repetitions by treatment, performing 30 dishes with 15 caterpillars each. It was found difference between plants (injuried and non-injuried) being uninjuries plants better to the larvae development. The same results were found to caterpillar performance. The leaves from injuried plants increase the time of development and decrease the insect weight. The damage plants led to the larvae. Showing lowest approximate digestibility, Efficiency of conversion of Ingested food, and Efficiency of Digested food than undamaged plants.

Index terms: Anticarsia gemmatalis, consumption, and correct performance.

[1083] OCCURRENCE PATTERNS OF *SPODOPTERA LITURA* (LEPIDOPTERA: NOCTUIDAE) IN SOUTHERN JAPAN AND SOUTH-EASTERN ASIA

<u>M. Murata</u>¹, A. Mishima², K.S. Chaug³, N. P. Oka⁴ & S. Tojo¹, Fac. of Agricul., Saga Univ., Saga, 840-8502, Japan, E-mail kd8333@edu.cc.saga-u.ac.jp; ²Fac. of Agric., Univ. of the Ryukyus, Okinawa, 903-0213, Japan, ³Dept. of Plant Protect., Natn. Chiayi Inst. of Agricul., Chiay, 60083, Taiwan, ⁴Fac. of Agricul., Hasanuddin Univ., Ujung Pandaug, Indonesia.

The moths of Spodptera litura have been regarded to be involved in long-distance migration, because they were captured together with long-distance migratory insects on the ships in the Pacific Ocean and East China Sea located at few hundred km distance from mainland Japan. But no evidence has been obtained for their immigration to western mainland Japan. In this research, we compared fluctuation patterns of S. litura males caught in sex pheromone traps in Japan, China, Taiwan, Philippines and Indonesia, especially in relation of weather factors associated with rain falls. The fluctuation patterns of the male adults were considerably similar between Kyushu (31-34°N), the most southern mainland of Japan and Chekiang (30°N, China), where prominently increased from late summer. On the other hand, in Okinawa (26°N), which is one of the most southern islands of Japan, the males abruptly increased during early summer, and further in autumn at the time of typhoon approach. The yearly numbers of males caught in Fukien (26°N, China) and Okinawa were less than halves of those recorded in above-mentioned two places. Numbers of males caught per year further declined as the observation places located to more south to the equator. In Kyushu, males were caught abruptly in the traps, when typhoons approached there, or when western air current from Chinese continent passed Kyushu and caused heavy rain falls at cold or stationary fronts. These facts support the possibility that the moths of this species are conveyed by typhoons or other weather factors from mid-southern China to Japan.

Index terms : the common cutworm, migration, typhoon, sex pheromone trap.

[1082] VELVETBEAN CATERPILLARS PREFERENCE TO SOYBEAN GENOTYPES WITH AND WITHOUT INJURY

A.T. Murata¹, S. A. De Bortoli², O. A. Fernandes² & L.M.X. Lopes³, ¹Dept. de Biologia, Fac. Filosofia, Ciências e Letras de Ribeirão Preto, Univ. de São Paulo, Av. dos Bandeirantes, 3900, 14040-901, Ribeirão Preto, SP, Brasil (Bolsista Fapesp), E-mail: nurataat@asbyte.com.br; ²Dept. de Fitossanidade, , Unv. Estadual Paulista, 14884-900, Jaboticabal, SP, Brasil; ³Dept. Química Orgânica, Instituto de Química, Unesp, Araraquara, SP, Brasil.

Soybean presents as several medicinal and defenses compounds. The productions of these compounds can came from the secondary metabolism and it occurs in response to injury, stress, and climatic factor, among others. The answer to these compounds is denominated Induce defense. These changes can increase the plant resistance to the herbivore attack, reducing the preference or the herbivore injury. It have being reported that soybean plant injuried produce or change the amount of certain compounds as flavonoids, isoflavonoids, proteins, acids and enzymes. The present work had the objective to study the velvetbean caterpillar behavior on two soybean genotypes (Embrapa 4 and BR37) with different amounts of isoflavonoids. The tests (choice and non-choice) were made in Petri dishes arenas 30 cm of diameter using leaf disks with 2.5 cm of diameter. The evaluations were accomplished 6 hours after to be released the caterpillars, being evaluated the damage in each disk by a scale of notes and through the foliar area reduce by Liquer-Lead-300. By the results could be observed that genotypes without injury was more damaged. The leaves from injuried plants went less attractive to the caterpillars.

Index terms: Anticarsia gemmatalis, Glycine max, secondary compounds, isoflavonoids. FAPESP (96/10486-0)

[1084] SYNOPSIS OF THE ARGENTINEAN DIABROTICINI (COLEOPTERA, CHRYSOMELIDAE, GALERUCINAE)

<u>N. C. Cabrera</u>, Depto. Entomología. Facultad de Ciencias naturales y Museo. Paseo del Bosque s/n. 1900 La Plata. E-mail ncabrera@museo.fcnym.unlp.edu.ar

The subfamily Galerucinae (Alticines excluded) constitute one of the most diverse groups of neotropical chysomelid with 58 described species for Argentinean fauna. The classification of Galerucinae is still now controversial, the nomenclature used in this paper follows Bechyné & Bechyné (1969). These authors recognize three tribes: Galerucini, Luperini and Diabroticini. Diabroticini is the most diverse and of economic importance group as several species are pests of crops. Diabroticini can be distinguished from those other tribes by having antennae very close to each other, placed above the anterior edge of the eyes, six segments in male's abdomen and five in female's, posteriorly rounded, without central incision. This contribution provide a synopsis of Argentinean Diabroticini with a key to identify them, diagnoses, habits and a detail of their geographical distribution. Specimens examined are from personal collections and specimens housed at different national and international museums. As a result of this study, Argentinean Diabroticini include now 40 species belong to seven genera. Diabrotica (17 species), Synbrotica (10 species) and Acalymma (7 species) constitute the best represented genera; the remainders, Paranapiacaba, Anisobrotica, Deuterobrotica and Cochabamba have one to three species each one. However, while the species of *Diabrotica* recorded here represent only 4.92% of all neotropical species, those of *Acalymma* 10,29% and those of Synbrotica 5,58%; Anisobrotica and Deuterobrotica with a single species each one, represent 25% of all species cited for the Neotropical Region. Only eight of these 40 species are exclusive from Argentina, the others are also distributed in bordering countries. Argentinean Diabroticini are distributed in the Amazonian and Chacoan Domains (Cabrera y Willink, 1980) and extends to Neuquén, the southernmost limit. Misiones province presents the greatest biodiversity (72% of all species cited for Argentina). Following Misiones, the provinces of Buenos Aires, Corrientes and Salta are those with the highest number of species. The lowest number is found in Patagonia. Index terms: biodiversity, Argentina, Diabrotica, Acalymma.
[1085] COST OF FLIGHT DISPERSAL IN *OREINA CACALIAE* (COLEOPTERA: CHRYSOMELIDAE)

<u>N. M. Kalberer</u> & M. Rowell-Rahier, Zool. Inst., Univ. of Neuchâtel, Rue Emile Argand 11, 2007 Neuchâtel, Switzerland. nicole.kalberer@zool.unine.ch

Movement patterns in Oreina cacaliae were compared all over the season. Mark-recapture experiments showed that in spring, the beetles flew from overwintering sites to the flowering spring host, where they started feeding. As soon as their main host plant Adenostyles alliariae emerged, they changed to that host by flight. The decision to fly is taken in autumn, when a part of the population leaves the host plant patch to fly to overwintering places. The non-flyers stay in the host plant patch and overwinter in the soil beneath the plants. In spring and summer of the following year they stay in the host plant patch and never fly. Flight and reproduction make demands on the insect's energy resources. The existence of the described dispersal polymorphism suggests that the possession of wings and ability to fly adversely affect demographic components like reproduction and survivorship. This hypothesis was tested by an analysis of the differences in life history parameters of the two dispersal morphs of O. cacaliae. We hypothesised that (a) there is a trade-off between dispersal and reproduction and (b) that size and survivorship differ in the two groups. Flyers laid fewer larvae than non-flyers but only when the beetles did not have access to food for some days after their flight, representing the situation in the field. Flyers were smaller in size than non-flyers, measured as elytra length. Small females larviposit significantly less than large females in the non-flyer group and survivorship was always reduced in the flyer group compared to the non-flyer group. Insect dispersal by flight may be an investment, of a portion of a population, in colonising and exploiting resources in a new habitat. Since there is a high degree of patchiness in plant communities, herbivores are continually faced with the problem of how to respond to the distribution and quality of their host-plant resources, and investing high costs may be justified.

mark-recapture, reproduction, survivorship

[1086] THE FAUNA HYMENOPTERA-BRACONIDAE MEDICAGO SATIVA IN SOUTH OF REPUBLIC TAJIKISTAN

N. SH. Saidov, Lab. of Experimental Ecology & Biomethod, Inst. of Zoology & Parasitology, 734025, P. Box 70, Tajikistan, E-mail: nurali@ac.tajik.net

The Medicago sativa, as fodder culture in agriculture of Tajikistan, is widely used in crop rotation as by the predecessor of a cotton plant. Restoring fertility of soil, serves the simultaneously important food supply of cattlebreeding. As a result of our researches on Medicago sativa fields of the South of Tajikistan 82 species Braconidae, relating to 13 subfamilies and 25 genus are established. Most abundantly in alfalfa biocenoses the species of a subfamily Microgastrinae (26) - endoparasites of Lepidoptera, from them 21 species belong to a genus Apanteles. From customary species relating to genus Apanteles, it is necessary to mark A. glomeratus L. - a parasite of the larva's Pieridae, A. metacarpalis Thoms. - is known as a parasite Coleophora tadzhikilla Danilev, A. telengai Tobias and A. vanessae Reinch. - parasites of the larva Chloridea viriplaca Hufn. Subfamilies Braconinae is represented by genus of Bracon with 12 species - ectoparasite, mainly - Lepidoptera. Among them it is necessary to mark a role of species B. hebetor Say and B. quadrimaculatus Tel. in depressing of number of the most dangerous pest technical and vegetable of cultures the Heliothis armigera Hbn. and parasites of many Coleoptera and Lepidoptera B. intercessor Nees and B. variator Nees. The subfamilies Euphorinae parasites of the Coleoptera, larvas Lepidoptera, larvas Hemiptera are includ 11 species. Here too of more often other species there are species from genus Aleiodes (7), Opius (7) and Chorebus (5). Other subfamilies of Braconidae by quantity of species considerably succumb described above: Cheloninae (4), Doryctinae (2), Brachistinae (2) and Exothecinae, Macrocentrinae, Homolobinae, Orgilinae on 1 species. The presence of considerable number Braconidae, marked on alfalfa biocenoses, is explained, firstly, that the alfalfa is a place of concentration of the pests and attracts Braconidae, basically as a forage plant of the hosts. The second factor attracting Braconidae are climatic conditions. The number Braconidae notably increases in the hot season of year, when temperature of air in apron plains mounts till 40-46 °C and microclimate alfalfa fields more suitable for Braconidae, than microclimate of other biotopes. Such conditions also promoted because on alfalfa except watering and harvesting, other measure are not carried out, in particular chemical control measure.

Index terms: Braconidae, endoparasite, ectoparasite, pest.

[1087] SEASONAL OCCURRENCES AND THE COMMUNITY STRUCTURE OF DUNG BEETLES IN NORTHERN JAPAN

N. Yamashita, Dept. of Animal Husbandry, Tohoku National Agricultural Experiment Station, Morioka, Iwate Pref. 020-0198, Japan, E-mail yama@tnaes.affrc.go.jp

The disposal of dung in cowshed has become a big problem in Japan in recent years. So, keeping livestock in pastures has drawn attention as the solution measure. Although some people claim that dung beetles consume and decompose dung in the pastures for the purpose of feeding and breeding, there are few quantitative and long-term surveys of dung beetle occurrence in northern Japan and the actual behavior of dung beetles is unclear. The intention of this study is to clarify the occurrence and dynamics of dung beetle community structure in the pastures of northern Japan. Surveys had been taken at three sites of the author's station from 1990 to 1992. Site A was a grazing pasture with about 40 head of cattle; B, pasture with about 18 head; and C, a hay pasture. Dung beetles were collected with traps using dung as bait during the pasturage period. A total of 148,980 individuals were collected. The collection included 13 species of tunneler-type beetles that dig tunnels below the dung pats and transport dung into it for feeding or breeding, such as Onthophagus lenzii and Aphodius haroldianus, and 14 species of dweller-type beetles that deposit eggs in dung pats on the ground and the imago feed in pats, such as A. rugosostriatus and A. urostigma. The numbers of tunnelers comprised 27.38%, and dweller's did 72.62% of a total individuals captured. From pasturage starting time (early in May), some species of dweller-type beetles were active and the tunnelers increased in June. The number of species and individuals, along with the diversity index (H'), peaked in June and July. After they temporarily declined in August, their numbers increased again in September and October as new beetles emerged. The largest number of beetles was collected from site A, followed by B and C, respectively. The number of species collected was about 20 from each site for three years. The population constructions were different at each site. The most dominant species from site B was the A. rugosostriatus, which made up $30\square 40\%$ of the individuals collected, and *O. lenzii* made up less than 15% of the population for three years from site A. But from site C, *O. lenzii* made up $30\square 45\%$ of the population, and A. rugosostriatus accounted for less than 20% over the three years. The community structures changed mainly with the relative abundance of the species. Most of the dung beetle activity occurred during one or two months, primarily before midsummer in northern Japan; however, O. lenzii contributed to the decomposition of dung in the pastures during the pasturage period.

Index terms: Aphodius rugosostriatus, Onthophagus lenzii, A. rugosostriatus, A. urostigma, diversity

[1088] COPPER INFLUENCE ON CHIRONOMID LARVAE IN NATURAL AND LABORATORY POPULATIONS

L. Nazarova, Kazan State University, Russia

Theratogenic effect of heavy metals on chironomid larvae mouth parts structure were investigated in natural populations of cooling pond of Zainsk power station. Methods of multiply regression were applied. There were found that association of few heavy metals (Pb, Cu, Cd, Zn, Co) have influenced on incedence of Chironomid larvae morphological deformities with the high level of probability. Most significant influence was revealed for Cu. In laboratory tests were investigated influence of different Cu concentration (5 mg/l, 1 mg/l, 0,1 mg/l, 0,02 mg/l) on incedence of morphological abnormalities and some biological features (mortality, behaviour, development) in Chironomus riparius larvae. In concentration 5 mg Cu/I all larvae have died in 2 hours from the beginning of experiment. Ratio of "larvae-pupae-imagos" amount at the end of the experiment in different Cu concentration has allowed us to make a supposition that Cu in concentration not exceed 1 mg Cu/l accelerate onthogenetic processes in Chironomids. With the increasing of Cu concentration an amount of morphological abnormalities increased from 10% in control to 75% in concentration 1 mg Cu/l. Mentum splits, gaps, lack of some teeth in mentum, mandibles or epipharingeal plate, hypo- and hiperpigmentation of head capsule were found. Linear dose-responsibility was observed only for the sum of all abnormalities including hypo - and hiperpigmentation and abrasion.

[1098] CHARACTERIZATION OF THE WAXY PARTICLES, AND THE PENETRATION AND FEEDING PROCESS OF WHITEFLIES

D. R. Nelson¹, **T. P. Freeman²**, **J. S. Buckner¹**, **& D GERLING**³, ¹Biosciences Research Laboratory, Agricultural Research Service, U.S. Dept. of Agriculture, 1605 Albrecht Boulevard., Fargo, ND 58105-5674, USA, E-mail denelson@prairie.nodak.edu; ²Electron Microscope Facility, Dept. of Plant Pathology, North Dakota State University, Fargo, ND 58105, USA, ³Dept. of Zoology, Tel Aviv University, Ramat Aviv, Israel 69978.

Whiteflies are a problem in greenhouses and on many economically important plants worldwide. The silverleaf whitefly, Bemisia argentifolii, is particularly devastating. Our recent findings of silverleaf whitefly feeding on cotton leaves showed that both the adults and nymphs can reach the phloem bundles from any position on the leaf, contrary to previous theory. This is believed to be true for any host plant and true for the greenhouse whitefly, Trialeurodes vaporariorum, the giant whitefly, Aleurodicus dugesii, the spiraling whitefly, Aleurodicus dispersus, and a recently discovered New World whitefly on the Canary Islands, Lecanoideus floccissimus. The labium of the adult whitefly feeding apparatus consists of four segments. The first segment is attached to the thorax and the three distal segments include a deep longitudinal groove that contains the stylet used to penetrate the leaf and feed on the phloem sap. The length of the labial groove, contained within the three distal segments, is equivalent to the length of the stylet. This length represents the maximum distance that the whitefly can penetrate the leaf in search of a phloem bundle. The average length of the stylets for the different species was: B. argentifolii 210 Im, T. vaporariorum 272 Im, A. dugesii 391 Im, A. dispersus 302 Im, and L. floccissimus 357 Im. The whitefly adult produces copious amounts of waxy particles, which they use to cover themselves. Many particles are shed over their surroundings. The waxy particles are formed from filaments extruded from wax plates present on the adult abdomens of these whitefly species. All of these adults had similar abdominal wax plates. Particles from *Bemisia* and *Trialeurodes* have a semi-circular shape. The particles from Aleurodicus are linear fragments. Also, female Aleurodicus have other abdominal wax plates that produce waxy filaments used to form oviposition trails. The whitefly species produced and shed waxy particles consisting of a mixture of long-chain aldehydes and long-chain alcohols of which the major components, depending on species, are 30, 32 or 34 carbons in length. The waxy filaments from female Aleurodicus are largely wax esters.

Index terms: Bemisia argentifolii, Trialeurodes vaporariorum, Aleurodicus dugesii, Aleurodicus dispersus, Lecanoideus floccissimus, waxes, aldehyde, alcohol, labium, stylet, feeding, phloem

[1090] GALLING HERBIVORY MEDIATED BY MUTUALISTIC INTERACTIONS BETWEEN ANTS AND APHIDS IN *BACCHARIS DRACUNCULIFOLIA* (ASTERACEAE)

<u>F.S. Neves¹</u>, M. Fagundes^{1,2}, B.G. Madeira & G.W. Fernandes¹, ¹Ecologia Evolutiva de Herbívoros Tropicais, DBG/ICB, Univ. Federal de Minas Gerais, CP 486, 30161-970 Belo Horizonte MG Brazil, e-mail: fneves@icb.ufmg.br, ²Dep. Biologia Geral, UNIMONTES, Montes Claros-MG Brazil.

A diverse fauna of insect herbivores, basically composed of free-feeding insects, ants, aphids, insect gallers, and their parasitoids occurs associated to Baccharis dracunculifolia (Asteraceae). In this system, Uroleucon erigeronensis (Homoptera: Aphididae) plays an analogous role to that of extrafloral nectaries, attracting several ants that feed on their Secretions, thus promoting a plant-aphid-ant association. Neopelma baccharidis (Homoptera: Psyllidae) is the most common galling herbivore found on B. dracunculifolia, and it is, in turn, attacked by three different parasitoid species. We tested the hypothesis that the ant-aphid interaction reduces the herbivory caused by N. baccharidis on B. dracunculifolia. 27 plants located in the Estação Ecológica at the Universidade Federal de Minas Gerais, Belo Horizonte, Brazil, were marked and used in an exclusion experiment to assess the effects of the ant-aphid interaction on the attack rates of N. baccharidis and its parasitoids. 4 shoots in each plant were selected and randomly rearranged in 4 treatments: T1 = shoots infested by aphids, without ants; T2 = shoots without ants and aphids; T3 = shots infested by aphids, with free access to ants; T4 = shots without aphids, with free access to ants. The exclusion of ants from treatments T1 and T2 was attained by applying a non-toxic resin (Tanglefoot[™]) on the base of the shoots and by cutting off the shoots which would allow access to ants. The treatments T1 and T3 were manually infested by U. erigeronensis. All plants were monitored twice a week. The number of galls was used as a measure of herbivory, and all N. baccharidis galls found were taken to the laboratory, where gall weight, number of larvae per gall, and parasitism rates were measured. The number of galls per shoot, number of larvae per gall, and parasitism rates did not vary among the treatments (p > 0.05, all). However, gall weight varied among the treatments (ANOVA: F = 7.949, p < 0.001, n = 1112), being significantly smaller on treatments T1 and T3. Therefore, the interaction between ants and aphids extended its effects to the first trophic level, limiting the injuries caused by N. baccharidis.

Index terms: three-trophic interactions, mutualism, Neopelma baccharidis

Symposium and Poster Session

[1091] A FAUNAL INVESTIGATION ON THE LONG-HORNED GRASSHOPPERS (ORTHOPTERA-TETTIGONIIDAE) OF GAZVIN TO DAMAVAND DISTINCT

M. M. Neyestanak & <u>P. A. Fard</u>⁴, Plant Pests and Diseases Institute, Evin Street, Tabnak Ave., Tehran, Iran, Entomology Dept. College of Agriculture Univ. of Tehran, Karaj Iran 31584 E-mail:pafard@chamran.ut.ac.ir.

During 1994 to 1996, the long-horned grasshoppers of different localities of southern slopes of Alborz mountains (Gazvin to Damavand distinct) were collected weekly in various methods, from April to November. The specimens were identified by means of the important morphological features, i.e. shape and denticles of the male genitalia (litillator), cerci, ovipositor, stridulatory and hearing organs, subgenital and supra anal plates in both sexes, etc. The determined specimens consist of five subfamilies, fifteen genera and nineteen species. The first records of the species not yet mentioned from this distinct are shown by an asterisk (*): 1) Bradyporus latipes; 2) Polysarcus elbursianus; 3) Leptophyes iranica; *4) Leptophyes trivitata; *5) Isophya caspica caspica; 6) Phaneroptera falcata; 7) Tettigonia viridissima; 8) Tettigonia caudata; 9) Platycleis escalerai iranica; 10) Platycleis intermedia mesopotamica; *11) Decticus annalisae; 12) Decticus albifrons; 13) Medecticus assimilis; 14) Paradrmadusa siazovi; 15) Uvarovistia incertus; 19) Homorocoryphus nitidulus.

Index terms: Grasshoppers-Titillator-Stridulatory

[1092] SPATIAL PATTERNS IN OVERWINTERING SURVIVAL OF *MELITAEA* CINXIA ON TWO HOST PLANT SPECIES

M. Nieminen, Dept. of Ecology and Systematics, Div. of Population Biology, P. O. Box 17 (Arkadiankatu 7), FIN-00014 Univ. of Helsinki, Finland, E-mail: marko.nieminen@helsinki.fi.

In Åland Islands, Melitaea cinxia feeds on two host plant species: Plantago lanceolata and Veronica spicata. These species have dissimilar distribution patterns, such that P. *lanceolata* occurs in practically all meadows, whereas V. spicata is most abundant in northwest and absent from the extreme east of Åland Islands. Recent studies have shown that in many regions within Åland egg-laying females prefer one host species to the other, but no constant spatial variation exists in the suitability of host species or in larval performance. Here I present results of one of the most important factors of larval performance in this highly dynamic system: the spatial variation in overwintering survival of larval groups between host species, subregions, and years in 1993-1999. The overall survival has been statistically significantly different from the average level in every winter. The survival has been higher on V. spicata (overall survival 69%) than on P. lanceolata (66%) in five out of six winters, but the survival has been statistically significantly higher in only one winter. There are no subregions (out of eleven where both hosts are present) where survival has been better on one host species in every winter. The survival has often been very variable both within and between subregions in a certain year, e.g. in 1995-96 40% on *P. lanceolata* and 82% on *V. spicata* in the westernmost subregion (Eckerö), but 85% on P. lanceolata and 64% on V. spicata in another subregion (Stalsby). Within subregions, the survival on one host has also varied enormously, e.g. in the east (in Kumlinge, where only P. lanceolata is present) the minimum has been 39% and maximum 82%. The spatial patterns of overwintering survival and extinctions of local populations caused by overwintering mortality will be compared with metapopulation dynamics of M. cinxia.

Index terms: Åland Islands, metapopulation, population extinction

[1093] AN ENTOMOFAUNA STUDY RELATED TO THE GROWING OF THE JAPANESE PEAR, VARIETIES (HOUSUI, KOUSUI AND NIJISEIKI), IN SANTA CATARINA STATE, BRAZIL

<u>I. Nora</u>¹ & T. Sugiura², ¹EPAGRI. Empresa de Pesquisa Agropecuária e Difusão de Tecnologia de Santa Catarina and ² JICA Japan International Cooperation Agency. Caixa Postal, 591 – 89500.000-Caçador, S. C., Brasil- Fone/Fax 55 (014) 49 563 3332 - E-mail: nora@unc-cdr.rct-sc.br

Studies were made during 1997/99 season to identify the main pests on Japanese pear. Several problems were discovered: nutritional, alternate bearing, damages caused by fungi and pests. Among the Arthropods, the South American fruit fly (Anastrepha fraterculus) caused serious injuries and was considered the key pest. In years when its incidence was too high it damaged 100% of the fruits. The second most important pest was the oriental fruit moth (Grapholita molesta) which caused deep galleries in the fruit turning them improper for commercialization, besides injuring the shoots and impairing the development of the whole plant. The two spotted spider mite (Tetranychus urticae), the European red mite (Panonychus ulmi), the pear-bud mite (Eriophyes pyri) and the desert spider mite (Tetranychus desertorum) also occurred in the region. However the dominant species was the P. ulmi followed by, T. urlicae. The E. pyri mite damaged young branches of the pear tree, mainly in the Nijiseiki cultivar and injuried with less intensity the other pear cultivars. The red mite (T. desertorum) was noticed, for the first time, in the cycle of the years 96/97 and produced leaf damages, in the pear trees, similar to those caused by T. urticae, however it occurred only in this cycle. Common cutworm litura (Spodoptera litura), weevils (Naupactus spp) and (Panthomorus spp), caused occasional damages in leaves. The leaf beetles (Diabrotica speciosa) injured flowers, leaves and young fruit of the pear tree and occurred during the whole cycle of the culture. The San Jose scale (Comstockaspis perniciosa) and oystershell scale (Lepidosaphes ulmi), caused damage in young branches and in the tree-trunk. The Aphis spp, damaged shoots, buds and normally occurred at the beginning of the vegetative cycle of the pear tree. The ants Atta spp and Acromyrmes spp, are important pear tree pests, they damaged the plant during its whole cycle but they injured the plant most during blooming and at the beginning of burgeoning. Predators and parasites also recorded were: Phytoseiulus persimilis, Amblyseius fallacis, Neoseiullus chilenensis, Cycloneda sanguinea, Stethorus punctum, Scymnus spp Doryctobracon areolatus, Doryctobracon brasiliensis, Opius bellus and Utetes anastrephae.

Index terms: The Japanese pear (Housui, Kousui, Nijiseiki), Tetranychidae, Eriophyidae, Tephritidae, Olethreutidae, Curculionidae, Chrysomelidae, Diaspididae and Phitosciidae.

[1094] DYNAMIC STATE VARIABLE MODEL OF OPTIMAL CLUTCH SIZE IN UROPHORA AFFINIS (DIPTERA: TEPHRITIDAE) ON SPOTTED KNAPWEED, CENTAUREA MACULOSA

R. M. Nowierski¹, Z. Zeng² & B. C. Fitzgerald¹, ¹Dept. OF Entomology, MONTANA State Univ., Bozeman, MT 59717, ²National Crop Insurance Services, 7201 W. 129th Street Ste. 200, Overland Park, KS 66213

A dynamic state variable model was developed for Urophora affinis (Frauenfeld)(Diptera: Tephritidae), an introduced biological control agent of spotted knapweed, Centaurea maculosa. The model predicts optimal clutch size (i.e., egg allocation) in U. affinis for the maximization of fitness given the frequency distribution of flower bud sizes and density of available buds for oviposition. Model predictions are then compared to field data obtained from six spotted knapweed sites in Montana. In general, the model predicted gall densites per capitulum well across a range of seed head sizes. Index terms: egg allocation, fitness, resource exploitation, behavioral ecology.

[1095] DIURNAL AND NOCTURNAL DRIFT OF AQUATIC INSECTS

<u>A. M. Oberto</u>, G. B. Raffaini & M. del C. Corigliano, Departamento de Ciencias Naturales, Universidad Nacional de Río Cuarto, 5800 Río Cuarto, Argentina. E-mail: aoberto@exa.unrc.edu.ar

The behaviour of the aquatic insects that composed diurnal and nocturnal drift was analysed in a second order stream of the Comechingones mountains, Cordoba, Argentina. Samples were collected with drift nets of 300 microns of mesh, placed every hour in the stream, during 57 serial hours. Benthos and marginal community samples were also taken from the studied stretch. Population densities were calculated for each community and the drift fraction. Descriptive statistics were carried out. Taxa were categorised according to their distribution and behaviour. The categories resulted from a combination between their presence in benthos, marginal communities, diurnal drift and nocturnal drift. From a total of 15 categories, 9 of them described organism behaviour and the others were empty sets. For the organisms that exhibited diurnal and nocturnal drift the ratio between densities was calculated. Among 42 studied population, 34 % were in benthos, marginal communities and diurnal and nocturnal drift. To develope time series statistics a group of species was selected by their frequency and abundance. These selected species were Baetis sp.1, Camelobaetidius penai, Caenis sp., Leptohyphes sp., Tricorythodes popayanicus, Chimarra argentinica, Smicridea sp. and of Simulium wolffhuegeli larvae. These species presented a clear circadian rhythm with significant higher densities during darkness. For the other species the variance and range between minimum and maximal drift density and other statistical parameters indicated specific behavioural drifting patterns. The majority of populations increased their abundance during the dark phase at a ratio of 1:10. It was observed that benthos organisms presented diurnal and nocturnal drift, while riverside taxa, like some Coleoptera and Heteroptera species, presented heterogeneous behaviour patterns.

Key-Words: Camelobaetidius penai, Tricorythodes popayanicus, Chimarra argentinica, Simulium wolffluegeli.

[1096] TRI-TROPHIC INTERACTIONS AMONG SPECIES ON MIKANIA GLOMERATA (ASTERACEAE) GALLS ON SOUTHEASTERN BRAZIL: A SPECIES RICH SYSTEM

R. A. M. Oda & <u>R. F. Monteiro</u>, Lab. Ecologia de Insetos: Depto Ecologia/IB/UFRJ -CP68020 - CEP21941-590 Rio de Janeiro, Brazil / E-mail: oda@biologia.ufrj.br; monteiro@biologia.ufrj.br

To understand the structure and dynamics of communities is of fundamental interest in ecology. Since one quarter of all insect species are parasitoids, analyses of such hostparasitoid assemblages are a major step in understanding the interaction types governing terrestrial communities, mainly in the Tropics, where the knowledge in this field is very scarce. The present research analyses the community associated to entomogenous galls of Mikania glomerata within six different locations, five of which placed within Tropical Rain forest conservation units (Atlantic Forest) in southeastern Brazil. Between february 1998 and march 1999, all galls found within a three-hour-time-lapse were collected every three months in each locality. A total of 12.441 galls induced by eight species have been collected, seven of these being regarded as new species or new genera (2) of gall midges (Diptera, Cecidomyiidae). A great number of inquiline species (17spp.) as well as hymenopterous parasitoids (87spp.) were also reared. The locality presenting the larger richness shown 57spp, among gall midges, inquilines and parasitoids, while the locality that presented the least species richness had 19spp, although most species were different with regard to the composition. The high parasitoid species wealth (maximun:47spp.) and the high parasitism rates found (84% at the most) have been common characteristics among the galls midges. Variation in gall maker composition was of 5.8 ± 1.17 , less than among the parasitoids (27.8 ± 9.78). Therefore wider distribution studies may shown an increase in parasitoid species rather than in gall maker species. Considering each locality as a unique system, there was no correlation between the number of galls and the richness of parasitoid species reared (r=0.68; p>0.05). If by one side the galls of M. glomerata sustain a great wealth of parasitoids, on the other hand the richness of species and the high parasitoid rates over the gall midges seem to be important for the diversity and the coexistence of these phytophagous. The work shows that M. glomerata galls are rich in species, but it is suggested that this may not be an exception and other plant species may present species rich systems. Taxonomic and ecological data of such still unknown species is essential for the understanding ecological patterns and processes as well as an alert for tropical biodiversity threatened of extermination.

Index terms: Insect galls, community structure, parasitoids.

[1097] MODELLING THE POPULATION DYNAMICS OF ATHERIGONA ORIENTALIS (DIPTERA, MUSCIDAE)

<u>S. G. Oliveira</u>¹, C. Bustamante² & J. R. Almeida^{1, 2}, ¹ Univ. do Est. Rio de Janeiro, Departamento de Biologia Animal e Vegetal, Setor de Ecologia, Rua São Francisco Xavier, 524, Maracanã – 20559-900, E-mail: sigomes@uerj.br; ² Univ. Fed. do Rio de Janeiro, Escola de Engenharia, Departamento de Hidráulica e Saneamento, CT – COPPE, bloco C, sala 211 Ilha do Fundão, 21941-590, E-mails: claudio@pec.coppe.ufrj.br e josimar@ppe.ufrj.br

Mathematical models are fundamental tools when dealing with populations from both scientific and management perspectives. In fact, the very idea of population dynamics is intertwined with mathematical descriptions and models. Custom-tailored models, developed to represent the most important factors that influence biological populations within specific contexts, can be extremely useful. They organize and integrate the knowledge about the organisms and their environment in a way that: 1) reveals issues that are poorly investigated or understood, helping to stabilish research directions and priorities, 2) show current trends in demographic behavior and potential consequences of changing conditions, allowing to assess different courses of action and 3) help in gaining deeper understanding, by testing hypothesis and analyzing relationships and causality chains. The complexity of interactions and the multiplicity of factors that influence their behavior undoubtedly place biological populations among the so-called high-order, complex systems, a class that includes most social and economic entities. The approach for analyzing and modelling such systems differ from the traditional one, developed for physical systems. It is based on an iterative multi-step procedure, in which the system is delimited, its main elements are recognized and their most important relationships with each other and with external factors are represented by mathematical formulations. We employed that approach to model the population dynamics of Aterigona orientalis in four different environments: tropical rain forest, mangroves and urban. A. orientalis is a cosmopolitan, hemisynanthropic fly in temperate and subtropical regions. The overall form of the model, as well as the most important processes, were based on the general ecology and natural history of Muscidae, but specific aspects, pertaining to A. orientalis were embedded in the mathematical formulations. This was mainly accomplished by estimating equations' parameters based on a significant body of data which includes the results of many laboratorial experiments as well as field surveys and experiments. Currently, the model is ready for first simulations and we will be going through calibration and validation to complete the model-building process.

Index terms: mathematical models, complex systems, ecology

[1098] THE POTENTIAL USE OF WOLBACHIA INFECTIONS AS TOOLS FOR MODIFYING INSECT POPULATIONS

<u>S. L. O'Neill</u>, Dept. of Epidemiology and Public Health, Yale University School of Medicine, 60 College St, New Haven CT 06520 USA. scott.oneill@yale.edu

Wolbachia are intracellular bacteria that naturally infect up to 20% of all arthropod species. These transovarially transmitted agents are well known for distorting the reproduction of their arthropod hosts so as to enhance their own transmission into populations. Their widespread occurrence, ability to be transferred between species in the laboratory and their ability to rapidly spread into host populations make them ideal candidates to be developed into tools for the genetic modification of insect pest species. I will present data on ongoing work in our group which is seeking to develop two different approaches to the use of *Wolbachia* in an applied context. The first will be the development of *Wolbachia* as a platform to express foreign genes in insect populations and the second will be the use of *Wolbachia* to distort population age structure of insects. Both of these approaches will be presented in the context of reducing the ability of insects to transmit pathogens to humans, plants or livestock. [1099] BIOLOGY OF *THYRINTEINA ARNOBIA* (LEPIDOPTERA: GEOMETRIDAE) ON THREE SPECIES OF *EUCALYPTUS*

A.L.T. Ottati¹ & <u>C.F. Wilcken¹</u>, ¹Dept. Plant Production, FCA/UNESP, Campus of Botucatu, P.O. Box 237, Botucatu, SP, 18603-970, Brazil, E-mail: aottati@fca.unesp.br

Among defoliator Lepidoptera, *Thyrinteina arnobia* (Geometridae) is considered the most important species than can inflict economic damage to eucalyptus forests in Brazil. Based on its importance, it is fundamental to gather basic informations that would lead to alternative methods of control of this pest. The objectives of this experiment were to compare the biology of *T. arnobia* fed with three species of *Eucalyptus* (*E. camaldulensis, E. dunnii* and *E. urophylla*), in oder to evaluate the effects caused by those hosts in two consecutive generations of the insect. Leaves used in the experiment were collected at the ErAUNESP (Botucatu, São Paulo sate) campus, and the studies were carried out at the Entomology Laboratory of the Plant Production Department (FCA/UNESP), under a

temperature of $25 \pm 1^{\circ}$ C, relative humidity of $70 \pm 5\%$ and photophase of 13 hours. The experimental design was a completeley randomized design, with 3 treatments and 100 replications. Data were submitted to analysis of variance and means separated by Tukey test. The results of biology, food consumption and food utilization showed distinct patterns for both generations. *E. urophylla* did not affect the general biology of *T. arnobia*; *E. camaldulensis* affected it moderately while feeding on *E. dunnii* resulted in deleterious effects in the biology of this species. We verified that the performance of *T. arnobia* in the second generation in *E. canaldulensis* and *E. dunnii* was worse than on the first generation, while insects reared on *E. urophylla* presented similar performance. Index terms: Forest pest, eucalypt.

[1100] FIRST RECORD OF SETINA IRRORELLA IN SOUTHERN ITALY AND OF SETINA ROSCIDA IN ABRUZZO (CENTRAL ITALY) WITH SOME CONSIDERATIONS ON EUROPEAN SPECIES OF GENUS SETINA (LEPIDOPTERA ARCTIIDAE LITHOSIINAE)

P. Parenzan¹ & S. Scalercio², 1- Ist. di Entomologia, Univ. di Palermo, Viale delle Scienze, 13, 90128 Palermo, Italia; 2 - Dip. di Ecologia – Sez. Zoologia e Zoocenosi, Univ. della Calabria, 87036 Cosenza, Italia.

Setina species are typically glacial relicts confined to the mountain of Southern Europe. In this work, we reporto on the first capture of Setina roscida on Gran Sasso (Passo delle Capannelle and Mt. S. Francesco, Abruzzo, Central Italy) as well as on the first observation of Setina irrorella in South Italy (Basilicata, Mt. Pollino: Serra Dolcedorme,). A survey of the six European species of Setina (i.e. Setina roscida ([Denis & Schiffermueller], 1775), S. flavicans (Hubner & Geyer, [1834-1836]), S. cantabrica de Freina & Witt, 1985, S. irrorella (Linnaeus, 1758), S. alpestris Zeller, 1865 and S. aurita (Esper, 1787)), is also provided. A new taxonomic grouping of European Setina species is suggested on the basis of morphological evidence drawn from the male genitalia. The S. irrorella group (S. irrorella, S. alpestris, S. aurita) has a spiny clasper, whereas the S. roscida group (S. roscida, S. cantabrica, S. flavicans) has a concave clasper. This new arrangement also is supported by ecological features.

[1101] BIOLOGY AND ONTOGENY OF ZELUS LEUCOGRAMMUS, (HEMIPTERA: REDUVIDAE) IN CERRADO-SAVANNA, BRAZIL: THE IMPORTANCE OF CLIMATIC VARIATIONS.

C. M. Paro, K. Del-Claro & F. R. Oliveira, Univ. Fed. Uberlândia, Inst. Biology, PG-Ecology, CP 593, Zip: 38400-902, Uberlândia, MG, Brazil. e-mail: cmparo@yahoo.com

The Heteroptera are one of the most diverse insect group in Brazil and they are importants for many economic, ecological and medical reasons. The Reduviidae family has been studied mainly by its medical and agricultural importance. Although insect biology and ecology are basic to the complete use of these animals in biological control, there are few studies in this field with Brazilian Reduviidae. *Zelus leucogrammus* is pointed out as a potential predator to be used in biologic control in Brazil. In our study we investigated the biology (ontogeny) of *Z. leucogramus* in laboratory conditions and directly in the field (cerrado-savanna like vegetation) between July, 1997 and March 1999. This Reduviidae presents 5 nymph instars and are bivoltine. Egg eclosion delayes (30.47 ± 4.31 days, n= 1033) in dry season (February-September), it presents an egg diapause (196.51 ± 4.95 days, n= 105) on the rainy season (October-January). Eggs with diapause arise individuals that have faster ontogenetic development (47 ± 3.02 days, n=34) than individuals borned during the dry season (80.18 ± 7.55 days, n=73). Our results showed that in cerrado climatic variations and food availability are critical factors on the ontogeny of Reduviidae. Index terms: *Zelus leucogrammus*, Reduviidae, biology, ontogeny, cerrado-savanna.

[1103] DIPTERA COMMUNITY COMPOSITION AND SUCCESSION FOLLOWING HABITAT DISTURBANCE BY WILDFIRE

M. A. Patten^{1,2}, J. C. Burger², T. R. Prentice², <u>J. T. Rotenberry</u>^{1,3} & R. A. Redak^{2,3}, ¹Dept. Biology, ²Dept. of Entomology, ³Center for Conservation Biology, Univ. California, Riverside, CA 92521 USA; E-mail rote@citrus.ucr.edu.

Both biogeographic and local processes determine composition and succession of biotic To infer processes involved, we compared patterns of richness and communities. community composition of families of Diptera at 12 burned and 12 unburned sites of coastal sage scrub vegetation type in southern California. Sites were sampled at 3-month intervals in 1996 and 1997. Fluctuations in richness over time were parallel in burned and unburned sites, permitting us to pool data over all sampling periods. Whereas burned and unburned sites clearly separated when ordinated by vegetative characteristics, they were not discernable as such on the basis of relative abundance of Diptera families. Thus, the overall Diptera community recovered more quickly than did vegetation. However, there remained a strong association between abundance within families of Diptera and vegetation on the plots, indicating the burn had effects on at least some components within the community. Recolonization of burned plots followed a predictable pattern, with generalized scavengers recolonizing fiirst, followed by animal feeders (predators, parasitoids, and hematavores), then by plant feeders (herbivores and pollinators), and with detritivores recolonizing most slowly. These results support the hypothesis that climate, seasonal fluctuations, and geography of a region determine overall community composition (i.e., communities on plots were more similar than different), but disturbance alters local distributions within the community (e.g., by altering microhabitat, which affects certain taxa more than others).

Index terms: Diptera, community succession, wildfire, recovery from disturbance

[1102] TRANS-OCEANIC DISPERSAL OF INSECTS OVER BAY OF BENGAL

S.C. Pathak, Department of Post - graduate studies and Research in Biological Sciences, Rani Durgavati University, Saraswati Vihar, JABALPUR 482001. India. E-mail pathaksc@hotmail.com

Trans-oceanic dispersal of insects (TODI) has been studied over and in Bay of Bengal. Air borne insects of terrestrial origin in the acolian environment were trapped using multinet trapping systems mounted at vantage points aboard the Ocean going Research Vessel (ORV) Sagar Kanya. Terrestrial insects that had fallen in the flotsam and the endemic ones (Halobatinae) were collected using regular neuston nets towed for 20 min at a time. Air borne insects trapped belonged to eleven orders of which four viz. Hemiptera, Diptera, Hymenoptera and Coleoptera accounted for almost 99 % of the total haul. A 45 day cruise of the area yielded as many as 16,429 air borne insects. Of these over 94% were hemipterans while dipterans (4%), hymenopterans (1%) and coleopterans (0.5%) constituted the rest. Trichoptera, Neuroptera, Thysanoptera, Odonata and Dictyoptera were represented by single digit numbers. Although order-wise diversity appeared to be low in this catch, diversity with families and species in focus was quite high, the proportions being 40 - 45% for Diptera, 16 - 25% each for Hemiptera and Hymenoptera and 10 - 12% for Coleoptera. Aerial density of these insects was not uniform and the sampling stations were grouped in clusters on the basis of the relative density of insects. Indices of species diversity, richness, and evenness highlight interesting aspects of this population. Homoptera dominated most of the clusters (Aphididae in clusters I & II, Psyllidae in clusters IV to VII, Delphacidae in clusters VIII & IX) except in cluster III which had Agromyzidae (Diptera) as the dominant group. A total of 82 insects including 23 live specimens of Halobates were recovered from the flotsam. These belonged to Hemiptera (82%), Diptera (4%), Coleoptera (4%) Hymenoptera (1%) and Neuroptera (1%). The rest (8%) were in such stages of disintegration that they could not be identified. Of the endemic insects, 21 specimens of Halobates germanus and 2 specimens of Halobates micans were trapped, both being reported for the first time from this region. Contribution of insects to the oceanic biomass in the study area was found to be 40 g/km² including 30 g/km² contributed by *Halobates*. The study area was toulous to be 700 km² minute study and 100 km² minute s Index terms : TODI, Halobates germanus, Halobates micans, oceanic biomass, insects of terrestrial origin

[1104] COLEOPTERA LIVING IN SUBTERRANEAN NESTS OF AVES ALCIDAE AND SPHENISCIDAE IN THE SUBTARCTIC AND SUBANTARCTIC REGIONS

M. Perreau, Université Paris 7, case 7020, 2 place Jussieu, 75251 Paris cedex 05 France

The burrows of mammals are a well known biotope for Coleoptera and many works have been made on their Coleopterous fauna. Less studied are the burrows of the few species of birds which are living in a subterranean nest. Among them are several species of the families Alcidae and Spheniscidae which are living respectively in subarctic and subantarctic regions. The coleopterous fauna of the nests of five species of Alcidae: Lunda cirrhata (Pallas, 1769) (tufted puffin), Fratercula corniculata (Naumann, 1821) (horned puffin), Aethia cristatella (Pallas, 1769), (crested auklet), Cyclorrhynchus psittacula (Pallas, 1769), (parakeet auklet), Synthliboramphus antiquus (Gmelin, 1789) (ancient murrelet) have been invetigated in north-eastern Siberia (Talan, oblast of Magadan). The nests of Spheniscus demersus (Linné, 1758) (Spheniscidae) (African Penguin) have been also investigated on Dassen island near Cape town, South-Africa. In Alcidae nests, several species of Staphylinidae, Silphidae, Agyrtidae, and Leiodidae Cholevidae have been collected. The main result is the rediscovery of Catops carinatus Jeannel, 1936, known up to now by only 5 specimen from Central Asia and Siberia, which appears to be quite common in nests. Calops alpinus Gyllenhal, closely related to C. carinatus, and very common in all eastern Europa and in Siberia, outside nests appears to be absent in nests. The auks carrions appear to be an intermediate biotope where both species can be found. Statistics have been done for each birds species, but no correlation has been found between the number of Catops collected and the species of bird.In the nests of Spheniscus demersus, species of the following families have been recorded (Carabidae, Trogidae, Scarabaeidae Aphodiinae, Staphylinidae, Histeridae, Tenebrionidae). Among them, one new species of Histeridae of the genus Atribalus has been discovered.

[1105] THE SUCCESSION OF A FRESHWATER POND AFFECTING THE FAUNA OF WATER BEETLES (COLEOPTERA: HYDRADEPHAGA) IN WESTERN SIBERIA

<u>P. Petrov</u>, Dept. of Entomology, Fac. of Biology, Moscow State Univ., 199 899, Moscow, Russia, E-mail pp@3.entomol.bio.msu.ru.

The succession of a freshwater pond in Boreal regions is the process of the pond's eutrophication and its becoming a bog. Knowledge of this succession's affecting a pond's insect fauna gives a tool for bioindication of succession stages and provides data on ecological preferences of species. In Western Siberia water beetles of the suborder Adephaga are represented by the families Haliplidae, Noteridae, Dytiscidae and Gyrinidae. Studying four freshwater ponds at different stages of succession (three ponds, a mesotrophic, a eutrophic and a distrohpic, and a bog) near the city of Tyumen in Western Siberia, 48 species were found. Most of them occur in the mesotrophic pond only, e.g. Hydroporus neglectus), yet there are several species occurring in the bog only (e.g. Hydroporus tristis). It has been shown that water-beetle fauna is changing gradually as pond succession goes on.

Index terms: *Hydroporus neglectus, Hydroporus obscurus, Hydroporus tristis,* eutrophication, bioindication.

[1107] THE ROLE OF PREDATORS IN THE POPULATION AND BEHAVIOURAL ECOLOGY OF THE SOLDIER-PRODUCING APHID SPECIES, PEMPHIGUS SPYROTHECAE

N. Pike & W. A. Foster, Dept. of Zoology, Univ. of Cambridge, CB2 3EJ, U.K. Email: np223@cam.ac.uk.

Only approximately 40 of the more than 4400 species of aphid described are social. This is notable because aphid colonies are often clonal; genomic conflict among individuals should not interfere with the evolution of altruistic behaviour. Ecological factors must determine the extent of altruism. The habit of gall formation is almost ubiquitous in the social aphid species, and is likely to have been prerequisite to their sociality. Pemphigus spyrothecae (Hemiptera: Pemphigidae) forms galls on the black poplar, Populus nigra, and has 1st instar morphs which are behaviourally and morphologically adapted for defence. Predation is likely to have heavily influenced the evolution and maintenance of such aphid 'soldiers'. Drawing from ecological surveys and behavioural experiments, we discuss the influences of a variety of specialist and generalist predators of P. spyrothecae. We demonstrate that Anthocoris minki (Hemiptera: Anthocoridae) and Heringia heringi (Diptera: Syrphidae) exhibit behavioural adaptations for predation upon P. spyrothecae and are responsible for significant mortality at different times during the galling season. Generalist predators occur only rarely with P. spyrothecae and may be foiled by the structural protection provided by the spiral galls as well as by the soldiers' behaviour. We discuss how predators are likely to have influenced the evolution of soldiers in P. spyrothecae.

Index terms: Anthocoris minki, Heringia heringi, sociality, altruism, gall

[1106] FIELD BIOLOGY OF THE GLASSY-WINGED SHARPSHOOTER IN SOUTHERN CALIFORNIA

P. A. Phillips, Cooperative Extension, Univ. of California, 669 County Square Dr. #100, Ventura, CA 93003, USA, E-mail paphillips@ucdavis.edu.

The glassy-winged sharpshooter (GWSS), Homalodisca coagulata, was introduced into Southern California from the southeastern US around 1990. Increasing populations of this bacterial plant pathogen vector pose a significant threat to several of California's valuable agricultural industries, including citrus, grapes, stone fruits, and almonds. In 1999 surveys for GWSS life stages and for associated parasitoids were conducted in five study sites: commercial lemon, orange, and avocado orchards: door-yard macadamia trees; and wild, native laurel sumac (Rhus ovata) shrubs. Two generations of GWSS occur each year in southern California. After a peak in adult activity during the winter months of January and February, oviposition begins in late February or early March, peaking in May. Adults live for several months. They lay their small, sausage-shaped eggs side-by-side in masses averaging 10 to 11 eggs each and ranging in size from single eggs to masses containing as many as 27 eggs. These eggs are laid just under the lower leaf epidermis of host plants. Oviposition damage to lemon fruit rinds was documented for the first time in late summer, 1998. An early September harvest in one orchard had a documented 8% of the fruit with GWSS egg masses noted on the packing line during fruit grading. No damage reports were received for 1999. Nymphs hatch in about two weeks and proceed to feed into leaf petioles or small stems while they progress through four molts before becoming winged adults. A second peak in adult activity occurs in the summer during the months of July and August. Peak oviposition from these first generation adults occurs in August. After the eggs have hatched, the old egg mass blister leaves a tan to brown scar. The last nymphs of this second generation can be observed during October. By November, only the adult stage is found, these being the adults that will over-winter to produce the first generation the following spring. Oviposition into laurel sumac and macadamia is about 2 to 3 times that of oviposition into citrus. Avocado also supports low levels of GWSS, although egg masses don't appear to be as readily laid into avocado leaf tissue as citrus leaf tissue. Only one biological control agent of any significance has been noted to date. A small egg parasite, Gonatocerus ashmeudi, (Hymenoptera: Mymaridae), attacks the GWSS egg masses starting in the spring. Its activity peaks in May and again in late summer, with this latter peak being the greatest when as much as 80-85% of the eggs can be parasitized. A short and successful foreign exploration trip into northern Mexico during April, 1999, produced another potential egg parasite on GWSS, G. triguttatust.

Index terms: Homoladisca coagulata, oviposition, citrus, avocado, Rhus ovata

[1108] NITROGEN AND POTASSIUM FERTILIZATION WERE INFLUENCING THE WHITEFLIES POPULATIONS IN CITRIC PLANTS

J. M. Pinto¹, W. C. Rodrigues¹ & P. C. R. Cassino², ¹Dept. de Fitotecnia, CPGF, UFRRJ, Seropédica, RJ 23.890-000, Brasil, E-mail: jmiranda@ufrtj.br; ²Dept. de Entomologia e Fitopatologia, CIMP, UFRRJ, Seropédica, RJ 23.890-000, Brasil.

This study was performed in a orchard of *Citrus reticulata*, cv. Ponkan, at the Universidade Federal Rural do Rio de Janeiro in Seropédica city, state of Rio de Janeiro, Brazil, during the period from October 1997 to July 1998 with the aim of assessing the influence of nitrogen and potassium mineral fertilizers on the populations of whiteflies: *Aleurothrachelus cruzi, Aleurothrixus floccosus, Dialeurodes citrifolii* and *Paraleyrodes bondari*. A two-factor experiment in a randomized complet-block design with four treatments and six replicates was used. The treatments consisted of two nitrogen (N) levels (0 and 110g/plant) and two potassium (K) levels (0 and 150g/plant), that were divided in two applications (2/3 on the first one, and 1/3 on the second one). Seven days after the start of fertilization treatments, the insect population densities were weekly sampled for each replicate. Only the populations of the whitefly *Dialeurodes citrifolii* significantly differed between treatments. The treatments exerted different effects on the population of this specie, showing an effect reduced on its population when N and K were applied concomitantly.

Index terms: Dialeurodes citrifolii, Aleurothrachelus cruzi, Aleurothrixus floccosus, Paraleyrodes bondari, Citrus

[1109] INFLUENCE OF DIFFERENT LEVELS OF NITROGEN AND POTASSIUM FERTILIZATION ON THE SCALES POPULATIONS ASSOCIATED WITH CITRIC PLANTS

J. M. Pinto¹, W. C. Rodrigues¹ & P. C. R. Cassino², ¹Dept. de Fitotecnia, CPGF, UFRRJ, Seropédica, RJ 23.890-000, Brasil, E-mail: jmiranda@ufrrj.br; ²Dept. de Entomologia e Fitopatologia, CIMP, UFRRJ, Seropédica, RJ 23.890-000, Brasil.

This study was performed in a orchard of Citrus reticulata, cv. Ponkan, at the Universidade Federal Rural do Rio de Janeiro in Seropédica city, state of Rio de Janeiro, Brazil, during the period from October 1997 to July 1998 with the aim of assessing the influence of nitrogen and potassium mineral fertilizers on the populations of scales: Coccus viridis, Orthezia praelonga, Pinnaspis aspidistrae and Selenaspidus articulatus. A two-factor experiment in a randomized complete-block design with four treatments and six replicates was used. The treatments consisted of two nitrogen levels (0 and 110g/plant) and two potassium levels (0 and 150g/plant), that were divided in two applications (2/3 on the first one, and 1/3 on the second one). Seven days after the start of fertilization treatments, the insect population densities were weekly sampled for each replicate. Only the populations of the ensign coccid Orthezia praelonga significantly differed between treatments. The treatments exerted different effects on the population of these species. The study of trophic relationship and bioecology showed that the accumulation of free amino acids on the leaves of *C. reticulata*, cv. Ponkan, caused a significant increase of the population density of O. praelonga. The populations of the armored scales Selenaspidus articulatus and Pinnaspis aspidistrae were correlated negatively with the concentration of potassium in the leaves. It indicated the potassium was a mineral element necessary for insect nutrition, and controlled the population increase of those scales. The diversity of predators in each treatments was also observed. The lacewing Chrysoperla spp. was the most effective predator of O. praelonga.

Index terms: Coccus viridis, Orthezia praelonga, Pinnaspis aspidistrae, Selenaspidus articulatus, Citrus

[1110] DRY-SEASON EMBRIONIC DORMANCY IN DEOIS FLAVOPICTA (HOMOPTERA: CERCOPIDAE): ROLES OF TEMPERATURE AND MOISTURE IN NATURE

C.S.S. Pires¹, E.R. Sujii¹, E.M.G. Fontes¹, C.A. Tauber², & M.J. Tauber², ¹ Embrapa Cenargen, Cx. Postal 02372, Brasília – DF, 70849-970, Brazil, E-mail cpires @cenargen.embrapa.br; ² Dept. of Entomology, Comstock Hall, Cornell University, Ithaca, NY 14853-0901. USA.

A field-based experimental study examined the roles of temperature and moisture in the dry-season embryonic dormancy and post-dormancy hatching of the spittlebug *Deois flavopicta* Stal from Brazil's dry interior region. The results show that dormancy consists of two discrete parts: an initial period of diapause that persists from April to the beginning of July, followed by a period of postdiapause quiescence that prevails until the rainy season begins (usually Oct.). Low temperature during the early part of the diapause period of postdiapause development whereas contact with liquid water determines the timing of postdiapause hatching. Soil temperatures during June and July and the relative humidity of the soil during August and September strongly affect overwintering survival and thus are important in determining the size of the nymphal population after dormancy. The findings indicate that, like hibernation and aestivation in temperate-zone insects, dry-season dormancy in tropical insects is a dynamic state that is influenced by seasonal changes in key environmental factors.

Index terms: Deois flavopicta, dry-season dormancy, moisture, temperature, egg diapause

[1112] PATTERNS OF HOST PLANT GROWTH AND ATTACK AND ESTABLISHMENT OF GALL-INDUCING WASP, ANDRICUS SP.

C.S.S. Pires¹ & P.W. Price², ¹ Embrapa/ Cenargen, Cx. Postal 02372, Brasília - DF, 70849-970, Brazil, E-mail cpires@cenargen.embrapa.br; Dept. of Biological Sciences, Northern Arizona University, Flagstaff, AZ 86001, USA.

We examined the effect of shoot size distribution within plants and different stage of host plant development on the pattern of attack of Andricus sp. on gambel oak, Quercus gambelli Nuttall. The gall-inducing wasp prefered large diameter shoots to small ones in 2 populations of host plant. Attack on larger shoots was significantly nonrandom and occurred even though these shoots were relatively scarce in the shoot population. Large shoots accounted only for 5.51% and 12.72% of the total shoots in an urban and forest site respectively. The percentage of attack on shoots in the largest shoot diameter class was 10.53 and 48.74% in the urban and forest site, respectively. Gall density decreased with maturity of the host plant and was 3 times higher on juvenile plants compared with mature plants. The distribution of attack in relation to plant age was not related to changes in shoot size with the age of the plants. Gambel oak may become resistant to gall formation with increasing age, Survival was 33.72% higher on large shoots (83.72%) compared to small shoots (50.00%). Larval survival did not change with plant age among host plants. The pattern of attack in relation to shoot size suggests that Andricus sp. prefer to oviposit on large shoots in which larval performance was highest. Andricus sp. might show a flexible oviposition preference hierarchy for shoot lengths. Females attacked the longest shoots available rather than showing a fixed preference for specific shoot lengths. Index terms: oviposition preference, population dynamics, plant vigour hypothesis.

[1111] FEEDING BEHAVIOR OF THE SPITTLEBUG DEOIS FLAVOPICTA (HOMOPTERA: CERCOPIDAE) ON WILD AND CULTIVATED HOST PLANT

C.S.S. Pires¹, P.W. Price², E.R. Sujii¹ & C. Avelar¹, ¹ Embrapa Cenargen, Cx. Postal 02372, Brasilia - DF, 70849-970, Brazil, E-mail cpires@cenagen.embrapa.br; ² Dept. of Biological Sciences, Northern Arizona University, Flagstaff, AZ, 86001-5640, USA.

We studied the movement and feeding behavior of nymphs of the grass feeding spittlebug Deois flavopicta Stal to evaluate the role of host plant species on the spatial distribution of the nymphs. The inter- and intraplant foraging patterns of the nymphs contributed to their patchy distributions. The young nymphs, despite their weak motility, moved from the hatching spot and chose feeding sites. They tend to move less when host plants were present. Plant quality near hatching sites influenced the movement pattern of newly hatched nymphs. Egg densities at the oviposition sites did not influence the movement of newly hatched nymphs. The distribution of nymphs in relation to differences in host species and shoot age of host plant was studied in the field and in multiple choice experiments. Both young and old nymphs preferred plants of the introduced host in the genus Brachiaria over the native grass Axonopus marginatus (Trinius) Chase. The nymphs fed gregariously on buds and young shoots as first and second instars and in small groups of third, fourth and fifth instar individuals on old shoots of different sizes. These patterns of atttack may be related to differences in tissue hardness and /or amino acid content between young and old shoots, and between host species. Nymphal survivorship was higher on B. ruziziensis, the preferred host plant. In addition, survivorship of newly hatched nymphs was higher on young buds and shoots compared to old shoots. The possible consequences of nymphal feeding behavior on population dynamics are discussed.

Index terms: grass-feeding, population dynamics, feeding preference.

(HYMENOPTERA: CYNIPIDAE)

[1113] MORTALITY RATE, REPRODUCTIVE OUTPUT, AND TRAP RESPONSE BIAS IN POPULATIONS OF THE BLOWFLY LUCILIA SERICATA

K. M. Pitts¹ & R. Wall¹, ¹School of Biological Sciences, Univ. of Bristol, Woodland Road, Bristol, BS8 1UG, United Kingdom. E-mail: Kieren.Pitts@bristol.ac.uk.

The sheep blowfly, Lucilia sericata, is the primary agent of sheep myiasis in Northern Europe. Current health and environmental concerns over the use of organophosphate dips have led to their phasing out as a control measure for the sheep blowfly within the UK. Novel control methods are therefore being developed. To maximise the success of these devices a clear understanding of the ecology of L. sericata and its responses to traps is required. In a field study the ages of female blowflies collected from farms in the southwest of England, between May and September 1996, 1998 and 1999, were determined using a combination of ovarian dissection and wing fray analysis. Using survivorship analysis, the mortality rates over the entire field season were estimated in day-degrees (a physiological measure of age). From this a mean life expectancy was calculated and also an estimate of lifetime reproductive output per female. The change in mortality rate throughout the season was also examined. The effect of emergence and senescence of generations will be discussed. In addition, the response of L. sericata to liver baited traps will be assessed and, in light of population age-structure information derived from the work, the effectiveness of baited traps as a control measure for the sheep blowfly will be discussed.

Index terms: Age, survivorship, day-degrees

[1115] FAT-BODY, A DECISIVE FACTOR OF SUNN PEST POPULATIONS LEVEL OF *EURYGASTER* GENUS

C. Popov, ¹Research Inst. for Cereals and Industrial Crops, 8264 Fundulea, N Titulescu Str., 1, Calarasi District, Romania, E-mail: fundulea@cons.incerc.ro

Eurygaster genus is represented in Romania by the species Eurygaster integriceps, Eurygaster maura, Eurygaster austriaca and Eurygaster testudinea, however only E. integriceps is able to develop numerous populations, which are extremely dangerous to some 1.500.000 ha. Methodology. Periodical analyses throughout diapause duration on fat body level, aimed to explain differences recorded between the size of populations of various species and the fat supply in E. integriceps. Fat extraction has been performed by Soxhlet method in petrol ether, with groups of 100 insects. For E. integriceps, due to its numerous populations, differentiate analyses of fat body by insect groups was feasible, starting from their weight. Results. On a 3-year average high difference has been detected between the fat-body of species analysed both in autumn and spring. In August, at diapause start, the level of fat-body was 36.8% in E. integriceps, 28.5% in E. maura, and 27.9% in E. austriaca. It was appreciated that physiological preparation of E. integriceps was better over the other species by more than 25%. Differences between species also maintained at the end of diapause, in April: 27.2% in E. integriceps, 22.0% in E. maura and 21.3% in E. austriaca. It resulted from these values that decrease of fat-body during diapause is similar to all species, reaching 23-25%. Differences between sexes have been revealed: cunsumption of females ranged between 19-26% from the total of accumulated supply, while in males was 26-34%. Fat-body level strongly influenced insect mortality during diapause (r=-0.94^{XX}), however without recording differences between species. Likewise, the level of physiological preparation of Eurygaster species adults, is strongly

reflected in their evolution, during the active period, after diapause, negatively influencing sterility (r=-0.838^{XX}), and positively female fecundity (r=+0.885^{XX}). There were high differences between percentage of sterile females (9.7% in *E.integriceps*, 18.5% in *E. maura*, and 27.6% in *E. austriaca*), and also average fertility (64.3 eggs/female in *E. integriceps*, 26.2 in *E. maura* and 19.8 in *E. austriaca*). Conclusions. It could be appreciated that the peculiarity of *E. integriceps* to develop numerous populations, and implicitly to be a particularly dangerous pest, is mainly due to its capcaity to accumulate a high food supply, as fat body. This fat-body provides good survival during winter, and high fecundity, fairly superior to the other species.

Key words. Eurygaster species, fat-body, diapause, fecundity, populations level.

[1114] BIOLOGICAL AND NUTRITIONAL ASPECTS OF NEZARA VIRIDULA (HEMIPTERA:PENTATOMIDAE) ON SOYBEAN GENOTYPES

<u>G.C. Piubelli</u>^{1,4}, I.C Arruda², F. M. Lara¹ & C.B. Hoffmann-Campo^{3,3}, ¹ Dept. de Fitossanidade (FCAV/Unesp), Via de Acesso Prof. Paulo Donato Castellane, Km 05, 14870-000, Jaboticabal, SP, Brasil; ² Protex (Núcleo Manejo Integrado de Pragas); ³ Embrapa Soja, C. Postal 231, CEP 86001- 970, Londrina, PR, Brasil. ⁴ Present address: Universidade Federal do Paraná, Departamento de Zoologia, Caixa Postal 19020, CEP 81531-900, Curitiba, PR, Brasil E-mail: giorla@enpso.embrapa.br

Stink bugs are important soybean pest and efforts have been made to obtain cultivars with, at lest, moderate level of resistance. Experiments were carried out to evaluate the effect of soybean genotypes ('BR-16', 'IAC-100', PI 227687, PI 229358, PI 274454) on Nezara viridula survival, initial weight, adult fresh weight, growth, weight gain and lipid accumulation. When fed on PI 227687 and 'BR 16' (control) pods, survivorship of N. viridula nymphs were 33.7 % and 72.5 %. Nymphs placed in Petri dishes containing PI 274454 and 'BR 16' pods, at the first day of second instar, weighed 1.06 mg and 1.04 mg, being heavier than those with PI 227687 (0.74 mg) and 'IAC 100' (0.66 mg). Adult fresh weights were 146.85 mg when insect fed on 'BR 16', 127.04 mg on PI 227687 and 125.50 mg on 'IAC 100'. The last two genotypes negatively affected stink bugs growth (adult fresh weight adjusted for development time, by ANCOVA) and gain of weight (adult fresh weight adjusted for nymph initial weight, by ANCOVA); they also accumulated less lipids in their bodies. Consequently, PI 227687 and 'IAC-100' are inadequate food source to N. viridula, being a promising alternative to be used in soybean breeding programs as source of resistance to stink bug.

Index terms: plant resistance, antibiosis, growth, gain of weight, lipid

[1116] BIOLOGICAL ASPECTS OF ORYZOPHAGUS ORYZAE (COLEOPTERA: CURCULIONIDAE) IN WATER-SEEDED RICE

II. F. Prando¹, D. R. Sosa-Gómez² & G. H. Rosado Neto³, ¹EEI-Epagri, Cx. Postal 277, 88301-970, Itajaí SC. E-mail: hfprando@zaz.com.br; ²Embrapa Soja E-mail: sosa@cnpso.embrapa.br; ³Zoologia/Entomologia UFPR E-mail: pgento@ufpr.br

In Santa Catarina state (SC), Brazil, around 135 thousand ha of irrigated rice are cultivated under the water-seeded system. The main insect pest in this system is Oryzophagus oryzae. Adults and larvae attack the crop. The adults cause greater damage on germinated seeds, by eliminating the epicotyl and radicle right after sowing, or on seedlings. The larvae attack the irrigated rice roots. The present research was conducted during 1997/1998 growing periods, with the purpose of investigating the biology of this pest. Adult insects were collected in Itajaí SC for identification and morphological studies. At the laboratory, the oviposition site, fertility and incubation period were observed. Larval instars were based on measurements of the head capsule. O. oryzae presents a well-defined sexual dimorphism, with females being larger than males (3.44 mm and 2.85 mm, respectively). Morphological characteristics are evident on the ventral side of the insect. The oviposition takes place on the rice plant sheath, preferably in the submersed parts. The eggs, white and slightly curved, are 0.88 mm long and 0.23 mm wide, and are located in each aerenchyma of the sheath. The average incubation period is 6.5 days, under $25 \pm 2^{\circ}$ C of temperature. After egg eclosion, the larvae remain for 1-1.5 days inside the sheath, feeding on the divisory membranes of aerenchyma. They leave the sheath through a circular orifice at 6-10 days after oviposition. The larvae are white almost transparent in the first instar, and yellowish white in the subsequent instars. They are apodal, have six pairs of spiracles on the dorsal abdomen, which bears strongly sclerotized hook-like structures. Head capsules measurements evidence five larval instars: I (0.18 mm), II (0.24 min), III (0.31 mm), IV (0.37 mm) and V (0.46 mm). The cocoons are impermeable, made of clay and plant residues. They attach firmly to young roots, from where the pupa removes its O2 supply. Inside the cocoon, the rostrum of the pupa is always turned to the fixation root.

Index Terms: rice weevil, behavior, oviposition, morphology.

[1117] COMPARATIVE STUDY OF NYMPHS AND ADULTS OF NUBITHIA GRISESCENS (HEMIPTERA, FULGOROIDEA, ISSIDAE)

P. H. Prates-Ir.¹ & G. S. Carvalho¹, ¹PUCRS, Entomology Laboratory, Ave. Ipiranga, 6681, P.O. Box 1429, RS, Brazil. E-mail: prates74@pucrs.br

Issidae includes one of the largest families among Fulgoroidea. The family is generally compost of small species. The immature and adults issids can be separate from the others planthoppers for the presence of two apical spines, one each side in the second segment of hind tarsus, as well as, for the presence of pre-apicals spines in the hind tibia. The immature issids present rostrum reaching hind trocanters and second segment of hind tarsus wider than third. They are moderately humpback. Nubithia grisescens is found predominantly in graminea. The present work has for objective the morphologic characterization of the immature stages and of the adults of Nubithia grisescens. Nymphs and adults were collected in Viamão, Rio Grande do Sul, Brazil. The insects were dissected with aid of tongs and histologic hole, include in solution of NaOH at 10% for 24 hours and colored with Fucsina. The pieces were examined and drawn with aid of estereoscope microscope and clear camera and photographed with aid of photographic machine coupled this. The pieces of genitalias were examined in eletronic microscope. Resulted of work drawings and/or pictures in the immature and adults of head; pronotum, mesonotum e metanotum; abdome; first, second and third pair of legs; first and second pair of wings; genitalia male and female in the several positions and subdivisions. Nymphs presents the same brownish coloration of the adults. Both presents three spines pre-apicals and eight apicals in the hind tibia. Immatures present front the bigger than adults. The first instar has only two tarsomeres being the hind tarsus more develop. The second to fifth instar have two tarsomeres in fore and median legs and three tarsomeres in hind leg. Rudimentary wings arise in thrid instar.

Index terms: planthoppers, Issidae, morphology, immature, adult

[1118] LINKING MULTITROPHIC INTERACTIONS ABOVE-BELOWGROUND

W.H. van der Putten, H. Duyts, J.A. Harvey, F.L. Wackers, L.E.M.Vet, E.P. Brinkman, G. de Deyn, G.T.A Doodeman, & C.D. van der Stoel. Centre for Terrestrial Ecology, Netherlands Institute of Ecology, P.O. Box 40, 6666 ZG Heteren, The Netherlands, E mail putten@cto.nioo.knaw.nl

Research on multitrophic interactions aims to identify the forces that regulate populations, and which ultimately shape community structure and function. To facilitate this objective, it is necessary to elucidate the cues and mechanisms used by plants (the first trophic level) when interacting with above- and belowground herbivores and pathogens (the second trophic level), as well as parasitoids and antagonists of the herbivores and pathogens (the third and higher trophic levels). The experimental programme we are establishing will aim to address the following questions: (i) under what conditions do above-ground multitrophic interactions dominate over belowground multitrophic interactions or vice versa?, and (ii) are common or different cues of communication between trophic interactions present in different ecosystem compartments (above- vs. belowground)? Another set of questions concerns aspects of selection. Are there hotspots of selection in these linked multitrophic interactions, or can selection be equally active at any trophic level both above- and belowground? A common theme to be addressed in all questions is to determine if there are drivers and passengers in these linked multitrophic interactions. Finally, we want to assess consequences of linkages of multitrophic interactions for maintaining biodiversity and ecosystem functions in a changing world.

Index terms: biodiversity, indirect, parasitoid, pathogen, herbivore

[1119] DISTRIBUTION WITHIN PLANT, SURVIVORSHIP AND MORTALITY SOURCES OF IMMATURE STAGES OF A TROPICAL LEAFMINER

J. M. Oueiroz, Dept. de Zoologia, C.P. 6109, Universidade Estadual de Campinas, Campinas SP 13083-970, Brasil, E-mail: jqueiroz@obelix.unicamp.br.

The ecological studies with Pachyschelus coeruleipennis, that mine leaves of Croton floribundus (Euphorbiaceae), was conducted along trails in Serra do Japi Reserve, Brasil (23°16' S, 47°00'W). The larval stadia of the leafminer are three, and the development time on leaves takes = 1 mo. To determine the distribution pattern, sources of mortality and survivorship of immature stages, 120 shrubs were sampled in February 1999. All leaves were examined for eggs and larvae, and each leaf with immatures was labelled with tape. Position of leaves on plants and eggs on leaves was noted. I observed plants biweekly until June when all leaves containing eggs and mines were cut off and brought to the laboratory to examine the fate of eggs. The density of eggs was $25 \pm 2/100$ leaves and most leaves had only one egg (71% of cases). Most of eggs recently oviposited are found on the top leaves and there was a significantly preference by females to oviposite in the upper portion of plants ($\chi^2 = 41.45$, d.f. = 4, P<0.001). Density of active mines and pupal cells were, respectively, $6 \pm 1/100$ leaves and $1 \pm 0.3/100$ leaves. Natural enemies were the main factor that regulated leafminer populations. Predation, parasitism and fungal attack account for 35.8% of mortality causes and interactions with external feeding herbivores added 9.8%. Mortality rate increased with the age of larvae, thus survivorship curve for the leafminer was slightly convex. Parasitism rate increased much more than predation at the last larval instar and was greater in late-season than in early-season population. While the absolute number of larvae that was predated increased only 1.2 times between early and late season, parasitized larvae increased 11 times. There was an increase in the leafminer mortality due to interactions with external folivores in late season population. Hence leafminer survival to pupal stage was significantly greater in early season population ($\chi^2 = 5.79$, d.f.=1, P<0.02). These factors contributed to the different shapes of survivorship curves in early and late season of Pachyschelus populations. The data presented here suggest that parasitism of larvae is the main factor that explains the survivorship pattern of this tropical leafminer.

Index terms: Pachyschelus coeruleipennis, Buprestidae, natural enemies, Croton floribundus, Euphorbiaceae

[1120] RELATIONSHIP BETWEEN BEMISIA SPP. DENSITY AND DAMAGE IN DRY BEAN (PHASEOLUS VULGARIS)

E. D. Quintela, Embrapa Arroz e Feijão, Caixa Postal 179, Santo Antônio de Goiás, GO, Brazil, 75375-000. E-mail: guintela@enpaf.embrapa.br

Whiteflies (Bemisia tabaci and B. argentifolii) injury to dry beans can result in significant yield reduction due to the transmission of the Bean golden mosaic virus (BGMV). Bean growers had sprayed weekly for whiteflies control during the winter cropping (May-July), even when the adult population and plants infected with BGMV are low. This study was conducted to determine quantitative action thresholds for whitefly control to help growers to make reliable decision when to spray. The dry bean (cultivar Perola) was planted in May 20, 1999 at Santa Helena de Goiás, GO, Brazil. The experiment was laid out in randomized block design with four replications, in plots of 64.80 m² (6x10.8 m). Treatments consisted of: 1. control (no insecticide spray); 2. seed treatment; 3. control of adults and nymphs weekly; 4. seed treatment and control of adults and nymphs weekly; 5, 6 and 7, control when adult thresholds reached 30, 50 and 70% of the plants infested, respectively; 8, 9 and 10. seed treatment and control when adult thresholds reached 30, 50 and 70% of the plants infested, respectively. The plant was considered infested when it had one or more adult per plant. Iniidacloprid 700 PM (300g/100 kg of seeds) was used for seed treatment. Insecticides were used in rotation when adult thresholds were reached. They included imidaeloprid 200 SC (500 ml/ha), methamidophos 600 SNAQ (800 ml/ha), and betacyfluthrin 50 CE (200 ml/ha). Adults, nymphs and eggs were counted weekly by sampling ten trifoliate leaves per plot. Crop phenology and environmental conditions were documented. At maturity, beans were hand-harvested and treatment yields determined. *Bemisia* populations were very low at all treatments in the first two weeks and never reached the lowest adult threshold of 30% of infested plant. After the 3rd week. the adult population and the number of eggs increased gradually in all treatments. The highest number of adults and eggs were reached at the 5th week (72.5% of plants infested and a mean of 3.7 eggs/leaf) and was similar for all treatments. Adults and number of eggs declined after the 6th week when the plants were in the flowering stage. No significant difference between treatment was observed for adults, number of eggs and nymphs sampled weekly. Preliminary analyses suggested that migratory influx was a major factor compromising the efficacy of all treatments. Yield of dry bean was similar for all treatment. The control treatment (no spray) produced 3085.2 kg/ha compared with 3096.6 kg/ha in the treatment that received the highest number of sprays (seed treatment + weekly spray). These preliminary results suggest that at this level of whitefly infestation, when the virus inoculum is low, there is no need of weekly insecticide treatment and some level of whitefly population can be tolerate.

Index terms: Aleyrodidae, action threshold, Bemisia tabaci, B. argentifolii.

[1121] BIOLOGY OF BEMISIA ARGENTIFOLII ON DRY BEAN (PHASEOLUS VULGARIS)

<u>E. D. Quintela¹</u>, E. S. Barbosa² & W. C. J. Silva³, ¹ Embrapa Arroz e Feijão, Caixa Postal 179, Santo Antônio de Goiás, GO, Brazil, 75375-000. E-mail: quintela@enpaf.embrapa.br. Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) internship ² Embrapa Arroz e Feijão, CNPq internship. ³ Embrapa Arroz e Feijão.

The silverleaf whitefly, Bemisia argentifolii, introduced in Brazil in 1991, has become the major pest of dry bean. It has replaced the sweetpotato whitefly, *Bemisia tabaci*, in several locations in Brazil. Various aspects of the insect biology, have been reported on tomato and cabbage. However, little information is available regarding the biology of this species on beans. Studies were conducted to determine some basic biological information of B. argentifolii reared on beans in greenhouse. One hundred plastic pots with three bean seedlings each (Cultivar Perola), 13 days old, were held in greenhouse with adults of whiteflies for 24 h, after which the adults were removed. The plants were then transferred to a small room in another greenhouse at fluctuating temperatures and relative air humidities between minimal and maximal means of 17.8 °C to 27.7 °C and 61.2% to 94.6%, respectively. Four bean leaves were examined daily for measurements of egg, nymph and empty pupal skins size (length and width) of 30 individuals. The time of egg hatch and adult emergence were also examined daily. An ocular micrometer attached to a dissecting microscope was used for the measurements at 50× magnification. The egg began to hatch 7 days after oviposition, but the highest hatching occurred after 8 days. A frequency distribution of nymph length and width and some exuviae identification for 1544 nymphs showed a range of 0.22 to 0.92 mm and 0.10 to 0.78 mm, respectively, and revealed 4 distinct modal peaks. The mean nymph length was 0.28 ± 0.02 , 0.36 ± 0.02 , 0.52 ± 0.05 , 0.78 ± 0.07 mm for the 1st - 4th stadia, respectively. The mean nymph width was 0.17 ± 0.02 , 0.23 ± 0.02 , 0.35 ± 0.05 , 0.54 ± 0.07 mm for the 1st -4th stadia, respectively. The mean growth ratio of nymph length and width was 1.41 and 1.47 for 1st 4th instar, respectively, and fitted the Dyar's rule for Lepidoptera. Nymph length and width increased steadily for 22 days and remained constant thereafter. The relationship between mean nymph length and time was best described by the exponential model $(r^2=0.87, n=1544)$. Similar results was observed for the relationship between mean nymph width and time. Adults of B. argentifolii began to emerge 15 days after egg hatch. After 24 days from egg hatching, most adults had emerged (91.2%). The measurements of empty nymph skins, showed nymph length and width ranging from 0.64 - 0.94 and 0.40 -0.66 mm, respectively. However, most of the adults emerged when the nymph length was $0.70-0.74\ mm$ and nymph width was $0.46-0.50\ mm.$

Index terms: Silverleaf whitefly, developmental biology, Aleyrodidae

[1122] SURVEYS ON *BEMISIA ARGENTIFOLII* WITH STICK TRAPS IN COTTON CULTIVATIONS IN MIGUELÓPOLIS - S.P. - BRAZIL

Z. A. Ramiro¹, A. Raga¹, K. C. A. Send², C. Tamaguti² & F. A. Colmanetti², ¹Centro Experimental do Instituto Biológico, C.P. 70, 13001-970, Campinas, SP, BRAZIL. E-mail zamiro@uol.com.br;

The first reports on the occurrence of white-fly in Brazil date from 1923. Nevertheless, the register of B. tabaci species occurring in levels of economic damages was made from 1968 on, in soybean, cotton and bean cultivations. Since then, this species has been seen in various regions all over the country in different cultivations, being the responsible for direct damages, by the adults as well as the nimphs - due to their eating habits: they suck all the sap from the plants – and indirect damages owing to the production of sooty mold that does harm to the photosynthesis. They are also vectors of virotic diseases such as mosaic on cottons. In 1992, a huge raise on this plague population in olericultures and in ornamental plants, in the state of São Paulo, proved that a new white-fly biotype, B. argentifolii, had been brought to Brazil. This biotype, of almost cosmopolite distribution, is considered the most important plague from this end of century. It is featured by easily adapting itself to new hosts and to different climate conditions as well as by presenting, in a short amount of time, populations which are resistant to the insecticides traditionally used on the B. tabaci control. In the crop dated from 1997/98, in Miguelópolis region, it occurred a B. argentfolii outbreak in soybean and cotton cultures, which resulted on total losses in some areas and a huge raise on insecticides applications. In the next crop, 1998/99, surveys on B. argentifolii adults were done from December/98 till February/99 in an area planted with cotton - "Coodetec". Aiming for the accompaniment of the incidence of this species over this area, stick traps were used. Twenty-five traps were weekly set around the culture and, twenty-four hours later, they were taken out in order to have the number of captured adults/trap counted. The greatest capture of adults collected into traps (an average of 9.3 adults/trap) happened in the last week of December. From the first week of January till the second week of February, collects that varied from 37 to 291 adults/trap/day were registered. It was verified that the greatest number of adults collected in the traps occurred in the two first weeks of each of those months. In situations of high populations of this plague, there are no possibilities of control. By the obtained results, in the areas of B. argentifolii occurrence, the agriculturist must monitor his cultures since the very beginning of germination and respect the necessary control measures before this insect population increases.

Bemisia argentifolii, cotton, floating

Symposium and Poster Session

[1123] IMPACT OF AREA ON THE BEHAVIORAL INTERACTIONS OF SOLENOPSIS INVICTA AND MONOMORIUM MINIMUM COLONIES

<u>A. Rao</u>¹ & S. B. Vinson¹, ¹Dept. of Entomology, Texas A&M University, College, Station, TX 77843-2475, USA, E-mail asha@tamu.edu & bvinson@acs.tamu.edu.

We have developed methods to assess the impact of native ant species on fire ant, *Solenopsis invicta*, colonies in the laboratory and greenhouse. When established native ant colonies, such as *Monomorium minimum*, were given access to small fire ant colonies in the laboratory, the fire ant colonies with up to and including 250-300 workers were destroyed. However, these fire ant colonies had no opportunity to move or escape. Therefore, we conducted similar studies in greenhouse arenas that more closely simulated field conditions, allowing fire ants to move or escape. Our hypothesis is that the farther a fire ant colony can move away from a competitor, the longer it may take for it to be discovered, and for competitive interactions to occur. Our study included areas ranging from 1.78×0.66 m to 0.19×0.18 m. *M. minimum* was observed to take over the fire ant colony even in the largest studied area in two months. Fire ant colonies were observed to move its nests several times, however, was eventually killed. These initial experiments have showed that *M. minimum* can negatively impact *S. invicta* colonies. The impact of these areas on the interactions, and the relationship between the area and the rate at which the fire ant colonies are eliminated are discussed.

Index terms: Solenopsis invicta, Monomorium minimum, behavior, competition, fire ant, native ant.

[1124] TEMPORAL AND SPATIAL DISTRIBUTION OF DIVING BEETLES IN A HIGHLY SEASONAL ENVIRONMENT (COMOÉ NATIONAL PARK, IVORY COAST)

N. Reinties & K. E. Linsenmair, Dept. of Animal Ecology and Tropical Biology, Theodor-Boveri-Institute of Biosciences, Am Hubland, D-97074 Würzburg, Germany. Email: reintjes@biozentrum.uni-wuerzburg.de

Seasonality combined with a high degree of unpredictability challenges the biota in the respective system. The analysis of Diving Beetle communities (Coleoptera, Dytiscidae) in temporary and permanent waters of the Guinea Savanna aims at contributing to our understanding on the evolution of spatial and temporal niche differentiation. From January to May 1999 beetles were collected in Comoé National Park, northern Ivory Coast. Owing to the highly seasonal climate the majority of the waters desiccates during the dry season from November to March. The study focused on two lotic systems, a river and a creek, and two lentic temporary ponds. In the course of the study period the creek and the ponds fell entirely dry for several weeks. The water body of the river shrank to isolated pools. Heavy rains at the end of March refilled the water system. Sampling of additional waters and light-trapping yielded supplementary data. Only results on the adults of the subfamily Dytiscinae are reported on here. Up to date adults of 12 species in 4 genera were found. Rhanthaticus congestus was the most common species, followed by Hydaticus matruelis and Hydaticus dorsiger. Species composition differed between the lotic and lentic sites. The lentic sites were dominated by species of the genus Cybister, while species of Hydaticus mostly inhabited the lotic systems. Adults were found throughout the study period. Especially adults of the three species mentioned above were recorded during all but 5 or 6 weeks, respectively. Five species were collected with light-traps. The results are discussed in the light of life history adaptations to the highly dynamic environment and the temporary limited availability of water.

Index terms: Dytiscidae, Dytiscinae, temporary waters, life history, Ivory Coast, West Africa

[1125] REPRODUCTION OF *DIURAPHIS NOXIA* (HOMOPTERA: APHIDIDAE) ON DIFFERENT WINTER CEREALS

M.E. Reviriego¹, L.R. Descamps¹ & <u>A.A. Suarez</u>², ¹Univ. Nac. Del Sur, San Andrés S/N, (8000) Bahía Blanca, Argentina, e-mail Errol Indicador não definido. ²E.E.A.INTA Anguil, Ruta Nac. N°5 Km 580, C.C. 11, (6326) Anguil, La Pampa, Argentina, e-mail asuarez@anguil.inta.gov.ar.

Russian wheat aphid (RWA) is an important pest of winter cereals in Argentina. The objective of this experiment was to determine the intrinsic rate of increase of RWA on wheat, barley, rye, oats and tritordio (*Triticum x Hordeum*). Under controlled conditions, $21\pm1^{\circ}$ C temperature and 14:10 (L:D) photoperiod, plant pots were arranged in a randomized complete block design with seven replications. Newly born nymphs were place on the youngest leaf of each 20 d old plant and covered with a plastic clip-on cage. The intrinsic rate of increase (rm) for each observation was estimated using the formula developed by Wyatt and White. The data obtained were analized using PROC GLM and means were compared using Means / LSD (p=0.05) (SAS Institute, 1988). Significant differences on rm were found among winter cereals. However, no significant differences were found on RWA pre-reproductive period. Rm was higher on wheat, barley and tritordio. RWA feeding on rye and oats showed lower rm.

Index terms: Russian wheat aphid, intrinsic rate of increase, winter cereals.

[1127] TRICHOMYCETES FUNGI (ZYGOMYCOTINA) ASSOCIATED WITH THE DIGESTIVE TRACTS OF BLACK FLY LARVAE (DIPTERA: SIMULIDAE) IN CENTRAL AMAZONIA, BRAZIL

C.M. Ríos-Velásquez¹ & <u>N. Hamada</u>², Instituto Nacional de Pesquisas da Amazônia (INPA), Caixa Postal 478, 69011-970, Manaus, AM, Brazil. ^{1,2}DCEN, ²CPEN, E-mail: nhamada@inpa.gov.br.

The Trichomycetes are filamentous fungi that grow in the digestive tract of arthropod larvae or nymphs, attached at the peritrophic matrix or on the chitinous walls of the hind gut. Many species in the order Harpellales have been found in black fly larvae. The relationship with the host can vary from comensal to parasitic, depending on the environment and on developmental factors. Host specificity can be at the specific, generic or family level. In Brazil, there is no record of a relationship of these fungi with black flies. The objetive of this study was to identify the Tricomycetes (Zygomycotina) fungi associated with the digestive tracts of Simulium goeldii and Simulium "6-B1" larvae, determining if there is any preference of the fungi for host species. Simulium goeldii and 3. "6-B1" larvae were collected in streams in Presidente Figueiredo and Manaus counties, Amazonas state, Brazil. Black fly larvae were dissected individually in distilled water and its digestive tract was mounted between slide and coverslip in distilled water, a light pressure was applied on the top of coverslip to squash the fungi. Measurements of talli and spores were made under a compound microscope for identification of the fungi, after this procedure, a drop of blue lactofenol was placed on the edge of the coverslip. After complete substitution of the water by lactofenol, the coverslip was scaled with finger nail polish. Infection rate was calculated, based on the total number of examined larvae and number of larvae with fungi. We dissected 68 larvae of S. goeldii, 54 of S. "6-B1" and 79 immature (instars prior to the last larval instar). Of the total latvae dissected, 85.1% were infected with Harpellales, within this order, one genus was associated with the peritrophic intered with Harpennes, within the solution of the solution with the hind gut: Genistellospora, matrix: Harpella; and three genera were associated with the hind gut: Genistellospora, Pennella and Smittium. Harpella, Genistellospora and Smittium were found in both black. fly species; the genus Peunella was only observed in S. goeldii larvae. More studies on biological aspects and ecology of the Trichomycetes and their hosts are needed to understand the relationships among them, the specificity of Trichomycetes and black fly species and the factors that determine this specificity.

Index terms: aquatic insects, comensalism, Harpellales, infection rates, Simulium

[1126] THE POLLINATORS OF CHICKLING VETCH (LATHYRUS SATIVUS, LEGUMINOSAE) IN CENTRAL ITALY

<u>G. Ricciardelli D'Albore & N. Palmieri,</u> Dept of Arboriculture and Plant Protection, Univ. of Perugia, Borgo XX Giugno, 06121 Perugia, Italy, E-mail ENTOMOL@UNIPG.IT

In two years (1998 - 1999) some researches have been carried out on the pollinators of Chickling vetch (*Lathyrus sativus* L), grass crop still cultivated enough in Central Italy, whereas on the pollinators of this species references are lacking. In an Umbrian tableland (Colforito 800 m. a.s.l.), on two chickling vetch fields of one hectare each, during the flowering bees have been observed and counted; a lot of those wild ones, have been catched and determined. In the same time fifty plants have been disposed for a free pollination and as many have been caged. The pollinators observed were: 90.94 % honeybees, 8.30 % some species of bumblebees and 0.76 % other solitary bees (*Anthidium, Ceratina, Chalicodoma, Halictus, Lasioglossum, Osnia* and *Megachile*). The free plants produced more seed than the caged (increase 436,60 %); therefore the chickling vetch is partially selfincompatible and not self-pollinating; consequently the enthomophilous pollination, besides conserving or increasing the genotype variability, is necessary for an excellent seed production.

[1128] THE BLACK LIGHT TRAP FOR MONITORING OF CODLING MOTH CYDIA POMONELLA (LEPIDOPTERA: TORTRICIDAE) IN POME FRUIT ORCHARD UNDER MATING DISRUPTION

O.G. Rivkina, S. B. Sexton¹ & <u>A. L. Il'ichev</u>², Corboy Fresh Fruit Pty. Ltd. P.O. Box 160, Merrigum, Victoria, 3618, Australia. ¹Biocontrol Ltd. 3Acacia Crt., Mt. Crosby, Qld, 4306, Australia. ²Inst. of Sustainable Irrigated Agriculture, P.O. Box1, Tatura, Victoria 3616, Australia.

The Pome Fruit orchard of 20 hectares (ha) located in Kyabram area of Goulburn Valley, Victoria had a history of high level of Codling Moth (CM) Cydia pomonella infestation. The orchard was under conventional spray program since established in the early 1920's. The population of CM increased dramatically during the last decade as a result of management decisions. In September of 1998 the orchard management was taken over by Corboy Fresh Fruit Pty. Ltd. The chemical spray program was tailored to target CM in particular with the use of methyl-parathion based spray insecticides. During the first year of management CM population was monitored by Delta Traps (DT) (AgriSense-BCS Ltd. USA) with 1mg of CM sex pheromone lure. The level of CM population at the end of 1998-99 season was very high and well in excess of 200 moths per trap accumulated over the season. In October of 1999 the orchard was treated with "Isomate C" (Biocontrol Ltd., Australia) for mating disruption (MD) at the rate of 500 dispensers per ha to reduce the CM population. The spray program remained unchanged as in the previous season. CM population was monitored by 3 DT with 10 mg CM sex pheromone lure and 3 Black Light Traps (BLT), supplied by Biocontrol Ltd. BLT consisted of a 4 watt blue violet fluorescent tube mounted in a flat aluminium baffle above a funnel trap. The automatic controllers contained a light sensor and a microprocessor programmed to switch on at sunset and turn off two hours later. DT was placed apart from BLT at the distances of 2, 10 and 20 meters in the William Bon Cretien (Bartlett) pear blocks to estimate possible interaction between the two trap types. No interactions were observed during monitoring period regardless the distance. During the 1999-2000 season BLT monitoring showed dynamic changes in CM population with two flight peaks of 70 and 20 moth per trap per week, while DT weekly catch was 1-3 moth per trap over the season without any flight peak indication. At the end of the season the level of CM population had dropped dramatically but BLT was sensitive enough to show a presence of CM in the orchard with the weekly average catch of 3 moth per trap. DT catch was zero at that time. The results show that BLT is a sensitive and reliable source of monitoring for CM population under MD in Goulburn Valley conditions compare to DT with 10 mg lure and will be discussed.

Index terms: Black Light Trap, Codling Moth, mating disruption.

[1129] FITTING POPULATION DYNAMICS MODELS TO SPATIAL INSECT DATA: SCALING DISPERSAL TO LANDSCAPE STRUCTURE AT MULTIPLE SPATIAL SCALES

J. Roland, Department of Biological Sciences, University of Alberta, Edmonton, Alberta, Canada, T6G 2E9, and S. Lele, Department of Mathematical Sciences, University of Alberta, Edmonton, Alberta, Canada, T6G 2E9.

We use estimating functions to fit density-dependent population models which incorporate parameters for dispersal among sites. We fit these models to spatial data from 130 populations of forest tent caterpillar collected over 8 years near Edmonton, Alberta, Canada. In fitting these models, we are able to scale parameters for density-dependence and dispersal by covariates such as landscape structure around each site where population data were collected. In doing so, we are able to assess the effect of landscape on the dynamics of tent caterpillar, and by having estimated landscape variables at multiple spatial scales, we are able to determine at which scale landscape has the strongest effect. Landscape effects on the dispersal parameter implicate moth dispersal as being affected by landscape structure.

Index terms: population dynamics, density-dependence, dispersal, parameter, landscape.

[1131] POPULATION FLUCTUATION OF ANASTREPHA SPP (DIPTERA: TEPHRITIDAE) IN AMAZONAS STATE, BRAZIL

<u>B. Ronchi-Teles</u>¹ & N. M. Silva², ¹ Dept. of Entomology - Instituto Nacional de Pesquisas da Amazônia - INPA, P.O. Box 478, ZIP 69011-970, Manaus-AM, Brazil.² FCA - Universidade do Amazonas - Faculdade de Ciências Agrárias, Campus Universitário, ZIP 69077-000, Manaus-AM, Brazil

The genus Anastrepha is endemic to the American continents. It is widely distributed in tropical and subtropical regions from southern USA to northern Argentina. The North region of Brazil consists of seven states totaling 3.867,886 km², or about 50% of Brazil and is largely covered by rain forest. Approximately 180 species of native and exotic fruit trees are known in this region. In spite of the high diversity and great quantity of fruit trees in this region, records of fruit flies are from occasional collecting. About 60% of the species of Anastrepha recorded from this region have no known hosts, and eight species (20%) are known only from the holotype. Thirty-two species of Anastrepha have been recorded from five states in Amazonia. However there is no records of Anastrepha species in two North region states (Acre and Tocantins). Between 1996 and 1998, adults of several Anastrepha species were collected in two orchards on the BR 174 (Km 20 and 40) north of Manaus. These adults were obtained by using MacPhail traps. Of the total number of fruit flies collected (4,742 specimens) 53.3% were females and 46.7% males. Thirteen species were collected: A. distincta, A. obliqua, A. striata, A. leptozona, A. serpentina, A. furcata, A. coronilli, A. bahiensis, A. atrigona, A. flavipennis, A. antunesi, Anastrepha sp 1 and Anastrepha sp 2. The most abundant species observed in this study, representing 87.9% of the all fruit flies collect in MacPhail traps were A. obliqua (35.5%) A. leptozona (26.5%) and A. distincta (25.9%). The number of flies/trap/day (FTD) peaked between December and March (rainy season) witch is the period of the maturation of fruits, and was highest in February. The voucher specimens are deposited at INPA (Instituto Nacional de Pesquisas da Amazônia) - Manaus, Amazonas, Brazil. This is the first fruit fly population fluctuation study in the Amazon region.

Index terms: Ecology, fruit flics, taxonomy, MacPhail traps

[1130] POPULATION ECOLOGY OF CORECORIS DENTIVENTRIS (ILEMIPTERA: COREIDAE) IN AN EXPERIMENTAL PLOT OF NICOTIANA TABACUM (SOLANACEAE): SPATIAL DISTRIBUTION AND DISPERSAL

H. P. Romanowski¹ & C. R. Canto-Silva¹, ¹Depart. de Zoologia, Inst. de Biociências, Univ. Federal do Rio Grande do Sul, Av. Paulo Gama, s/n, Porto Alegre, RS, Brasil, Cep. 90046-900. E-mail: hpromano@vortex.ufrgs.br.

The spatial distribution of organisms within populations is of crucial importance for their ecology. Processes that may govern the population dynamics of insects, such as predation and parasitization, are directly or indirectly influenced by their spatial distribution. Also, for efficient monitoring and management of pest species, knowledge on the patterns of distribution and dispersal within and between plants are fundamental. These patterns were studied for all developmental stages of Corecoris dentiventris (Hemiptera; Coreidae) in an experimental plot of Nicotiana tabacum (Solanaceae), at Porto Alegre (30° 05'S and 51° 13'W), RS, Brazil. Twenty plants were sampled in 31 sampling occasions, from November 1996 to March 1997. In each occasion, the number of individuals in each stadium and their position in the plants were registered. Adults were marked to allow subsequent recognition. Adjustment of the data to the Poisson, Positive and Negative Binomial models was tested; indexes of dispersal were estimated. The spatial distribution pattern was aggregated for the immature stages and random for the adults. Values obtained For the "Taylor power law" index revealed a gradient of increase in aggregation from eggs (b=1.987), young (b=2.312) and old nymphs (b=3.307). Within-plant dispersal is started by young nymphs and culminates with aggragation at the upper third of the plant. Adults disperse between plants: at least an average of 1.4 ± 0.05 movement per individual and a mean distance covered of 8.8 ± 0.57 meters was recorded. Dispersal was most intense soon after the teneral period and there were not registers for flyght during the daylight. Index terms: Tobacco, within-plant distribution, between-plants distribution, population dynamics

[1132] ASSOCIATION BETWEEN ANASTREPHA SPP (DIPTERA: TEPHRITIDAE) AND THEIR PARASITOIDS IN TWO SPECIES OF FRUIT IN AMAZONAS STATE, BRAZIL

N. M. da Silva ¹ & B. Ronchi-Teles ², ¹ Universidade do Amazonas – Faculdade de Ciências Agrárias, Campus Universitário, CEP 69077-000, Manaus-AM, Brazil. ² Dept. of Entomology – Instituto Nacional de Pesquisas da Amazônia – INPA, P.O. Box 478, CEP 69011-970, Manaus-AM, Brazil.

This study deals with the occurrence of intraspecific competition between fruit fly species and their parasitoids in two species of fruit tree (Pouteria caimito and Spondias mombin) collected at two sites in Amazonas state; the highway BR 174 (Km 08) and the University of Amazonas both in Manaus. Observation were made between November and January (harvest time) in 1997-1998 and 1998-1999. These fruits were heavily infested by fruit flies. P. caimito by Anastrepha leptozona and A. serpentina, S. mombin by A. obliqua and A. antunesi. A total of 4,627 fruit fly pupae were obtained, from which emerged 3,377 adults and 375 parasitoids. The fruits were placed in individual containers to obtain the fruit flies and parasitoid adults. Intraspecific competition was detected between polyphagous species (A. leptozona and A. obliqua) and monophagous (A. serpentina and A. antunesi) in both species of fruit tree No association between the parasitoids and their hosts (fruit fly) could be established because the emergence of two species from the same fruit and the size of pupae obtained from fruits were similar. The fruit fly species collected from S. mombin were parasitized by Opius bellus, Opius near bellus and Asobara anastrephae. Doryctobracon areolatus was found parasiting only Anastrepha species that infested P. caimito fruits.

Index terms: Ecology, intraspecific competition, fruit flies..

[1133] MIGRATIONS OF LOCUSTS OUT OF THEIR NORMAL RANGE

L.J. Rosenberg & P.J.A. Burt. Environmental Sciences Dept., Natural Resources Inst. Univ. of Greenwich, Chatham Maritime, Chatham, Kent, UK ME4 4TB, E-mail peter.burt@gre.ac.uk

Desert Locusts (Schistocerca gregaria) are major pests of agriculture in Africa, the Middle East and South-West Asia. Swarms are known to make downwind flights over hundreds and thousands of kilometres between seasonal breeding areas. At the end of the summer of 1988, swarms of locusts moved north and south along the western margin of North Africa, and in October and November they crossed the Atlantic Ocean, reaching the Caribbean and neighbouring parts of South America for the first recorded time. This longdistance migration was investigated through the construction of over 100 trajectories, at heights of 950 and 850 hPa and an associated examination of the weather conditions at the time of the migration. Results suggest that the locusts are most likely to have travelled on easterly waves, although the duration of the trajectories suggests that the locusts' flight time was significant longer than previously estimated for other long-distance migrations. Potential source areas in Mauritania, Senegal, Gambia and Guinea-Bissau have been identified. During the same period as the trans-Atlantic migration, groups of locusts also reached Europe, as did dust clouds from the Sahara. This migration will be discussed in relation to more common Desert Locust migrations and possible unique weather conditions over the Atlantic Ocean. Implications for pest control are also discussed. Index terms: Schistocerca gregaria, Desert Locust, migration, Atlantic Ocean

[1135] USE OF NATURAL EXTRACTS OF BASIL, DILL AND FENNEL LIKE ALTERNATIVE MEASURE OF CONTROL OF *MACROSIPHOM EUPHORBIAE* (HEMIPTERA: APHIDIDAE)

<u>S. Russo¹</u>, S. M. Rodríguez¹, M. H. Michetti¹, S. Delfino² & A. E. Pelicano¹, ¹Cátedra de Zoología Agrícola, ² Cátedra de Estadística. Fac. de Agronomía, Univ. of Bs. As. Av. San Martín 4453 (1417). Bs. As. Argentina, E-mail Errot Indicador não definido..uba.ar

Vegetables extracts were prepared from stems, leaves and flowers of basil (Ocinum basilicum), dill (Anethemun graveolens) and fennel (Foeniculum vulgare). The solvent was benzene to 1% and 2%. Filter papers humidified with different solutions, and over them were put leaves of lettuce with 10 aphilds each one. A randomized complete design DCA were used and the sampling unit was the Petri dish. Six treatments with four repetition were evaluated: T1 to T4: control with solvent applications; E1 to E4: dill essence at 1%; A1 to A4: basil essence at 1%; H1 to H4: fennel essence at 1%; AH to AH4: basil essence at 1%; H1 to AE4: basil essence and dill at 1%; these series were repeated at 2%. The effect "knock- down" and the percentage of dead aphilds to the 30 minutes, 6, 24 and 48 hours were verified. The analysis of the data was made througt an ANVA corresponding to the DCA and Tukey comparation applying a significance level of 5%. Not significant differences was registred at low concentrations. There were differences at highest ones. The mixture of: a) basil and dill, b) basil and fennel showed sinergic effect, "know-down", lettuce.

[1134] DIPTERA OF THE PÁLAVA BIOSPHERE RESERVE OF UNESCO (CZECH REPUBLIC)

<u>R. Rozkošný</u> & J. Vaňhara, Dept. Zoology and Ecology, Faculty of Science, Masaryk Univ., Kotlářská 2, 611 37 Brno, Czech Republic. E-mail: rozk@sci.muni.cz & vanhara@ sci.muni.cz

In coordination with the interested institutions and 36 specialists, a project of commented prodromus has been prepared, comprising all literary records and recent data obtained from investigations on Diptera inhabiting the Pálava Biosphere Reserve of UNESCO in its proposed extended concept. Each family included is briefly characterized and documented by a complete list of species found in the study area, with references to published data and collection materials. The lists of references present complete bibliography of the group from the Pálava B.R. The concluding part summarizes information on the present state of knowledge, taxa described from the Pálava B.R., monitoring and biomonitoring, and conservation. Although the research of Diptera in the area under review is by far not complete, 2,862 species have been ascertained. This number represents more that 46 % of the relevant fauna of Diptera occurring in the Czech Republic (6,211 spp.). From the species described at least partly on the basis of type material originating from the study arca (37 spp.), 31 taxa are still valid. Some 209 species are known to occur exclusively in the Pálava B.R. within the framework of the Czech Republic. Analysis of some long-term observations has proved the extinction of 5 species in the area. A comparatively high number of species (149 spp.) is, regarding the authors' experience and specific natural conditions in southern Moravia, included in the categories of species conservation and treated as critically endangered (23 spp.), endangered (57 spp.) and vulnerable (69 spp.). The survey is a rich source of information that can be used for completing the natural characteristics of the study area, for launching programmes monitoring the dipteran families included, for objective assessing the risks connected with the human activities in this area and, at the same time, for improving the protection of its valuable ecosystems and rare species.

Index terms: Nematocera, Brachycera, Central Europe, monitoring, conservation

[1136] RESPONSE OF XYLOPHAGOUS BEETLES AND THEIR NATURAL ENEMIES TO INCREASED RESOURCE AVAILABILITY FOLLOWING A SEVERE ENVIRONMENTAL DISTURBANCE

<u>K.L. Rvall</u> & S.M. Smith, Faculty of Forestry, University of Toronto, Toronto, Ontario, M5S 3B3, Canada. Email: krista.ryall@utoronto.ca.

Historically, in eastern Canada, bark beetles have not posed significant problems in the forest landscape and, hence, there is little data available on their population dynamics specific to this region. However, a recent severe environmental disturbance (specifically the ice storm of January 1998) provided a massive input of available resources for these beetles by causing extensive damage to numerous red pine (*Pinus resinosa*) plantations. This has raised concerns over the possibility of future pest outbreaks which could lead to further tree mortality because of increased beetle populations and severe levels of stress in the residual trees at both the stand and regional level. Recent literature on xylophagous beetles and their natural enemies has suggested the importance of scale in detecting pine engraver beetle (*Ips pini*) have increased rapidly at the stand level in response to the large volume of brood material. However, on a smaller scale (i.e. at the level of the log sample), reproductive output and success of individual parental beetles has been negatively influenced by increasing population size at both the log- and stand-level.

The natural enemy complex associated with *I. pini*, particularly the predator *Thanasimus dubius*, has responded positively to higher beetle populations at the stand-level in an apparent delayed density-dependent manner. This type of top-down control has been shown to help control outbreaks of more aggressive bark beetle species and, thus, may help suppress these pine engraver populations. On a smaller scale (the log sample), enemy-caused mortality displays an inversely density-dependent relationship with host density. This research will be discussed in relation to the outbreak cycle and will provide valuable information on the importance of scale, particularly the larger stand- or landscape-level, in the responses of pest populations and their natural enemies to increased

Index terms: Ips, Thanasimus, predation, outbreaks, scale

[1137] IDENTIFICATION OF THE SPATIAL DISTRIBUTION PATTERNS OF INSECT SPECIES BELONGING TO THE HOMNOPETRA-STERNORILYNCA COMPELX IN CITRUS PLANTS (*CITRUS* SPP.) IN THE STATE OF RIO DE JANEIRO THROUGH THE USE OF VARIOUS STATISTICAL AND MATHEMATICAL MODELS

S.S.P. de Souza¹, R. Silva-Filho^{1,2}, W.C. Rodrigues^{1,2}, & O.R.F. Azevedo^{1,2}, Dept. de Entomologia e Fitopatologia, IB, Univ. Federal Rural do Rio de Janeiro, BR 465 Km 07, Seropédica, RJ, CEP 23.890-000, Brasil, ¹E-mail: sousols@ufrrj.br, ²cimp@ufrrj.br.

The spatial distribution of insects has been regarded as one the most important ecological parameters when field experiments and/or observations are conducted, because such can exert an influence upon the dynamics of a species' population, making possible the occurrence of changes in the impact on the part of various mortality agents (either biotical or abiotical) by virtue of the spatial variations in the degree of the individuals' vicinity within each population, thus determining their territory. An interesting and commonly observed feature in various natural or non-natural ecosystems is the high number of unoccupied habitat units, and others densely inhabited, which generates different spatial distributions resulting from births and deaths of individuals. Considering that the prior knowledge of a species spatial distribution constitutes a key factor for a pest monitoring system for the utilization of the MIP which can secure information on changes in tactics and/or strategies for control, optimization of sampling techniques, determination of economical injuries and the incorporation of the spatial dynamics of population models which provide the information on which factors would determine numerical oscillations and even their persistence both in natural and non-natural environments; also, the existence of various statistical models compatible with the biological and/or ecological processes of the species concerned, which would interpret such biological patterns of spatial distribution of insects in their populations, the complexity of their utilization of Homoptera-Sternorhyncha species, mostly those belonging to the, Ortheziidae, Diaspididae, and Coccidae families, prompted the elaboration of this piece of research owing to the existence fo sample data obtained in the period between 1993 and 1999, and also to the lack of such studies on this group of Insecta.

Index terms: Homoptera-Sternorhyncha, spatial distribution, Pinnaspidus aspidistrae, Selenaspidus articulatus, Coccus viridis, Orthezia praelonga. [1139] A SURVEY OF THE ENTOMO-WILDLIFE ASSOCIATED THE GUAVA ORCHARDS (*PSIDIUM GUAYAVA*) CULTUVAR OGAWA 2, WITH THE UTILIZATION OF LURING TRAP MODEL C-47 AND THE (BINOMIAL) 'PRESENCE-ABSENCE' SAMPLING METHOD, IN THE STATE OF RIO DE JANEIRO, BRAZIL

<u>S.S.P. de Souza¹</u>, W.C. Rodrigues^{1,2}, J.B. da Silva^{1,2}, R. Silva-Filho^{1,2} & A.F. Monteiro Junior¹, ¹Dept. de Entomologia e Fitopatologia, IB, Univ. Federal Rural do Rio de Janeiro, BR 465 Km 07, Seropédica, RJ, CEP 23.890-000, Brasil, ¹E-mail: sousols@ufrrj.br, ²cimp@ufrrj.br.

With climate conditions favorable to its expansion not only in north and northwest of the state of Rio de Janeiro, the guava tree culture has shown a great productive potential also in the other regions where it is grown. Usually this happens in small properties and, although there is not any agricultural policy for its commercial exploration, this culture has yielded significant economical returns mostly owing to the excellence of a few cultivars which yield high quality fruits for in natura consumptiom. Even with its potential to generate revenues, this culture has not devoted studies with regard to the bioecological aspects of its entomo-wildlife. As to the insects cited as harmful to the guava tree, only the fruit-fly, trips, borer, and bugs are regarded as harmful, although there are other insects harmful to the culture. The lack of bioecological knowledge of this agroecosystem encouraged the start of this piece of research in the state of Rio de Janeiro, as a way to observe what is actually occurring in terms of insects associated to guava tree in some regions of the state. The work began in July 1999 at the municipality of Japerí, Baixada Fluminense/Rio de Janeiro, in a property with seven culture-lots, with 120 producing trees per to lot, and ages ranging between 6 and 9 years, and a total of 850 trees. Trap Model Carvalho 47 is being tested in this orchard, a trap devised for the capture of species of the families Bostrychidae and Platypodidae, using forest essences. The trap was modified for best suitableness to this study. The traps were distributed in blocks with different colors and luring substances. Each block was made up of two colors and five different lures. The colors being testes are yellow and blue, whereas the luring substances are alcohol, sugarcane whisky, molasses, guava leaf extract and water on witnessing, amounting to 10 traps for each two lots. For the observation of the population dynamics the same methods adpted by Souza (1999) are being utilized. Results of first collections have shown a great possibility of using this technique in population survey of insects occurring in this culture. Index terms: guava tree pests; MIP; alternative sampling method; monitoring; alternative trap.

[1138] MONITORING AND POPULATION DYNAMICS OF THE ENTOMO-WILDLIFE ASSOCIATED TO THE CULTIVATION OF COCONUT PALM (COCOS NUCIFERA) BY MEANS OF TRAPS MODEL C-47: L – MUNICIPALITY OF ITAGUAÍ, STATE OF RIO DE JANEIRO, BRAZIL

S.S.P. de Souza¹, J.B. da Silva^{1,2}, R. Silva-Filho^{1,2}, O.R.F. Azevedo^{1,2} & P.R.R. Silva¹, ¹Dept. de Entomologia e Fitopatologia, IB, Univ. Federal Rural do Rio de Janeiro, BR 465 Km 07, Seropédica, RJ, CEP 23.890-000, Brasil, ¹E-mail: sousols@ufrrj.br, ²cimp@ufrrj.br.

The growing importance of coconut tree cultivation in the state of Rio de Janeiro has awakened the interest on the part of the growers in the planting of orchards with this palm tree owing to the incentives recently offered by the state government in order to expand it to those regions adequate to the growing of the coconut palm. This was motivated by the increase in the consumption of coconut water in natura on the part of the population, thus generating revenues to the state. The need for a better knowledge of the bioecological aspects associated to those relating to the phenology of this culture as well as to the cultural dealings in the management of such orchards have prompted this piece of research in the expectation that a monitoring methodology might be attained on this entomowildlife through the experiments with effective sampling methods and/or techniques, and with ease of utilization, accessible to grower, and that might make possible the decrease of anti-pest chemicals so widely employed. This, of course, would also decrease the harmful impact on the environment, caused by such products in these agroecosystems. This piece of research started in April 1999 at the municipality of Itaguaí, Rio de Janeiro, still regarded as the highest productivity region. The studies are being carried out in a private property with 5-year-old 800 coconut trees; the production is only starting, and this experimentation will be extended to other producing counties in the State. Trap model Carvalho 47 is under test in this orchard, a trap first devised for capturing poliphagous coloptera in forest essence. The original trap was modified for best suitableness to the coconut tree. Traps were allocated in four blocks according to color and five different luring substances. Colors used were, yellow, blue, beige, and pink. Luring substances being used are, namely, molasses, alcohol, sugar-cane whisky, inflorescence extracts and water (witness). The results from first collections have shown that there is a preference for coloration and luring substrate, and the use of this sampling technique can also be effective for the survey of insect populations of Coleoptera, Hymenoptera, and Diptera, amongst others observed in this culture, and also there is possibility of its utilization as a monitoring technique for the culture's MIP.

Index terms: coconut palm; coconut pests; monitoring; alternative luring trap; population dynamics.

[1140] THE OCCURENCE AND BIOLOGICAL ASPECTS OF THE JUMPING PLANT LICE (HOMOPTERA:PSYLIDAE) ON GUAVA PLANTS (*PSIDIUM GUAYAVA*) AND 'SOMBREIRO' TREES (*VICTORIA FAIRCHILDIANA*) IN THE STATE OF RIO DE JANEIRO, BRAZIL

S.S.P. de Souza¹, R. Silva-Filho^{1,2}, R.C.Barbosa^{1,2}, A.L. da Silva^{1,2}, O.R.F. Azevedo^{1,2} & A.F. Monteiro Junior^{1,2}, ¹Dept. de Entomologia e Fitopatologia, IB, Univ. Federal Rural do Rio de Janeiro, BR 465 Km 07, Seropédica, RJ, CEP 23.890-000, Brasil, ¹Email: sousols@ufrj.br, ²cimp@ufrj.br.

The present studies were started in September 1998 in guava orchards at the municipality of Japeri, as well as streets and squares of the West region of the state of Rio de Janeiro, and also on federal and county highways of said state. The observation are being made at 15-days intervals and the methods used for observing the biological, ecological, and/or economical parameters are based upon various monitoring tactics, with the purpose of adjusting them the integrated pest management. In the last three years, the guava orchards have been intensively under attack of psyllida (sap-sucking insects) in almost all Brazilian regions where this fruit is grown. Coincidentally, at these same periods, the problem is being observed in 'sombreiro' trees which decorate the state's streets and highways. Such infestations are caused by different species, as seen by the observation of the injuries caused to the host plants. In guava trees these insects cause the rolling-up of leaves, since they oviposit at the leaf edges, whereas on the 'sombreiro' trees they densely infest the underneath surface of the leaves, forming dense agglomerations; on the upper part of the leaves, they preferably stick to the central nervure. Both species have been causing considerable economical losses possibly resulting from biological unbalances originated by frequent use of chemicals applied and/or by inadequate management practices. The species found on the guava tree leaves belong to the Triozinae sub-family, for they cause the upward rolling-up of the limbus in young leaves and then such leaves rot and fall. The species attacking the 'sombreiro' resemble Chermidae (Psyllinae), but not causing the same one damage on the leaves such as the former ones; however there occur drastic falling of leaves at the end of each cycle. Also, at each cycle there is a observed reduction of the leaf limbus. The results obtained up to present indicates that Triozoida sp. attack guava trees, whereas the 'sombreiro' trees are being attacked by Euphalerus sp., which also infest medicinal plants such as arruda(Ruta sp.) (herb of grace).

Index terms: Psyllidae; Triozida sp.; Euphalerus sp.; sombreiro pests; guava pests; Ruta sp.

[1141] INVASION SEQUENCE DETERMINES PREDATOR-PREY DYNAMICS IN A MULTISPECIES ASSEMBLAGE

<u>S. M. Sait¹</u>, W-C. Liu², D. J. Thompson¹, H. C. J. Godfray² & M. Begon¹, ¹School of Biological Sciences, Nicholson Building, Univ. Liverpool, P.O. Box 147, Liverpool, L69 3BX, UK. E-mail lesait@liv.ac.uk; ²Dept. of Biology and NERC Centre for Population Biology, Imperial College at Silwood Park, Ascot, SL5 7PY, UK.

Recently there has been a trend towards the study of multi-species interactions in ecology. Theory has shown that predator-prey interactions within multi-species communities can exhibit a range of dynamical patterns. There are a number of sequences through which such community assemblages can be constructed, unlike one or two-species systems, but the impact of assembly sequence on predator-prev dynamics has not previously been investigated. Here, we examine census data obtained from experimental three-species systems and demonstrate that the dynamic trajectories of a predator and its prey are determined by the order in which invasion by the third species occurs. The multi-species system comprises a lepidopteran host, the Indian meal moth Plodia interpunctella, and two of its natural encinies; a baculovirus and a predator, the parasitoid wasp Venturia canescens. The dynamics of the component host-pathogen and host-parasitoid systems are characterised by generation cycles of abundance of the host and parasitoid. Replicated three-species systems were constructed by adding the parasitoid to established host-pathogen cultures, or by adding the pathogen to established host-parasitoid systems. Where appropriate adult moths, wasps and infected larvae were monitored and the time series data compared using autocorrelation function analyses. When the parasitoid was the invading species both the host and parasitoid consistently exhibited an immediate and dramatic shift from generation to multi-generation cycles. However, when the pathogen was the invading species, the host and parasitoid exhibited either one of two dynamical patterns; in some replicates the host and parasitoid went through a period of transient dynamics before ultimately exhibiting multigeneration cycles, this gradual shift in pattern contrasting markedly with the immediate change. In the remaining cultures there was no evidence of either a generation or multigeneration cycle in the host and parasitoid. Instead, the transient period persisted for as long as the three-species cultures remained extant. An agestructured model of the three-species interaction supports our results and shows, moreover, that the length of the transient period is sensitive to small changes in pathogen density after invasion. We argue that transient dynamics following species invasions are highly significant ecologically and may be of such duration that they may be as, or more important than equilibrium states that are never effectively attained over timescales typically observed in complex natural systems.

Index terms: baculovirus, cycles, parasitoid, Plodia interpunctella, Venturia canescens

[1142] A SURVEY OF FECAL FIRING AND HOUSECLEANING IN LEPIDOPTERAN CATERPILLARS

B.A. Salazar, J.D. Hatle & D.W. Whitman, 4120 Dept. of Biological Sciences, Illinios State Univ., Normal, IL 61790-4120, USA, E-mail basalaz@ilstu.edu.

Fecal firing and fecal housecleaning are two behaviors employed by Lepidopteran caterpillars to distance themselves from their feces. We tested 73 caterpillar species (18 families) from a deciduous forest in eastern Maryland, and various desert habitats in southeastern Arizona for fecal firing and fecal housecleaning in order to address the following four questions: are these two behaviors associated with shelter building; are they negatively associated with morphological defenses (hairiness, spines, etc.); are they negatively associated with aposematic coloration; and how are they distributed phylogenetically? We found 12 out of 73 species of caterpillars fecal fired. Our results indicate that fecal firing appears to be associated with shelter building. Fecal firing does not appear to be associated with any particular caterpillar surface morphology, and it appears to be negatively associated with aposematic coloration. Fecal firing also appears to be restricted phylogenetically and is common only within the family Hesperiidae. We observed repeatable fecal housecleaning behavior in only 2 out of the 57 caterpillar species tested. One of these caterpillars was a member of the family Noctuidae and the other was Panopoda rufimargo (Noctuidae). Overall, we found little evidence that fecal firing functions to distance caterpillars from their feces in order to avoid either visual or chemical detection by predators and/or parasitoids. We also hypothesize that fecal firing probably evolved in shelter building caterpillars to conserve space.

Index terms: aposematic, phylogenetically, Hesperiidae, Noctuidae, Panopoda rufimargo

[1143] OBSERVATIONS ON THE AQUATIC HEMIPTERA (GERRIDAE) DIVERSITY FAUNA FROM DISTURBED AND NON-DISTURBED ENVIRONMENT OF AMAZÔNIA CENTRAL, BRASIL

<u>R. T. M. Sampaio</u> & I. R. Brandão, Instituto Nacional de Pesquisas da Amazônia, P. O. Box 478, 69011-970, Manaus/AM, BR. rsampaio@inpa.gov.br. Funding: PPG7/FINEP/ PPI/INPA-MCT.

The aquatic Hemiptera: Heteroptera mainly colonize continental water bodics. The crescent interest on the aquatic entomofauna in the last years, is due mostly by the potencial bioapplication of these insects on the evaluation of the water quality after environmental disturbance. Information on either disturbed and non-disturbed types of environment are precious if one wishes to understand the antropogenic effects over some region.. Manaus and surrounding warters are being pressed by the iminent urban development, causing areas to be highly disturbed, along preserved areas around roads and the city. Data from about ten years collecting on disturbed and non-disturbed streams of Manaus and adjacent areas were evaluated and showed a tendency of some Gerridae genera and species, even belonging to the same genera, to be present only on nondisturbed areas. The survey is a result of 26 collection travels around Manaus city. Richness from three streams of disturbed environment were selected to compare to non disturbed ones. A total of 277 Gerridae specimens were collected where 154 (8 genera and 12 species) from the non-disturbed areas and 123 (6 genera and 7 species) from the disturbed one. Limnogonus hyalinus, Brachymetra albinerva, Tachygerris surinamensis, Neogerris lotus and Metrobates laetus have been collected only on non-disturbed areas. Otherwise Neogerris celeris and Brachymetra lata have been collected on both areas, the last one doubled the number of specimens presented. Brachymetra shawi and Neogerris visendus were mostly collected from non-disturbed and disturbed areas respectively. Also the presence of males and females different numbers on both types of environment has shown differences. The significance of these results as possible application on biotecnology as bioindicators of quality of water will be discussed. The relevance of these studies is in considering the Amazon area as a great water resource and Gerridae a tropical family, as 54 from the 57 existing genera are endemic on this area althoug little is known about its diversity.

Index-terms: Aquatic Insects; Hemiptera; Heteroptera: Gerridae.

[1144] AN AQUATIC INSECT FAUNA FROM THE SUNDANCE FORMATION (LATE JURASSIC), NOR'THERN WYOMING AND SOUTHERN MONTANA, U.S.A.

J.A. Santingo-Blay¹, <u>C.C. Lebandeira</u>^{1,2}, L. J. Pribyl¹ & L.D. Martin⁴, ¹Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, Washington, DC, 20560, USA, e-mail: *labandeira.conrad@nnnh.si.edu*; ²Department of Entomology, University of Maryland, College Park, MD, USA 20742; ⁴University of Kansas Natural History Museum, Lawrence, KS, USA 66045

The Late Jurassic Sundance Formation, of Oxfordian to Kimmeridgian age and corresponding to a date of about 155 million years, is a lowland basinal or perhaps marginal marine deposit consisting of finely-laminated, platy lithographic limestone that once bore a benthos of lime mud. This deposit bears an allochthonous palynoflora consisting of probable schizeacean fern spores; bennettitalean Eucommiidites pollen; and conifers that include Araucarites pollen, cheirolepidacean Classopollis pollen, and possible podcearpaceous wood fragments. The vertebrate fauna consists of one fish species whereas the nektonic insect fauna contains 15 species of mostly Hemiptera and Coleoptera. Sedimentological, paleobiological, and geochemical evidence indicates a shallow basin near sea level that periodically infilled with terrestrial clay sediment from influxes of fresh water. Evidently bottom conditions were inhospitable to respiring organisms. Unlike other mid-Mesozoic deposits of similar age, such as Solnhofen in southern Germany, the Sundance Formation lacks land-derived taxa. Major insect taxa include the heteropterous Belostomatidae, Corixidae, Naucoridae, and extinct The Coleoptera are represented principally by Dytiscidae and possible Enicocoridae. extinct Parahygrobiidae. Rare caddisfly cases constructed of quartzose sand grains are also present. Adult and subadult taxa occur in abundance, allowing some taxa to be evaluated by bivariate morphometric analyses. Soft-bodied preservation of insects by carbonate minerals, principally calcium phosphate, reveals segmented appendages, spines, mouthparts, surface ornamentation, and even premortem color patterns of elytra revealed by variable gray hues. These exceptional details are photographically documented under alcohol immersion at long exposures with fluorescent light. Preparation of fossil material involves careful and repeated surface etching in dilute acetic acid, followed by water rinses and removal of microcrystalline lime matrix by camelhair brushes. This deposit and the Todilto fauna in New Mexico are the only diverse, mid-Mesozoic, North American, fossil insect deposits. As Sundance taxa become better known, their taxonomic affinities to contemporaneous deposits in Eurasia and Brazil should reveal important biogeographic patterns. We are evaluating the Late Jurassic response of continental aquatic insects to north/south distributions of land masses separated by an east/west Tethyan Sea, prior to formation of the Atlantic Ocean. Index: Late Jurassic, fossils

[1145] THE STUDY OF ABUNDANCE, BITING BEHAVIOR AND PARITY OF ANOPHELINE IN ENDEMIC MALARIA AREA IN PORTO VELHO – RONDONIA – BRAZIL

F. Santos¹, A. E.F.L.Cunha¹, A. O. Maia¹ & O. L. Silva¹, ¹ Health National Foundation

Studies of abundance, biting behavior and seasonal distribution of Anophelines are essential for malaria control programs. The strategy of selective control is based on the need to use selective tools for vector control. Therefore it is necessary that studies are conducted, to understand the population dynamics and seasonal variation of vectors. That way, control measures can be targeted to priority sites, and resources optimaly used. To conduct this study, 11 localities in a peri- urban area of Porto Velho were selected, where adults and larvae were collected monthly from January to December 1997. Larval collections were done at 100 different sites, using a dipper (350 ml) in previously selected permanent breeding sites. Collected larvae were counted and 3rd and 4th instars were transported to the laboratory for species identification. Adults were collected at intra- and peridomiciliary surronding during 4 hours using human bait, with the help of na oral aspirator and stored in plastic cups for transport to the laboratory to identification. The ovaries of Anopheles darlingi females were dissected to determine parity. In total 2,243 adults mosquitoes were collected and, of the species collected, Anopheles darlingi was the predominant species in the peridomiciliary site and, of the parous females. A higher number of mosquitoes was collected at sites with more malaria cases. During the study period, 765 larvae were collected, with An. darlingi as the predominant species. It has been demonstrated that Anopheles darlingi is the principal vector of malaria in the periurban area of Porto Velho town, because it was encountered at high densities. It is also said the density and presence of this is directly related to the number of malaria cases in the localities. More detailed studies have to be done, because we assumed that the faillure in the malaria control programs is due to the change in the resting behavior.

[1147] ANT-HERBIVORES INTERACTIONS IN TOCOYENA FORMOSA (RUBIACEAE) IN CERRADO VEGETATION

J. C. Santos¹ & K. Del-Claro¹, ¹Inst. de Biologia, Univ. Fed. Uberlândia – Uberlândia, MG, CP 593, Cep 38400-902, Brazil. e-mail: jcsantosbio@hotmail.com.

Extrafloral nectar is one of the most common reward that plants offer to animals, specially ants. Although Tocoyena formosa K. Schum. (Rubiaceae) is a cerrado plant without extrafloral nectaries, ants feed on its nectar. After flowers were visited by its pollinators (hawkmoths) the corolla drops but the floral nectary continues active producing nectar on the top of fruit in development and attracting visiting ants. In this study we investigated if ants visiting the "floral nectaries" of Tocoyena can produce some benefit to the plant. Field work was conduced between July 1997 and january 1998 in a cerrado reserve (cavanna neotropical vegetation) at Clube de Caça e Pesca Itororó de Uberlândia (CCCPIU). We tagged 50 individuals of T. formosa, all of similar height (0.5-1.5m) and developmental state, each one without leaves or reproductive structures in the beginning of study. Treatment plants (N = 15) received an ant exclusion resin (Tanglefoot R) in their basis and control plants (N = 35) were maintained in their natural state, with free access to ants. We visited weekly each plant to verify the integrity of the resin barrier and species visiting the "floral nectaries". We quantified data on leaf herbivory, fruit production, presence of ants and herbivores on plants. The results showed that there was not statistical difference in folivory between groups or ant species. Although ant excluded plants presented a lower proportion of fruits formed by buds produced, and plants with ants have also presented heavier fruits, these differences were not statistically significant. The *Ectatomma* genus was more efficient in protection of buds and fruits than ants absence and between the second state of the second state investigating benefits of ant visitation to floral nectaries of a cerrado plant. Although, our results did not present statistical difference between plants with and without ants, we suggested that benefits, mainly in fruit production and development may exist with ant presence and other experiments conduced in other years with a major sample size will demonstrated it definitely.

Index terms: Tocoyena, Rubiaceae, ants, herbivory, ant-plant interaction

[1146] COMPARISON OF FOUR METHODS FOR COLLECTING ADULT ANOPHELINE MOSQUITOES IN AN ENDEMIC AREA IN PORTO VELIIO – RONDONIA – BRAZIL

<u>F. Santos¹</u>, J. B. P. Lima² & I. A. Braga¹, ¹ Health National Foundation; ² Army Biological Institute

For many years, the most representative method to collect Anopheline mosquitoes is the human biting catch, but this method is expensive, laborious, and exposes collectors to the risk of contracting malaria. Four collections methods were compared in the malaria endemic area of Porto Velho -- Rondonia -- Brazil. The Shannon trap, the Shannon modified trap, human biting catch with the collector using cotton black socks and the regular human biting catch. On exposed legs and the protectes them, to collected mosquitoes, oral aspirator was used, and on shannon traps, the oral and mecanic aspirators were used. The experiment was conducted at four different locations with equal distance between them and was repeated four times at each location. The randomized design experimental was used. The ovaries of female Anopheles darlingi were dissected to determine parity. The results showed the most abundant species was Anopheles darlingi, that is the principal species involved in the malaria transmision, and the best collection methods the regular human biting catch. In the paity rate by all methods, the proportion of nulliparous females was not significantly higher than the proportion parous. In spite of a questionable method, the human biting catch is the best and the most representative compare to others for monitoring the anophelines populations in endemic malaria areas. However, studies should continue search the alternative methods for monitoring the malaria vectors without risking the volunteers life.

[1148] INTERPLAY OF VEGETATIONAL FEATURES AND MICROCLIMATE ON BOLL WEEVIL CAPTURE IN PHEROMONE TRAPS

T. W. Sappington¹ & K. R. Beerwinkle², ¹USDA-ARS, IFNRRU, 2413 E. Hwy. 83, Weslaco, TX 78596 USA, E-mail tsapping@weslaco.ars.usda.gov; ²USDA-ARS, APMRU, 2771 F&B Road, College Station, TX 77845 USA, E-mail kbeerwinkle@tamu.edu.

Traps baited with the synthetic pheromone of the boll weevil (Anthonomus grandis) are used extensively to monitor local and long-range movement, to detect and monitor local populations and potential problem fields, and to guide treatment decisions in cotton. Quantification of the effects of environmental factors and their interactions on boll weevil trap captures is important to efforts to optimize trap deployment, and to appropriate interpretation of capture data. Paired trap lines were placed on opposite sides of a brush line at six different sites on a plantation in the Lower Rio Grande Valley of Texas, USA. A strong negative relationship between mean daily wind speed and total daily capture of boll weevils accounts for about half of the observed day-to-day variation in trap captures. In addition, our data indicate that much of the variation between traps within days may arise from differences in local wind speed as governed by local vegetation depending on wind direction. Brush lines in this study slowed the wind by 40-70% and mitigated its effects such that traps on the leeward side averaged 2.5-2.9 fold higher captures than traps on the windward side. The magnitude of the effect of windward or leeward placement of traps on weevil captures depended on the relative strength of the wind and density of the brush. Under light winds (< 10 km/h), there were no increases in leeward trap captures. However, on days of moderate (10-20 km/h) or strong (> 20 km/h) winds, leeward trap captures averaged 3.9- or 2.4-fold greater than windward captures, respectively. Traps on the leeward side of a heavy brush line captured ~4.5-fold more weevils than on the windward side on days with moderate winds. Mechanisms of the effects of brush lines on differential weevil captures are being investigated with the use of four automated pheromone traps. These log the entry times of boll weevils into the trap, as well as temperature, wind speed, and wind direction from a small weather station associated with each trap. Thus, fine scale microclimatic measurements can be correlated with weevil captures within narrow windows of time. By taking into account the ability of brush lines to dampen the effects of wind on boll weevil trap captures, researchers and producers can dampen some of the daily and positional variation in trap captures by more careful placement of traps relative to windbreaks. Our results also have implications for situations in which detection of very low populations of local or immigrant weevils is critical, such as in boll weevil eradication and post-eradication zones.

Index terms: Anthonomus grandis, flight, movement, wind, sampling.

[1149] INSECTIVOROUS BIRD COMMUNITY DEPENDING ON FORESTS

<u>S. Sato</u>, Shikoku Res. Ctr., For. and Forest Prod. Res. Inst. 2-915, Asakura-nishimachi, Kochi, 780-8077, Japan. E-mail shigeho@ffpri-skk.affrc.go.jp

To preserve an animal community on reduced and fragmented natural forests, we need to understand the mechanisms sustaining the animal community. It is necessary to know not only the structure of the community but also the interactions with other creatures. The interactions between forest bird communities and insect communities, which are major food resources for birds, have been studied only a little. Here the author analyzed the bird communities of differently treated forests to understand the effects of the modification of forest vegetation on insectivorous bird communities through the insect communities. The author surveyed the bird communities in early summer, which was the breeding season of most birds, on 11 sites including primary forests, secondary forests and coniferous plantations in warm-temperate zone of Shikoku, southwestern Japan. According to their food guilds, the insectivorous birds were classified to the predators of leaf-eaters on crown layer the predators of leaf-eaters on hush layer, the predators of wood-borers and phloemborers and the predators of ground wanderers. The reactions of bird community to the vegetation change were different among the food guilds. The predators of leaf-eaters on crown layer were poor in species on young secondary forests and young plantations, while the predators of leaf-eaters on bush layer were rich on secondary forests and young plantations. The predators of wood-borers and phloem-borers were few on plantations. Those results suggest that human impacts on forests affect the structure of bird community through the change of insect community.

Index terms: food guild, warm-temperate forest, ecological interactions, Japan.

[1151] HOST RECOGNITION IN XIPHYDRIID WOODWASPS

N. M. Schiff¹, <u>L. II. Williams</u>, <u>III²</u>, A. D. Wilson¹ & L. D. Price², ¹Center for Bottomland Hardwoods Research, Southern Research Station, U.S. Forest Service, P.O. Box 227, Stoneville, MS 38776-0227, USA, E-mail nschiff@asrr.arsusda.gov; ²USDA-ARS SIMRU, P.O. Box 346, Stoneville, MS 38776-0346, USA, E-mail livy@ars.usda.gov.

There are approximately 22 genera and 100 species of woodwasps in the family Xiphydriidae. The family has a worldwide distribution, but only the genus Xiphydria, with 9 described species, occurs in the United States. Xiphydriids are medium-sized wasps that are uncommonly collected. Larvae bore through hardwood hosts and consume wood decayed by ascomycetous, symbiotic wood-decay fungi. Most U.S. species are relatively oligophagous but at least one species, X. *tibialis*, has been reared from a wide range of hardwoods. There is little information about how xiphydriid woodwasps locate and accept hosts. Observations of Xiphydria species engaged in host searching behavior suggest that wasps may use both chemical and physical stimuli to find and recognize host woods. We recorded electroantennogram (EAG) responses of xiphydriid wasps to plantproduced terpenes and alcohols, and to fungal symbionts. Xiphydria antennae responded significantly to all stimuli, and a dose response was observed for plant-produced compounds. Behavioral assays were conducted which allowed wasps to choose between host and non-host woods. Parallel assays that eliminated physical and contact chemical cues from the host, but allowed passage of olfactory cues were also conducted. Results of EAG and behavioral studies suggest that Xiphydria sawflies use their antennae to recognize olfactory and/or contact chemical stimuli from their hosts. Physical cues also appear to play a role.

Index terms: Xiphydria, sawfly, fungi, electroantennography, olfaction.

[1150] BIODIVERSITY OF *FAGUS* GALL MIDGES: COEXITENCE AND LIFE HISTORY STRATEGY

<u>S. Satou¹</u>, K. Tsuda² & J. Yukawa³, ^{1,3} Entomological Laboratory, Faculty of Agriculture Kyushu University, Fukuoka, 812-8581 Japan, E-mail: shin@agr.kyushu-u.ac.jp; ² Kinpo-Kagoshima

At least 26 species of gall midge produce leaf galls on *Fagus crenata* [Fagaceae] in Japan. Most of them are widely distributed in Japan, except a few which are found in restricted areas. Such diversified conditions on a single host species enable us to study mechanisms maintaining biodiversity and interactions between organisms belonging to a same and different trophic levels. Periodical dissection of galls, rearing experiments, and host plant phenological data indicated that respective species of gall midge emerged differently in spring to summer seasons, corresponding to the changes of leaf opening phenology. Their life histories can be divided into three patterns according to overwintering stages, emergence seasons, and oviposition sites. Each pattern was adopted by a species group of gall midges belonging to one or two related genera. Population density expressed by the number of galls per leaf was extremely low for almost all species, and the spatial distribution pattern of their galls were contagious. These phenomena were considered to be caused by the oviposition concentrated on particular fresh leaves that were synchronized with gall midge emergences.

Index terms: Fagus crenata, leaf opening phenology, spatial distribution pattern

[1152] ATTACK DYNAMICS OF THE SPRUCE BARK BEETLE *IPS* TYPOGRAPHUS IN STANDS WITH AND WITHOUT REMOVAL OF WINDTHROWN TREES AFTER A STORM FELLING

<u>M. Schroeder</u> & Å. Lindelöw, Dept. of Entomology, Swedish Univ. of Agricultural Sciences, P. O. Box 7044, SE-750 07 Uppsala, Sweden, E-mail Martin.Schroeder@entom.slu.se.

The spruce bark beetle, Ips typographus, is one of the economically most important pests of mature spruce forests in Eurasia. At high population levels the risk for successful attacks on standing trees increases. One factor promoting high population levels in I. typographus is windstorms by providing a surplus of defenceless breeding material in form of fallen trees. An increase of the amounts of breeding material results in low attack densities which releases the beetle population from the usually strong intraspecific competition. Thus, removal of downed spruce trees, to prevent *I. typographus* reproduction has for a long time been the most important measure to reduce the risk for bark beetle attacks on standing trees in the managed forest. But for nature conservation reasons efforts are now being made to increase the amounts windthrown trees left in the managed forests. In the present study the attack dynamics of I. typographus were studied for four years in a number of stands damaged by a storm felling in November 1995. Both stands with removal (managed stands) and without removal (unmanaged stands) of windthrown trees were included in the study. In the four summers following the storm disturbance 50 - 322 standing trees were killed by *l. typographus* in the five unmanaged stands which corresponds to 53 - 86 % of the numbers of attacked windthrown trees. In the first summer after the storm disturbance 531 windthrown trees were attacked by I. typographus in the five unmanaged stands. In contrast, only one standing tree was killed by I. typographus this year in the same stands. Also in the second summer many windthrown trees were attacked while in the third summer no windthrown trees suitable to I. typographus remained. The number of trees killed by I. typographus in unmanaged stands where all the windthrown trees had been left peaked in the second or third summer after the storm felling. In the four summers following the storm felling about two to four times as many standing trees were killed per ha in the unmanged stands compared with in the managed stands.

Index terms: bark beetle killed trees, Picea abies, forest management

[1153] SPIDER COMMUNITY OF AGRICULTURAL ECOSYSTEMS IN CENTRAL AND SOUTH RUSSIA

R. R. Seifulina, Department of Entomology, Biological faculty, Moscow State University, 119899, Moscow, Russia, E-mail: raviljevna@yahoo.com

The investigations were carried out in the agricultural landscape in Moscow region in 1994-1997 and in Krasnodar region (the South of Russia) in 1998. The species composition, spatial distribution and seasonal dynamics of spiders were studied in the different crop fields, on their margins and in adjacent biotopes. The areas of fields were 12-14 ha in Moscow and 60 ha in Krasnodar. Spiders were regularly collected with entomological sweeping and pitfall traps during the crop vegetation season. Samples were taken in the centre of the field, on the field edges (7-10 m into the field), on the field grassy margins and in adjoined biotopes. The distance between the nearest edge and centre in Moscow was about 150 m and in Krasnodar - 400 m. A total 234 species of 121 genera of 20 families were found. 168 species captured in the fields and their margins. Most of these species (about 90%) were collected on the margins. Number of species decreased from the margins to the field centre. The analysis of spider species composition suggests that only some species are able to penetrate into the field. On the contrary, practically all the species inhabiting fields occurred in the margins as well. Therefore the margins are regarded as the main source and refuge for spiders in the agroecosystem. About 95% of all collected epigeic specimens belong to Linyphiidae and Lycosidae families according to pitfall traps. Oedothorax apicatus (Linyphiidae) dominated in the studied agrocenoses in Moscow (29%) and was mass in Krasnodar regions (10%). Four species of Pardosa (Lycosidae) and two of Erigone (Linyphiidae) were mass in Moscow regions as well. P. agrestis dominated (68%) and Trochosa spp. (Lycosidae) were abundant in winter wheat fields in Krasnodar region. P. agrestis occured more frequent in the field central zone at the end of spring. On the contrary, O. apicatus was more ample on the edge of field. According to sweeping, Xisticus ulmi (Thomisidae), Tetragnatha extensa (Tetragnathidae) and Microlinyphia pusilla (Linyphiidae) dominated in field vegetation in Moscow region, while Hypsosinga pygmaea (Araneidae) in Krasnodar region. Eurytopic, widespread, opened space species constitute the basis of studied spider communities. Species composition actually does not depend on the cultivated crop. However, the latter is sure to influence the number, dominance structure, spatial distribution and seasonal dynamics of mass species.

Index terms: Araneae, Lycosidae, Linyphildae, agrocenoses, species composition.

[1154] MODELLING THE POPULATION INTERACTIONS BETWEEN THE CROWN WEEVIL MOGULONES LARVATUS AND ITS HOST PLANT ECHIUM PLANTAGINEUM

<u>A.W. Sheppard¹</u>, M. Rees² & K. Grigulis¹, ¹CRC for Weed Management Systems, CSIRO European Laboratory, Baillarguet, 34980 Montferrier-sur-Lez, France; ²Imperial College, Silwood Park, Ascot, Berks, SL5 7PY, UK

Population models are used to understand the ecological mechanisms involved in interactions between insects and their food resources. In host-parasitoid systems these have achieved levels of complexity, which have provided detailed evidence of some subtle stabilizing mechanisms in the interactions between populations of predator and prey. Such models in herbivore-plant systems have, in general, been quite simple by comparison. In most cases the models used have been based on the dynamics of the host plant incorporating the impact of the insect herbivore as a constant or stochastic variable within a range defined from field observation. Such modeled systems are either unregulated (matrix models) or regulated by density dependence only in the host plant. We have been constructing and exploring a suite of models for the interactions between a root-crown boring weevil, Mogulones larvatus, introduced into Australia and locally wiping out populations of the annual pasture weed, Echium plantagineum. A simple cohort-based model, like others in the past, incorporates weevils simply as a constant impact change in survival and/or fecundity of the host plant. The results are over-optimistic about the impact of the weevil on the populations of its host. A more complex individual-based model incorporates a) variation in weevil impact and b) integrates the dynamics associated with how the adult egg-laying weevil population responds to changing sized and density of its host and c) incorporates larval competition within individual hosts. Density dependence is present therefore in both weevil and host plant components of this model. Outputs from this model highlight the following conclusions. Firstly, including a seedbank-refuge in the model increased host-plant population stability in the face of impact from the weevil. Secondly, including variation in weevil impact amongst plant individuals greatly decreased the effects of the weevils at the population level and this critically depended on the form that this variation took (i.e poisson or negative binomial). Finally, including density dependence in the both the weevil and host plant populations in the model increased the stability of the interactions between them. This study shows that it is valuable to move beyond simple population models for understanding the interactions between insect herbivores and their host plants, but it is vital in this process that field data on herbivore impact assesses variation as well as the mean of the impact and attack levels they cause.

[1155] INSECT COMMUNITY ON RUMEX OBTUSIFOLIUS AS A HOST PLANT

M. H. Shim¹, O. S. Kwon² & <u>S. H. Nam¹</u>, ¹Dept. of Biology, Taejon University, 96-3, Yongwun-tong, Tong-gu, Taejon, 300-716, Republic of Korea; ²Dept. of Sericulture and Entomology, National Institute of Agricultural Science and Technology, 61, Seodun-tong, Kwonscon-gu, Suwon, 441-100, Republic of Korea.

This study was conducted to investigate the insect community on *Rumex obtusifolius* which is a naturalized plant in Korea. The study was started on October 1998 and finished on September 1999. Five study sites were chosen near Samsan stream, near Daecheong lake. Data collection was done onsite every other week during the study period. A total of 5 orders 33 families 85 species was identified to live on the plant. Insects belong to Coleoptera showed highest occurrence in July. Population dynamics of insects at each study site was analyzed. It is concluded that *R. obtusifolius*, a newly naturalized plant in Korea, has successfully established itself as a host plant.

[1156] DISTRIBUTION OF SCAPTOCORIS CASTANEA (HEMIPTERA: CYDNIDAE) POPULATION IN THE SOIL IN FLORÍNEA COUNTY, STATE OF SÃO PAULO, BRAZIL

R. C. Siloto, A. Raga & M. E. Sato, Inst. Biológico, P.O. Box 70 - 13.001-970, Campinas, SP, Brazil. E-mail: resiloto@carpa.ciagri.usp.br

The burrowing bug, Scaptocoris castanea, causes serious damage in several crops in Brazil, mainly soybean, corn, cotton and pasture, sucking the roots of the plants and affecting their development and production. The ability of this insect to move deeply in the soil, associated with their irregular distribution, makes the chemical control of this pest very difficult. In this study, we have evaluated the distribution of the insect in the soil, making correlation with the weather conditions, especially rainfall. The study has been carried out in Florínea county for a period of 18 months. The evaluations have been realized monthly, counting the number of nymphs and adults in soil samples of 25 cm by 25 cm (area) by 50 cm (depth). The sample of soil was separated into two parts: 0-25 cm and 25-50 cm deep. During all the evaluated period, the number of nymphs was higher the number of adults (4:1). This higher proportion of nymphs was more clearly observed during the dry periods (rainfall lower than 70 mm a month) when the nymph/adult ratio reached 11:1. The highest percentage of nymphs (67.4) in the layer of 0-25 cm was registered in Jan/99, which was correspondent to the month with the highest rainfall (551 mm). On the other hand, the lowest percentage (21.0) of nymphs in this layer was in July/99, which was one of the months with the lowest rainfall (48 mm). The highest population of adults in the lower layer was observed during Dec/98 and Jan./99, while the highest population of adults in the upper layer was in Mar./99 and Apr./99. Considering the total population of burrowing bugs (nymphs + adults), the highest number of insects (62.2 insects; with 60% of them in the layer of 0-25 cm) was observed in Apr./99 after five months with high rainfall (average: 390 mm a month). The lowest number was registered in Apr./99 (16.2 insects; with 79% of than in the layer of 25-50 cm), after a six month period with low rainfall (average: 67 mm a month). These data indicate that the rainfall (and consequently the soil moisture) has influence on the number and distribution of S.castanea in the soil.

Index terms: burrowing bug, rainfall, population dynamics.

Index terms: Biological control of weeds, Boraginaceae, Curculionidae, Australia.

[1157] FEEDING TIME OF *PHTHIA PICTA* (HEMIPTERA: COREIDAE) IN DIFFERENTS AGES ON FRUITS OF TWO CULTIVARS OF TOMATO

R. A. da Silva¹ & <u>G. S. Carvalho</u>^{1,2}, ¹Dept. Fitossanidade, Univ. Fed. do Rio Grande do Sul, P.O. Box 776, Porto Alegre, RS 90001-970, Brazil; ² Dept. Biologia, Pont. Univ. Católica do Rio Grande do Sul, P.O. Box 1429, Porto Alegre, RS 90619-900, Brazil, Email: gervasio@pucrs.br.

Among the pests of the tomato culture (Lycopersicon esculentum) is Phthia picta, a bug that make punctures on fruits when feeding. This study was carried out in the Laboratório de Entomologia, Departamento de Fitossanidade, Faculdade de Agronomia, UFRGS, Porto Alegre, RS, with the following objectives: to register the number of punctures per insect, the feeding time per puncture and the total feeding time of males and females of P. picta in differents ages, in two commercial cultivars of tomato (Empire and Santa Clara). Twelve insects fed with fruits of Empire since the first nymphal stage were used in this assay. The bugs were divided in four groups: A1 (3 females), A2 (3 females), B1 (3 males) and B2 (3 males). The insects of each group were individualized in pot of plastic (8cm of diameter x 12cm of height) covered with voil, under controlled conditions (26 ± 1°C; 70 ± 10% RH and photophase of 14 h). Each group was observed four times, when the insects were 13, 16 and 19 days of adult life. The observations consisted in to submit the bugs of the groups for a period of 24 hours without food, under controlled conditions, after to offer fruits of Empire (to groups A1 and B1) or Santa Clara (to groups A2 and B2) cultivars and to observe under environmental temperature the bugs for three hours, registering the number of punctures maked per insect and its duration. The feeding time was considerated the period between the beginning of insertion of the bug's stylets on fruit and the moment that its are retired. In the period among the observations, each insect received a fruit of the group correspondig cultivar. In the first observation only the insects of group B1 fed on fruits. Among the other insects the following behaviors were observed: resting, moving and sometimes food-touching. So, the first observation was not used for statistics analysis. The Analysis of Variance showed that the number of punctures per insect (4,00 in Santa Clara and 4,14 in Empire) and the feeding time per puncture (17,25 minutes in Santa Clara and 22,91 minutes in Empire) are not differents between cultivars. In the same way, no significants differences were found in the total feeding time of the insects: among differents ages (54,82, 36,30 and 61,83 minutes, respectively in 13, 16 and 19 days); between cultivars (42,15 and 59,81 minutes, respectively in Santa clara and Empire); between sexes (43,90 and 58,06 minutes, for females and males, respectively). Index terms: Lycopersicon esculentum, insecta, bug, puncture.

[1158] DAMAGE CAUSED BY SNOUT BEETLES OF THE GENERA PANTOMORUS AND NAUPACTUS IN THE "TAHITI" TRUE LIME IN ARARUAMA CITY, RJ - BRAZIL

R. Silva-Filho¹, O.R.F. Azevedo¹, P.R.R Silva^{1,2}, W.C. Rodrigues^{1,3}, P.C.R. Cassino^{1,4} & S.S.P. Souza¹, ¹Dept. de Entomologia e Fitopatologia, IB, Centro de Manejo de Pragas "Cincinnato Rory Gonçalves", UFRRJ, BR 465 Km 07, Seropédica, RJ, Brazil, CEP 23890-000, Brazil, E-mail: cimp@ufrrj.br, ²E-mail: pramalho@fst.com.br; ³E-mail: wcosta@ufrrj.br; ⁴E-mail: pr.cassino@uol.com.br.

The snout beetles of the genera *Pantomorus* and *Naupactus* (Brachyderinae) are extremely commun in association with citrus in the majority of the Brazilian regions that produce citrus. They attack flowers, roots and leaves of citrus plants. These snout beetles never were observed in so high population density as were observed in the period of October, 1998 to December, 1999, in São Vicente de Paulo, Araruama (RJ) where they are damaging seriously the leaves of "Tahiti" true lime plants. A monitoring was carried out in a plot of 210 plants. The results showed a great occurrence of those species caused a reduction of leaf limb area, and significant loss of plant photosynthetic surface results in reduced yield and quality of fruit. Those species were also found in higher density than the other insect species that feed on the citrus trees in the study area.

Index terms: Coleoptera; Curculionidae, Pantomorus; Naupactus; Integrated Management.

[1159] ORIENTATIONAL RESPONSES OF HELICOVERPA ARMIGERA LARVAE TOWARDS LEAVES OF DIFFERENT LEGUMINOUS CROPS

A. K. Singh & S. Mullick, Dept. of Zoology, Univ. of Delhi, Delhi-110007, India.

Orientational bioassays of first instar Helicoverpa armigera (Lepidoptera: Noctuidac) larvae towards the leaves of four leguminous crops viz. chickpea (Cicer arietinum), pigeonpea (Cajanus cajan), blackgram (Vigna mungo), and cowpea (Vigna unguiculata) were conducted in the laboratory. The larvae showed positive orientational responses towards the whole leaves of all the test plants. In no-choice tests, the orientational preferences of larvae were statistically equal for chickpea, pigeonpea, and blackgram but these were significantly higher than the orientational preference for cowpea leaves. The orientational responses of larvae for the crushed leaves of pigeonpea were found to be significantly lower, as compared with the crushed leaves of chickpea, blackgram, and cowpea. Larval attraction for the crushed leaves of chickpea, blackgram, and cowpea was statistically identical in no-choice tests. The orientational responses of gram podborer larvae for crushed leaves of cowpea were significantly higher than the whole leaves. However, the whole pigeonpea leaves elicited higher orientational responses than the crushed leaves. Maceration was not observed to affect the attractancy of chickpea and blackgram leaves, as the orientational responses of larvae to the crushed and whole leaves were statistically equal in no-choice tests. Foliage extracts in hexane of all the test plants elicited significantly higher responses of larvae than the control. Also, methanol extracts of leaves of all the test plants attracted significantly higher percentage of larvae in nochoice tests (p<0.05). However, in two-choice tests, hexane extracts of leaves elicited significantly higher orientational responses of larvae compared to the methanol extracts of same leaves (p<0.01). The results indicated that all the test plants contain stimuli, which elicit positive orientational responses of larvae. These positive factors are extractable in hexane and methanol, which is higher in former than the latter.

Index terms: Pulses, foliage extracts, larval attraction, olfactory responses.

[1160] BIOLOGICAL ATTRIBUTES OF SPOTTED STEM BORER, CHILO PARTELLUS FED ON MAIZE CULTIVARS

A. K. Singh & A. K. Varshney, Dept. of Zoology, Univ. of Delhi, Delhi-110007, India.

Effects of two maize cultivars, Basilocal and Kisan, on the biological attributes of Chilo partellus, were studied in the controlled conditions. Average larval mortality was higher on Kisan leaves (71%) in comparison with that on Basilocal leaves (55%). Also, growth of larvae was significantly lower on the former than on the latter (P < 0.05). The stem borer larvae were reared on artificial diets, incorporated with fresh foliage paste of these cultivars. Survival rate was found to be significantly higher on the diet incorporated with Basilocal foliage than on that containing the Kisan foliage. Sexwise pupal weights were statistically similar on both the test diets. However, significant differences were observed in the weights of male and female pupae. The female pupae were significantly heavier than the male pupae obtained on each diet. The percentage of larvae completing development and emerging as adults on the Kisan and Basilocal foliage diets was 40% and 60%, respectively. The proportion of males to females was almost equal in the population reared on the Basilocal diet. However, the ratio of males was significantly lower than the females in the population reared on the Kisan foliage diet. The developmental period of the insect was statistically identical on both the test diets. But its growth index was higher on Basilocal foliage diet than on the Kisan foliage diet. Longevity, oviposition period, and number of eggs laid were similar for the females reared during larval stages on both the diets. However, hatchability of the eggs delivered by the females reared on the Basilocal foliage diet was significantly higher when compared with those laid by the females reared on Kisan foliage diet. These results indicate that Kisan maize cultivar contains some factors, which cause antibiosis to *C. partellus* larvae and restrict the build up of its population on the Kisan cultivar, as compared with the Basilocal. Index terms: Hatchability, development, sex ratio, oviposition.

[1161] FURTHER OBSERVATIONS ON THE NOCTURNAL OVIPOSITION BEHAVIOR OF BLOW FLIES (DIPTERA : CALLIPHORIDAE)

D. Singh¹ & M. Bhartl², ¹²Department of Zoology, Punjabi University, Patiala - 147002, India, E-mail devinder@pbi.ernet.in.

It had generally been believed that blow flies do not oviposit at night before Greenberg (1990) reported that blowflies do lay eggs at night as well. This observation had wide applications since it may alter the calculated minimum postmortal interval by several hours. Though Greenberg's experiment was meticulously planned, it did have one major shortcoming. In this experiment he put the oviposition medium under the bushes on the ground. So the flies could have actually crawled rather than fly to this piece of meat. Hence one question still remains unanswered i.e. can the flies lay eggs on a dead body after getting attracted from some distance? To put it in a simple way the question is - do blow flies fly at night? The present studies have been undertaken to find an answer to this question. The details will be discussed during the presentation of the paper. Index terms: Night oviposition, Calliphoridae, forensic entomology

[1163] SOIL MACROFAUNA AND MESO UNDER DIFFERENT VEGETATION COVERING

M.LJ. Soares¹; <u>E.C.Costa²</u> & M.A.G.Costa², ¹ Rua Álvares de Azevedo, 02/306-C – CEP 97010-010 – Santa Maria, RS – Brasil; ² Depto. de Defesa Fitossanitária, Centro de Ciências Rurais – Universitáde Federal de Santa Maria, Campus Universitário, prédio 42, 1° andar, 3225 – CEP 97105-900 – Santa Maria – RS – Brasil – e-mail: eccosta@ccr.ufsm.br.

The relationship among soil plant communities might be indicated by studies on soil fauna. Representants for Phylum Annelida and Arthropoda. Determination of productive and fertile situation for areas with economical relevance into rural sector, could be associate with the presence representants of Phylum Annelida and Arthropoda whose constitute the soil macrofauna and meso were determined. The extraction of meso and macrofauna was done from soil samples collected on the experimental field of University, Santa Maria,(USIM). Using an extractor of soil were collected during spring of 1996, summer, fall and winter of 1997. They were extracted on 0-5, 5-10, 10-15 and 15-20 cm of soil depth. Also, in this areas, soil was sampled for chemical and fisical analysis. Another relation is associated to kind of vegetation covering whose it's possible to observe the faunal population density and quality. Representants of soil macrofauna and meso are recognized. The predominance of the Class Insecta and the variety of orders were related with vegetation covering. Was obtained the total individual quantity in relation to percentile and number of individual for square meter in agree to order was obtained. The variables were statistical analyzed to the determination of mathematical models to demonstrated the situation.

Index terms: soil arthropods, mathematical models

[1162] BIOLOGY OF ISODONTIA FUSCIPENNIS COMPLEX IN TRAP-NESTS (IIYMENOPTERA: SPHECIDAE)

L. A. Soares⁴, H. R. Pimenta², R. P. Martins³ & <u>L. R. S. Zanette⁴</u>, ² in memorian ^{1.3,4} Lab. of Insect Behaviour and Ecology, Biological Science Inst., Fed. Univ. of Minas Gerais, P. O. Box:486, Belo Horizonte, MG, 31140-390, Brazil, E-mail: ³wasp@mono.icb.ufmg.br; ⁴enzo@mono.icb.ufmg.br

During two years (X/92-X/93 and X/95-X/96), nests of Isodontia fuscipennis were collected using trap-nests (n=4800) in four distinct areas, two of secondary forest and two of grassland, at 1 and 2 m. high, in the UFMG's Campus, at Belo Horizonte, M.G., Brazil. The trap-nests were made of bamboo canes, 84 to 190 mm long ,with 76 to 241 mm of internal diameter and with an opening at one extremity. Among the available nests, 113 were used by *Isodontia fuscipennis*. These nests consisted of linear series of one to six brood cells, weakly separated by wads of grass stems and filled with plant material (grass stems and fibres). The final closure of the nest entrances was done by the females, with tufts of small dry brushwood and grass stems which can protrude from the opening by as much as 30mm. The cells were provisioned with adults and nymphs of grasshoppers (Tettigoniidae). The wasp's eggs were laid on the cephalothorax junction of the prey. The number of preys per cell varied from 3 to 6. From the collected nests, 156 adult wasps emerged, 56,2% were females and 43,7% males. The order of emergence was not related to sex. Females were larger than males (width of the thorax- females = $2,63 \pm 0.22$ mm / males = $2,37 \pm 0,20$ mm). The only natural enemy found was an Ichneumonidae wasp. The majority of nest's occupations (60,1%) occurred during the dry season (June to September).

Index terms: solitary wasps, nesting behaviour, grasshoppers.

[1164] DIVERSITY OF NATIVE BEES (HYMENOPTERA: APOIDEA) AND USE OF FLORAL RESOURCES IN A SECTION OF THE CHACO SERRANO (BOSQUE SERRANO) IN CENTRAL ARGENTINA

C.A. Sosa & M. Manfrini de Brewer, Centro de Inv. Entomol. F.C.E.F. y N. Univ. Córdoba. Av. Vélez Sársfield 299 C.P. 5000. Córdoba. Argentina. E-mail: csosa@com.uncor.edu

The diversity of natives bees in a section of the Bosque Serrano in Córdoba (31°10' S, 64°20° O) was determined and the utilization of floral resource by them in this area was analized. Eight samples monthly were made during september to march between 1996 and 1999. The Candfield's transect method was used (1 m. of large by a band of 2 m. of width) and the activity of bees was observed during 10 minutes. Diversity of plants presents, numbers of flowers availability, diversity of flowers visitors and its pattern of activities, mechanisms of search and obtaining the flower's resources availability were registered. 3994 specimens corresponding to 38 genera and 68 species included in 5 families were sampled. Bombus bellicosus (n= 594; 14.87%), B. morio (n=718; 17.97%), B. opifex (n=872; 21.83%), Dialictus sp. 2 (n=158; 3.95% at total) y Xylocopa ordinaria (n=342; 8.56%) were the dominant species. Period between '96-'97 was the most important in relation to the diversity and abundance of native bees. During others periods few differences in relation to the first years were established. During the study specimens of Bombus and Halictidae were the first species to appear at the beginning of spring that continued until the summer was finished. Anthophoridae and Megachilidae predominated at finish of spring, but Andrenidae and Colletidae were more important at beginning of summer. Angiosperms (principally Apiaceae, Asteraceae, Fabaceae, Lamiaceae, Malvaceae, Solanaceae and Verbenaceae) including 34 families and 129 species, were used by bees as floral resources. During the study there were not differences about the diversity of plant species. Important differences between years in relation to the utilization of resources was established. We can conclude that in the three years the families more abundant was Apidae y Halictidae. In relation to the utilization of resources, we established an important differences between years. Dominant species to select the resources were the most generalist bees.

Index terms: Bombus, Xylocopa, Dialictus, Colletidae, Andrenidae.

[1165] RELATIONSHIP BETWEEN CARPENTER BEES (HYMENOPTERA: APIDAE) AND THE FLORA OF THE CHACO SERRANO IN CENTRAL ARGENTINA

C.A. Sosa & M. Manfrini de Brewer, Centro de Inv. Entomol. F.C.E.F. y N. Univ. Córdoba. Av. Vélez Sársfield 299 C.P. 5000. Córdoba. Argentina. E-mail: csosa@com.uncor.edu

The fauna of carpenter bees (Xylocopinae) and the relationship with the flora of the Bosque Serrano in Córdoba (Argentina) was analyzed. Four samples monthly were made during october to march between 1994 and 1995, at two localities in Córdoba: Cabana (30°20'S, 64°10'O) and Quebrada Los Hornillos (31°10'S, 64°10'O). Both sites are in the Chaco Serrano area. The carpenter bees were captured during the period of more activities (between 9-13 Hs.) and when were on the flowers. The patterns of activities and the diversity of plants that they visited were observed. Five species of carpenter bees were registered: Xylocopa ordinaria (84,27%), X. splendidula (10,110%), X. artifex (2,25%), X. subcyanea (2,25%) and X. ciliata (1,12%). Females were predominant (96,63%), all specimens of X. ordinaria and splendidula were female. Males (3,37%) were registered in X. artifex, X. ciliata and X. subcyanea only. The bees visited 22 species of plants including in Acanthaceae, Asteraceae, Apiaceae, Fabaceae, Lamiaceae, Lythraceae, Solanaceae and Zygophillaceae. Three patterns of behavior were established: lodging on flower (principally in the visits to Asteraceae and Apiaceae), entering into the corolla (in Fabaceae and Lamiaceae) and vibrating the anthers (exclusive on Solanaceae's flowers). At 60% of the visits, the bees tacked nectar, at 47% collected pollen and the 23% without resources. The results show that each species of Xylocopa presented a specific behavior when a particular plant was visited: X. ciliata will be monolectic on Asteraceae; X. artifex, X. subcyanea and X. splendidula will be oligolectic on Asteraceae, Fabaceee and Solanaceae; and X. ordinaria will be polilectic on all families of plants observed. During this periods of studies there are no differences in the relationship carpenter bees-plants between localities and years.

Index terms: Xylocopa, floral resources, behavior.

(1166) POPULATION BEHAVIOUR CHANGES OF THE PROCESSIONARY MOTH (*THAUMETOPOEA PITYOCAMPA*) IN PORTUGAL

E. Sousa, M. Moreira & M.L. Inácio, Dept. Protecção Florestal. EFN. Quinta do Marquês 2780 Oeiras. Portugal E-mail: dpf.efn@mail.telepac.pt.

The Leiria National Forest is a 28 acres state propriety in the middlewest of Portugal of maritime pine (*Pinus pinaster*), considered to be a climax area for this forest species. Normal processionary moth defoliation is being detected every year in these pine stands. However, since 1997 abnormal intensive defoliations were observed during summer periods causing a new considerable tree damages, and the agent was identified as *Thaumetopoea pityocampa*. These observations reveal a change in the population behaviour which seems to by related to a bio-ecological readjustment induced probably by biotic and/or abiotic factors. The previous documented knowledge of the *T. pityocampa*, such as thermal requirements and thresholds, and the data from captures of light and sexual feromone bailed traps placed in some pine plots were analysed by degree-day methods in order to develop an adult emergencies predictive model. This forecast model will be an important tool to prevent future abnormal population outbreaks.

Index terns: Thaumetopoea pityocampa, Pinus pinaster, biological cycle changes, Portugal

[1167] HOST PLANTS OF ZAPRIONUS INDIANUS IN THE STATE OF SÃO PAULO, BRAZIL

M. F. S. Filho¹, D. A. O. Prestes¹, M. E. Sato¹ & A. Raga¹, ¹Inst. Biológico, Caixa Postal 70, Campinas, SP, Brasil, 13001-970, E-mail: miguelf@dglnet.com.br.

Zaprionus indianus (Dip.: Drosophilidae) was detected in Brazil in February 1999 infesting fig fruits (Ficus carica), in Valinhos County, State of São Paulo. Losses of 40% were estimated in the fig orchards without including decaying vegetable matter. The females oviposite in the superficial ostiole and the larvae move into the syconia for feeding. Probably fungus and yeast are inoculated in the fruit. The cavity of ripening figs bears a big number of adults which can be found in foraging and mating. In that County, adults of Z. indianus infest also fresh figs in summer period where the high relative humidity and temperature are characteristical conditions. Zaprionus. indianus is considered a polyphagous species and it is abundant in ripe fruits. Adults were found in rotten vegetables on the soil. In the field several fruit samples were collected to identify the main hosts of Z indianus in the State of São Paulo. Fruits hanging on the tree and from the ground were collected and kept in the laboratory. Adults emerged from 22 botanical species (14 exotics and 8 natives) belong to 10 families as follow: Anacardíaceae (Mangifera indica, Spondias purpurea), Combretaceac (Terminalia catappa), Ebenaceae (Diospyrus kaki), Malpighiaceae (Malpighia glabra), Mimosaceae (Inga affinis), Musaceae (Musa spp.), Myrtaceae (Eugenia involucrata, E. pyriformis, E. schomburgkii, Janbosi, Oxalidaceae (Averritoa carambola), Rosaceae (Eriobotrya japonica, Prana mume, P. persica, Fragaria x ananassa, Pyrus communis) e Sapotaceae (Achras sapota). Index terms: Drosophilidae, Ficus carica, hosts.

[1168] EFFECT OF NYMPHAL DENSITY ON DEVELOPMENT AND PERFORMANCE OF *LEPTOGLOSSUS ZONATUS*, THE LEAF-FOOTED BUG (HETEROPTERA:COREIDAE) ON CORN (*ZEA MAYS*)

C. E. P. Souza^{1, 2, 3}, B. F. Amaral-Filho^{1, 3} & A. Mafra-Neto^{1, 2}, 1- Fac. Filos. Ciênc. e Letras de Ribeirão Preto, Univ. de São Paulo, Av. Bandeirantes, 3900, Ribeirão Preto São Paulo, Brazil, 14040-901; 2- 100A Chapman Hall Univ. of California-Riverside, Riverside, United States, 92521; 3- Univ. Est. de Campinas – Depto. de Zoologia, caixa postal: 6109, Campinas. São Paulo, Brazil.

The duration of nymph stage, percentage of mortality, weight of the adults (male and female), the sexual ratio and reproductive activities of the leaf-footed bug *L. zonatus* fed on corn were studied under controlled laboratory conditions. The experiment consisted of the standardization of size of the rearing space and the amount of food to supplied to *L. zonatus* fed on (T1), 10 nymphs (T2), 15 nymphs (T3), 20 nymphs (T4) and 25 nymphs (T5). The duration of the nymph stage was shortest at the lowest density (T1= 31.25 \pm 0.25 days). The rate of survivorship was highest for T4 (51%) and lowest for T5 (38.28%). The sexual ratios varied among treatments: T1=0.6; T2=0.23; T3=0.54; T4=0.45 and T5=0.53 (ratio=females/males). Mating significantly reduced the longevity of females: the longevity of unmated females was 114,8±15.0 days whereas mated females lived only 50.20±10.1 days. Females had higher fresh body weight than males, except for those in treatment T1. We discuss some of the possible adaptive and developmental advantages of aggregation for *L. zonatus*.

Index terms: Leptoglossus zonatus, nymphal density, leaf-footed bug, coreid, corn

[1169] CONTRIBUTIONS TO THE BIOLOGY AND ECOLOGY OF NEOLEUCINODES ELEGANTALIS (LEPIDOPTERA: CRAMBIDAE)

C. M. de Souza¹, <u>J. L. Blackmer</u>² & A. M. Viana-Bailez¹, ¹Lab. de Proteção de Plantas, Univ. Estadual do Norte Fluminense, Campos dos Goytacazes, RJ, Brazil, CEP: 28015-620, E-mail: claudio@uenf.br. ²Current address: USDA-ARS, 4135 E. Broadway Rd., Phoenix, Arizona, USA 85040-8803.

Neoleucinodes elegantalis, the small tomato borer, is one of the most important tomato pests in South America. Localization of the preferred oviposition sites, as well as a better understanding of the life cycle of this moth could facilitate field monitoring and/or improve pest management methods. From 1998 to 1999, in the region of São José de Ubá, Rio de Janeiro, Brazil, several commercial tomato fields were monitored for eggs of N. elegantalis. Eggs were detected on adaxial (4.3%) and abaxial (15.8%) calyx surfaces, petiole (2.5%), fruits (77.0%), and rarely on flowers. Most eggs (67.2%) were oviposited on fruits 21-35 mm in diameter. A large percentage (78.00%) of egg masses had fewer than 1-4 eggs, which suggests that N. elegantalis may use an egg-spacing or ovipositiondeterring pheromone. Laboratory assays were used to gain a better understanding of the basic biology of N. elegantalis. Eggs were obtained using paraffin-coated artificial fruit (35 mm diameter, dark green or red). At 15, 20, 25, and 30 °C egg hatch occurred between 8-12, 7-10, 7-10, and 5-6 d, and egg viability was 83, 99, 100, and 90%, respectively. Most eggs (70.0%) hatched during the first hour of photophase. The larval to pupal period ranged from 28-35 d and pupal weights were 51.3 ± 8.0 and 59.8 ± 7.0 mg for males and females, respectively. A large percentage of adults (51%) emerged within 4 to 6 h after the initiation of scotophase. The majority of copulations (65.5%) occurred 24 to 48 h after emergence, and 5 to 7 h after the initiation of scotophase (56.5%).

Index terms: small tomato borer, oviposition, life cycle, tomato, artificial oviposition substrate

[1171] TOXICITY OF TOMATO ALLELOCHEMICALS TO EGGS AND NEONATE LARVAE OF Neoleucinodes elegantalis (LEPIDOPTERA: CRAMBIDAE)

C. L. M. de Souza¹, A. M. Viana-Bailez¹ & <u>J. L. Blackmer</u>², ¹Lab. de Proteção de Plantas, Univ. Estadual do Norte Fluminense, Campos dos Goytacazes, RJ, Brazil, CEP: 28015-620, E-mail: claudio@uenf.br. ²USDA-ARS, 4135 E. Broadway Rd., Phoenix, Arizona, USA. 85040-8803.

Neoleucinodes elegantalis, the small tomato borer, is one of the most important pests of tomatoes in South America. The wild tomato genotypes, Lycopersicon hirsutum f. hirsutum and L. hirsutum f. glabratum, are the main sources of resistance genes against several insect pests of tomato. These genotypes possess high densities of glandular 2-tridecanone (2TD), 2-undecanone trichomes, which have high concentrations of (2UD) and zingiberene (ZIN). The objective of this work was to evaluate the toxicity of these substances to the eggs and neonate larvae of N. elegantalis. The eggs and larvae were exposed to filter paper that had been treated with increasing concentrations of these compounds, which were first dissolved in acetone, and then allowed to evaporate. The average concentrations corresponded to those detected in wild genotypes (12.5, 60 and 125 mg/ml for 2UD, 2TD and ZIN, respectively). The methyl ketone, 2TD, was extremely toxic to eggs and resulted in 62.5 and 97.5% mortality at 40 and 120 [g/[], respectively. 2UD and ZIN were less effective, even at the highest concentrations (20 and 200 De/11, respectively), only resulting in 17.5 and 20% egg mortality. Egg viability for control treatments (water and acetone) was 92.5 and 90.0%, respectively. For neonate larvae, 40 and 120 g/01 of 2TD resulted in 72.5 and 95% mortality, respectively. ZIN at 200 □g/□l and 2UD at 20 □g/□l resulted in 67.5 and 20% mortality, respectively. Survival of larvae, 5-6 h after the initiation of tests, for control treatments (water and acetone) was 100 %. These findings indicate that 2TD, a methyl ketone present in type VI trichomes of L. hirsutum f. glabratum, holds promise as an alternate means of controlling both eggs and neonate larvae of N. elegantalis.

Index terms: 2-tridecanone, 2-undecanone, zingiberene, Lycopersicon hirsutum, small tomato borer

[1170] OVIPOSITION PREFERENCE AND DEVELOPMENT OF NEOLEUCINODES ELEGANTALIS (LEPIDOPTETRA: CRAMBIDAE) ON TOMATO GENOTYPES

C. M. de Souza¹, <u>J. L. Blackmer</u>² & A. M. Viana-Bailez¹, ¹Lab. de Proteção de Plantas, Univ. Estadual do Norte Fluminense, Campos dos Goytacazes, RJ, Brazil, CEP: 28015-620, E-mail: claudio@uenf.br. ²Current address: USDA-ARS, 4135 E. Broadway Rd., Phoenix, Arizona, USA 85040-8803.

The wild tomato genotypes, Lycopersicon hirsutum f, hirsutum (Hir) and L, hirsutum f. glabratum (Gla) have been shown to be resistant to several insects, primarily due to their high densities of glandular trichomes and defensive allelochemicals. Despite the economic losses caused by Neoleucinodes elegantalis, the small tomato borer, limited effort has gone into screening cultivars for resistance against this pest. A moderate level of resistance against N. elegantalis has been reported for the cultivars Angela Hiper (Ah) and Roma VF (Rvf); however, a susceptible cultivar, Santa Clara (Sc) is widely planted throughout Brazil. The presence of either antixenotic and/or antibiotic resistance to N. elegantalis was examined under greenhouse conditions using choice and no-choice tests with the genotypes Hir, Gla, Ah, Rvf and Sc. Choice tests were setup in a randomized block design with 5 genotypes, 4 blocks, and 3 plants/genotype/block. No-choice tests were setup in a randomized entirely design with 5 genotypes and 6 repetitions. Oviposition preference and development of N. elegantalis were used to characterize resistance. N. elegantalis did not deposit eggs on Hir or Gla, suggesting that these two genotypes may possess traits (chemical or mechanical in the form of trichomes) that interfere with oviposition. Among the cultivars tested, *N. elegantalis* exhibited a significant preference, at least with regards to oviposition, for Ah over either Sc or Rfv fruits. Significant differences were also observed among these cultivars for the larval-pupal period and pupal weights. The larval-pupal period was significantly longer and pupal weights were lower for insects reared from Rfv (23.5 d; 40.8 mg) than for either Ah or Sc (20.96d; 49.2 mg and 20.57 d; 44.6 mg, respectively). No differences in egg hatch or viability, larval viability, pupal period or viability, sex ratio or adult viability were observed among the cultivars tested. These findings suggest that the wild genotypes possess traits, probably antixenotic in nature, that interfere with the initial stages of host finding and/or acceptance, while the cultivar Rfv possess traits, probably antibiotic in nature, that interfere with normal development.

Index terms: Host-plant resistance, antixenosis, antibiosis, Lycopersicon esculentum, Lycopersicon hirsutum

[1172] OCCURRENCE AND BIOECOLOGICAL ASPECTS OF WHITEFLIES (HOMOPTERA; ALEYRODIDAE) ON CITRUS ORCHARDS IN THE STATE OF RIO GRANDE DO SUL, BRAZIL

<u>S.S.P. Souza</u>¹ & P.C.R. Cassino¹, ¹Dept. de Entomologia e Fitopatologia, IB, Univ. Federal Rural do Rio de Janeiro, BR 465 Km 7, Seropédica, RJ, CEP 23.890-000, Brasil, E-mail sousolsp@ufrj.br, pr.cassino@uol.com.br.

A field work was conducted with the aim of studing the bioecological aspects of Aleyrodidae in order to develop a binomial sampling plan of presence-absence for Aleurothrixus floccosus, Dialeurodes citrifolii, Aleurotrachelus cruzi, and Paralyrodes bondari. Insect samples were taken randomly from September, 1995 to March, 1998 in 23 cities of the state of Rio Grande do Sul, in the south of Brazil. The samples were taken in two citrus orchards of 'Valência' localized in the counts of Butiá e Viamão, with the purpose of monitoring aleirodids species. In the others 21 cities visited, the principal aspects observed it was the occurrence of the species of 'whiteflies' in order to obtain the geographical distribution of them in this state. Sixteen citrus trees were sampled, and 4 opposite branches/tree in two height's levels were evaluated weekly. The population dynamics of those species were established using the degree of infested leaves estimated by the binomial sampling plan. The patterns of distribution of the aleirodids species were by the binomial sampling plan. The platents of the interaction of the interaction of the properties of infested leaves were estimated through the Wilson & Room's mathematical model. The number of samples needed to evaluate the population density was calculated ($\infty = 0.2$ and D = 0.1 - 0.2). The results showed that sample sizes with standard error 0.2 were more feasible for monitoring whiteflies in citrus orchards. The efficacy of the methods used, in this experiment demonstrated that they should be used in monitoring program of Aleyrodidae in citrus IPM systems. However, it is necessary to be aware, because these results may not be applicable to other regions due to the own behaviour of the alcirodids species, cultivars and localities. The degrees of frequency (occurrence) for each specie in the 23 cities visited for this purpose were: A. floccosus (100%), D. citrifolii (87.50%), P. bondari (66.17%), A. cruzi (50%), Bemisia tabaci (41.67%), Trialeurodes vaporariorum (29.17%) as well as P. crateraformans.

Index terms; Citrus whiteflies; citrus pests; Aleurothrixus floccosus; Dialeurodes citrifolii; Aleurotracheulus curzi; Paraleyrodes bondari; Bemisia tabaci.

[1173] DETERMINATION OF THE SPATIAL DISTRIBUTION OF CITRUS WHITEFLEIS' BY OF TAYLOR'S POWER LAW COEFFICIENTS AND WILSON & ROOM'S MATHEMATICAL MODEL ON 'VALÊNCIA' CITRUS ORCHARDS, STATE OF RIO GRANDE DO SUL, BRAZIL

S.S.P. de Souza¹ & P.C.R. Cassino^{1,2}, ¹²Dept. de Entomologia e Fitopatologia, IB, Univ. Federal Rural do Rio de Janeiro, BR 465 Km 07, Seropédica, RJ, CEP 23.890-000, Brasil, E-mail: sousols@ufrrj.br, 2pr.cassino@uol.com.br.

Prior knowledge of the model of spatial distribution of species, pest, and natural plant enemies is a key factor which should be taken into account in developing sampling methods in agroecosystems, since the position occupied by an specimen in relation to one another within a population is the most important ecological characteristics of the species because of their bearing on birth and deaths of individuals. In the identification of the organisms distribution within their populations various biological patterns of mathematical models can be used for frequencies distributions, and the Poisson's function most properly describes the randomness of such organisms. However, the pieces of research conducted in this field have shown that the insects spatial distributions usually do not follow that pattern, and such distributions are most precisely described by some of the existing contagious distributions. On observing the importance of this feature, and the lack of studies on Aleyrodidae on Citrus spp., the option was to conduct such studies by using the Taylor's power law, by means of the calculation of the relation variance/average of data at each sampling, and then the mathematical model proposed by Wilson & Room (1983) was tested. This piece of research was conducted at the municipalities of Butiá and Viamão, state of Rio Grande do Sul. Samplings were made weekly for and two years and six months (September, 1995 to March, 1998), on orange tree leaves cv. Valência'. Species observed were: Aleurothrixus floccosus, Dialeurodes citrifolii, Paraleyrodes bondari, and Aleurotrachelus cruzi. Results showed that the models adopted for the identification of the spatial distribution of these species under the specific conditions in those regions were effective for species showing higher population density per leaf (for instance, A. floccosus, on both sites) and, inadequate for those which showed low population levels (such as A. cruzi, D. citrifolii, and P. bondari, at Butiá, and P. bondari and D. citrifolii at Viamão). It was also observed that every species shows a tendency to follow a differentiated mathematical model according to its spatial distribution.

Index terms: A. floccosus, D. citrifolii, P. bondari, A. cruzi, distribution.

[1174] A REGRESSION METHOD FOR IN SITU ESTIMATION OF APHID NUMBERS

J. Srikanth, Sugarcane Breeding Institute, Coimbatore 641007, India

In situ estimation of aphid numbers in aggregations on plant parts demands consideration of colony characteristics, such as the extent of plant surface colonized and the intra-plant variation in colonization rate relative to surface area. Using Aphis craccivora Koch (Homoptera : Aphididae) on cowpea as case study and regression analysis between aphid number (colony size) and the three colony dimensions, viz. length (colony length), circumference (colony thickness) and surface area (colony area) of colonized portions, I show that colony area as the predictor gives the best estimate of aphid numbers on stems and pods. In three arbitrary infestation classes, namely heavy, medium and low, colony size showed the highest correlation coefficient with colony area followed by colony length and colony thickness, in both stem and pod. Standard partial regression coefficients of colony dimensions also indicated the relative importance of colony area as predictor of colony size. Simple linear regression between colony size and colony area was adequate for aphid number estimation, as multiple regression with combinations of colony characteristics did not significantly improve prediction. Significantly different colonization rates in stem and pod, particularly at high densities, necessitate estimation of different regressions for colony size estimation on these parts. In situ estimation of aphid numbers on stem or pod involves two steps: laboratory standardization of regression equations between colony size and colony area in different infestation classes for these parts separately; in situ estimation of aphid number on sampled plant part by predicting from colony area using the regression equations. By assigning 100 % coverage of colony area to the sample colony with the highest density cm2, and sorting the sample colonies in the descending order, I generated colony data for five proposed infestation classes in stem and pod. With correlation and regression analysis of these simulated colony data, I demonstrate that estimation of aphid numbers can be improved further by increasing the number of classes as well as defining them more objectively on the basis of per cent coverage of colony area. I also discuss the extension of the method to other hosts of the aphid and to other homopteran insects that aggregate or form dense sedentary colonies.

Index terms: Aphis craccivora, estimation of numbers, infestation classes, correlation and regression

[1175] DEMOGRAPHIC ECOTOXICOLOGY: AN ACTUARIAL PERSPECTIVE ON PESTICIDE EFFICACY

D. Stark, Ecotoxicology Program, Dept. of Entomology, Washington State Univ. Puyallup, Washington 98371 USA, E-mail stark@puyallup.wsu.edu.

Demography is a powerful tool that can be used to develop estimates of the total effect of toxicants (lethal and sublethal) at the population rather than the individual level, something that traditional toxicological assays can't do. Here I will present several examples of demographic ecotoxicology, showing the advantages and disadvantages of this approach. I will also examine alternate methods for estimating population growth rate that are faster and less expensive than developing life tables yet provide a good approximation of r. An example will be presented using a matrix modeling approach based on life table data, that determines the combinations of pesticide-induced mortality (lethal effect) and reduction in fecundity (sublethal effect) that result in positive, negative, and stable population growth rates (r) for the Seven-Spot lady beetle, Coccinella septempunctata L. and its prey, the pea aphid, Acyrthosiphon pisum Harris. The level of mortality and reduction in fecundity that populations of each of these species can withstand is very different and appears to be dependent upon intrinsic life history variables. Differences in life history variables among species should therefore be a major consideration in risk assessment and when considering integrating pesticides and biological controls.

Index terms: matrix models, life history variables, risk assessment

[1176] THE BLACK SCALE OF GRAPES TARGIONIA VITIS IN GREECE

G. J. Stathas & D.C. Kontodimas, Dept. of Entomology, Benaki Phytopathological Inst., 8 S. Delta Str., 145 61-Kifissia (Athens), GREECE, E-mail bpilibr@otenet.gr

The phenology and natural enemies of the diaspidid, Targionia vitis, were studied in ifested vineyards in Greece in 1998-99. In Southern Greece, this viviparous species, develops one generation per year and overwinters as a mated female. Fecundity was estimated by dissecting not yet-reproducting females collected during the first 10 days in May and recording the eggs inside, was found to be 82 - 105 eggs. The neonate crawlers appeared in mid - May. First and second instar nymphs appeared in June and developed to male and female nymphs by mid - July. The flights of males were observed from mid -July until the end of August. By the beginning of September the whole population consisted of mated females. The aphelinid parasitoid, Aphytis abnormis was observed to parasitise second instar nymphs and adult females of the scale. The parasitisation percentage reached 7% by the end of August – beginning of September. Larvae and adults of the nitidulid predator Cybocephalus fodori were also recorded. Index terms: Aphytis abnormis, Cybocephalus fodori, diaspidid, phenology, fecundity.

[1177] BIOLOGICAL ASPECTS OF ZAPRIONUS INDIANUS, A NEW PEST OF FICUS CARICA IN VALINHOS, SÃO PAULO, BRAZIL

C.P. Stein¹ & E.P. Teixeira¹, Centro de Fitossanidade, Instituto Agronômico de Campinas, Caixa Posta 28, 13001-970, Campinas, São Paulo, Brasil, E-mail: cpstein@cec.iac.br, edson@cec.iac.br

Zaprionus indianus (Diptera: Drosophilidae) was registered for the first time in Brazil as a pest of fig (Ficus carica var. roxo-de-valinhos) in March of 1999 in Valinhos, São Paulo State. At this time, this fly caused a loss on prodution and exportation of fig around 40% and 80%, respectively. This species is common in Africa and was fist described from material collected in the India. Apparentely it has rapid progression in the tropical region. The female lays its eggs inside the ostiole. After enumerging, the larvae reachs the interior of the fruit which becomes inapropriate for the consumption. Besides two native species of the Brazilian Cerrado, lobeira (Solanum licocerpum) and araticum (Annona crassiflora), 74 botanical species belonging to 31 families were registered as hosts for Z. indianus. The species has been observed in Santa Catarina, Rio de Janeiro, Minas Gerais, Mato Grosso do Sul and Goias States. Experiments to elucidate biological aspects of this fly were carried out in laboratory. Samples of the fly were kept at 25 ± 1° C, 14-hour photophase, in artificial diets (banana, yeast) with or without dietary supplement (Saccharomyces cerevisiae). The observations demonstrated that the incubation period ranged from 24 to 36 hours; larval period from 8 to 15 days; pupal period from 4 to 9 days. The longevity of adults mated ranged from 24 to 83 days and 21 to 96 days, with and without dietary supplement, respectively. The adults life span individualized with dietary supplement ranged from 5 to 56 days. There were no significant differences between the longevity of males and females in all the cases. The average number of adults originated from a couple without dictary supplement was 75,87 (33 - 134) while those ones with dietary supplement produced 313,50 (93 - 698) adults. The sex ratio has 0,5607. Index terms: Diptera, Drosophilidae, biology, damage.

Symposium and Poster Session

[1179] ALTITUDINAL MIGRATIONS OF BUTTERFLIES AND OTHER INSECTS IN NORTHWESTERN COSTA RICA: ECOLOGY AND CONSERVATION

R. D. Stevenson¹ & W. A. Haber², ¹ Dept. of Biology, Univ. of Massachusetts, Boston, MA, 02125, USA, ²Missouri Botanical Garden, P.O. Box 299, St. Louis, MO 63166, USA; E-mail robert.stevenson@umb.edu

Over the past 15 years, a variety of studies and approaches (direct observations, flight traps, censuses of forest fragments and extensive forest tracts) centered at Monteverde, have established altitudinal and cross-country migrations of butterflies over the Tilarán mountains (Puntarenas, Alajuela, and Guanacaste Provinces). Approximately 60% of the 263 butterfly species censused (many more occur) in the dry forests of the Pacific lowlands below Monteverde migrate to the highlands or the Atlantic coast. A higher proportion, 75% of the 594 species recorded in Monteverde, leave or pass through the region (1200-1800 m). Beetles, wasps, and dragonflies have also been observed to migrate. The migrations have complex seasonal patterns that are correlated with climate and phenological changes. Rainfall ceases from mid November to mid May in the Pacific lowlands, and many species leave during this time of year. The F1 generation produced in the Pacific lowlands by adults that came from the Atlantic side in April and May, migrates back to the Atlantic side from late June through July creating another peak in migration intensity. Examples of specific species will illustrate the complexity of the patterns. Seasonal migration is clearly an important ecological phenomenon for Costa Rican butterflies and other insects, but our current knowledge of the biology of many rare species is too incomplete to assess their conservation status. Nevertheless, the effect of deforestation, fire, and use of pesticides probably reduces lowland populations and threatens some species. In the context of the likely historical changes in the butterfly fauna, alternative hypotheses about the vulnerability to extinction of Pacific lowland migrant and resident butterflies are presented.

Index terms: Butterflies, insects, tropics, migration, conservation.

[1178] SURVEY OF VECTORS SHARPSHOOPERS OF XYLELLA FASTIDIOSA IN COFFEE PLANTATIONS IN SÃO PAULO STATE, BRAZIL

<u>C. P. Stein</u>, Centro de Fitossanidade, Instituto Agronômico de Campinas, Caixa Posta 28, 13001-970, Campinas, São Paulo, Brasil, E-mail: cpstein@cec.iac.br

The bacteria Xylella fastidosa is a plant parasit that in Brazil has been observed mainly in cultures of plum and citrus. This bacteria was registrated for the first time infecting coffee plants causing the "coffee branch atrophy" disease, in cultures in Macaubal and São José do Rio Preto, São Paulo State, in 1995. The sharpshoopers of the family Cicadellidae (Cicadellinae) and Cercopidae which feed on xylem are known as the major vectors of the X. fastidiosa. A survey to verify the occurring especies of sharpshoopers in coffee plantations in São Paulo State, was carried out in 8 differents sampling dates at plantations of Coffea arabica var. Mundo Novo in Pindorama, Mococa (feb – jun/99) and Campinas (mar – jul/99). Samples were performed using yellow strick traps (10 x 24 cm) hung on the plants at height of 1.5 m from the ground. In this way, 2135, 1004 and 1330 specimes were trapped, respectively in Pindorama, Mococa and Campinas. From these, Cicadellidae represented 80.70, 75.00 and 88.95% of the total sharpshoopers trapped. The major species trapped in Pindorama, Mococa and Campinas were Oncomotopia fascialis (24.59; 24.00; 61.13%), Dilobapterus costalimai (3.37; 2.23; 18.20%) and Acrogonia terminalis (9.23; 2.69; 2.48%), that belong to Cicadellinae subfamily. These three trapped species of Cicadellinae represented 55.36% (Pindorama), 27.09% (Mococa) and 83.92% (Campinas) of the total of shapshoopers trapped.

Index terms: Coffea, Cicadellidae, Oncomotopia fascialis, Dilohopterus costalimai, Acrogonia terminalis. [1180] FEEDING AND METABOLIC RATE OF GALUMNA ELIMATA (ACARI: ORIBATIDA) UNDER DIFFERENT TEMPERATURES

V. Šustr¹ & J. Huberl², ¹Academy of Sciences of the Czech Republic, Inst. of Soil Biology, Na sádkách 7, České Budějovice, 370 05, Czech Republic, E-mail sustr@upb.cas.cz; ²Research Inst. of Plant Protection, Drnovská 507, Praha 6, 161 06, Czech Republic.

The oribatid mite Galumna elimata was reared under laboratory conditions on algae (*Protocccus* spp.) at different temperatures (5-30°C) for 21 days. The ability of the physiological compensation of feeding activity for temperature was tested. Oxygen consumption of mites increased with temperature. This relationship was similar before and after acclimation, no compensation was observed. Presence of animals on algae food increased exponentially with temperature before acclimation, but it was higher at 15°C after acclimation at constant temperature. Defecation increased exponentially with temperature, the relationship was similar before and after acclimation. The food boluses contained algae or algae mixed with unknown fungal hyphae in individuals acclimated to 15 and 20°C. The concentrated mucoid substances prevailed in animals exposed to cold, indicating lower feeding activity at 5°C. However, the higher weight-specific amylolytic activity was found in the whole body homogenates of mites exposed to cold acclimation (5°C) in comparison with individuals acclimated to 15 and 20°C. The acclimation response of weight-specific amylolytic activity was accompanied by elevation of protein-specific amylolytic activity. Microanatomical features did not confirm any increased secretion activity of mesenteric and caecal cells in cold acclimated animals. Granulation and apocrine secretion of these cells increased with increasing temperature as with food ingestion. Based on these findings, we concluded that specific amylolytic activity reflected passively the different changes in protein composition of the body at different temperatures and its elevation is without direct adaptive importance. The results were used for preliminary estimation of production of fecal pellets during the year in natural conditions

Index terms: mites, respiration, defecation, amylase, acclimation.

[1181] INTERACTIONS OF MICROFLORA AND LARVAE OF BIBIONIDS IN TRANSFORMATION OF PLANT LITTER

V. Šustr & J.Frouz, Academy of Sciences of the Czech Republic, Inst. of Soil Biology, Na sádkách 7, České Budějovice, 370 05, Czech Republic, E-mall: sust@upb.cas.cz

Dipteran larvae play an important rule in soil of some deciduous forests. They may consume an important part of annual litter fall and produce large amount of faecal pellets, which may form an important part of fermentation horizon of some moder forest soils. The changes of leaf litter during the passage through the gut are important for consequent changes of faecal pellets. The quality of produced faecal pellets influence litter micro-flora and soil forming processes in the forest. We measured the changes of pH, direct counts of bacteria and pH optimum of enzymatic activity in digestive tract of larvae of Bibio marci and Penthetria holosericea (Bibionidae). The pH of the litter offered as a food was about 5. The gut content became highly alkaline (pH about 10) in anterior part of the midgut. pH decreased in the posterior part of the midgut and in the hindgut and excrements had neutral or slightly alkaline pH (about 7.5-8). The direct counts of bacteria decreased strongly in the midgut content in comparison with litter and midgut caeca. Their numbers increased again in freshly produced excrements. Similar pattern appeared when the excrements are re-consumed, but the absolute numbers of bacteria were higher. The pH optimum of amylase was about 10. Similar results were obtained in both species. In Penthetria holosericea, pH optima of other carbohydrases were 7 (trehalase and cellobiase) or 8 (maltase and saccharase). Bacteria killed in the anterior part of the midgut may be important food source for larvae and the utilization of bacterial assemblage growing in excrement can be one from the reasons for coprophagy. The pH optimum of amylolytic activity indicated, that maximum of amylase activity may be expected in alkaline anterior midgut where the bacteria were suppressed. This supported the idea that amylase is of animal origin. Recently, similar method is applied to receive some indication about the role of micro-flora and gut wall cells in production of other enzymes including enzymes of cellulase complex.

Index terms: Diptera, Bibionidae, digestion, bacteria, amylase.

[1182] RESPONSE OF APHYTIS MELINUS TO AN EXPERIMENTALLY-INDUCED OUTBREAK OF CALIFORNIA RED SCALE

<u>S. L. Swarbrick</u>¹ & W. W. Murdoch², ^{1, 2} Dept. of Ecology, Evolution & Marine Biology, Univ. of California, Santa Barbara, CA, 93106-9610, USA

Control of California red scale, Aonidiella aurantii, by the parasitic wasp, Aphytis melinus, is an outstanding example of successful biological. Scale populations are kept at very low densities and the abundance of both scale and parasitoid is remarkably constant over many The ecological processes underlying the success have not yet been generations. established. In these, as many other insect populations, it has been difficult to detect density-dependence. Nevertheless, our previous experiments suggest that regulation occurs on the local spatial scale.We are conducting a large-scale field experiment in a lemon grove in Fillmore, California, aimed at demonstrating the role of A. melinus in controlling red scale and at discovering the mechanisms producing the stable interaction between the host and parasitoid. We created scale outbreaks in individually-caged lemon trees by adding scale crawlers over a single generation (3 months). Controls are caged trees with no scale added and uncaged trees in the grove. We then measured abundance of red scale and A. melinus, and parasitism, as scale converged to ambient control density. The results show the parasitoid controlling and regulating the scale population with astonishing speed. Scale populations converged to ambient density within a year. There is a clear density-dependent response in parasitism by *A. melinus*. This suggests that failure to detect density dependence in previous studies may be due to the tightness of the regulation. Control occurred on individual trees, confirming previous suggestions that regulation of pest abundance occurs locally. Control may occur on an even smaller spatial scale. A previous experiment showed apparent convergence of scale to ambient density following an outbreak created on a single, large, caged branch of a grapefruit tree. Experiments to explore the detailed mechanisms are now in progress.

Index terms: Aonidiella aurantii, population regulation, biological control

[1183] DYNAMICS OF OCCURRENCE OF CRIOCERIS ASPARAGI (COL., CHRYSOMELIDAE) AS OBSERVED AT AN ASPARAGUS PLANTATION WITHIN A 15 YEARS' LASTING TIME LAPSE

<u>J. Szweida</u>, Research Institute of Vegetable Crops, ul. Konstytucji 3 Maja 1/3, 96-100 Skierniewice, Poland, E-mail jszwejda@inwarz.skierniewice.pl

Asparagus beetle (*Crioceris asparagi*) occurring at the same asparagus plantation in 1983, 1984 and 1999 was subjected to observations on its biology and intra-seasonal occurrence dynamics. In 1983 and 1999 - egg, larval and adult developmental stages were less numerous within the first than in the second generation of asparagus beetle, the situation in 1984, however, being reversed. Weather conditions have been found the most important factor affecting the occurrence of *C. asparagi*. Adult beetles were always observed at the end of April during the emergence of plants. Observations on location of eggs laid by females on asparagus in the three cited years have revealed that the most attractive plant part, comprising from 50 to 80 % of eggs laid were the "needles" and then flowers, lateral branches and main stems with shares reaching up to 25, 10 and 5 %, respectively. Studies on harmfulness of larvae have shown that five individuals can completely destroy the upper part of the stem causing a precocious yellowing and drying up of the asparagus plant. No significant differences in the time of adult occurring, egg laying and larvae developing have been stated between the study years compared.

[1184] THE INFLUENCE OF INCREASED ATMOSPHERIC CO2 AND TEMPERATURE ON NEPHOTETTIX CINCTICEPS LIFE CYCLES ANDECOSYSTEMS

O. Takahashi, 1, M. Okada 2, K. Kobayashi 3 & S. Kawabe3, 1 Dept.of Entomology, Iwate Univ. 3-18-8, Ueda. Morioka. Iwate 020-8550, Japan.; 2 Tohoku National Agricultural Experiment Station. 4 Akahira. Shimo-kuriyagawa. Morioka. 020-0123, Japan. 3 National Institute of Agro-Environmental Sciences. 3-1-1, Taukuba, Ibaraki 305-8604, Japan.

It is predicted that atmospheric CO2 concentration will increase up to about 560ppm by the middle of 21th century. Because CO2 is a "greenhouse" gas, the increase in atmospheric CO2 is also predicted to affect the Earth's temperature with expected increases of about 20 by the year 2050. This will affect the ecosystems and life cycles of insects. The increase in atmospheric CO2 will also have a large influence on the growth of host plants, mainly by increasing the rates of photosynthesis and growth. The nutrient content of plants grown under elevated CO2 has been shown to be different from that of plants grown under ambient CO2. Most importantly, protein content usually decreased. Lower plant protein content has been shown to decrease the survival rate and weight of larvae of some insect species. For rice at least, it has been shown that the plants derived from seed harvested from crops grown under elevated CO2 are more vigorous and have greater biomass than plants grown from seed from seed obtained from ambient crops. The reason for this is not known, however it is possible that this paternal effect also influences plant nutrient status. If this is the case, it is likely that insect growth and activity is different when feeding on these plants. It is aim of this study to test the combined effects of elevated CO2, temperature and seed source on the developmental and reproduction activity of the green rice leafhopper, Nephotettix cncticeps , on the rice. Here we report on the first results from this study and discuss its implications. Index terms: CO2, temperature, Nephotettix cncticeps

[1185] ECOLOGICAL AND EVOLUTINARY CORRELATIONS AMONG ACCEPTABILITY, OVIPOSITION PREFERENCE AND PERFORMANCE IN ZABROTES SUBFASCIATUS (COLEOPTERA, BRUCHIDAE)

I.R.V. Teixeira & F.S. Zucoloto, Depto. Biologia FFCLRP-USP. Av. Bandeirantes, 3900, 14040-900, Ribeirão Preto, SP, Brazil. E-mail: isabelfe@usp.br

Phaseolus vulgaris is considered the usual host to the Zabrotes subfasciatus eggs. The immature are limited to oviposition place, eating only this host. As Z subfasciatus, most insects have restricted diet. The ecological and economic importance of these species is unquestionable and there have been many discussions about the ecological and evolutionary aspects that influenced this condition. This work has as objective to study several factors related with the oviposition behavior and performance in different hosts and to understand how these behavior and performance develop and change throughout generations. Five hosts were used: 2 varieties of the usual host (A1 e A2) and 3 unusual hosts: Cicer arietinum (B), Glicine max (C) and Lens culinaris (D). For each host were done tests to measure acceptability (egg average), oviposition preference (egg % in each host, 1x1) and performance (adults emergency, number of offspring eggs and their emerging adults). The directional experiments to performance were done by observing each generation, when a newborn couple was placed to oviposit on same host that it developed (10 generations). The artificial selection was done to increase the oviposition on the less chosen host. In each generation newborn females from this host were placed to oviposit between the two hosts used. The experiments were developed between A1 and A2 and between A2 and B. The acceptability results showed the followed rank: the biggest was on A1, followed by A2, C, D and B. One preference hierarchy was revealed: 1-A1, 2-A2, 3-C, 4-D and 5-B. The performance was better in A1, followed by A2 and relatively good in B; in C and D there were no adult emergencies. The artificial selection of performance showed a notable increase in A1, A2 and B in only 7 generations. In only 5 generations, 70% of eggs already oviposited in A2 (initially, the less oviposited variety). However, between A2 and B there was any increase in B. These results suggest that descendent performance didn't influence directly the acceptability and preference. In this case, behavioral as physiological factors contributed to diet restriction. The performance showed a fast fitness increase in each host tested throughout generatons. The selection of preference showed that when 2 usual hosts varieties were used, this behavior had enough variability to permit a positive answer to selection that resulted in a preference inversion, which didn't occur when the host was the unusual, showing the behavior importance in size diet determination.

Index terms: Artificial selection, Fitness, hosts, behavior variation, hierarchy

[1186] POPULATIONAL FLUCTUATION OF *PANTHERODES PARDALARIA* (LEPIDOPTERA: GEOMETRIDAE) IN RIO GRANDE DO SUL STATE, BRAZIL

J. A. Teston^{1,3}, A. Specht^{1,2} & E. Corseuil^{1,4}, ¹ PPG-Biociências PUCRS, Av. Ipiranga, 6681, Caixa Postal 1429, CEP 90619-900, Porto Alegre, RS, Brasil; ² Curso de Agronomia, UNISUL, Av. José Acácio Moreira, 787, CEP 88704-900, Tubarão, SC, Brasil, E-mail: spechta@pucrs.br; ³E-mail: jateston@pucrs.br; ⁴E-mail: corseuil@pucrs.br.

Geometrid moths are characterized by their relatively small and fragile body with quite developed wings. These characteristics do makes them with that, among the macrolepidopterans, the ones with smaller dispersion capacity, what turns them particularly adapted for relationships with the environmental conditions of small areas. Pantherodes pardalaria is a common species in Rio Grande do Sul State and of easy identification due so its predominant yellow coloration with grayish circular stains which external borders and central areas darker. Its larvae feeds on plants of the genus Tecoma (Bignoniaceae), Urera and Boehmeria (Urticaceae), being considerate plagues of the ramie crop (Boehmeria nivea). Objectifying to verify the influence of different places and times, monthly collections were accomplished in 10 places (districts) of the State, from January to December 1998, with two black-light traps model "Pennsylvania", with lamps F15 T12 LN, in each place. In Iraí there were 1,860 sampled specimens; in São Pedro da Serra 824; in Lagoa Vermelha 195; in Camaqua 94; in Cachoeira do Sul 77; in Santana do Livramento 23; in Vila Maria 21; in Pelotas 5; in Piratini 5 and Mostardas 3. The multivariate analysis of variance indicate significant differences between the places and months. This significance, according to the places, highlighted Iraí, followed by São Pedro da Serra. In relationship to the months, it indicated differences with peak populational in August in the three places with larger abundance. In Iraí the peak was repeated in October, but the population stayed quite elevated during the three months. In relation to the presence in the samplings, this was constant in São Pedro da Serra (87.5%), Iraí (83.3%) and Camaqua (54.2%), accessory in Vila Maria (45.8%), Cachoeira do Sul (25.0%) and accidental in the other places, varying from 4.2% to 16.7%. In the areas where the collections were accomplished, it was observed the presence of Urera spp., which development begins in the end of the winter, being vulnerable to the conditions of extreme heat. The distribution and phenology of these plants determinate the abundance and constancy values of this moth on different places, being that some representatives can be found during the whole year in forests.

Index terms: Ecology, Ennominae, Population dynamic

[1187] POPULATIONAL FLUCTUATION OF PANTHERODES PARDALARIA (LEPIDOPTERA: GEOMETRIDAE) IN RIO GRANDE DO SUL STATE, BRAZIL

J. A. Teston^{1,3}, **A. Specht**^{1,2} & E. Corseuil^{1,4}, ¹ PPG-Biociências PUCRS, Av. Ipiranga, 6681, Caixa Postal 1429, CEP 90619-900, Porto Alegre, RS, Brasil; ² Curso de Agronomia, UNISUL, Av. José Acácio Moreira, 787, CEP 88704-900, Tubarão, SC, Brasil, E-mail: spechta@pucrs.br; ³E-mail: jateston@pucrs.br; ⁴E-mail: corseuil@pucrs.br

Geometrid moths are characterized by their relatively small and fragile body with quite developed wings. These characteristics do makes them with that, among the macrolepidopterans, the ones with smaller dispersion capacity, what turns them particularly adapted for relationships with the environmental conditions of small areas. Pantherodes pardalaria is a common species in Rio Grande do Sul State and of easy identification due so its predominant yellow coloration with grayish circular stains which external borders and central areas darker. Its larvae feeds on plants of the genus Tecoma (Bignoniaceae), Urera and Boehmeria (Urticaceae), being considerate plagues of the ramie crop (Boehmeria nivea). Objectifying to verify the influence of different places and times, monthly collections were accomplished in 10 places (districts) of the State, from January to December 1998, with two black-light traps model "Pennsylvania", with lamps F15 T12 LN, in each place. In Iraí there were 1,860 sampled specimens; in São Pedro da Serra 824; in Lagoa Vermelha 195; in Camaqua 94; in Cachoeira do Sul 77; in Santana do Livramento 23; in Vila Maria 21; in Pelotas 5; in Piratini 5 and Mostardas 3. The multivariate analysis of variance indicate significant differences between the places and months. This significance, according to the places, highlighted Iraí, followed by São Pedro da Serra. In relationship to the months, it indicated differences with peak populational in August in the three places with larger abundance. In Iral the peak was repeated in October, but the population stayed quite elevated during the three months. In relation to the presence in the samplings, this was constant in São Pedro da Serra (87.5%), Iral (83.3%) and Camaqua (54.2%), accessory in Vila Maria (45.8%), Cachoeira do Sul (25.0%) and accidental in the other places, varying from 4.2% to 16.7%. In the areas where the collections were accomplished, it was observed the presence of Urera spp., which development begins in the end of the winter, being vulnerable to the conditions of extreme heat. The distribution and phenology of these plants determinate the abundance and constancy values of this moth on different places, being that some representatives can be found during the whole year in forests.

Index terms: Ecology, Ennominae, Population dynamic.

[1188] INSECTS ASSOCIATED TO THE LONG PEPPER IN THE STATE OF ACRE, BRAZIL

M.J. Thomazini¹, ¹Embrapa Acre, P. O. Box 392, Rio Branco, AC 69908-970, Brazil, Email marcilio@epafac.embrapa.br.

The long pepper (Piper hispidinervum) is an arbustive plant, that occur naturally in fallow areas in the State of Acre, Brazil, mainly in Acre River Valley. This plant has being studied for obtaining essential oils that contain substances used in the production of biodegradable insecticides and fragrances. However, the process of domestication of this species, with the cultivation in commercial scale, can be a factor that leads to the appearance of pests. This research had the objective to determinate the main insects associated to the long pepper. The insects were collected, fortnightly, from May/98 to May/99, with an entomological net in 150 plants of an 0.5 ha experimental area at Embrapa Acre. Insects present in the inflorescence were observed in 20 plants of the germoplasm bank, during the rain season (October/98 to February/99), by walking around each plant during 4-5 minutes. This insects were collected using a mouth aspirator. After one year of insects sampling, using entomological net, 190 species were collected, but only 10 of them were collected frequently. The diversity and the amount of insects increased with the development of the plants. However, during the months of July, August and September (dry season) the population of insects was low, turning to increase in October (beginning of the rains). In the end of January the plants were cut for oil extraction, so the samplings started again only in March. The main insects collected were natural enemies such as lacewings (Chrysopidae), ladybugs (Coccinelidae) and wasps (Vespidae). The main phytopagous insects collected were crysomelids and cicadellids. The insects collected with entomological net and identified, at least, until genera were: Cerotoma tingomarianus, Diabrotica speciosa, Mormidea maculata, Cycloneda sanguinea, Homophoeta aeguinoetialis, Zulia entreriana, Doru lineare, Molomea sp., Polybia sp., Lebia sp., Maecolaspis sp. In the inflorescence of long pepper were collected mainly hymenopterous belonging to families Apidae (subfamily Meliponinae) and Halictidae. It was not detected any insect species that could be considered a pest of this crop and, probably, most of these insects come from crops surrounding the long pepper and use this plant as a shelter or alimentary suplementation.

Index terms: Piper hispidinervum, Coccinelidae, Apidae, insect diversity

[1189] POPULATION FLUCTUATION AND INFESTATION LEVELS OF THE CUPUAÇU FRUIT BORER, CONOTRACHELUS HUMEROPICTUS, IN AGROFORESTRY SYSTEMS IN STATE OF RONDONIA, BRAZIL

M. J. Thomazini¹, ¹Embrapa Acre, P. O. Box 392, 69908-970, Rio Branco, AC., Brazil, E-mail marcilio@cpafac.embrapa.br.

The cupuaçu fruit is one of the most promising crop to be explored commercially in the agroforestry systems at Brazilian North Region. Among the pests related to this crop, the fruit borer, insect belonging to the Conotrachelus genera, is the most important one due to its damages and for being disseminated in several states of the North Region. The C. humeropictus population was evaluated weekly during the period from March/98 to January/00 in 20 cupuaçu plants in two areas of the RECA Project, Nova California, RO, Brazil. In one of the areas, ten plants were chosen near to the forest to verify the influence of it in the intensity and in the beginning of the borer infestation. The insects were collected in a nylon screen (with four squared meters) placed under the cupuaçu treetop. The branches of the tree were shaked for five seconds approximately and the adults of the borer were counted on the nylon screen. For determination of fruit infestation the number of infested (with a hole of larval exit) and non infested fruits were recorded. The adult of C. humeropictus was collected in almost all the samples, but occurred at lower levels during the vegetative period. The population of this insect pest is directly related with the plant phenology and with the climate. Thus, the pest population level was higher at the stages of flowering and fruit formation and at the end of the harvest period, and lower in the dry season. It is important to point out that the insect distribution is not homogeneous in the region, existing areas with large infestation, others with less or without the presence of the insect. Some factors as the insect dispersion, cultural treatments, age and density of cupuaçu plants in agroforestry systems can determinate those differences. The plants sampled near the forest presented, during the study period, a larger number of adults than those sampled inside the cultivation area. Such fact demonstrates that the forest around the cupuaçu plants can serve as source of alternative hosts or shelter for C. humeropictus. Losses greater than 50% in fruits production were found in one of the areas in 98/99 season, due to the insect, which emphasize the importance of this pest in this region.

Index terms: Theobroma grandiflorum, Curculionidae, insect-pest, Occidental Amazonia

[1191] MIMETIC ASSEMBLAGES OF LYCID BEETLES IN SOUTHERN BRAZIL

<u>R. F. Torres</u>¹ & K. Del-Claro², ¹Federal University of Paraná, Dept. of Zoology; Home address: R. Carlos Cavalcanti, 19, ap.1702, Curitiba, PR, Brazil, 80020-280, e-mail: rodrigo@bio.ufpr.br ²Federal University of Uberlândia, Dept. of Biosciences, C.P. 593, Uberlândia, MG, Brazil, 38400-902, E-mail: delclaro@ufu.br

Lycid beetles are traditionaly considered aposematic models due to their conspicuous coloration and unpalatability. We would like to know if they participate of any Batesian/Müllerian mimetic relationship at Mananciais da Serra, a subtropical Atlantic Rain Forest area in southern Brazil (Piraquara city, Paraná State). Some classical premises of the Batesian and Müllerian minicries were tested in the field: mimics must resemble models in their conspicuous appearance and behaviour; mimics must occur at the same place (habitat) and time as models; mimics must be less abundant than their models. Collections of about 6 h intervals (morning and afternoon), along a 6 km transect, were carried out weekly for one year. All the insects that resembled the local lycid pattern in habitat, morphology and coloration (black-yellow-black transversal bands in the elitra) were captured with a hand net. Definition of models and mimics was based at the literature on chemical defenses and palatability to predators of the groups of insects studied. Models, which exhibited Müllerian mimicry among themselves, were in the following taxa (number of species in parenthesis): Coleoptera - Lycidae (3), Meloidae (1), Oedmeridae (1), Catharidae (5) and Lampyridae (3); Hemiptera - Coreidae (1). The Batesian mimics (Coleoptera) were: Cerambycidae (2), Belidae (1), Elateridae (1) and Chrysomelidae (3). Two mimetic complexes were distinguished: one with large models and mimics, the other with small ones. Models and mimics occurred sincronously, abundance of models being greater than that of minics along the year. Results were placed in relation to the hypothesis of the existence of a palatability and resemblance spectrum between models and mimics, and to the presence of local potential vertebrate and invertebrate predators. The study presents field evidences that suggest Batesian/Müllerian minicry relations between lycids and other insects in the area, and points out the species involved in such mimicries.

Index terms: Lycidae, Coleoptera, mimicry, aposematism, rain forest.

[1190] BIONOMICS OF THE CITRUS YELLOW MITE, EOTETRANYCHUS CENDANAI (TETRANYCHIDAE)

T. Thongtab¹, <u>A. Chandrapatya¹</u> & G.T. Baker², ¹Dept. of Entomology, Kasetsart Univ., Bangkok 10900, Thailand, E-mail agramc@ku.ac.th; ² Dept. of Entomology and Plant Pathology, Box 9775 Mississippi Sta. Univ., Mississippi State, MS, USA 39762

Eotetranychus cendanai Rimando was found on six different citrus plants and two are new host records: Citrus hystrix DC., Citrus aurantifolia Swingle, Citrus reticulata Blanco, Citrus maxima (Burm. f.) Murr., x Citrofortunella microcarpa (Bunge) D.O. Wijnands (new record) and Murraya paniculata (Linn.) Jack (new record) in 34 provinces and completed its life cycle on the five edible host plants under the study. The egg, larva, protonymph and deutonymph stages lasted 4.8-5.8, 1.52, 1.1-1.8 and 1.24 days. Completion of the life cycle required 11.20-13.97 days. A fertilized female produced 6.30-26.38 eggs (0.96-2.43 eggs/days). Female longevity lasted 6.55-10.52 days. Fertilized females produced offspring with sex ratio of male: female 1:1.02-1:2. Life table study of *E. cendanai* indicated that net reproductive rate of increase (Ro) = 14.1 times, cohort generation time (Tc) = 17.37 days, intrinsic rate of increase (r_m) = 0.156

individual/day and finite rate of increase $(\lambda) = 1.165$. Major mortality occurred during larval stage followed by nymphal and egg stages. Index terms: *Eotetranychus cendanai*, citrus plants. [1192] MIMICRY DYNAMICS OF WASPS AND OTHER INSECTS IN SOUTHERN BRAZIL R. F. Torres¹ & K. Del-Claro², ¹Federal University of Paraná, Dept. of Zoology: Home

R. F. Torres¹ & K. Del-Claro², ¹Federal University of Paraná, Dept. of Zoology; Home address: R. Carlos Cavalcanti, 19, ap.1702, Curitiba, PR, Brazil, 80020-280, e-mail: rodrigo@bio.ufpr.br ²Federal University of Uberlândia, Dept. of Biosciences, C.P. 593, Uberlândia, MG, Brazil, 38400-902, E-mail: delclaro@ufu.br

Stinging wasps are traditionaly considered aposematic models due to their outstanding appearance and behaviour associated with unpalatability. We would like to know if they participate of any Batesian/Müllerian mimetic relationship at Mananciais da Serra, a subtropical Atlantic Rain Forest area in southern Brazil (Piraquara city, Paraná State). Some classical premises of the Batesian and Müllerian mimicries were tested in the field: mimics must resemble models in their conspicuous appearance and behaviour; mimics must occur at the same place (habitat) and time as models; mimics must be less abundant than their models. Collections of about 6 h intervals (morning and afternoon), along a 6 km transect, were carried out weekly for one year. All the median-sized black-bodied Vespidae and the other insects that resembled them in habitat, morphology, size, coloration and behaviour were captured with a hand net. Stinging wasp species, all with the same vespid pattern, were defined as models, and only their high fidelity mimics were studied. Models, which exhibited Müllerian minucry among themselves, were in the following taxa (number of species in parenthesis): female Hymenoptera - Vespidae (5), Sphecidae (1), Pompilidae (2) and Halictidae (1). The most numerous model was the vespid Polybia (Trichothorax) minarum. Batesian mimics were: Diptera - Syrphidae (3), Tabanidae (1) and Asilidae (1); Lepidoptera - Ctenuchidae (1); Hymenoptera Ichneumonidae (4), Formicidae (1) and male Pompilidae (2). Models and mimics occurred sincronously, abundance of models being greater than that of mimics along the year. Results were placed in relation to the hypothesis of the existence of a palatability and resemblance spectrum between models and mimics, to the central role played by aculeate Hymenoptera as models in many mimicry complexes, and to the presence of local potential vertebrate and invertebrate predators. The study presents field evidences that suggest a Batesian/Müllerian mimicry complex involving wasps and other insects in the area, and describes the mimetic aspects of such species.

Index terms: Hymenoptera, Diptera, Lepidoptera, aposematism, rain forest.

[1193] MIGRATION, METAPOPULATIONS, AND LANDSCAPES: RECENT DEVELOPMENTS

J.M.J. Travis, Climate Impacts Group, Department of Ecology, Plant Ecology, Lund University, SE-223 62 LUND, Sweden, E-mail justin.travis@planteco.lu.se.

Throughout the last decade we witnessed the development of an extensive literature investigating metapopulation processes. Much of the earlier work was theoretical in nature, but more recently an increasing number of field studies have been published demonstrating that many of the model predictions do occur in real populations. In this contribution, recent developments in metapopulation biology will be reviewed. Using entomological examples, the key roles that are played by dispersal and landscape structure will be emphasised. Dispersal is the process that holds the constituent subpopulations together, and as such is critical to the functioning of the metapopulation as a whole. Most metapopulation models assume a fixed, density-independent rate of dispersal between patches, and also make simplifying assumptions about the distance of dispersal. However, empirical results show that a rich variety of different forms of dispersal exist. Thus, there is an urgent need for models that incorporate more realistic dispersal functions. Dispersal is also likely to be under different selection pressures in a fragmented habitat than would act in a pristine landscape, and this too may have important consequences for metapopulation processes. Landscape structure is a second key determinant of the form of metapopulation dynamics that will be observed. Recently progress has been made linking more realistic landscape patterns with traditional metapopulation models. There is a continuing need to bring the disciplines of Landscape Ecology and Population Ecology closer together.

Index terms: migration, dispersal, metapopulations, landscapes, evolution

[1195] ANALYSIS OF SPECIFIC ADAPTATION TO A DOMICILE HABITAT: A COMPARATIVE STUDY OF TWO CLOSELY RELATED COCKROACH SPECIES

C. W. Tsai & H. J. Lee, Dept. of Entomology, National Taiwan University. No. 1 Roosevelt Rd., Sec. 4, Taipei 106, Taiwan. E-mail: m480@ccms.ntu.edu.tw

The German cockroach, Blattella germanica and the double-striped cockroach, B. bisignata are closely related species. Both of them are belonging to the germanica species-group and have similar appearances, life history characters, reproductive cycles, and courtship behaviors. One of their significant differences is their living habitat: B. germanica is a domicile species, but B. bisignata lives in field. When we kept 20 pairs of B. germanica and B. bisignata together in a small space (2 litters) for 3 months, B. germanica out competed B. bisignata and drove the latter to extinction. It decreased its newly emerged adult body weight and increased its mortality, when B. bisignata was reared in group. We found no evidence of aggregation pheromone and gregarious behavior existing in B. bisignata. From the results of mate preference experiment, females B. germanica only accepted conspecific males as mates, but females B. bisignata could equally accept both species as mates when the long distance calling was bypassed. Based on an unique characteristic of domicile habitat, limited space, *B. germanica* strives with the help of aggregation pheromone and gregarious behavior. Its keen discrimination for conspecific mates at close range certainly helps maintain species integrity in the limited crowd environment. In addition, its high reproductive potential keeps the leading edge in the competition with B. bisignata.

Index terms: Blattella germanica, Blattella bisignata, competition, aggregation pheromone, mate preference.

[1194] CLIMATE CHANGE, DISPERSAL AND INSECT BIODIVERSITY

J.M.J. Travis, Climate Impacts Group, Department of Ecology, Plant Ecology, Lund University, SE-223 62 LUND, Sweden, E-mail justin.travis@planteco.lu.se.

Climate change poses a major potential threat to insect biodiversity. This poster briefly reviews current knowledge of the various effects of changing climatic conditions on insect species, and highlights some less considered problems that may affect many insect species. It has been suggested previously that species with good dispersal characteristics are more likely to be able to shift their ranges in response to climate change than more sedentary species. This makes intuitive sense, and for plant species may be the single most important factor determining whether a species will persist. However, for many insect species the problem is more complex. For example, there is likely to be a difference between the response of specialists and generalists. A generalist species with good dispersal capabilities is best suited to tracking changing climatic conditions, as it can migrate with the climate and feed on a species it finds in the new part of its range. This is not necessarily true for a specialist species, even a highly dispersive one, as the species it feeds on may not yet be present in the new region. There are many other ways in which the interaction between species characteristics (such as dispersal) can determine the nature and extent of the problems faced by a particular species during climatic change. Dispersal is likely to be under strong selection during range shifting events, and the selection pressures may be very different to those exerted when the climate (and ranges) are stable. Model results illustrate the way in which dispersal is likely to evolve during range shifting events.

Index terms: migration, dispersal, range shifting, biodiversity, climate change, evolution

[1196] THE ROLE OF FRASS-COVER ON INSECT EGGS: FROM THE VIEWPOINT OF PARASITIZATION REDUCTION

M. Tsukada, Entomology Laboratory, Faculty of Bioresources, Mie University, Tsu, Mie 514-8507, JAPAN, E-mail: tsukada@bio.mie-u.ac.jp

Frass-covering on eggs is known from many insect species. However, its ecological significance has not been explicitly documented. I examined the effects of frass covering the overwintering eggs of andromeda lace bug, Stephanitis takeyai (Heteroptera: Tingidae), on egg parasitization rate by the wasp, Anagrus takeyanus (Mymaridae). S. takeyai is trivoltine in central Japan, and usually alternates its host plants seasonally. In such a habitat, most wasp individuals in the overwintering eggs of the bug, which are inserted into living leaves of an evergreen shrub, enter summer diapause immediately after winter diapause. The parasitization rate in this generation is ca. 80 %. When the wasp was experimentally excluded by fine meshed gauze during ovipositional period of the bug, the hatchability of eggs was nearly 1.0. Therefore, if the frass cover reduces parasitization rate, it would directly increases the fitness of the mother. The estimated rate was significantly lower in egg masses covered by frass (0.72) than in uncovered egg masses (0.82). Although the difference in parasitization was only 10 % between them, the hatchability was 50 % higher in egg masses with the cover than without, due to the high parasitization rate. Though the egg-mass size was significantly larger in the masses with cover (48.6) than that without cover (27.8), there was no positive or negative relationship between egg-mass size and parasitization rate. Therefore, at least in the winter season, parasitization by the wasp is the main mortality factor of the eggs, and frass cover on the egg mass functions as a parasitization avoidance mechanism.

Index terms: Stephanitis takeyai, Anagrus takeyanus, egg parasitoid, oviposition, maternal care.

[1197] A TRITROPHIC ANALYSIS OF HOST PREFERENCE AND PERFORMANCE IN THE POLYPHAGOUS LEAFMINER LIRIOMYZA HUIDOBRENSIS

<u>G. Valladares</u>^I, A. Salvo^I & M. Videla^I, ¹ Centro de Investigaciones Entomológicas, F.C.E.F.Y.N., Univ. Nac. Córdoba, Av. Vélez Sársfield 299, (5000)-Córdoba, Argentina, E-mail: grv@onenet.com.ar.

Most species in Agromyzidae (Diptera) show close association to a species or genus of plant host. Liriomyza huidobrensis (Blanchard) is one of the rare polyphagous species as well as one of the most important pests in the family. Oviposition preferences of this leafminer within its local host range in Central Argentina were analysed, considering consequences for larval development and translation of such plant-insect relationships into the third trophic level (parasitoids). Infestation levels, suggesting apparent preferences, were estimated from field samples taken fortnightly in various crops at Córdoba (Argentina) along 2 years. Larvae were reared to assess percentage parasitism, and to measure adult body size of leafminer and parasitoids. In laboratory tests, host preferences and larval performance (as development time, survival, pupal weight and adult size) were further assessed, on three selected plant species (Vicia faba, Phaseolus vulgaris, Cucurbita maxima). L. huidobrensis was recorded on 24 crop species, its density noticeably varying among them. Adult leafminers were significantly bigger on plants where the species was more abundant. Parasitoid assemblages on the leafminer differed among host plants, regarding number of species (2 - 12 Hymenoptera species, their richness being associated to sample size), parasitism rate (between 2% and 77%, being independent of host abundance or number of species involved), and relative representation of the main parasitic species. Average body size of particular parasitoid species significantly increased on plants where leaf mining larvae were also bigger. In the laboratory, L. huidobrensis females consistently preferred V. faba for feeding and ovipositing. Larval development time was significantly shorter, while survival was 2.5 times higher and adults reached bigger size on the former plant than on the other hosts. In almost every aspect considered, a pattern of decreasing preference and performance on V. faba - P. vulgaris - C. maxima was observed, in coincidence with the tendency for infestation levels observed in the field. From these observations, Liriomyza huidobrensis appears as a very efficient generalist, being able to select the most adequate plant hosts from among its wide range, and developing greater populations on such hosts. Plant host suitability did not seem to be obviously altered by parasitoids, although some parasitoids benefited from the higher performance of the leafminers, attaining bigger body size on plants where their hosts were bigger.

Index terms: host selection, insect-plant interactions, parasitoids, Agromyzidae

[1198] EFFECT OF HABITAT TYPE ON AQUATIC INSECTS IN FOUR STREAMS OF PATAGONIA (ARGENTINA)

S.M. Velasquez¹ & <u>M.L. Miserendino¹</u>, ¹Laboratorio de Ecología Acuática. Universidad Nacional de la Patagonia, Sede Esquel, Sarmiento 849, 9200 Esquel, Chubut, Argentina, E-mail Jauram@teletel.com.ar

Streams and rivers contain a variety of habitats with different physical and chemical conditions. The availability of habitats, as well as the benthic resources and the nature of their faunal assemblages, have been focus of several researchs. The benthic community pattern in relation to the habitat type is an unknown aspect in Patagonian rivers. In this study, we examined the distribution of aquatic insect communities among habitat types in four Patagonian streams. The studied streams were located in the Patagonian Andes (41° 26' S, 71º 26' W). The main differences among rivers were in stream order, discharge and species of the riparian vegetation. The streams studied were Blanco, Baguilt, Rifleros and Nant y Fall; in each stream one representative reach was sampled twice in both low and high water period. Stream habitat composition was defined as: sand (S), cobble (C). boulder (B), leaf-pack (LP) and aquatic plants (AP). Three random benthic insect samples were collected from each habitat type, at each stream, on each sampling date. Samples were obtained using a Surber net (250 µm mesh). All organisms captured were fixed with formalin (4 %), and in the laboratory were preserved with ethanol (70 %). Communities were dominated by insects of the orders Ephemeroptera (Meridialaris chiloeensis, M. laminata), Trichoptera (Brachisetodes major, Smicridea sp., Parasericostoma ovale), Diptera (Paratrichocladius sp) and Plecoptera (Aubertoperla illiesi, Klapopteryx kuscheli). A few species were able to live in unstable substrates such as sandy bottoms. Specific richness was higher in leaf-packs and aquatic plants than in boulders and cobbles. Our results suggest that habitat types in riffles support more abundance and biomass than habitat pools.

Index terms: riffle habitats, leaf pack habitats, aquatic plants, abundance, specific richness.

[1199] INTRAGUILD INTERACTIONS IN AN ARTHROPOD FOOD WEB ON PLANTS

M. Venzon¹, A. Janssen² & M. W. Sabelis², ¹Agriculture and Livestock Research Enterprise of Minas Gerais (EPAMIG), 38001-970, Uberaba, MG, Brazil. E-mail venzon@bio.uva.nl; ²Section Population Biology, University of Amsterdam, Kruislaan 320, 1098 SM, Amsterdam, The Netherlands, E-mail janssen@bio.uva.nl.

In theory, intraguild predation can affect dynamics of herbivores and their natural enemies and this may cascade down to effect on plants. Although several empirical studies reported on effects of intraguild predation on predator-herbivore dynamics, only few have considered effects on plants. Including effects on plants is important because intraguild predation modifies the effectiveness of plant defence through its interaction with the herbivore's enemies. We studied the effects of a generalist (intraguild) predator (Orius laevigatus) on population dynamics of the specialist predatory mite Phytoseiulus persimilis and the herbivorous mite Tetranychus urticae, and on the performance of cucumber plants in a greenhouse. Behavioural studies showed that the generalist predator and the specialist mite predator were both attracted to plants infested by herbivorous mites and that each of the two predators did not avoid plants occupied by the other predator. Observations on foraging behaviour of the generalist predator further showed that it attacks and kills large numbers of specialist predators and herbivores, suggesting a possible role for intraguild predation on herbivore densities and plant performance. However, addition of the generalist predator to populations of herbivorous and predatory mites on cucumber plants had small effects on herbivore numbers and no effect on predator numbers, plant weight and fruit weight. We discuss possible biological mechanisms causing the absence of effects. Moreover, we argue why this absence is important for biological control as well as for understanding of the evolution of indirect plant defense.

Index terms: Orius laevigatus, Phytoseiulus persimilis, Tetranychus urticae, behaviour, olant performance

[1200] BIOLOGICAL AND NUTRITIONAL ASPECTS OF ANTICARSIA GEMMATALIS (LEPIDOPTERA: NOCTUIDAE), RAISED ON SOYBEAN, PEANUT AND ARTIFICIAL DIET

H. V. Vescove¹, A. T. Murata² & S. A. De Bortoli³, ¹Depto. de Fitossanidade, Univ. Estadual Paulista, CEP. 14870.000, Jaboticabal, SP, Brasil, E-mail: vescove@bol.com.br (bolsista CNPq/PIBIC). ²Depto. de Biologia, Univ. de São Paulo, CEP 14040.901, Ribeirão Preto, SP, Brasil (Fapesp fellowship). ³Depto. de Fitossanidade, Univ. Estadual Paulista, CEP 14870.000, Jaboticabal, SP, Brasil.

The work was carried out to study biological and nutritional aspects of Anticarsia gemmatalis raised on soybean (varietis Foscarin and IAC17), peanut and artificial diet, under lab conditions ($T = 27\pm2^{\circ}C$, $UR = 70\pm10\%$, and 14 hours of photophase). The experimental design used 4 treatments and 10 replications, being evaluated the folowing parameters: length of each larvae instar, length of larvae period, final larvae weight, weight of each larvae instar and pupae, larvae mortality, and sexual rate. Also, the nutritional indexes were obtained to the fourth larvae instar. According to the results, larvae raised on peanut showed the longest larvae period (15 days), being 13.2 and 13.1 days to the Foscarin and artificial diet, respectively. The sexual rates to the larvae raised on Foscarin, IAC17, peanut and artificial diet were 0.55, 0.60, 0.65 and 0.65, respectively. The greatest consumption was observed to the artificial diet (520.06 mg) and the greatest digestibility (44.25%).

Index terms: velvetbean caterpillar, nutrition indexes, biology, Glycine max, Arachis hypogaea

BAHIA, NORTHEAST BRAZIL

B. F. Viana¹ & A. M. P. Kleinert², ¹Dept. de Zoologia, Inst. de Biologia, Univ. Federal da Bahia/UFBA, Salvador, BA, Brazil, ZIP 40.170-290, E-mail: blande@ufba.br; ²Dept. de Ecologia, Inst. de Biociências, Univ. de São Paulo/USP, São Paulo, SP, Brazil, ZIP 05.508-900.

Aspects of the community structure of Apoidea of a restricted area of dunes with "restinga" vegetation in Salvador (12°56'S; 38°21'W) Bahia State of Brazil were analysed. Samplings, with standardised methodology, were accomplished for 1 year, 3 times a month of the 6:00 a.m. at the 6:00 p.m. A total of 3983 individuals (3770 females and 213 males) of 49 species, belonging to 5 families were collected on the flowers. The fauna of Abaeté is composed, in its majority for solitary bees of big load, whose larger representative, so much in species as in individuals, it is of Anthophoridae (26 and 2373, respectively) proceeded by Apidae (10; 1321); Halictidae (6; 159); Megachilidae (5; 105) and Colletidae (2; 25). The bees were active during the whole year, presenting picks in the period of low rainfall. The daily activity was larger between 8:00 a.m. and 2:00 p.m., coinciding to the period in that the relative humidity decreased and the temperature increased. The abundance pattern and the richness were plenty similar to the other studies accomplished in similar habitats in the Brazilian Northeast. 49% of the species sampled were represented for less than 8 individuals and 6 species were abundant representing 84% of the total individuals collected. The rainfall associated with the availability of resources seems to be the main factors regulators of the bees' flight activity in Abaeté, along the year. The foraging activity was related positively with the intensity of flowers in the field (r=0.68; p <0.05).

Index terms: Community structure, Apoidea, Hymenoptera, Coastal sand dune.

[1202] GROUND BEETLE COMMUNITY STRUCTURE AS A BIOINDICATOR OF FOREST HEALTH IN TWO PINE-BUNCHGRASS ECOSYSTEMS SUBJECTED TO DIFFERENT DISTURBANCE EVENTS

J. Villa-Castillo & M. R. Wagner, School of Forestry, Northern Arizona University, P. O. Box 15018, Flagstaff AZ 86011, USA, E-mail jvc@dana.ucc.nau.edu.

Forest health in northern Arizona Pinus ponderosa forest has declined since European settlement. Reintroduction of fire and thinning are the main practices suggested to regain forest health. We designed a landscape-level experiment to evaluate forest stand treatment impact on ground-beetle (Coleoptera: Carabidae) community structure and evaluate its potential use an indicator of forest health. A gradient from low-to-high disturbance was established. The treatments across the gradient were: unmanaged stands, thinned-only stands, thinned plus prescribed burned stands, and wildfire burned stands. A thorough screening of 100 stands was carried out to select 4 homogeneous replicates per treatment. During the summer of 1998 and 1999 we recorded ground-beetle species caught in pitfall traps. Ten traps were located in a circular fashion in the center of each 20-40 ha stands. We addressed the influence of time after disturbance on forest health by sampling ground beetles in Pinus hartwegii stands in Nevado de Colima National Park, Mexico. We located stands where salvage logging after bark beetle attack was undertaken 2, 5, 11 and 15 years previously. The control treatment was established on currently infested stands without salvage logging. In northern Arizona, we collected as many as 20 species of ground beetles in thinned plus prescribed burning and wildfire sites, and as few as 2 species in unmanaged and thinned-only stands. Lower diversity was also found in Nevado de Colima, Mexico stands being both recently bark-beetle attacked and logged. Older disturbed sites had greater diversity, than recently disturbed sites but diversity was still low. Results in Nevado de Colima are strikingly similar to those in Northern Arizona treatments where fire was not a treatment factor. We concluded that ground beetle community structure has great potential as a bioindicator of forest health in relatively simple pine-bunchgrass ecosystem types.

Index terms: Carabidae, diversity, Pinus ponderosa, Pinus hartwegii, forest health

[1203] ADAPTIVE POTENTIAL OF THE SWEET-POTATO WHITEFLY BEMISIA ARGENTIFOLII TO SEVERAL HOST PLANTS

G. L. Villas Bóas¹, F. H. França¹ & N. Macedo², ¹Embrapa Hortaliças, Caixa Postal 218, 70.359-970. Brazilia-DF. Brazil. E-mail: geni@cnph.embrapa.br; ² CCA/UFSCar, Caixa Postal 153, 13600-000. Araras-SP.

The sweet-potato whitefly *Bemisia argentifolii* (Homoptera: Aleyrodidae) is potentially damaging for several crops and ornamentals. The objective of this research was to determine the adaptation of the pest to poinsettia, cabbage, beans, zucchini, cassava, tomato and corn by the determination of life table parameters important to support the establishment of IPM strategies. The experiments were carried out at the Experimental Station of Embrapa Hortaliças, located in Brasilia from November 1998 to September 1999 in BOD chambers and greenhouse. The biological development of the sweet-potato whitefly was studied from a population base generated from poinsettia cuttings obtained in Cassava (2.7 \pm 0.4 eggs) and corn (1.9 \pm 0.3 eggs). Pre-imaginal development was lowest in cabbage and beans (20.5 \pm 0.3 and 21.9 \pm 0.7 days, respectively). Highest pre-imaginal mortality was found in cassava (98 \pm 1.3 %) and corn (94 \pm 2.8 %) suggesting that the pest has not adapted to the hosts. Sexual ratio female: male usually favored females in crom (3:1), tomato (2:1), zucchini (1.5:1); ratio was similar on cabbage (1:1) and poinsettia (1:1), and for cassava it was 1:2.

Index terms: biology, host plant, poinsettia, tomato, cabbage.

[1204] CLIMATE DETERMINED PATTERNS IN THE OUTBREAKS OF THE AUTUMNAL MOTH (*EPIRRITA AUTUMNATA*, LEP.: GEOMETRIDAE)

T. Virtanen¹ & S. Neuvonen², ¹Section of Ecology, Dept. of Biology, Univ. of Turku, Finland. Present address: Finnish Forest Research Institute, Rovaniemi Research Station, P.O. Box 16, 96300 Rovaniemi, Finland. E-mail tarmo.virtanen@metla.fi, ²Kevo Subarctic Research Institute, Univ. of Turku, 20014 Turku, Finland

Outbreaks of E. autumnata occur in northern and mountainous parts of Fennoscandia. Occasionally mountain birches (*Betula pubescens* ssp. czerepanovi) are killed over large areas. Earlier it has been found that the driving factors behind the population cycles of E. autumnata consist of delayed negative feedbacks caused by parasitoids and delayed induced resistance of host trees, but the areal distribution and intensity of outbreaks is affected by climate. We have studied (1) how the distribution of the outbreak areas of E. autumnata can be explained and modelled on the basis of altitude-related egg-killing winter minimum temperatures, (2) how summer temperatures (directly and via lower and higher trophic levels) affect the populations of E. autumnata, (3) how predicted climate warming could affect to these relations. Utilizing a digital elevation map with a GIS, we developed models for egg survival and minimum temperature, taking into account altitude and local topography. In our study area from 1961 to 1991 more than 33% of the years had eggkilling winters in the mixed birch-pine forests zone, and 15% of years in the healthy birch forest zone. So, during that time outbreak possibilities were noticeably restricted by winter minimum temperatures. During the larval period of E. autunnata, we found differences in both food plant quality and parasitism between sites in an altitudinal gradient. Differences in the performance of *E. autumnata* were related to temperature conditions: at higher temperatures survival and the egg production index were lower, and larval parasitism was higher than at lower temperatures. The higher parasitism at higher temperatures was probably due to greater parasitoid activity during warmer days. In a comparison of different sources of spatial and annual variation in the performance of E. autumnata, the most important factor appeared to be winter time egg mortality, followed by parasitism, and finally the variation in food plant quality. If climate warms as predicted, the birch-growing areas in our study area protected by low temperatures from outbreaks will be only one third as great as that of today by the middle of the next century. On the other hand, the effects of warmer summers on the outbreaks suggest decrease in outbreak intensity. It seems that more quantitative data would still be needed, if we want precisely evaluate the net outcome of a warmer climate for the population dynamics of E. autumnata.

Index terms: Epirrita autumnata, Insect outbreaks, Climate change, GIS.

[1205] ASSESSING THE HISTORICAL AFFINITIES OF NEOTROPICAL BEETLE FAUNAS AT A JOINT UK-BELIZEAN FIELD SITE

<u>A. P. Vogler^{1,2}</u>, D. J. G. Inward^{1,2} & T. G. Barrraclough², ¹Department of Entomology, The Natural History Museum, Cromwell Road, London, SW7 5BD, and ²Department of Biology, Imperial College at Silwood Park, Ascot, Berks SL5 7PY, UK

The Natural History Museum (London) is operating a field station in the Cayo District of the Maya Mountains south western Belize, jointly with the Belizean Ministry of Forestry. Before the establishment of this research facility some five years ago, very little faunistic and taxonomic work had been done in this area in the centre of the largest contiguous tropical forest in Central America stretching across the border with Guatemala's Peten region. Only very limited resources for survey work on insects was available, but it was desirable to have basic information on the kind of taxa present in the area. To establish a rough categorisation of the insect fauna at this site we pursued a strategy whereby the local fauna is put in the context of existing information from literature and the collection of the NHM, focussing on three taxonomically narrow groups of insects that had been readily collected during a short field trip to the site. These included Scarabaeidae, Cerambycidae (both Coleoptera), and Sphingidae (Lepidoptera). We first established the geographic ranges of the species encountered, based on literature and collection records. Similarly, geographic ranges for closely related species (species in the same genus) were recorded, and the presence of each species in five major geographic regions of Central America was established. Comparisons of geographic ranges were then made for the focal species and their close relatives. This crude measure of distribution revealed strong geographic patterns and is informative with regard to the evolutionary affinities of these taxa. Broadleaf tropical forest harboured mostly species with highest diversity in the Neotropics, whereas a nearby pine-oak forest had a major Nearctic element, indicating that plant communities and insect assemblages share common geographic origins. In dung beetles, a mostly tropical group, however, the assemblage of the pine-oak forest essentially constitutes a subset of the species found in the broadleaf forest, but there were several cases where each forest type harboured a different, but closely related species. This type of analysis can provide valuable information on historical processes of species movements and lineage splitting. A more detailed analysis carried out on dung beetles is now underway, based on information on phylogenetic relationships from molecular data. Because of the need for recently collected material in DNA studies, the Maya Mountain and many other Neotropical sites are an extremely important resource for molecular work. Index: biodiversity survey; faunal affinities; dung beetles; Belize

[1206] FACTORS LIMITING THE RED IMPORTED FIRE ANT (SOLENOPSIS WAGNERI) IN ITS NATIVE RANGE IN BRAZIL

K.M. Wackford¹ & D. H. Feener, Jr.², ^{1,2} Dept. of Biology, Univ. of Utah, 257 South 1400 East, SLC, UT, 84112-0840, USA, ¹ E-mail: wackford@biology.utah.edu, ² E-mail: feener@biology.utah.edu

Invasive species which assume dominant, destructive roles in their new communities are often much less dominant in their native ranges. In many cases, invasive species are successful in new locales because they have left behind key competitors, predators, pathogens, or parasites. Although the Red Imported Fire Ant (Solenopsis wagneri) has been a major pest invader in the US for over fifty years, to date no studies have comprehensively examined its ecological interactions in its native range in Brazil. In Brazil, the fire ant is a dominant competitor, and may be the most dominant ant in its preferred habitat of short grass. However, is does not achieve the levels of monodominance that it does in the U.S. Instead, it shares both short and tall grass habitats with at least twenty other species of directly competing ants. In a four-year study, wc examined three interacting factors that limit the fire ant in its native range: competition, flooding, and parasitoids. The ants Camponotus rufipes and Paratrechina fulva are superior competitors to the fire ant, but prefer less-flooded locations in taller grass. Seasonal flooding forces the movement of fire ant nests and intensifies competition between fire ants and superior ants by forcing them to occupy the same tall grass habitats for part of the year. Flooding may also favor competitively inferior ants that can colonize short grass areas after floods more rapidly than fire ants. The presence of multiple species of species-specific phorid parasitoids restricts the foraging of fire ants and decreases their competitive ability. Here we evaluate of the importance of several factors; competitive superiors, flooding, and parasitoids, to the limitation of the fire ant in its native range.

Index terms: Solenopsis invicta, Camponotus rufipes, Paratrechina fulva, flooding, Pantanal

[1207] COMPETITION BETWEEN TWO ARMORED SCALES FOR CITRUS LEAVES COLONIZATION

M. A. Watanabe¹, F. J. Tambasco¹, E. A. B. De Nardo¹, R. I. Viana¹ & G. D. Pereira¹, ¹Laboratório de Quarentena Costa Lima, Embrapa Meio Ambiente, P. O. Box 69, 13820-000 Jaguariúna, SP, Brazil. E-mail watanabe@enpma.embrapa.br.

Seven citrus orchards located in São Paulo State citrus region were monthly monitored for armored scale population dynamics studies. The most abundant species are the rufous scale Selenaspidus articulatus and the black scale Parlatoria ziziphi, where the first one is the dominat species. The P. ziziphi population only increases in the absence or drastic reduction of the former. A random sample of 100 leaves were collected from each orchard and each leaf was examined under stereomicroscope for species identification and counting. The population dynamices data were plotted against time and the pairs of graphics for these species compared for examination of alternance in the incidence, what is an indication of alternate ecological niche occupation. Correlation with mean monthly temperature and precipitation was also examined. S. articulatus scale occurred in high densities during the wet and hot season from October to March. During the dry and cold season from April to September, its incidence was low. No correlation with temperature and precipitation was found for P. ziziphi which incidence is poorly affected by climatic factors. Each female of S. articulatus lays an average of 150 eggs, whereas P. ziziphi female an average of 34,3 eggs. Thus under favourable conditions - wet and hot season the former species population -+6 --* builds up rapidly, winning the competition. During the dry and cold season, after S. articulatus death, P. ziziphi succeeds establishing in the vaccant ecological niche, its number even surmountign that of the former species.

Index terms: Selenaspidus articulatus, Parlatoria ziziphi, population dynamics, competition

[1208] INVESTIGATIONS INTO CARABIDES AT TYPICAL HABITATS OF THE NATURE RESERVE AND WINE GROWING REGION "SÜBER SEE", SACHSEN-ANHALT, GERMANY

C. Weinhold & K. Epperlein, Inst. of plant breeding and plant protection, Martin-Luther-Univ. Halle-Witten-berg, 06108 Halle/Saale, E.-Abderhalden-Str. 27, Germany

The investigation area is a nature reserve. The whole area is characterized by an especially warm and dry climate which allows to grow wine at this latitude. Investigations into the carabid fauna were carried out from spring 1998 until spring 2000. Nine plots with different types of cultivation and stages of intensity were chosen as typical habitats. So investigation plots were established at arable land, wine- and fruit-growing land, an uncultivated meadow on a north slope and a relatively moist forest habitat around a spring. In each investigation area 6 pitfall traps were installed and emptied regularly around the year. After 2 vegetation periods the results show that this highly parcelled out area is habitat for a high number of carabides. 89 different species were be registered of which 17 species are listed in different categories in the Red Data List of Sachsen-Anhalt. The occurrence of Acupalpus interstitialis (Reitter) and Ophonus sabulicola (Panzer) is especially remarkable. This nature reserve is the only known habitat in Sachsen-Anhalt of this species. Great differences in number of individuals and number of species could be observed between the different plots. The results show that the influence of the stages of intensity of cultivation seems to have greater influence on both facts than the type of cultivation. Altogether it is obvious that the many different forms of landuse in this relatively small area cause the great variety of carabides. Therefore the preservation of the site should be extended to the surrounding areas with their special structure and different types of use.

[1209] WHY DO DROSOPHILIDS PRODUCE AGGREGATION PHEROMONES WHEN IT GUIDES PARASITOIDS TO THEIR OFFSPRING?

B. Wertheim, L. E. M. Vet & M. Dicke, Laboratory of Entomology, Wageningen University, P.O. Box 8031, 6700 EH Wageningen, The Netherlands, E-mail Bregje.Wertheim@users.ento.wag-ur.nl

Chemical communication plays a central role in the biology of almost all insects. The effects of chemical communication are manifold and can be found on both the individual level (behaviour, evolution) and on population or higher ecological levels (e.g. the interaction between insects and their natural enemies, or interspecific competition). So far, most studies on pheromones (i.e. the chemical signals) have been focussing on mechanisms, chemical identity or on applied questions. Yet, the fascinating ecology of chemical communication has hardly been studied. In this project, we study the role of a class of chemical signals, the aggregation pheromones, in an evolutionary, behavioural and population ecology context. These volatiles are emitted by an individual and induce aggregative behaviour in members of the same species. They are widespread among insects and have been reported in over 175 species, belonging to 35 families and 10 orders. Yet here again, the whole complex network of ecological interactions and evolutionary processes involving aggregation pheromones is largely unexplored: Why do some insects use aggregation pheromones? What are the advantages for both emitter and responder? And what consequences do aggregation pheromones have on higher ecological levels, such as population dynamics and community ecology? Drosophilids also use aggregation pheromones, and mechanisms are well described in a number of Drosophila species. We chose these fruit flies as a model system and our aim is to study the ecological costs and benefits of the use of aggregation pheromones in this system and the role of the aggregation pheromones in interspecific interactions. So far, we have been testing several hypotheses for benefits. The results of different laboratory and field experiments have quantified the impact of the pheromones both in intra- and interspecific interactions. And it has become evident that evolution might be strongly directed to multi-functionality of single pheromones. On the other hand, several costs have also been identified. One especially intriguing cost involves the interaction with natural enemies: The volatile aggregation pheromone is exploited by parasitoids foraging for drosophilid larvae. The use of aggregation pheromones by the adult flies increases the conspicuousness of the larval hosts to their natural enemies. This espionage by parasitoids of communication between fruit flies was investigated in laboratory set-ups and subsequently it was shown to have significant consequences for the risk of being parasitized in the field. The results of the studies in this model system could contribute to a more general understanding of the ecology of chemical communication in insects.

Index terms: Drosophila, Leptopilina, chemical communication, ecology, fruit flies.

[1210] GALL MIDGE - PARASITOID DYNAMICS AT THE LANDSCAPE SCALE - EFFECTS OF DISTURBANCE AND PROLONGED DIAPAUSE

O. Widenfalk & C. Solbreck, Dept. of Entomology, Swedish Univ. Of Agricultural Sciences, P.O. Box 7044, SE-750 07 Uppsala, Sweden, E-mail: olof.widenfalk@entom.slu.se.

The gall midge Contarinia vincetoxici induces flower galls on the perennial herb Vincetoxicum hirundinaria, a plant that occurs in small and isolated patches in the landscape. Although the gall midge is a poor colonizer and subjected to high mortality, imposed by frequent drought and parasitism, most patches are continuously occupied by the midge with only minor density fluctuations over time. This persistence is explained by a prolonged larval diapause, a strategy to îspread the risk? over time. An experiment, where complete gall removal for four years only marginally affected gall densities compared with control plots, shows the strong buffering effect of prolonged diapause. However, in the same experiment the rate of parasitism was affected by gall removal. One parasitoid - with a low frequency of prolonged diapause - decreased markedly whereas another ñ with a higher frequency - was only marginally reduced. This result is consistent with the observed distribution of parasitism in the landscape, where the most sensitive parasitoid species is restricted to larger patches with a low frequency of disturbance.

Index terms: Contarinia vincetoxici, Omphale salicis, Synopeas accuminatus, population dynamics, prolonged diapause.

[1211] PLANT QUALITY AND THE ORGANIZATION OF CYNIPID GALL WASP COMMUNITIES

M. A. Williams & J. T. Cronin, Dept. of Biology, Univ. of North Dakota, P.O. Box 9019, Grand Forks, ND 58202 -9019, USA, E-mail mwilliam@badlands.nodak.edu.

Two of the most influential hypotheses used to explain variation in herbivore loads among plants are the plant vigor and plant stress hypotheses. The plant vigor hypothesis predicts that insects will preferentially feed or lay eggs upon the most vigorous, healthy, or fast growing plants (e.g., those high in nitrogen). In contrast, the plant stress hypothesis predicts that stressed plants will incur greater infestation levels (often thought to be a consequence of decreased production of defensive chemicals when stressed). There are a growing number of studies that have tested these hypotheses with a single herbivore species. However, very few studies have subjected a whole assemblage of insects and their natural enemies to experimental tests of these hypotheses. Because members of the herbivore assemblage may respond differently to changes in plant quality, and these effects may in turn affect higher trophic levels, the composition of the insect community is likely to vary depending on the condition of the plant's environment (i.e., a donorcontrolled system). We experimentally tested the plant stress/vigor hypotheses using five species of cynipid gall wasp and their natural enemies associated with prairie rose, Rosa species of cympic gain wasp and the matter matter arkansana. In the Spring of 1999, we established 180 1-m² plots each containing a minimum of 10 roses. Each plot was assigned to 1 of 3 salt and nitrogen addition treatments (none, low and high levels), where elevated levels of salt were intended to stress the plants and elevated levels of nitrogen were intended to increase plant vigor. At monthly intervals throughout the summer we recorded plant morphological changes and xylem water potential of sub-sampled plants (indicative of plant stress), collected leaf samples for later chemical analysis, and recorded abundances of cynipid galls on each rose plant. Preliminary results indicate the following. First, both salt and nitrogen additions stressed the rose plants, as indicated by changes in plant physical condition, reduced growth rates and altered chemistry (C:N ratios, amino acid profiles, etc.). Second, densitydependent relationships among roses and insect associates were rare: rose density per plot had no effect on cynipid abundance, nor did cynipid densities have much effect on parasitism rates. Third, the assemblage of cynipids tended to be most abundant in plots with low salt and nitrogen additions, but there were exceptions. Currently, we are conducting a more detailed analysis of the effects of our treatments on rose-plant chemistry, analyzing the effects of treatments on the inquilines and natural enemies of these cynipids, and assessing whether nitrogen and salt treatments had interactive effects on cynipid and natural enemy abundances among plots.

Index terms: Diplolepis sp., plant quality, plant stress, plant vigor, Rosa arkansana

[1212] SPATIO-TEMPORAL DYNAMICS OF AERIAL INSECT POPULATIONS EXAMINED WITH VERTICAL-LOOKING RADAR

I. P. Woiwod¹, J. W. Chapman⁴, A.M. Dewar², D. R. Reynolds³, A. D. Smith³ & J. R. Riley³, ¹IACR Rothamsted, Harpenden, Herts., AL5 2JQ, UK, E-mail Ian.Woiwod@bbsrc.ac.uk; ²IACR Brooms Barn, Higham, Bury St Edmunds, Suffolk, I228 6NP, UK; ³ NRI Radar Unit, Great Malvern, Worcs., WR14 1LL, UK.

Routine monitoring of high-flying insects is now possible due to the development of an inexpensive vertical-looking radar (VLR). Such a system has operated on the roof of the Entomology & Nematology Department at Rothamsted, south-east England, since May 1999. The aerial insect fauna has now been monitored continuously over an extended period and has provided some unique information on the dynamics of the aerial distribution system of insects. Data have been collected for targets passing through the radar beam at altitudes ranging between 150 to 1200 m above roof level; the radar records for a 5 minute sample period every 15 minutes, 24 hours a day. The novel signal analysis capability of the VLR allows the calculation of the averial density, body mass, speed and direction of movement, body alignment and altitude of the over-flying insects. Analyses of the day-to-day variation in insect aerial density, diurnal patterns of flight activity and density-height profiles, will be presented and related to meteorological factors. Spatial analysis of the VLR data with insect samples routinely collected by the Rothamsted Insect Survey's suction and light-trap networks, and aerial netting at Cardington, Bedfordshire, some preliminary identifications of the larger insects recorded by the VLR have been made.

Index terms: VLR, monitoring, aerial density, aerial netting, Rothamsted Insect Survey

[1213] GRAIN APHID PERFORMANCE ON TRITICALE

A. Wojcicka, <u>B. Leszczynski</u>, R. Krzyzanowski & R. Lipinska, Dept. of Biochemistry, Univ. of Podlasie, Prusa 12, PL-08110 Siedlee, Poland, E-mail leszczb@ap.siedlee.pl

Grain aphid, Sitobion avenae Fabr. is recognised as a serious pest of cereals across Europe. During last decades, a lot of efforts were put through to determine natural resistance factors to cereal aphids. Hitherto, role of such cereal allelochemicals as: hydroxamic acids, phenolic compounds and indole alkaloids in the resistance mechanisms were established. Present paper reports on surface waxes of triticale as resistance factors to the grain aphid. Commercial triticale cultivars slightly and heavy covered by the epicuticular waxes were used in the experiments and laboratory resistance tests were performed. Triticale heavy covered with the surface waxes negatively influenced the grain aphid growth and development. Aphids fed on such cultivars showed longer prereproductive period (time from birth do maturity), reduced fecundity and survival and lower values of intrinsic rate of natural increase rm. EPG (electrical penetration graphs) recordings showed some differences in the aphid feeding behaviour on the triticale. Aphids seen on the cultivars with heavy wax layer spent more time without probing of such plants or penetrating only peripheral tissues: epidermis and mesophyll. While on the wax-less cultivars, the aphid activity was mostly concentrated on salivation into sieve elements and phloem sap ingestion. The possible role of surface waxes as triticale resistant factors to the grain aphid is discussed.

Index terms: Sitobion avenae, fecundity, survival, surface waxes, EPG

[1215] THE CAAS ENTOMOLOGICAL RADAR

K. Wu, D. Cheng & Y. Guo, Institute of Plant Protection, Chinese Academy of Agricultural Sciences, Beijing, 100094, China, E-mail wukm@mail.east.net.cn.

The CAAS entomological radar is equipped with a marine radar (RA722UA) manufactured in Japan by Anritsu Corporation and an antenna system of Chinese meteorological radar. The radar has a microcomputer, image-processing LSI, and a custom-LSI for processing and storing the echo signal, displaying the radar image with high brightness, and for providing various high-level functions. It possessed a peak power of 10kW and an operating frequency of 9.4GHz (X band, 3.2cm wavelength). The radar antenna consists of a double feed and a 1.5 m parabolic. The picture of the radar observations is recorded by a computer and a special camera which can take multiple-exposure photographs. Simulation observations indicate that the insect radar can display clearly single insect target from 2000 to 3000m.

[1214] PRELIMINARY STUDIES ON FORENSIC ENTOMOLOGY IN MEDELLIN-COLOMBIA

M. Wolff & A. Uribe, Dept. Biology, Univ .of Antioquia. AA 1226 Medellín-Colombia. E-mail Errot Indicador não definido.

This is the first report of an ongoing study of insect succession in carrion carried out in Medellfn - Colombia using pigs (*Sus scrofa*) as a model to determine the insect sequence over 225 days. During this period 2131 insects were collected in the following families; Calliphoridae, Muscidae, Sarcophagidae, Syrphidae, Vespidae, Apidae, Formicidae, Hailicitiae, Staphylinidae, Histeridae, Carabidae, Scarabaeidae, Silphidae, Tenebrionidae, Dermestidae, Cleridae, Nitidulidae, Forficulidae, Gelastocoridae, Coreidae and Hesperidae. Five decomposition stages were observed (fresh, bloated, active decay, advanced decay, and dry remains) and four ecological categories (necrophagous, predators, omnivorous and adventive). During the fresh stage the first insects that appeared were flies of the families Sarcophagidae and Muscidae and specimens of Formicidae (Hymenoptera). During the bloated period Calliphoridae (Diptera) was predominant being the first in oviposition. During the third and fourth stages (active decay and advanced decay) the most abundant family was Muscidae, although Silphidae (Coleoptera) also stood out. During the last stage (dry remains) the dominant family was Formicidae (Hymenoptera) followed by Dermestidae (Coleoptera) with a large number of inmature insects.

Index terms: carrion entomofauna, forensic entomology, insect succession

[1216] THE APPLICATION OF CECIDOMYIDS GALLS ON THE SYSTEMATICS OF THE GENUS MACHILUS (LAURACEAE) IN TAIWAN

<u>S. Y. Yang</u>¹, M. Y. Chen¹ & J. T. Yang², ¹ Dept. of Botany, National Chung-Hsing Univ., Taichung, Taiwan 402, E-mail syyang@dragon.nchu.edu.tw; ² Dept. of Entomology, National Chung-Hsing Univ., Taichung, Taiwan 402

The plants of the genus Machilus (Lauraceae) in Taiwan have high diversity of cecidomyiids galls induced by the genus Dpahnephila (Cecidomyiidae). Using amplified fragment length polymorphism (AFLP) to analyze the 38 trees of four Machilus taxa in Taiwan including Machilus kusanoi, M. thunbergii, M. zuihoensis var. zuihoensis and M. zuihoensis var. mushaensis. UPGMA of the AFLP data revealed three distinct clusters. M. zuihoensis var. zuihoensis and M. zuihoensis var. mushaensis were indistinguishable with three primer combinations and they are suggested to be the same taxon. PCR and DNA sequencing methods were used to analyze the nucleotide sequences of the mitochondrial 16S rDNA gene of the 29 gall midges from three gall types of four Machilus taxa. The phylogenetic tree inferred from the partial 16S rDNA sequence by Neighbor-Joining method of proportion distance, revealed that the analyzed gall midges can be divided into three groups according to the gall types. The phylogenetic tree within each group can't separate the two varieties of M. zuihoensis. The systematic relationships of four Machilus taxa from the data of host plants are congruent with the data gathered from gall makers. Based on AFLP and DNA sequencing methods, M. zuihoensis var. zuihoensis and M. zuihoensis var. mushaensis can't be distinguished, and they are more closely related to M. thunbergii than to M. kusanoi. Our studies suggest the gall makers of genus Daphnephila provide insights into the plant systematic relationships. Index terms: Dpahnephila, AFLP, 16S rDNA.

[1217] HOST UTILIZATION, OVIPOSITION PATTERNS AND POPULATION DYNAMICS OF A DIPTERAN MINER OF BIRCH STEMS

T. Ylioja, Punkaharju Research Station, Finnish Forest Research Institute, Finlandiantie 18, FIN-58450 Punkaharju, Finland, E-mail tiina.ylioja@metla.fi.

Larvae of Phytobia betulae (Diptera: Agromyzidae) mine several meters downward through the differentiating xylem in stems of birch (Betula pendula and Betula pubescens). The long larval tunnels become filled with brown parenchyma tissue and leave a historical record of Phytobia abundance within the annual rings of birch trees. We collected stem disks and measured the number of larval tunnels that were created each year within individual host tree. Samples were collected from three even-aged birch stands (30, 47 and 65 years). General linear models fitted to the data explained a majority (about 60-80%) of the variation in Phytobia abundance, and indicated a strong contribution from exogenous, bottom-up effects from host trees. Phytobia abundance increased and then decreased in a consistent pattern that followed the development of even-aged birch stands. We tested for contributions from density-dependent processes by fitting response surface models to residuals from the general linear models (mean population growth rate); the best densitydependent model explained about 10% of the total variation in Phytobia abundance, most of which was attributable to immediate negative density-dependence, but some of which was attributable to delayed negative density-dependence. Apparently, changes in the condition of host trees, which changed with stand age, determined the level around which negative density-dependence was tending to regulate population abundance. Intraspecific competition might be important in regulating Phytobia abundance. Phytobia females lay their eggs singly into the soft tissue of current year shoots in birch canopies. Superficially, neither the shoot resource nor the differentiating xyleni are obviously limiting for Phytobia, but behavioral mechanisms associated with oviposition could nonetheless lead to intraspecific competition. Oviposition patterns from 48 5-year old birch trees were determined by tracing the larval tunnels backwards to the oviposition shoots. Successful ovipositions were more frequent in the upper parts of tree crowns and fast growing long shoots were preferred. Ovipositions tended to be aggregated in that there was more than one oviposition per shoot more frequently than expected if the eggs were laid in random. The number of ovipositions per shoot was correlated with the length of the oviposition shoot. This pattern suggests that high quality shoots are limited and that young larvae may compete for space and food within these preferred shoots. It still seems unlikely that intraspecific competition is the only factor that regulates population density and we suspect that there are other unknown effects from e.g. predation and inducible host plant defenses.

Index terms: Phytobia betulae, Diptera, Agromyzidae, Betula, density-dependence.

[1218] NATURAL HYBRIDIZATION AND EVOLUTION IN PARNASSIUS (LEPIDOPTERA: PAPILIONIDAE) IN SIBERIA AND RUSSIAN FAR EAST

E. V. Zakharov, Lab. of Entomology, Inst. of Biology and Soil Science, 159 Vladivostok's Century Ave, Vladivostok, 690022, Russia, E-mail entomol@mail.primorye.ru.

Natural hybridization events are of considerable interest because they provide evidence for the occurrence of interspecific gene exchange or introgression. In animals, it seems to be a rule that the nuclear gene pool is protected from contamination by genes of other species by very strong mechanisms of reproductive isolation. Most obvious of them are the sterility of hybrids and the physiological disharmonies between the genes of the hybrids. However, numerous observations of natural hybrids suggest more genetic exchange between animal species than formerly thought. Existence of phenotypically presumed hybrids between some Parnassius species was described from different locations in Siberia and Russian Far East as long ago as the beginning of the century. However, those publications did not present any obvious facts corroborating hybrid origin of the specimens, which had phenotype slightly distinguishing them from parent species. Our objectives were to prove hybrid origin of such the specimens and to evaluate evolutionary significance of natural hybridization. Using PRC-based technology, we tested some Parnassius (sensu lata) species to reveal species-specific molecular markers. We have discovered that these butterflies have a high level of intragenomic heterogeneity and a high degree of genetic polymorphism. Nevertheless, we found some conservative sequences that were treated as species-specific markers. Using these markers, we estimated origin of presumed hybrid specimens. In some cases, we had a complete additive pattern of RAPD-markers of parent species as if we had F1-hybrids. Sometimes we had evidences of introgression between different Parnassius species that testified to hybrid origin of several subspecies. Data obtained in our research allowed us to carry on phylogenetic analysis and to reconstruct possible ways of evolution in Parnassius. The results received and the numerous observations provided by amateur entomologists let us to conclude that in Parnassius butterflies natural hybridization is not just an occasional phenomenon. Mostly it occurs fairly often and causes appearance of F1-hybrids and sometimes it played a role of the evolutionary mechanism that led to formation of new forms, subspecies or species.

Index terms: Parnassius nomion, Parnassius bremeri, Parnassius phoebus, Parnassius eversmanni, RAPD-PCR

[1220] UNUSUAL NEST SUBSTRATE OF AN AUGOCHLORINE BEE WITH DESCRIPTION OF NEST STRUCTURE AND POLLEN RESOURCES

<u>A. Zillikens¹</u>, Z. Mihalkó^{1,2} & J. Steiner², ¹Zool. Inst., Univ. of Tübingen, Auf der Morgenstelle 28, 72076 Tübingen, Germany, E-mail anne.zillikens@uni-tuebingen.de; ²Univ. Fed. de Santa Catarina, CP 476, 88010-970 Florianópolis, SC, Brazil.

Sweat bees (Halictidae) have been studied intensively because they exhibit a wide spectrum of life histories ranging from solitary breeding to reproductive division of labour. Within the tribe Augochlorini such eusocial organization has been reported for species of the genera Augochlorella, Pereirapis and the subgenus Oxystoglossella. Nests of halictid bees are also of special interest under aspects of comparative studies of behaviour and the evolution of social organization. Halictid bees typically nest in the soil but Augochlora sensu stricto is known to nest in rotten wood. Two nests of Augochlora (Oxystoglossella) sp. have been detected in the rosettes of bromeliads in a secondary forest belonging to the Atlantic rain forest biom, Santa Catarina. Details on substrate and cell arrangement are provided and nest structure is discussed in relation to data reported for related species. Nests were opened to collect brood and pollen. Nest 1 contained all stages from egg to pupae as well as a newly emerged female whereas the second contained only three larvae at the end of the feeding stage. Obviously, larvae were developing without diapause suggesting a bi or even multivoltine life cycle. This is also supported by the prolonged activity period of adult females which were observed foraging on flowers at least till mid February. Analysis of foraged polien from the female scopae, pollen balls and faeces found in the nests revealed an origin from plants of at least 18 species. These belonged to various families such as Aquifoliaceae, Melastomataceae, Myrtaceae, Rubiaceae but pollen of Asteraceae dominated in number. Thus Augochlora (Oxystoglossella) sp. can be characterized as a polylectic forager.

Index terms: Augochlora (Oxystoglossella) sp., Augochlorini, nest structure, polien sources, eusociality, annual cycle.

[1221] PROPOSAL OF MODIFICATION IN LIFE TABLES TO STUDY THE EFFECT OF PROPORTIONAL MORTALITY DIFFERENCES ON LIFE EXPECTANCIES

<u>C. J. Von Zuben¹</u> & R. H. C. Fonseca¹, ¹Dept. of Zoology, UNESP, Ave. 24A, 1515, P.O. Box 199, Rio Claro, SP 13506-900, Brazil, E-mail vonzuben@rc.unesp.br

In situations where male and female life expectancies differ, for the same species, one question that arises is "how much do the mortality rates differ that ultimately determine the life expectancy differences?" (Carey, 1993). This author addressed this question by

letting \hat{e}_0^m denote a new male expectation of life at age 0 computed using a modified

age-specific mortality schedule \hat{q}_x^m where $\hat{q}_x^m = (1+\delta)q_x^m$ and q_x^m is the original

male age-specific mortality rate at age x. The same procedure can be made for \hat{q}_x^f in females. The utilization of different δ values to alter age-specific mortality yields hypothetical modified life tables. The magnitude of δ values will determine the factor that modifies uniformly across all age classes the age-specific mortality schedule. The importance of this analysis is to obtain the δ value that allow the male \hat{e}_0 to approximate to that of the female and vice versa. In this sense, the objective of the present work is to propose a way to permit this kind of modification in life tables, from \hat{q}_x values. The following steps are suggested: (1) from the \hat{q}_x value, it is possible to calculate $\hat{p}_x = 1 - \hat{q}_x$; (2) to evaluate $\hat{l}_x = \prod_{y=0}^{x-1} \hat{p}_x$; (3) to obtain $\hat{d}_x = \hat{q}_x \hat{l}_x$; (4) to evaluate \hat{L}_x from the expression $\hat{L}_x = \hat{l}_x - \hat{d}_x/2$; (5) to calculate $\hat{T}_x = \sum_{y=x}^{w} \hat{L}_y$, where W represents the last day of possible life and finally (6) to estimate the hypothetical new life expectancy through. In considering the expression $\hat{e}_0 = \sum_{x=0}^{w} \hat{l}_x - (1/2)\hat{d}_x \Big| \hat{l}_0$ to calculate the new value of life expectancy, the

estimate the hypothetical new file expectancy integral. In constanting the expectancy, the $\hat{e}_0 = \sum_{x=0}^{w} \left[\hat{l}_x - (1/2) \hat{d}_x \right] / \hat{l}_0$ to calculate the new value of life expectancy, the parameters \hat{L}_x and \hat{T}_x (steps 4 and 5 respectively) remain implicit in the calculation of \hat{e}_0 .

[1221] ROLE OF HOST PLANT QUALITY IN HERBIVORE POPULATION DYNAMICS IN HABITATS DISTURBED BY POLLUTION

E. L. Zvereva, Sect. of Ecology, Univ. of Turku, Turku FIN-20014, Finland, E-mail elezve@utu.fi.

Population density of the leaf beetle, Melasoma lapponica, its mortality due to natural enemies, and quality of its primary host plant, Salix borealis, were monitored in 10 sites around the nickel-copper smelter at Monchegorsk (Kola Peninsula, NW Russia) during 1991-1999. In clean localities, density of M. lapponica was low during all study years (due to high mortality from generalist predators) and demonstrated no among-year variation. In polluted localities, where abundance of predators was very low, densities of the leaf beetle were higher than in clean sites and demonstrated significant annual fluctuations, reaching outbreak levels asynchronously in different sites. Although mortality due to parasitoids was high (up to 60%), it was density independent and thus did not contribute to leaf beetle density fluctuations. In contrast, host-plant quality (assessed in bioassays with M. lapponica by preimaginal mortality and female fecundity) was a good predictor of next year changes in leaf beetle density. Outbreaks were preceded by an increase in S. borealis quality compared to low-density sites. In the year of peak density willow quality decreased, significantly reducing preimaginal survival, adult survival during hibernation and fecundity, which resulted in 2-3-fold decrease in density in the next year. However, densities did not decrease any more during the following five years, consistently with an improvement of willow quality after one-year drop. Amelioration of willow quality in polluted habitats may result from (i) high spring temperatures, (ii) SO2 impact, (iii) winter and spring damage of apical buds by herbivores, gaseous pollutants and frost (due to lower temperatures, stronger wind and thin snow cover in forest death areas). The decrease in plant quality was caused by severe defoliation by the leaf beetle during an outbreak - the effect known as delayed inducible resistance (DIR). However, experiments showed that DIR in boreal willow might be weakened by pollution, keeping herbivore density at high levels for several years. I conclude, that while in undisturbed habitats natural enemies play the leading role in regulation of populations of *M. lapponica*, in deteriorated habitats, where relationships with natural enemies are disturbed, host plant quality becomes the main factor driving population dynamics of this herbivore. Pollution induced or mediated changes in host plant quality and plant responses to herbivory in enemy-free space explain frequent and long-lasting herbivore outbreaks in disturbed habitats.

Index terms: *Melasoma lapponica*, *Salix borealis*, regulation, induced amelioration, induced resistance

[1222] MODE OF ACTION OF INDOXACARB IN PEST INSECTS AND IMPLICATIONS FOR CONTROL

K. D. Wing, M. E. Schnee, M. Sacher & M. Connair¹, E. I. DuPont and Co., Inc.Crop Protection Products, Stine-Haskell Research Labs, P.O. Box 30, Elkton Rd. Newark, DE. 19714, USA, Email:keith.d.wing@usa.dupont.com

Indoxacarb is a new insecticide from E.I. DuPont which has broad spectrum and agronomic utility, a new mode of action, and high levels of environmental and non-target safety. The oxadiazines DPX-MP062 (Indoxacarb; 75%S;25%R) or DPX-JW062 (racemic) are bioactivated to their N-decarbomethoxyllated metabolites (DCMP/DCJW) via esterase/amidases in the gut and fat body of Lepidoptera. The bioactivation is nearly quantitative within 5 hrs. post-ingestion in several Lepidoptera, but slower after topical application of either technical materials or SC formulated material. Pest representatives of Hemiptera, Homoptera and other insect orders perform this bioactivation much more slowly than the Lepidoptera, either by oral or topical application. Temporal progression of neurotoxic symptoms and ensuing toxicity correspond well with appearance of the active metabolite in all insects; results of a comparative study are presented. After bioactivation, the toxic metabolite blocks sodium channels in a voltage-dependent and nearly irreversible manner. When sodium -dependent compound action potentials (CAPs) in a Manduca sexta larval motoneuron preparation are monitored, they show a rapid, dose-dependent block after treatment with 0.01- 1 um DCJW. However they are only weakly responsive to even 1uM JW062. Other data presented strongly support the bioactivation hypothesis. Voltage-clamp experiments in embryonic *Periplaneta americana* cells reaffirm the voltage-dependent sodium channel block, and show that DCJW or DCMP are qualitatively similar to dihydropyrazoles and other related compound classes, and certain local anesthetics. These compounds may share a common binding domain in the sodium channel distinct from the pyrethroid/DDT site, making Indoxacarb highly active on insects resistant to other insecticides and an excellent Integrated Pest Management tool. Thus the key factors for Indoxacarb insect pest toxicity in the field are 1.Maximizing insect ingestion bioavailability on crop plants with optimized formulations and application 2. Rate of compound penetration, bioactivation and sodium channel sensitivity in the particular insect, which are inherent to the pest. Lepidopteran larvae are extremely sensitive to Indoxacarb, because of this combination of factors. [1224] MODE OF ACTION OF THIAMETHOXAM, A NOVEL LIGAND OF NICOTINIC ACETYLCHOLINE RECEPTORS – A COMPARATIVE STUDY OF NEONICOTINOIDS AND INSECTS

P. Wiesner, L. Kaufmann, F. Schuermann & <u>H. Kayser</u>, Novartis Crop Protection AG, Research Biochemistry, WRO-1060.4.04, CH-4058 Basel, Switzerland. E-mail: hartmut.kayser@cp.novartis.com.

Neonicotinoids represent a novel chemical class of insecticides which are structurally and functionally related to nicotine. Due to their systemic activity and high performance in the field, neonicotinoids are becoming increasingly used for the control of sucking insects and some other pests, also those showing resistance to organophosphates and pyrethroids. This is obviously due to the fact that neonicotinoids, as is well documented for imidacloprid, act by binding to nicotinic acetylcholine receptors, which thus became a validated novel insecticidal target site. Thiamethoxam, which is currently marketed as a second generation neonicotinoid, represents an example of the thianicotinyl subclass, which is distinguished by a thiazolyl group from the other pyridyl-based compounds. The mode of action of thiamethoxam has been studied in aphids (Myzus persicae, Aphis craccivora) as target insects, and in the locust (Locusta migratoria) as a lab model insect. Competition binding studies with membrane preparations of nicotinic acetylcholine receptors, performed with [^tH]-imidacloprid, revealed significant species differences in IC50 values for thiamethoxam which were in the range of nicotine in the aphids, but 100-fold higher than nicotine in the locust. In all insects, the best competitor of imidacloprid was thiacloprid, the weakest one was nithiazin in the aphids and thiamethoxam in the locust. Furthermore, the inhibition curve for *M. persicae* receptors suggested a heterogeneous population of binding sites in this insect. Minor structural variations at the heterocycle carrying the niro binding sites in this insect. Minor structural variations at the neterocycle carrying the hirro group were shown to have a large impact on the affinity to the binding site of imidacloprid. In electrophysiological studies, which were limited to *Locusta migratoria* for technical reasons, thiamethoxam, like other neonicotinoids, acted on nicotinic acetylcholine receptors by reducing the action potentials elicited by acetylcholine pulse-applied to isolated neuronal somata from the metathoracie ganglion. The IC50 value from the fourth of the source of the sou this functional assay compared fairly well to that obtained in the competition binding assay (µM range). Imidacloprid was active at a lower level (nM range) in both locust assays. On the isolated locust foregut, imidacloprid produced a tonic contraction, whereas assays. On the isolated locust foregut, initiation in posticed a tone contraction, infectors thiamethoxam was inactive. Overall, the results suggested that differences may exist in the modes of action between these two compounds, and possibly among neonicotinoids in general, though they all presumably act on nicotinic acetylcholine receptors. Index terms: Aphis craccivora; Myzus persicae; Locusta migratoria

[1223] CHARACTERISATION OF NEONICOTINOID MODE OF ACTION AT INSECT NICOTINIC ACETYLCHLOINE RECEPTORS

R. J. Lind, Zeneca Agrochemicals, Jealott's Hill Research Station, Berkshire, RG42 6ET, UK.

The introduction of neonicotinoid insecticides such as imidacloprid (IMI) has led to increased interest in insect nicotinic receptor pharmacology. The specific binding of a number of labelled cholinergic ligands to membranes of the aphid Myzus persicae was investigated. Saturation and kinetic data for [⁴H]-IMI; [⁴H]- and [²³I]- σ -bungarotoxin (α BgTx); and [²H]-epibatidine (EPI) all demonstrated more than one class of binding site. In each case the number of high affinity sites was about 25% of the total. By contrast, [⁴H]-methyllycaconitine (MLA) had only a single high affinity binding component, apparently corresponding to all of the other ligand sites, and therefore appears to be a "universal" ligand for insect nAChR. This is unlike mammalian brain, where MLA is a highly specific probe for some receptor subtypes. Unlabelled nicotinics were used to displace labelled probes from high affinity sites. Although the pharmacology, there were differences in the order of potency of the displacing ligands, again indicating heterogeneity of the aphid nAChR. The differing binding characteristics of the different subunits. Others have shown that genes for multiple nicotinic receptor subunits are expressed in *M. persicae*. However, apparent heterogeneity could also arise through co-operative interactions within the same receptor. Dissociation experiments show that such interactions occur in *M. persicae*.

Index terms: nicotinic acetylcholine receptor, Myzus persicae, imidacloprid, α bungarotoxin, epibatidine, methyllycaconitine, radioligand binding. [1225] SPINOSAD: PROPERTIES OF A SUCCESSFUL REDUCED RISK INSECT CONTROL PRODUCT

G.D. Thompson, T.C. Sparks & F.K. Dietz, Dow AgroSciences, Indianapolis, IN, USA

During the 1990's the U.S. Environmental Protection Agency (EPA) established a Reduced Risk category for new products and gave them priority in the registration process. Registrants applying for the category were required to demonstrate that their new product had improved properties when compared to current products in one or more of the following categories in a descending order of priority. The factors were: human health effects, non-target organism effects, groundwater risks, reduced application rates or frequency, low pest resistance potential, highly compatible with Integrated Pest Management, and improved efficacy. Spinosad is a fermentation metabolite of the actinomycete *Saccharopolyspora spinosa* Mertz and Yao. Spinosad was one of the first products accepted into the EPA reduced risk category. It has received rapid registrations and is currently registered on over 100 crops in over 20 countries as Tracer*, Success* or SpinTor* Naturalyte* Insect Control. The toxicology, environmental fate, and mode of action properties that qualified spinosad as a reduced risk product are reviewed. Additionally, an overview of the insecticidal properties that re equally responsible for the rapid adoption of the new active are provided. A vertebrate selectivity ratio (mammalian toxicity divided by insect toxicity), suggests that spinosad is a very selective insect control agent.
[1226] PYMETROZINE, A SELECTIVE FEEDING INHIBITOR FOR SUCKING INSECTS, ACTS THROUGH A NOVEL MECHANISM

L. Kaufmann, B. Popp, F. Schuermann & <u>H. Kayser</u>, Novartis Crop Protection AG, Research Biochemistry, WRO-1060.4.04, CH-4058 Basel, Switzerland. E-mail: hartmut.kayser@cp.novartis.com.

Pymetrozine is a new insecticide, highly selective for sucking insects, which is primarily used for the control of aphids; it is further active against whiteflies and rice hoppers. This unique selectivity of pymetrozine corresponds to its unique chemistry. However, bearing an essential 3-pyridyl group it is also reminiscent to the neonicotinoid class of insecticides. By directly recording feeding behaviour in several aphids it was previously shown that pymetrozine immediately (and selectively) blocks sucking by acting on the pumping mechanism thus finally resulting in death by starvation. To decipher this novel mode of action, studies on the locust (Locusta migratoria) were initiated since (repeated) application of pymetrozine to this non-target insect similarly resulted in feeding inhibition. As specific symptoms of intoxication by pymetrozine, locusts stretched and raised their hind legs without being paralyzed. This effect is unique to pymetrozine among the insecticide classes on the market suggesting a novel action mechanism. Overall, these symptoms and the effect on behaviour point to a neuro(-muscular) mode of action. In agreement with its unique symptoms, pymetrozine was not active in all tests on established target mechanisms of insecticides. A neuronal mode of action, obviously a novel one, became evident from the immediate increase of spontaneous spiking activity of locust ganglia, as recorded in situ, and from a similar activation of peristalsis of the isolated foregut when perifused with pymetrozine; it was active down to the nM range in both assays. In further experiments with the gut preparation the target site of pymetrozine could be clearly localized to the ingluvial ganglion; the gut muscle per se did not respond to the insecticide, but it remained sensitive to 5-HT. Isolated neuronal somala from the metathoracic ganglion (which, when intact, could be activated by pymetrozine) did not show either agonistic or antagonistic effects of pymetrozine on any neurotransmitter receptor. Using a radiolabeled close analog of pymetrozine, the presence of specific binding sites in the locust nervous system could be demonstrated down to the nM range. Remarkably, binding of pymetrozine was not inhibited by imidacloprid and thiamethoxam. respectively; however, nicotine was an effective displacer of pymetrozine. Hence, as a tentative conclusion, the binding site of pymetrozine may represent a novel neuronal receptor, though it might belong to the nicotinic acetylcholine receptor family. Index terms: aphids; neuronal receptor; Locusta migratoria

Symposium and Poster Session

[1228] MOLECULAR STUDIES OF INSECT ACETYLCHOLINESTERASE: IS THERE NEW LIFE IN AN OLD TARGET?

M. S. Williamson¹, S. B. Walsh¹, G D Moores¹, A. L. Devonshire¹, A. Taylor³, R. Viner³, C. Personeni² & T. Lewis², ¹Biological & Ecological Chemistry Department, IACR-Rothamsted, Harpenden, AL5 2JQ, UK. E-mail martin.williamson@bbsrc.ac.uk; ²Zeneca Agrochemicals, Jealott's Hill Research Station, Bracknell, Berks, RG42 6ET, UK.

Acetylcholinesterase (AChE) is the target enzyme for two major classes of insecticides, the organophosphates (OPs) and carbamates. The widespread use of these compounds over many years has, however, led to the development of resistance in a range of insect pests. This, together with ongoing safety concerns over their vertebrate toxicity, has resulted in a general decline in their use and effectiveness over recent years. Nevertheless, these compounds still constitute over 50% of the world insecticide market (\$4.5 billion in 1998). A major drawback in the mode of action of these compounds is that they are irreversible inhibitors of AChE that can also bind and modify other serine hydrolases within the nervous system. To investigate the mode of action and mechanism of resistance of these insecticides in more detail, we have cloned the AChE gene from the housefly (Musca domestica) and compared its sequence across a panel of resistant strains with altered (insensitive) AChEs. A number of base mutations were identified in the resistant strains, including five that result in changes in the encoded AChE protein sequence; V180L (Torpedo residue V150), G262A & G262V (G227), F327Y (F290) and G365A (G328). In vitro expression of these mutant AChEs using the baculovirus system have confirmed that all except the V180L mutation contribute to the varying levels of resistance observed in the original strains, and this is consistent with structure-based modelling studies that show these mutations are located at the base of the active site pocket where they appear to affect the access and/or binding of insecticides. In order to exploit recent advances in our understanding of the structure and catalytic mechanism of AChE, we are using a combination of computer modelling, molecular biology and biochemistry to investigate the activity of reversible inhibitors that show large differences in their selectivity for either insect or vertebrate AChEs. Our results suggest that key differences within the active site pocket of the enzyme between vertebrates and invertebrates can be exploited for the design of potent new inhibitors with novel modes of binding that are highly selective for insect AChEs. Moreover, such inhibitors are unlikely to be predisposed to the existing resistance mutations that occur within insect populations. Index terms: Musca domestica, inhibitors, mutation, resistance, expression, baculovirus

[1227] THE MOLECULAR BASIS OF TARGET SITE RESISTANCE: HOW MANY MUTATIONS?

R.H. ffrench-Constant, Dept. of Biology, Univ. of Bath, BAth, BA2 7AY UK, E-mail bssrfc@bath.ac.uk

Field isolates of target site resistance are often associated with single major genes. Over the last five years we have been studying the number of resistance associated mutations found in these target sites: the *Rdl* encoded GABA receptor, the *para* encoded sodium channel and the *Ace* encoded insect acetylcholinesterase. The central question examined in each case is: How many mutations can cause resistance and why? We have examined this question using several different approaches. 1) Surveys of resistance associated mutations present in nature. 2) Detailed biophysical analyses of the effects of these mutations on the associated receptor/enzymes. 3) Chemical mutagenesis of *Drosophila* to examine how many different combinations of mutations can give resistance in the laboratory. In this talk we will examine each of the three targets and discuss the applicability of each of these three approaches in trying to understand how many mutations have been found in each receptor or enzyme and why.

Index terms: Drosophila melanogaster, para encoded Sodium channel, Rdl encoded GABA receptor, Ace encoded acetylcholinesterase

[1229] SODIUM CHANNEL MUTATIONS AND PYRETHROID RESISTANCE

K. Dong¹, Z. Liu¹, J. Tan¹, J. Ren¹, S.M. Valles² & A.L. Goldin³, ¹Department of Entomology and Neuroscience Program, Michigan State University, East Lansing, MI 48824, USA, E-mail dongk@pilot.msc.edu; ¹USDA-ARS, Center for Medical, Agricultural and Veterinary Entomology, 1600 SW23rd Dr., Gainesville, FL 32608; ¹Department of Microbiology and Molecular Genetics, 240 Medical Science Building B, Irvine, CA 92697.

For decades, pyrethroid insecticides have been used widely to control many insect pests. Due to intensive use, however, many insect pest populations developed resistance to these compounds. One class of resistance mechanism is knockdown resistance (kdr). A single amino acid substitution, from leucine to phenylalanine, in the Para sodium channel protein has been found to be responsible for kdr in several insect species, including German cockroaches. Recently, we identified two more mutations in the para gene of five fieldcollected German cockroach strains that exhibit high levels of kdr. The two mutations, from glutamic acid (E434) to lysine (K434) and from cysteine (C764) to arginine (R764), respectively, are located in the first intracellular linker connecting domains I and II. Two additional mutations from aspartice acid (D57) to glycine (G57), and from proline (P1888) at leave to leave in (L1888), respectively, were found in one of the resistant strains. The four mutations co-exist with the previously identified L993F kdr mutation and are present only in the highly resistant individuals of a given strain. These findings suggest that the four novel mutations might be responsible for high levels of knockdown resistance to pyrethroid insecticides in the German cockroach. A full-length *para* cDNA has been isolated from a pyrethroid-sensitive German cockroach strain, CSMA, and *kdr*-associated mutations have been introduced into this cDNA. We have succeeded in functional expression of cockroach para cDNAs in Xenopus oocytes. We are currently examining the effects of the kdr-associated mutations on Para channel properties and channel sensitivities to deltamethrin, a pyrethroid insecticide.

Index terms: Blatella germanica, knockdown resistance, functional expression, Xenopus oocyte

Symposium and Poster Session

[1230] INVESTIGATIONS ON NEONICOTINOID RESISTANCE IN BEMISIA TABACI FROM ALMERIA, SPAIN

R. Nauen & A. Albert Bayer AG, Agrochemicals Division, Research Insecticides, D-51368 Leverkusen, Germany, E-mail: RALF.NAUEN.RN@bayer-ag.de

The first neonicotinoid insecticide to be commercialized in 1991 was imidacloprid. Meanwhile several other compounds belonging to this chemical class and which are structurally related to imidacloprid have also been launched or are under development. All these compounds are active as agonists of the insect nicotinic acetylcholine receptor (nAChR). Neonicotinoids are especially active against homopteran pest species, such as aphids, leaf- and planthoppers and whiteflies. Whereas in aphids and leafhoppers numerous monitoring programs revealed no signs of developing resistance, several field derived strains of the tobacco whitefly, *Bemisia tabaci*, especially from southern Spain, showed considerable loss of susceptibility towards neonicotinoid insecticides such as acetamiprid, imidacloprid and thiamethoxam. Furthermore, our laboratory bioassays revealed high levels of resistance to a broad range of chemically diverse active ingredients in different types of laboratory bioassays. In order to elucidate the possible mechanisms conferring resistance to neonicotinoid insecticides in *B. tabaci* from Almeria/Spain, biochemical and biological investigations were undertake. We studied the affinity of imidacloprid to nicotinic acetylcholine receptors (nAChR) in whitefly homogenates using tritium labelled imidacloprid, the effect of synergists in different bioassay types, possible behavioural components associated with neonicotinoid resistance as well as possible fitness costs. Options for resistance management strategies will be discussed in the light of our results.

Index terms: whiteflies, imidacloprid, nAChR

[1231] ROLE OF ESTERASES IN RESISTANCE TO PYRETIIROIDS IN LEPIDOPTERA

<u>R.V. Gunning</u>¹, G.D. Moores² & A.L. Devonshire³ ¹NSW Agriculture, Tamworth Cent. Crop Improvement, RMB 944, Calala Lane, Tamworth, NSW, Australia, 2340; ^{2,3} IACR-Rothamsted, Harpenden, Herts., AL5 2JQ, UK.

Some Lepidoptera and in particular the Noctuidae, are major pests of crops, such as cotton, throughout the world and chemical insecticides are considered necessary for control. These insects are routinely exposed to pyrethroid insecticides and it is therefore not surprising that a number of economically important species have developed resistance to these insecticides. Esterase- mediated hydrolysis and sequestration of pyrethroids has been shown to be important as a mechanism of resistance in many insect species and the presence of elevated enzyme activity has become increasingly monitored as a biochemical marker for resistance in many insect pests. Esterase-moderated resistance to pyrethroids has been found to be important in a number of Lepidopteran species, with increasing evidence that esterases play a major role in Helicoverpa armigera (Hübner) Helicoverpa punctigera (Wallengren), Heliothis virescens (F.) Spodoptera exigua (Hübner) Spodoptera littoralis (Boisd.) and Wiseana cervinta. Most studies have shown increased hydrolytic activity in the resistant strains, however, pyrethroid sequestration appears also to be important. The best documented case implicating esterases in pyrethroid resistance is in Australian H. armigera. Pyrethroids were first introduced for control of Helicoverpa spp. in the late 1970's and resistance was first diagnosed in H. armigera, in late 1983. The spin the task of the state of t could be partially suppressed by piperonyl butoxide (PBO). Pyrethroid synergism by PBO, led to a widely held assumption, that pyrethroids were metabolised by monooxygenases. However, it has become clear, that an overproduction of esterase isoenzymes is responsible for pyrethroid resistance in *H. armigera*. The esterases both sequester and metabolise pyrethroids. Biochemical studies showed that PBO was in fact an esterase inhibitor in H. armigera and recent studies with H. virescens concur with these findings. Some organophosphates are effective esterase inhibitors in *H. armigera* and can restore pyrethroid susceptibility. Pyrethroid/esterase binding studies revealed that pyrethroids which contain a halogenated benzyl group bound more readily to *H. armigera* esterases and were more resisted, in comparison to pyrethroids where the benzyl ring was replaced by a dihalogenated aliphatic entity. Pyrethroid resistance in H. punctigera was

also shown to be the result of an esterase mediated resistance mechanism. Index terms: Helicoverpa armigera, Helicoverpa punctigera, Heliothis virescens, Spodoptera exigua, Spodoptera littoralis, Wiseana cervinta [1232] RESISTANCE AND SYNERGISM TO ORGANOSPHOSPHATE INSECTICIDES IN POPULATIONS OF LEUCOPTERA COFFEELLA (LEPIDOPTERA: LYONETIIDAE)

D. B. Fragoso', <u>R. N. C. Guedes'</u>, M. Picanço' & W. C. Antunes', 'Dept. of Biology Animal, Federal Univ. of Viçosa, Viçosa, MG 36571-000, Brazil, E-mail: guedes@mail.ufv.br..

Insecticide resistance is an increasingly wordwide problem. In this context, the objective of this study was to detect resistance of *Leucoptera coffeella* to the insecticides chlorpyrifos, disulfoton, ethion and methyl-parathion and to preliminarly identify the probable resistance mechanisms involved. The biological material used encopassed ten populations of L. coffeella from important coffee producing counties of the State of Minas Gerais, which were field-collected and reared in cages within a greenhouse. An additional population from an area adjacent to the coffee nursery of the Federal University of Viçosa was used as susceptibility standard. At first, preliminary biossays were carried out using 3rd instar larvae of the susceptible population to obtain the range of concentrations to be used in the concentration-response bioassays aiming the determination of the LC, The data obtained from the concentration-response biossays were subjected to probit analysis to estimate the CL₂₉ for each insecticide, which were used as discriminatory concentrations to recognize the resistant populations. Significant differences in mortality between the field-populations and the susceptibility standard were recognized by the Z test with correction for continuity. The results showed resistance in the majority the insect populations studied. Eight of them showed resistance to disulfoot, five to etholon, four to methyl-parathiom, and just one showed resistance to chlorpyrifos. Correlation and multiple regression analysis, were used to evidence the association between the frequency of resistant individuals and the insecticide use. The results obtained suggested patterns of cross-selection between the insecticides and the existance of cross-resistance in the populations under investigation. In the study of the the probable resistance mechanisms of L. coffeella to these insecticides, bioassays with insecticide plus sinergyst were carried out for the susceptible population using the same metodology referred above with the goal of obtaining the LC_y to be used to identify the probable main detoxification enzymes involved in the resistance. Detoxification by cytochrome P450-dependent monooxygenases and glutathion-S-transferases seem to be the main resistance mechanisms to organophosphates insecticide in L. coffeella. Detoxification by esterases seem to play a minor role on organophosphate resistance in this insect-pest, suggesting a possible case of multiple resistance.

Index terms: Insecticide resistance, Leucoptera coffeella, organosphosphates.

[1232] STOCHASTIC AND DENSITY – DEPENDENT MODELS IN DEMOGAFIC ECOTOXICOLOGY

R. Laskows

ABSTRACT NOT RECEIVED

[1234] DIFFERENTIAL SUSCEPTIBILITY AMONG LIFE STAGES TO TOXICANTS: IMPLICATIONS FOR EFFECTS ON NON-TARGET INVERTEBRATES

I. D. Stark¹ & J. E. Banks⁷, ¹Ecotoxicology Program, Dept. of Entomology, Washington State Univ. Puyallup, Washington 98371 USA, E-mail stark@puyallup.wsu.edu; ²Univ. of Washington – Tacoma, 1900 Commerce St., Tacoma WA, 98402 USA E-mail: banksj@u.washington.edu.

A great deal of work has been conducted to determine the impact that pesticides and other toxicants have on nontarget organisms both by ipm practitioners and those concerned with conservation biology, although most studies are designed to estimate toxicological effects on one life stage, some have focused on the susceptibility of different life stages to pesticides and other toxicants. however, little attention has been paid to the population-level significance of differential susceptibility among life stages. if for example one life stage of an insect is much more susceptible to a pesticide than another, how does this translate to overall population growth? Furthermore, populations in nature often exist as mixtures of ages and stages that change over time. the role that population structure plays in susceptibility has also not been explored thoroughly. Our work in demographic ecotoxicology has indicted that differential susceptibility among life stages and differences in initial population structure can have major consequences at the population-level. As such, this should be explored further if we want to develop realistic measures of toxicant impacts on ecosystems, we will present a series of mathematical simulations based on life table data for the seven-spot lady beetle, coccinella septempunctata l. And its prey, the pea aphid, acyrthosiphon pisum harris that indicate that differential susceptibility to toxicants among life stages may have serious implications for both populations and even communities in both natural and managed ecosystems. Index terms: demography, matrix models, pesticides

[1235] CAPTURING POPULATION, COMMUNITY AND LANDSCAPE PROCESSES IN PESTICIDE ECOTOXICOLOGY

P.C. Jepson, Dept. of Entomology, Oregon State University, Cordley Hall, Corvallis, OR 97331, USA.

Carabid beetles and linyphiid spiders fall at the extremes of the dispersal spectrum for predatory arthropods colonizing temperate agricultural crops. Models have been developed that explore the ways in which the contrasting life histories of carabids and linyphiids affect the impact of pesticide sprays on population density and local persistence. Although such models may be of value in improving our understanding of the mechanisms that underlie the loss of natural enemies in some sprayed systems, they are of limited value in the management of pesticide use, or in prediction of potential impacts on the wide range of beneficial taxa that contribute to important ecological functions in agricultural crops. The development of indices of tolerance to pesticides at the community level, provides an opportunity to build new ways of predicting pesticide risks. Estimates of the so-called 95% protection level (or HC5), the maximum dose that in theory, will be non-toxic to 95% of the species present within a habitat, will be presented for invertebrates that inhabit forest streams and riparian zones in Oregon. The potential value of this statistic for pesticide management at the watershed level will be reviewed. Databases may provide an effective tool for the analysis of possible impacts to highly diverse assemblages. The web-based modeling and database system Pond-Fx (http://www.ent3.orst.edu/PondFX/), will be summarized and explored, to demonstrate one approach to the integration of chemical, toxicological and ecological data, in the prediction of pesticide risks to non-target invertebrates in pond systems.

Index terms: Carabidae, Linyphiidae, aquatic macroinvertebrates, 95% Protection Level (HC5), riparian invertebrates

[1236] CURRENT SATATUS OF TRANSGENICS FOR INSECT CONTROL S. Macintosh

ABSTRACT NOT RECEIVED

[1237] CORN ROOT - WORM ACTIVE

J. Patell

ABSTRACT NOT RECEIVED

[1238] NOVEL INSECTICIDAL TOXINS FROM *PHOTORHABDUS*: ALTERNATIVES TO BT?

R.H. ffrench-Constant, Department of Biology, University of Bath, BAth, BA2 7AY UK.

With widespread concerns over resistance to Bt transgenic crops the need for alternatives is paramount. We have cloned four insecticidal toxin complex (tc) encoding loci from the bacterium *Photorhabdus luminescens*. This bacterium lives in the gut of nematodes that invade insects where it is released to help overcome the insect host. Each of the four loci encodes a high molecular weight protein toxin and Tca together with Tcd have been shown to constitute the majority of the oral toxicity to lepidoptera via genetic knock-out. The LC₁₀ of Tca is similar to some of the less active Bt toxins but feeding is inhibited at much lower doses. The histopathology of Tca action on the insect midgut is shown and potential implications for possible modes of action are discussed.

[1240] MOSQUITO ACTIVES

<u>B. Federici</u>

ABSTRACT NOT RECEIVED

[1239] EXPRESSION OF *BACILLUS THURINGIENSIS* CRY2A PROTEINS IN PLANT CHLOROPLASTS: INCREASING TOXICITY TO SUSCEPTIBLE AND *BACILLUS THURINGIENSIS* RESISTANT INSECTS

W. I. Moar '& H. Daniell', 'Dept. of Entomology and Plant Pathology, Auburn Univ., 301 Funchess Hall, Auburn, AL 36849, USA, E-mail <u>wmoar@accessg.auburn.cdu</u>. ² Dept. of Molecular Biology and Microbiology, University of Central Florida, Orlando, FL 32816 USA

The use of commercial, nuclear transgenic crops expressing Bacillus thuringiensis (Bt) toxins has escalated in recent years due to their advantages over traditional chemical insecticides. However, in crops with several target pests with varying degrees of susceptibility to Bt (e.g. cotton), there is concern regarding the suboptimal production of toxin, resulting in reduced efficacy and increased risk of Bt resistance. Additionally, relance on a single (or similar) Bt protein(s) for insect control, increases the likelihood of Bt resistance development. Expression of economically important genes via the chloroplast has been reported for insect and herbicide resistance with much higher expression levels than nuclear transgenic plants. Besides extremely high protein levels (potential "high dose"), chloroplast gene expression also results in tissue specificity. The maternal inheritance of the chloroplast genome in most crops also reduces the potential for outcrossing of foreign genes to other plants (especially weedy species). We report here, the overexpression of the Cry2Aa2 protoxin in tobacco chloroplasts, and a possible approach to delay the evolution of Bt resistance in the field. Cry2Aa2 was chosen because of its high toxicity against many insect pests, limited homology to Cry1A proteins, small size of the protoxin, and increased stability. When transgenic tobacco leaves expressing Cry2Aa2 protoxin in chloroplasts were fed to susceptible, Cry1A resistant and Cry2Aa2 resistant tobacco budworm, *Heliothis virescens*, cotton bollworm, Helicoverpa zea, and the beet armyworm, Spodoptera exigua, 100% mortality was observed against all insect species and strains. Southern blot analysis confirmed stable integration of cry2Aa2 into all of the chloroplast genomes of transgenic plants. Transformed tobacco leaves expressed Cry2Aa2 protoxin at levels between 2 and 3% of total soluble protein, 20-30 fold higher levels than current commercial nuclear transgenic plants. These results suggest that plants expressing high levels of a non-homologous Bt protein should be able to overcome or at the very least, significantly delay, broad spectrum Bt resistance development in the field.

Index terms: Heliothis virescens, Helicoverpa zea, Spodoptera exigua, genetic engineering

[1241] ECOLOGICAL IMPLICATIONS OF THE LARGE-SCALE PRODUCTION OF INSECTICIDAL, TRANSGENIC PLANTS

A. Hilbeck, Swiss Federal Institute of Technology, Geobotanical Institute, Zurichbergstr. 38. CH-8044 Zurich, Switzerland, E-mail: hilbeck@geobot.umnw.ethz.ch

The adoption of genetically engineered crop plants proceeds very fast. Currently, several In a adoption of genetically engineered crop plants proceeds very fast. Currently, several cultivars of 8 major crop plants are commercially available including soybcan, corn, cotton, canola, potato, tomato, tobacco, sugar beet but many more plants with new and combined, multiple traits are close to registration. While currently agronomic traits (herbicide resistance, insect resistance) dominate, traits conferring 'quality' traits (altered oil compositions, protein and starch contents) will begin to dominate within the next years. However, acompany the advectory for the sector accompositions of the sector accomposition of the sector accom However, economically the most promising future lies in the development and marketing of crop plants expressing pharmaceutical or nutraceuticals ('functional foods') and plants that express a number of different genes. From this, it is clear that future agricultural and, ultimately, also natural ecosystems will be challenged by the large-scale introduction of entirely novel genes and gene products in entirely novel combinations at high frequencies all of which will have unknown impacts on their associated complex of nontarget organisms, i.e. all organisms that are not targetted by the insecticidal protein. In a multiple year research project, we investigated tritrophic and bitrophic effects of transgenic Btexpressing corn on the natural enemy species, *Chrysoperla carnea* (the green lacewing), and a number of other predator species. In these laboratory trials, we found prey-mediated effects of transgenic corn, expressing the gene from Bacillus thuringiensis (BI-corn) that codes for the expression of an insecticidal toxin (Cry1Ab), causing significantly higher mortality of an important insect natural enemy, the Green Lacewing (Chrysoperla carnea, order: Neuroptera). This was the first report on the susceptibility of a third trophic level insect (i.e. natural enemy) to a Bt-toxin which was believed to only affect herbivores in the order of Lepidoptera. In further laboratory trials, we confirmed that the route of exposure (fed directly or via herbivorous prey) and the origin of the Bt (from transgenic plants or incorporated into artificial diet) strongly influenced the degree of mortality. In further molecular studies, we confirmed direct toxicity of Cry1Ab by finding receptor binding in C. carnea midgut epithelium. Field implications could be multifold but will be difficult to assess because they interfere in very intricate ways with complex ecosystem processes that we still know only very little about. However, there is a number of lessons that can be learned from the past that could help anticipating potential implications and designing long-term, area-wide monitoring programs to detect possible adverse effects on ecosystem functioning and biodiversity at a stage where early intervention might still help to avert undesired developments.

[1242] NON-TARGET EFFECTS OF TRANSGENIC INSECTICIDAL CORN -THE MONARCH AND BEYOND

L. C. Hansen & J. J. Obrycki, Dept. of Entomology, Iowa State University, Ames, IA 50011, USA, E-mail: lrahnsen@iastate.edu

During the past 5 years, transgenic crops expressing a insecticidal protein from Bacillus thuringiensis (Bt) have been widely planted in the United States. The speed with which this new technology has become commercially available has caused controversy over how to assess and manage the risk of transgenic plants. Previous examinations of non-target ecological effects of transgenic insecticidal crops have focused on species that are representative of crop-based food webs, for example, natural enemies, phytophagous species, or plant pathogens. However, unintended effects on species beyond field borders have not been fully addressed. Consumption of transgenic insecticidal pollen on non-crop plants outside crop fields is one probable mechanism since insecticidal toxins may be expressed in wind-dispersed pollen. Recently, experimentally applied relatively high concentrations of transgenic Bt corn pollen on milkwed leaves in the laboratory were shown to cause significant mortality of monarch larvae (Losey, et al. (1999) Nature 399, 214). This laboratory study raises questions about the effects on monarch populations of naturally deposited Bt corn pollen on milkweeds. Field deposition of pollen was assessed by placing potted milkweed plants within and around a transgenic corn field. The cumulative deposition of transgenic pollen in 1998 was highest within the corn field (74 to 217 pollen grains/cm²) and decreased to between 6 and 20 pollen grains/cm² at 3 m from the edge. Similarly in 1999, deposition within the field was highest within the corn field (80-115 pollen grains/cm²) and decreased to 5 to 7 pollen gains/cm² at 3 m and 1 pollen grain/cm² at 10 m. Monarch larvae were exposed for 48 hrs. to three densities (14, 135, and 1300 pollen grains/cm²) of two types of transgenic (MAX 454, 7333Bt) and nontransgenic (4494) pollen. Exposure to 135 pollen grains/cm² leaf surface, of transgenic event 176 caused 50% larval mortality within 5 days and 62% mortality prior to pupation. Exposure to similar amounts of pollen from a transgenic event Bt11 hybrid caused 38% mortality within 5 days and 46% mortality prior to pupation. At both 1,300 and 135 pollen grains/cm² leaf area, 5-day survival of monarch larvae following a 48 hr exposure was lower on transgenic pollen. The two higher concentrations of transgenic pollen from event 176 significantly reduced survival to the pupal stage. At 14 pollen grains/cm², survival was similar for the three pollen types. Based upon the expression of toxin in transgenic pollen, and wind dispersal of this pollen beyond the edges of agricultural fields, we predict that the effects of transgenic pollen on monarchs may be observed at least 10 meters from transgenic field borders. However, the highest larval mortality will likely occur within 3 meters from the edge of a transgenic field.

[1243] INTERACTIONS BETWEEN TRANSGENIC OILSEED RAPE AND PARASITOIDS

T. H. Schuler, R. P. J. Potting, I. Denholm & G. M. Poppy, Dept. of Entomology & Nematology, IACR-Rothamsted, Harpenden, AL5 2JQ, UK, E-mail Tanja.Schuler@bbsrc.ac.uk..

The behaviour of non-target insects is likely to play a role in determining how their populations will be affected by transgenic plants expressing toxin genes of Bacillus thuringiensis (Bt). We have investigated this for a model system involving Bt oilseed rape expressing the CrylAc toxin (highly active against many lepidopteran pests), the diamondback moth (Plutella xylostella) and the braconid parasitoid Cotesia plutellae. The latter, a solitary endoparasitoid, is an important enemy of P. xylostella, itself notorious as the first insect pest to evolve resistance to microbial Bt sprays in the field. We present evidence that although parasitoid larvae forced to develop in Bt-treated susceptible hosts inevitably died with their hosts, behavioural factors are likely to limit the scale of this effect under field conditions. Furthermore, the performance of parasitoids attacking Btresistant hosts on transgenic plants demonstrated no measurable adverse effects of Bt toxins on the behaviour of adult C. plutellae or the survival of parasitoid larvae. Any tactic aimed at suppressing pest populations risks disrupting the dynamics of natural enemies, due to a reduction in host or prey densities. These effects will be most pronounced for species, such as hymenopteran parasitoids, that tend towards greater ecological specialism and may even be specific to particular pest organisms. The apparent lack of effects on survival or host-seeking ability of the parasitoid implies a considerable environmental advantage over broad-spectrum insecticides used for pest management at present. It is also possible that the continued ability of C. plutellae to locate and parasitise Bt-resistant hosts on transgenic crops could assist with constraining the build-up of Bt-resistant pest populations. More generally, these results highlight the need to consider behavioural as well as toxicological aspects when investigating possible side-effects of transgenic crops on non-target organisms.

Index terms: Bacillus thuringiensis, Plutella xylostella, Cotesia plutellae, behaviour, diamondback moth

[1244] NON-TARGET EFFECTS OF BT-COTTON: A CASE STUDY FROM AUSTRALIA

L. J. Wilson & G. P. Fitt, CSIRO Cotton Research Unit and Australian Cotton Cooperative Research Centre, Locked Bag 59, Narrabri, Australia, 2390, E-mail lewisw@mv.pi.csiro.au

The advent of transgenic cotton containing the CrylAc gene offers the potential to significantly reduce pesticide use on Australian cotton, where the primary pests are the larvae of Helicoverpa armigera and H. punctigera. However, there is the potential for non-target effects of this technology, including effects on species dependent in some way on lepidoperan larvae for food, unforeseen effects on other components of the cotton fauna that use the plant, or its residues, as food or indirect effects due to reduced spraying. We undertook a series of large scale experiments to address some of these issues, with a particular emphasis on comparison of the overall fauna complex present in conventional and transgenic crops. Experiments had three treatments, unsprayed conventional cotton, unsprayed Bt-cotton and sprayed conventional cotton. Five experiments were completed over four years. The sprayed treatment was not replicated due to the risk of insecticed drift. Regular samples were collected using suction samples, pitfall traps and visual assements were also made. In general across all experiments there was significant reduction in most taxa in the sprayed treatment compared with both unsprayed treatments. Comparing the unsprayed Bt-cotton and conventional cotton there were no significant differences between treatments in any taxa, except for the abundance of lepidopteran parasitoids which were less abundant in Bt-cotton due to the reduced abundance of hosts. Outbreaks of spider mites tended to be more prevalent in the commercially sprayed cotton, while outbreaks of aphids occurred earlier in the unsprayed conventional and Bt-cotton. We did not investigate the response of specific non-target species to Bi-cotton, nevertheless the results suggest that Bi-cotton had little detrimental effect on the overall abundance or diversity of insects, compared with unsprayed conventional cotton. Index terms: Helicoverpa, Bt-cotton, pest management

[1245] UK FIELD-SCALE TRIALS OF GM HERBICIDE TOLERANT CROPS TO DETECT THE ENVIRONMENTAL EFFECTS ON INVERTEBRATE ABUNDANCE AND BIODIVERSITY

L. P. Woiwod', A. M. Dewar², A. Haughton⁴, C. Hawes³ & M. Heard⁴, ¹IACR Rothamsted, Harpenden, Herts., AL5 2JQ, UK, E-mail: Ian.Woiwod@bbsrc.ac.uk; ²IACR Brooms Barn, Higham, Bury St Ednuunds, Suffolk, IP28 6NP, UK; ³Scottish Crops Research Institute, Invergowrie, Dundee DD2 5DA UK; ⁴ITE Monks Wood, Abbots Ripton, Huntingdon, Cams. PE17 2LS, UK.

At present no genetically-modified (GM) crops are grown commercially in the United Kingdom. The first four awaiting introduction are GM herbicide tolerant maize, spring and winter oilseed rape (canola) and beet. As these crops are intended to allow more efficient weed control, concern has been expressed that their widespread introduction will reduce further the food resources available to wildlife associated with conventional arable agriculture in the UK, particularly birds, many of which have recently shown alarming population declines on farmland (Firbank et al. 1999). In response to these concerns the British Government has introduced the concept of 'managed development' of GM crops which involves a voluntary delay in their commercial introduction whilst research is carried out to investigate likely effects on the abundance and biodiversity of wildlife at the field scale (Firbank et al. 2000). The field-scale trials described here will form the major part of these investigate likely effects on the abundance field scale and introduction of these four crops into the UK. Sampling will be targeted on weed and invertebrate populations as these are likely to be the most rapidly affected by any change in crop husbandry and herbicide regime and hiey also have important functional roles in the food chain supporting mammals and birds. Indicator invertebrate groups selected for detailed study are Collembola, carabid beetles, Heteroptera, adult butterflies, bees, Lepidoptera and sawfly larvae, and gastropods. The background to this study, the choice of indicators, and the reason that this ecological research programme has become so controversial will be discussed.

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[1246] EFFECTS OF TRANSGENIC PLANTS ALONG THE FOOD CHAIN: CAN THEORY HELP?

G. L. Lövei, Danish Institute of Agricultural Sciences, Department of Crop Protection, Research Centre Flakkebjerg, DK-4200 Slagelse, Denmark.

Transgenic plants grown in agricultural fields will become parts of natural ecological systems, such as parts of food webs. Ecological theory of food webs will be reviewed with a focus on the presence and significance of indirect interactions in ecological communities. Evidence will be presented which indicates that: 1. indirect interactions frequently occur in food webs; 2. such indirect interactions can be more significant than direct interactions; 3. there is no inevitable time delay between the manifestation of direct and indirect effects; indirect fects can appear quickly.

and indirect effects: indirect effects can appear quickly. Several genetic manipulations aim at changing the chemical composition of plants, while not necessarily making them toxic to insects. A review of literature on the occurrence of significant effects reverberating along the food chain as a result of modified base resource quality indicates that such effects are likely to occur with transgenic plants, too. Nontarget effects of transgenic plants can be significant, and we cannot ignore them in environmental impact evaluations.

Keywords: transgenic plants, non-target effects, tri-trophic links, food webs

[1248] INSECT RESISTANCE MANAGEMENT ON INSECT PROTECTED CROP IN LATIN AMERICA: PERSPECTIVES, CHALENGES AND EXPERIENCES

O. D. Fernandes¹ & G. W. Videla², ¹Monsanto Brazil, Av. Nações Unidas, 12.901, 70 andar. 04578-000. S. Paulo, SP. Brazil, E-mail odnei.d.fernandes@monsanto.com; ²Monsanto Argentina, Maipú 1210, Piso 6, Buenos Aires, Argentina, E-mail: guillermo.w.videla@monsanto.com

Lepidopteran pests are the major insect pests of soybean, corn and cotton in Argentina and Brazil. These countries have, respectively, the following crop areas: 8 milion ha and 12.5 milion ha of soybeans, 19 milion ha and 12.7 milion ha of corn, and 500,000 ha and 800,000 ha of cotton. Field studies utilizing genetically modified crops containing Btgenes are being conducted in these countries. Bt-Corn and Bt-Cotton have been commercially introduced in Argentina. In Brazil these technologies are under development. To date, control of lepidopterans pests in these crops is mainly done with the use of chemical insecticides. In this scenario, genetically modified plant, expressing the Bt proteins, may become an important pest control tool, if the principles of Integrated Pest Management (IPM) are considered. Insect Resistance Management (IRM) strategy is being addressed within the basis of the IPM philosophy, considering the scientific knowledge and the current agricultural practices for each crop. The basic principles of IRM (i.e., IPM, Refuge for susceptible pests, Monitoring target pests susceptibility, and Educational program) have been presented as important tools for the success of the program. In regards to the Refuge component, areas with specific sizes for each crop, in the different countries are being established, considering both local biological aspects and the international experience. Susceptibility baselines are being determined for different key pests. This information will be useful for resistance monitoring, which will be done in coordination with Research Institutes. To implement the IRM program, partnerships with research, education and extension institutes are being formed to provide information to growers and educate them on the importance, advantages and practicability of the program to assure a long-term viability of the technology. Key to a successful implementation of an IRM plan is the establishment of concerned efforts with seed companies. Technical recommendations based on a uniform IRM program will facilitate farmer understanding of the strategies to be implemented. Monsanto in Latin America, utilizing experiences gathered internationally, is working to set an effective IRM program, and is proactively seeking enrollment of seed companies in this effort.

Index terms: transgenic crop, resistance management, lepidopterans

[1247] SOME ASPECTS OF THE ENVIRONMENTAL RISK ASSESSMENT OF GENETICALLY MODIFIED PLANTS IN BRAZIL

D. M. F. Capalbo & V.L.S.S. Castro, Embrapa Environment, Caixa Postal 69, Jaguariúna, SP, 13820-000, Brazil, E-mail deise@cnpma.embrapa.br.

In the last decades, the anachronism between the need of new products to control agriculture pests and the offering of alternatives to them, has led to the development of new biological control tools. Among them are the genetic modified plants and microorganisms (GMOs) but their environmental risks are unknown because of the recent use of this technology. In the evaluation of environmental risks many aspects should be taken into account, specially when analyzing the GMOs: competitive displacement, alergenicity, toxicity, pathogenicity as well as the possibility of mutation of the new organisms. In Brazil any type of GMO has to get its authorization for use and commercialization from the National Technical Biosafety Committee (CTNBio) of the Ministry of Science and Technology. Although this Committee was established in 1995, only in 1997 an environment release of a GMO was applied. This caused an strong debate among environmentalists, official agencies, scientific and non scientific society, as well as among themselves. At that time, it came up the necessity for establishing a protocol for food safety and environment risk assessments of the GMOs and its establishment is being discussed. Many studies are under development for Brazilian agriculture utilization, and among them are those developed by Embrapa, envolving a multidisciplinary researchers group studying the environment risk assessment of some of Embrapa's GMOs. It is expected to generate enough knowledge to maintain the biodiversity and protect the environment, and also to reduce the public concern on the GMOs release. Embrapa Environment Unit, is responsible for establishing the main non target organisms to be studied and to develop, evaluate and validate such a protocol. As a conclusion it is expected to generate a better scientific knowledge and support for the risk analysis for the effective safe management of the GMOs used in the country. Index terms: biosafety, GMO, protocol

[1249] DEVELOPMENT AND IMPLEMENTATION OF RESISTANCE MANAGEMENT STRATEGIES FOR BT COTTON IN AUSTRALIA

G.P. Fitt & **R.T. Roush**², 1 - Australian Cotton Co-operative Research Centre, CSIRO Entomology, P.O. Box 59, Narrabri NSW 2390, Australia.Email: gary.fitt@ento.csiro.au. 2 - Centre for Weed Management Systems, University of Adelaide, Glen Osmond, SA 5064, Australia

Pesticide resistance is a challenge to many agricultural production systems. In Australia, cotton production has been dependent on the use of a range of pesticides for management of *Helicoverpa* spp., sucking pests and mites. *Helicoverpa* armigera has shown a propensity to readily evolve resistance to synthetic pesticides. With the introduction in 1996 of transgenic cotton varieties expressing the Cry1Ac gene from Bt, a pre-emptive resistance management strategy was implemented. While Bt resistance is not evident in field populations of *H. armigera*, the potential for resistance is high. The strategy has five components: (i) effective refuge crops to generate moths not exposed to Bt proteins (ii) cultivation of crop residues to destroy overwintering pupae of *H. armigera*, (iii) planting windows for Bt cotton to avoid wide divergence in phenology among transgenic crops, (iv) defined thresholds for late season management and (v) monitoring of Bt resistance levels. Considerable research has validated and refined elements of the strategy. It is critical to avoid resistance to the Cry1Ac protein until pyramided varieties can be introduced. For this reason the Australian industry has also restricted Bt cotton to 30% of the cotton area until two gene varieties become available. Deployment of Bt genes and resistance management must also be co-ordinated across the many crops throughout a cropping system.

Index Words: Bt Cotton, resistance_management, Helicoverpa.

[1250] NORTH AMERICAN CORN

R. L. Hellmich, USDA-ARS, Corn Insects and Crop Genetics Research Unit and Dept. of Entomology, 109 Genetics Laboratory, c/o Insectary, Iowa State University, Ames, IA 50011, USA, E-mail: rlhellmi@iastate.edu.

Growers in some regions of North America have rapidly adopted Bacillus thuringiensis (Bt) transgenic maize for controlling lepidopteran pests. Dramatic control of European corn borer, Ostrinia nubilalis, on these plants has many scientists concerned about high selection pressure to toxins in these plants and subsequent adaptation. In cotton-growing Tegions there are concerns about corn earworm, also called cotton bollworm, *Heliocoverpa* zea, resistance to these plants. There are many complexities with Bt corn insect resistance management (IRM) that are being considered by scientists, regulators, and growers. Within a few years IRM may become even more complex as transgenic maize for coleopteran pests become available. This talk will emphasize current IRM issues including refuge management, educating growers, monitoring for resistance, remedial plans, and alternatives to current practices.

Index terms: transgenic maize, Bacillus thuringiensis, resistance management.

[1252] BOTANICAL INSECTICIDES: ACCEPTABILITY OF ESTABLISHED PRACTICES AND CHALLENGES IN DEVELOPING NEW ONES

B. P. S. Khambay, Biological and Ecological Chemistry Department, IACR-Rothamsted, Harpenden, Hertfordshire, AL5 2JQ, UK, E-mail: bhupinder.khambay@bbsrc.ac.uk

The use of botanical insecticides remained the main method for controlling insect pests until the end of 19th century. Highly effective synthetic insecticides have now largely replaced them globally on medium to large-scale farms. Continued interest in botanicals within sections of the community in developing countries arises mainly from emotive rather than scientific considerations. Key factors include the perceived advantages (e.g. lower mammalian toxicity) associated with 'natural' materials. However several considerations, including limited photostability, production costs and patent protection, have deterred multinational companies from developing souch products. In contrast, their widespread use by small-scale farmers in many developing countries is primarily dictated by economic considerations where safety and efficacy are assumed on the basis of long traditional practices. Scientific studies have indicated that these can be dangerous assumptions. The international scientific community has till now concentrated mainly on issues surrounding the registration of botanical insecticides in developed countries. However, there is now clearly the need for greater effort in evaluating the efficacy and safety of the traditional practices used by resource-poor farmers so that they too can be confident of producing safe and healthy foods. The opportunity then arises for them to benefit from globalisation of markets through GATT. This introductory presentation to the session will highlight the broad issues surrounding

This introductory presentation to the session will highlight the broad issues surrounding the development and use of botanical insecticides and will include experiences from research at IACR-Rothamsted.

[1251] PINK BOLLWORM RESISTANCE TO BT COTTON

B.E. Tabashnik, T.J. Dennehy, Y. Carrière, Y.B. Liu, S.K. Meyer, A. Patin, & M.A. Sims, Department of Entomology, University of Arizona, Tucson, AZ 85721 USA, E-mail brucet@ag.arizona.edu.

Many insects have evolved resistance to *Bacillus thuringiensis* (Bt) toxins in the laboratory and diamondback moth has evolved resistance to sprays of Bt toxins in the field. The refuge strategy is the major tactic used for slowing evolution of insect resistance to crops that are genetically modified to produce Bt toxins. Refuges consist of host plants that do not produce Bt toxins and thus allow survival of susceptible insects. So far, Bt cotton has been extremely effective in controlling the pink bollworm (*Pectinophera gossypiella*), a global pest of cotton that is the key lepidopteran pest of cotton in Arizona. However, intense selection for pink bollworm resistance to Bt cotton is likely because of the high proportion of Bt cotton in Arizona and limited use of alternate host plants by this pest. The refuge strategy is expected to be most effective when three assumptions are valid: 1) random mating occurs between susceptible adults emerging from non-Bt cotton refuges and resistant adults emerging from Bt cotton, 2) inheritance of resistance is recessive, and 3) the frequency of alleles conferring resistance is less than 0.001. We are testing these assumptions for pink bollworm in Arizona with experiments in the field, greenhouse, and laboratory. Results to date suggest that violations of one or more of the assumptions are likely. Thus, pink bollworm is at high risk for rapid evolution of resistance to Bt cotton.

Index terms: Bacillus thuringiensis, Pectinophora gossypiella, transgenic cotton

[1253] OPPORTUNITIES AND PROBLEMS FOR DEVELOPMENT AND USE OF BOTANICAL INSECTICIDES IN INDUSTRIALIZED COUNTRIES

M.B. Isman, Faculty of Agricultural Sciences, Univ. of British Columbia Vancouver, BC, Canada V6T 1Z4, Email: murray.isman@ubc.ca

The Food Quality Protection Act (1996) in the United States will dramatically limit the uses of synthetic insecticides (e.g. organophosphates, carbamates and pyrethroids) in the years to come. As all fresh produce imported into the United States must meet US standards for pesticide residues, the impact of this legislation will be felt by many other countries who depend on the US as an export market. One positive result however, is the creation of a window of opportunity for alternative products and technologies for pest control, among which are botanical insecticides. Neem (Azadirachta indica, Meliaceae) control, among which are bolanical insecticutes, teem or analytic matter, means of the subject of intensive investigation worldwide for over 25 years, and subsequently, a voluminous literature. In spite of this, neem has yet to become well established as an important pest control product in the United States, where it has been approved for use on food crops since 1993. To this point, cost of production of reliably efficacious, standardized neem products has been a limiting factor, but competition among companies producing neem insecticides should make neem more cost-effective to growers. Although many people view neem as the modern paradigm for the development of botanical insecticides, neem has also suffered from a major problem common to modern botanicals – reluctance of regulatory agencies to approve it for use. While neem has been approved in the US, several other industrialized countries (e.g. Germany, Canada) have yet to give approval in spite of reviews spanning several years. Insecticides based on plant essential oils represent a completely different approach to the development of botanicals. Widely used as flavoring agents in the food and beverage industries, essential oils and their pure constituents (mostly monoterpenoids) are readily available in large quantities and can be relatively inexpensive. Some of these are exempt from registration in the US, even though they show considerable efficacy against insects. As such, it has been possible to get pest control products based on plant essential oils from the research laboratory to the market in less than two years. A number of other well investigated botanicals have yet to reach the marketplace, primarily because they fail to meet the criteria of (1) availability on a commercial scale, (2) chemical standardization, or (3) registration. Regulatory agencies could use modified criteria to review these types of products in a fair manner. Index terms: neem, plant essential oils, pesticide registration

[1254] CURENT DEVELOPMENTS WITH ETHNOBOTANICAL INSECTICIDES FROM GHANA: REVIVING AND MODERNISING AGE-OLD PRACTICE

S. R. Belmain⁴, H. F. Andan³, D.E. Neal³ & J.R. Cobbinah⁴, 'Natural Resources Institute, University of Greenwich, Central Avenue, Chatham Maritime, Kent ME4 4TB, UK, E-mail: <u>S.R.Belmain@gre.ac.uk;</u> ³Ministry of Food and Agriculture, P.O. Box 950, Tamale, Ghana; ³Medical Research Council, P.O. Box 138, Lancaster Road, Leicester LE1 9HN, UK; Forestry Research Institute, UST Box 63, Kumasi, Ghana

Insecticides of botanical origin are particularly relevant for small-scale subsistence farmers. In this context, botanicals have many advantages over synthetic pesticides because they are normally gathered locally by farmers and can provide an inexpensive method of pest control. For the majority of farmers in the world, commercial insecticides are often too costly or unavailable. Similarly, many uneducated farmers use synthetic pesticides inappropriately, leading to environmental and human safety hazards as well as promoting insecticide resistance. These factors have led to increased efforts to understand indigenous pest control strategies with a view to reviving and modernising age-old practices. However, previous studies assessing the insecticidal properties of plants have often failed to simultaneously assess their safety. Potential vertebrate toxicity associated with using insecticidal plants requires investigation before their institutional promotion at farm-level. The objectives of our research have been to identify plants from Ghana that are traditionally used by subsistence farmers as post-harvest protectants, screen them for bioactivity against target pests, develop optimal application protocols and assess their potential deleterious effects against vertebrates. Participatory rural appraisal surveys in Ghana identified hundreds of plant species with uses against a range of target pests. Laboratory screening of plants with known ethnobotanical uses as storage protectants showed that thirteen plant species were effective in controlling common storage pests. Laboratory bioassays showed that powdered admixed roots of Securidaca longipedunculata were the most effective material in controlling all the insects tested by dose-dependently reducing overall F, emergence and increasing adult mortality. The next most effective plants in controlling storage pests were *Ocimum americanum* and Chamaecrista kirkii. Farmer participatory research trials and field station trials in Ghana were used to develop optimum application protocols and showed similar results to laboratory bioassays. Rodent feeding trials with six of the plant species showed that none of the plants were toxic when incorporated into rat diet at 1%. However, a 5% concentration of *S. longipedunculata* and *C. kirkii* was found to affect rodent growth rate, reduce kidney size and increase liver cell hyperplasia. The implications of these findings are discussed in the context of increased promotion of botanical usage.

Index terms: Callosobruchus maculatus, Prostephanus truncatus, Rhyzopertha dominica, Sitophilus zeamais, botanicals, indigenous knowledge

[1255] THE USE OF BOTANICAL INSECTICIDES IN BRAZIL

<u>S. S. Martinez</u>¹, 'Área de Proteção de Plantas, Instituto Agronômico do Paraná, C. Postal 481, 86.001-970, Londrina-PR, Brazil, E-mail: suemart@onda.com.br

The extraction, commercialisation and exportation of botanical insecticides, mainly rotenone and pyrethrum, were a regular practice in Brazil before 1940. The intensive use of synthetic insecticides during the following decades, in Brazil as in the world, promoted serious environmental problems and human and animal intoxication, thus indicating the need of natural alternatives for insect control. The research on botanical insecticides received special input with the development of equipments like the NMR and HPLC, which helped to identify and to quantify the chemical compounds responsible for the action on the insects. Brazil has a very wide range of plant species with properties against insects. Nonetheless the studies on the use of these plants on pest control during the last decades are not many and they are mostly restricted to laboratory conditions. Species rich in rotenoids have been tested on crop pests, like: Tephrosia toxicaria, T. tunicata and T. candida killed larvae of Empoaska kraemeri and adults of Diabrotica speciosa, besides showing antifeedant effects on D. speciosa. These extracts have totally suppressed populations of Zabrotes subfasciatus in stored dry beans. Pachyrhyzus tuberosus killed larvae of Ascia monuste and showed antifeedant effects. Derris spp. killed larvae of Musca domestica. Other studies include plants like Sesamum indicum and Ricinus communis to control Atta spp. However these studies still need to be continued so to have DL50 determined, the methods of extraction well established, the products standardised. During the last 15 years the interest of research on botanical insecticides in Brazil directed to Azadirachta indica, the neem tree, mainly due to the high effectiveness of the compounds, facility of extraction, low toxicity to vertebrates and to the great amount of steps already clarified. Biotypes from different origins were planted in different regions in Brazil in order to evaluate their adaptation. The content of azadirachtin is being determined in these plants and during the development of the plants and the storage of the seeds. Several introductions of neem seeds were made and commercial areas are now being established in Central, Southwest and Northern Regions of Brazil. Neem extracts are being tested on crop pests, to be used particularly in organic coffee. Results on coffee pests are promising. Other Meliaceae species native in Brazil, like Melia azedarach, Trichilia sp., Cedrela sp., Cabralea glaberrima, are being tested on insect pests with similar effects.

Index terms: Azadirachta indica, Melia azedarach, Tephrosia sp., rotenoids, Meliaceae

Symposium and Poster Session

[1256] USE AND PERSPECTIVES OF BOTANICAL PESTICIDES IN CUBA

M. Alfonso, R. Avilés, J. Estrada y N. González, Institute of Fundamental Research on Tropical Agriculture (INIFAT), Santiago De Las Vegas, La Habana, Cuba. E-mail: inifat@ceniai.inf.cu.

Agricultural situation in Cuba changed dramatically when the Law of Agricultural Reform was promulgated and big state enterprises were founded . Then, pesticides and fertilizers were increasingly used, leading to an external supply based development. In the middle 80' this scope started to be replaced when a system of Integrated Pest Management as a state policy and the Pesticide Central Register were established, as well as the Biopesticides Production Enterprises Network and new production structures were created. These measures enabled to face the globalization challenges. Effective management concerning natural resources, biofertilizers and biotechnologies in terms of sustainability was carried out, and food production in cities increased by means of Urban Agriculture an the application of Organic Agriculture that lead to a production of more than one million tons of vegetables annually. During this period, botanical species traditionnally used by farmers have been processed in different ways leading, for instance, to aqueous extracts from tobacco harvest residues and to Tabaquina, a formulation for the white fly (*Bemisia tabaci*) control in beans. More recently, making use of native and introduced flora as a source of biologically active compounds, neem tree (Azadirachta indica) cultivation has been increased and china berry tree (*Melia azedarach*) and other plant species as *Gliricidia sepium*, *Solanum globiferum* and *Tagetes* spp. have been used to prepare formulations against a wide variety of insects, mites, nematodes, snails and weeds being ennemies of important crops as tobacco, banana, vegetables, corn, beans and others.

[1257] THE UPTAKE OF BOTANICAL INSECTICIDES BY FARMERS: A CASE STUDY OF TOBACCO BASED PRODUCTS IN NIGERIA

S. Morse¹, N. Ward³, N. McNamara³ & <u>I. Denholm</u>⁴, ¹International Development Centre, University of Reading, Reading RG6 6AU UK, E-mail s.morse@reading.ac.uk; ³Natural Resources International, Chatham Maritime, Chatham, Kent UK, E-mail a.f.ward@gre.ac.uk; ³Diocesan Development Services, P. O. Box 114, Idah, Kogi State, Nigeria; ⁴Institute of Arable Crops Research, Rothamsted, Harpenden, Herts., ALS 2JQ, UK, E-mail ian.denholm@bbsrc.ac.uk.

This paper will present the results of extensive experience in the development and promotion of tobacco-based insecticides for the control of field crop pests in Kogi State, Nigeria. An NGO, the Diocesan Development Services began the development of tobacco-based insecticide formulations during the early 1990s in partnership with a major European development donor and a 'sister' NGO based in Kenya. Since the mid-1990s these have been tested under 'farmer managed' on-farm conditions for two crops that are particularly vulnerable to pest attack in Kogi State: cowpea (Vigna unguiculata) and maize (Zea mays). The results of this on-farm programme, and a number of associated surveys conducted in the late 1990s, suggest that farmers are aware of botanical insecticides and do make limited use of them. It was also clear that even crude tobacco formulations had a significant benefit on cowpea and maize yields relative to the absence of pest control, although commercial insecticides were more effective. However, while having advantages of cost and availability over commercial insecticides, tobacco based products appear to have serious disadvantages that limit their widespread use, and some of these are discussed in the paper. One example is that tobacco sprays were not effective on the pod sucking bug insects that have a major effect on cowpea seed quality, and this is a major determinant of market price. It is clear that the uptake of botanical insecticides is influenced by a wide range of factors both within and external to the broad and complex 'crop protection' decision-making environment, and technical efficacy is but one element amongst many that has to be considered. A better understanding of these factors and how context-specific they may be is required in order to maximise their adoption by farmers under 'resource poor' conditions.

Index terms: Nigeria, botanical insecticide, tobacco, cowpea, maize.

[1258] GENETIC PRINCIPLES AND THE EVOLUTION OF INSECTICIDE RESISTANCE

[1260] THE IMPACT OF POLYPHAGOUS INSECT DISPERSAL ON DEPLOYMENT DECISIONS FOR TRANSGENIC CROPS

J. A. McKenzie, Department of Genetics, Faculty of Science, The University of Melbourne, Victoria 3010, Australia.

Insecticide resistance has developed to a range of different insecticides in a number of different species. the phenomenon has been investigated by specialists from many distinct discipline areas. the most effective studies have frequently used, or combined, the expertise of these specific disciplines within an evolutionary framework to inform strategies of resistance management. resistance systems, in turn, lend themselves to the investigation of more general evolutionary phenomena because the selective agent is known, the biochemical/molecular/physiological basis of selection is defined and relative fitness differences between susceptible and resistant phenotypes are sufficiently large to enable experimentation on a manageable time scale. Underpinning an evolutionary approach to resistance management is a foundation of the genetic theory of adaptive change. Applied to insecticide resistance, this theory predicts that if selection acts within the phenotypic distribution of susceptibles, that is at insecticide concentrations lower than that required to kill all susceptibles, the lc₉₉₉₉ of susceptibles rare resistant mutations are favoured and a monogenic response is more likely. Experiments in the australian sheep blowfly, lucilia cuprina (diptera: calliphoridae) confirm these general expectations and demonstrate that if a monogenic resistant variant is present in a susceptible population exposed to concentrations less than the $l_{\alpha_{mn}}$ of susceptibles the likelihood of establishment of the resistant allele is a function of the frequency of the allele in the population, the pleiotropic effect of the resistant allele and the concentration of exposure. The consequences of these results to the general general denote the order of the derivation of resistance management strategies will be discussed to provide an introduction to the other papers of the symposium.

Index Terms Lucilia cuprina, monogenic/polygenic response

[1259] EXPLAINING THE NON-COFFEE DRINKERS: DO WE KNOW WHY SOME ORCHARD PESTS EVOLVE RESISTANCE AND SOME DON'T?

D.M. Suckling, HortResearch, PO Box 51, Lincoln, Canterbury, New Zealand.

Orchards are highly modified environments, which are largely monocultures of high-value perennial crops. They provide a stable habitat of high quality food for herbivores, often of much higher nutritional and moisture content than the surrounding landscape. They are usually large areas, readily colonised by generalist or specialist arthopods in the local vicinity, and the complex trunk and canopy architecture offers a multitude of micro-habitats for establishment. For several decades in the second half of the 20° Century, many orchard pests were managed with a pesticide-intensive approach reliant on a single mortality factor to achieve the economic threshold. Differences in the rate of appearance, level, spread of pesticide resistance can be considered from our knowledge of the process of evolution. We have some understanding of predisposing factors towards insecticide resistance, involving attributes related to crop colonisation by pests (polyphagy, generation time on that crop, dispersal, patch size and ratio of treated to untreated habitat), as well as crop management factors (pesticide application frequency and persistence, previous pesticide use), and the interaction between the target pest and pesticide (life stages and target site affected, etc.). Despite this, some surprises still energe.

Keywords: Mutation, phenotypic expression, selection, gene flow

M. A. Caprio¹ & D. M. Suckling³, ¹Dept. of Entomology and Plant Pathology, Box 9775, Mississippi State, MS 39762, USA, E-mail mcaprio@entomology.msstate.edu; ¹HortResearch, PO Box 51, Lincoln, Canterbury, New Zealand.

In most cases, resistance management options, if considered for a product at all, only consider these options from the perspective of a single crop. However, many insects are polyphagous and move among multiple crops and agroecosystems. As a result of this movement, each of these systems interconnects to utilize a common and limited natural resource, susceptibility to one or more toxins. We have utilized a two-locus spatially explicit stochastic simulation model to explore the interactions resulting from insect movement among different habitats and the resistance management choices made in each system. These interactions are important to understand when developing deployment strategies for transgenic crops. Resistance management in one crop, particularly a crop with a high value and high conventional pesticide inputs, could be compromised by the use of the same or similar toxins in crops where the transgene is less likely to provide as much benefit. Simulations of an apple-clover system in New Zealand and the corn-cotton agroecosystem in the South Eastern U.S.A. suggest that the population dynamics of the entire system may be at least as important as the level of cross-resistance between toxins utilized in different crops attacked by the same pest species. Deployment decisions for transgenic crops in agroecosystems where insects move among multiple crops should consider the role of the individual crops as refuges for other crops and the economics trade-offs between the relative roles of crops as refuges for the maintenance of susceptibility and the benefits of transgenic technology to that crop.

[1261] NATURE'S SELECTION: GENETICS AND EVOLUTION OF RESISTANCE IN *HELICOVERPA ARMIGERA*

J.C. Daly, K.P. Olsen & R. Akhurst. CSIRO Entomology, GPO Box 1700, Canberra, ACT, Australia, 2601, E-mail: J.Daly@ento.csiro.au.

Resistance to a number of insecticides has evolved independently in field populations of *H. armigera*. In the two cases studied in detail, resistance is partially dominant. In contrast, resistance management strategies (RMS) for transgenic cotton, containing the Cry1Ac toxin from *Bacillus thuringiensis* (Bt) have assumed that any likely resistance genes will be inherited as a recessive trait. Recently, we have selected strains of *H. armigera* in the laboratory that are resistant to the Cry1Ac toxin. This strain can develop successfully on transgenic Bt cotton. We have begun crosses to determine the mode of inheritance. Preliminary results suggest that the resistance is consistent with a major gene that is incompletely dominant. We propose that such a gene is likely to shorten the period during the growing season in which the Bt cotton is effective at killing larvae. RMS will need to include the possibility of such a gene evolving in the field. Index: *Bacillus thuringiensis*, resistance, management strategies

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[1262] RESISTANCE IN DIAMONDBACK MOTH: LESSONS FROM THE HELIOTHINES

D. G. Heckel, L. J. Gahan & B. E. Tabashnik, Dept. of Genetics, Univ. of Melbourne, Parkville 3052, Victoria, Australia, Email d.heckel@ genetics.unimelb.edu.au; ²Dept. of Biological Sciences, Clemson Univ., Clemson, SC 29634, USA; Dept. of Entomology, Univ. of Arizona, Tucson, AZ 85721, USA.

Over the past several years we have developed a genetic linkage map for the heliothine genera *Heliothis* and *Helicoverpa*, and used it to map and characterize genes conferring resistance to chemical and biological insecticides. To test whether this approach is useful in other lepidopteran pests, we have begun mapping diamondback moth (*Plutella xylostella*, DBM) resistance to insecticidal toxins of *Bacillus thuringiensis* (Bt). DBM is a worldwide pest of vegetables and is still the only insect to evolve resistance to at least four Bt toxins (including Cry1Ac) and enables DBM larval survival on transgenic plants. We utilized a similar experimental design as in the heliothine mapping studies to map Bt. Cry1Ac resistance gene we previously mapped in a laboratory-selected strain of *Heliothis virescens*. If these two species have independently developed the same resistance risk in other lepidopteran species that are targets of Bt-transgenic crops, such as *Helicoverpa amigera* and *Ostrinia nubilalis*.

Index terms: Bacillus thuringiensis, Plutella xylostella, resistance, Heliothis virescens, Helicoverpa [1264] HOW OFTEN DOES RESISTANCE ARISE IN NATURAL POPULATIONS: CYCLODIENE RESISTANCE AS A CASE STUDY

R.II. ffrench-Constant, Department of Biology, University of Bath, BAth, BA2 7AY UK.

Cyclodiene resistance is associated with a single amino acid substitution in the *Rdl* encoded GABA receptor subunit. Replacements of this same amino acid have been found in all target site resistant insects studied to date. This raises the important question: Does the mutation arise once and spread, or do novel mutations occur repeatedly at the same site? We have examined this question by looking at the global population genetics of several very different insects: 1) The *Drosophila melanogaster/simulans* group. 2) Whiteflies of the genus *Bemisia.* 3) The coffee berry borer *Hypothenemus hampei.* 4) The red flour beetle *Tribolium castaneum.* In this talk we will examine how the number of associated lifestyle of the insect. For example, in the strictly inbreeding coffee berry borer, resistance appears to have arisen only once in one inbreeding ine in one South Pacific island. Whereas in the outbreeding beetle *Tribolium* we can detect clear evidence several repeated global origins of the same resistance associated mutation.

[1263] A HITCH-HIKER'S GUIDE TO RESISTANCE IN THE SHEEP BLOWFLY

R. D. Newcomb¹, D. M. Gleeson², J. R. Stevens³, R. J. Russell⁴, J. G. Oakeshott⁴, ¹HortResearch, Private Bag 92169, Auckland, New Zealand, E-mail rnewcomb@hort.cri.nz; ²Landcare Research, Private Bag 92170, Auckland, New Zealand; ²School of Biological Sciences, Univ. of Exeter, Prince of Wales Rd, Exeter EX4 4PS, UK; ⁴CSIRO, Div. of Entomology, GPO Box 1700, Canberra, ACT 2601, Australia.

In the sheep blowfly Lucilia cuprina resistance to organophosphorus insecticides (OPs) is encoded at the Rop-1 locus. Increased levels of resistance to diethyl over dimethyl OPs is caused by a Gly137Asp substitution in the E3 protein encoded by Rop-1. This single substitution transforms the carboxylesterase into an OP hydrolase. A second type of OP resistance is encoded by another substitution in the same enzyme, Trp251Leu/Ser, which confers increased levels of resistance to dimethyl over diethyl OPs. We have studied Rop-I sequence variation in two sets of samples of sheep blowfly. In the first set of 40 isogenic lines of L, cupring from Australasia there was a absolute correlation between resistance to diethyl and dimethyl OPs, reduction in carboxylesterase activity, gain of OP hydrolase activity and the presence of the two Rop-1 substitutions described above. Sequence variation in a 1.2 kb region including these two substitutions and three introns surrounding them revealed that each of these mutations has occurred at least twice. Only three lines were susceptible to OP insecticides and each was of a different haplotype. In the second set of wild caught L. cuprina from around the world four new haplotypes were observed with all but one carrying resistance substitutions. In a similar global sample of the sibling species, *L. sericata*, 15 haplotypes were observed, including one containing the Gly137Asp substitution in New Zealand and four containing the Trp251Leu/Ser substitution. We have used these data to assess the predictions of the hitch-hiking model of molecular evolution. In particular; i) whether the original advantageous mutational events were rare and modern alleles are derived from a small number of these events, ii) whether levels of neutral variation at the locus under positive selection and linked loci have been reduced and iii) whether levels of neutral variation within L. cuprina are reduced in this region relative to levels observed in susceptible haplotypes in sibling species.

Index terms: Lucilia cuprina, organophosphorus resistance, carboxylesterase

[1265] ESTIMATING FITNESS IN COLORADO POTATO BEETLE

P. A. Follett, USDA-ARS, U. S. Pacific Basin Agricultural Research Center, PO Box 4459, Hilo, Hawaii 96720

Experiments were conducted to examine age, space, and time components of selection for resistance in Colorado potato beetle under field conditions. Fitness components were measured for permethrin-resistant, susceptible, and hybrid strains of this insect on permethrin-treated and untreated potato. Results indicated that there is significant selection against susceptible genotypes during all larval stages and in the adult stage at the time of permethrin application. Therefore, targeting a particular life stage to avoid selection is not an option. After insecticide application to potato plants, relative fitness of 1-d-old larvae of the three strains changed through time as permethrin residues decayed and plants grew. Selection against susceptible individuals persisted for the duration of the experiment (14 d), but the selection differential diminished with time. Selection against susceptibles was more intense on old foliage than new foliage treated with permethrin, probably due mainly to greater leaf expansion of new foliage. Tactics for slowing the rate of resistance development should emphasize reducing the proportion of the population subjected to insecticide selection and the frequency of selection.

Index terms: Leptinotarsa decemlineata, permethrin, insecticide resistance, ecological genetics, adaptation

[1266] ATTEMPTS TO MEET THE THREAT OF PYRETHROID RESISTANCE TO THE CONTINUED SUCCESS OF INSECTICIDE TREATED BEDNETS AGAINST MALARIA VECTORS

C.F.Curtis & <u>J Kolaczinski</u>, London School of Hygiene & Tropical Medicine, London WC1E 7HT, UK

Insecticide treated bednets appear to be the most promising method for malaria vector control, but only pyrethroids are currently used for net treatment and already there are reports of broad spectrum pyrethroid resistance in the main malaria vector, Anopheles gambiae, in three West African countries (Chandre et al 1999, Bull WHO 77: 230-4). Insecticide treatment of nets acts by improving the personal protection provided by the net to the individual net user and also, when nets are used by a whole community, by mass killing of mosquitoes attracted to the nets by the odour of the occupants. We have repeatedly found in Tanzanian trials that this mass killing effect greatly reduces the numbers of mosquitoes in a village population living long enough for malaria parasites to have matured inside them. Effective protection of the net user will probably require a net treatment with excito-repellent action on mosquitoes, but mass killing of mosquitoes attracted to nets presumably requires only a rapid insecticidal effect. In areas where the An.gambiae population is either pyrethroid susceptible or resistant we have tested various pyrethroids, as well as the non-pyrethroids pirimiphos methyl and carbosulfan, in experimental huts which allow evaluation of both the protection of sleepers under nets from biting, as well as of mosquito killing. Comparison of our data with that of Darriet et al (WHO/Mal/99.1088) suggests that some pyrethroids, but not others, may still perform satisfactorily against the existing form of resistance, but we are working to clarify this. Pirimiphos methyl was ineffective in prevention of biting but highly effective at mosquito killing. Carbosulfan was encouragingly effective at both functions against a pyrethroid resistant population (Fanello et al, 1999, Parassitologia 41: 323-6). We propose to investigate carbosulfan-pyrethroid mixtures for resistance management.

[1267] INSECTICIDE RESISTANCE GENES IN CULEX PIPIENS COMPLEX MOSQUITOES FROM CHINA

C. L. Qiao, X. Li, J. M. Xing & K. Zhang, The State Key laboratory of Integrated Management of Pest Insects and Rodents, Inst. of Zoology, Academia Sinica, Beijing, China, 100080, E-mail: qiaocl@panda.ioz.ac.cn

Insecticide resistance to organophosphorus chemicals has been studied at the gene and the population levels in the *Culex pipiens* complex in various geographic areas of China. In this species, overproduction of nonspecific esterases is a common mechanism of resistance to (OP) organophosphorus insecticides. The overproduction of all esterases B is due to the gene amplification of the same DNA haplotype which has been found in mosquitoes with an esterase B1 protein, independently of their geographical origin: Xishan and Beijiao in Beijing, Gaomi in Shandong province, Shashi and Wuhan in Hubei province, Guangzhou in Guangdong province and Kunming in Jiangsu province. It was observed that there were large variations in gene amplification levels. This situation is supported by the B1 amplification that has a unique origin, and has subsequently spread by migration and selection by OP insecticides. Esterase B1 has spread without limitation compared with that of A2B2 esterases in China, as B1 is observed in South, North and Central China, whereas the A2B2 distribution is found only in the South of China, Shanghai, the Kunming in Yunnan province, and Hangzhou in Zhejiang province. That variations exist in the esterases of several resistant populations indicates polymorphism in the mosquito enzymes. This finding supports the hypothesis of insecticide resistance occurring multiple times involving different resistance-conferring esterases. Index terms: organophosphorus, esterases, amplification

[1268] BIFENAZATE (D2341), A NOVEL AGENT TO CONTROL SPIDER MITES

<u>R. C. Moore</u>¹, M. A. Dekeyser³, P. T. McDonald³ & G. W. Angle Jr.³, ¹Uniroyal Chemical Co., World Headquarters, Middlebury, CT, USA; ²Uniroyal Chemical Co., Research Laboratories, 120 Huron Street, Guelph, Ontario, Canada; ³Uniroyal Chemical Co., New Product Research, 74 Amity Road, Bethany, CT, USA

Bifenazate (N'-(4-Methoxy-biphenyl-3-yl)-hydrazinecarboxylic acid isopropyl ester) is an novel carbazate acaricide discovered by Uniroyal Chemical for mite control in a range of agricultural and ornamental crops. The compound has a very good toxicological and environmental profile. Bifenazate shows no cross-resistance with currently available acaricides and provides preliminary results indicate it has a novel mode of action for mites. Bifenazate provides excellent control at low rates against all stages of tetranychid mites. Bifenazate shows minimal impact on beneficial insects and mites and is recommended for use in integrated pest management (IPM) programs. Bifenazate has shown no crop injury at rates well in excess of proposed field rates. Index terms: Panonychus species, tetranycid mites, new acaricides.

[1269] THIAMETHOXAM: NEW INNOVATIVE APPLICATION OPPORTUNITIES FOR A SYSTEMIC PRODUCT

R. Senn', W. Fischer¹, P.Wyss² & A. Morcos³, Novartis Crop Protection AG, 'Werk Rosental, CH-4058 Basel, Switzerland, 'Biology Research Insect Control, CH-4332 Stein, 'Agrochemical Research Station, Kaha, Qalubiya, Egypt

Thiamethoxam is a second-generation neonicotinoid belonging to the subclass of the Thianicotinyl compounds. Its physicochemical properties are favourable for an efficient transport in water. Studies with C⁴ radiolabelled material applied as a soil drench to tomato plants were done. Results show that thiamethoxam after uptake by the root hairs is transported via cell walls (apoplast) and cytoplasm (symplast) to the xylem in which it is transmitted in acropetal direction within the plant. Clear differences between three selected neonicotinoids, acetamiprid, imidacloprid and thiamethoxam were observed at 6 hours, 3 and 14 days after application. Acetamiprid was taken up by the roots very fast but did not and 14 mays after application. Acctainipita was taken up by the foots (p) has but not last for a long time in the plant, whereas thiamethoxam was slower in uptake into the tomato roots, but clearly for a longer time present in the plant. Imidaeloprid was in between the two other compounds. Due to the high water solubility of 4100 mg/ and the negative log P value of -0.13, thiamethoxam is neither adsorbed to the organic matter nor negative log F value of -0.13, thiamemoxam is neutrer adsorbed to the organic matter for affected by normal soil pH values. In greenhouse tests neither pH values of 5.5 to 8.1 nor organic matter content of 2-20% did affect the efficacy of thiamethoxam against *Aphis* gossypii on cotton. In addition it is available for uptake even under relatively dry soil conditions. This fact could be confirmed in a field trial done in Egypt, where tomato crops grown under wet conditions (normal irrigation) and under dry conditions (minimal irrigation) were compared. Soil application methods such as into drip irrigation system injection, in furrow spray, drench after transplanting, side dress or seedling dip, are suitable methods to control Homoptera, Coleoptera, Hemiptera and other insect pests over an extended period. The best placement of thiamethoxam is in the root zone, which means 2-4 cm below the sowing line at planting. In order to reach the root zone, thiamethoxam should be incorporated. After soil surface application, the product has to be washed in with enough irrigation water to move the active ingredient to the root zone. Product placement and irrigation have to be combined in a way that the water will lead the compound to the root zone. Over or under-irrigation may influence the efficacy level. Main advantages of any soil application method are the long time protection, the protection of the whole plant including the new growth and its convenient application.

Index terms: Thiamethoxam, soil application, chemodynamics.

[1270] INDOXACARB: ATTRIBUTES THAT IMPACT FIELD PERFORMANCE AND CONTRIBUTE TO CONSERVATION OF BENEFICIALS

J. T. Andaloro, K. D. Wing, L. J. Flexner, R. A. Cameron, J. P. Saienni, & C. J. Williams, DuPont Agricultural Products, Stine Research Center, Elkton Road, Newark, DE, 19711, USA.

Indoxacarb is a new oxadiazine insecticide from DuPont globally available in SC and WG formulations for fruits, vegetables, and cotton. Indoxacarb is very safe to workers and consumers with minimal re-entry time, post-harvest intervals, and personal protective equipment. Indoxacarb has a novel mode of action and is extremely potent at its biochemical target, blocking the sodium channel. Indoxacarb is a broad spectrum lepidopteran insecticide with activity against selected sucking insects at 25 to 125 grams AI/ha. The primary route of entry is mainly through ingestion and secondarily by contact resulting in irreversible paralysis and quick feeding cessation causing death within 48 hours. Indoxacarb has low water solubility and is not systemic. However, due to its lipophilicity it partitions in the leaf's waxy cuticle optimizing control of certain sucking insects and providing rainfastness and good residual activity. Indoxacarb formulations are very stable in the tank at extreme temperatures over a three day period. Compatibility with various insecticide, fungicide, and foliar nutrient tank mix partners to date has been excellent, assuming the proper product mixing sequence is followed. The behavior of indoxacarb in the application process and interactions with target crops are being

investigated; particularly as they apply to droplet flight, evaporation, droplet impact, leaf spreading, initial retention, leaf penetration, and residual. Indoxacarb exhibits selective safety to many beneficial arthropods due to differences in toxicity, differences in feeding behavior of herbivorous vs insectivorous insects, and different modes of entry resulting in the conservation of beneficials in commercial agricultural ecosystems. In addition, Indoxacarb's safety to workers and the environment, consistent and reliable efficacy, low use rate, and unique mode of action make it an excellent fit in Integrated Pest Management and Resistant Management programs and a prudent choice to alternate, replace, or complement existing insecticide chemistries.

Index terms: indoxacarb,oxadiazine,insecticide, biological efficacy, beneficial safety.

[1271] BIORATIONAL AGENTS – MECHANISM AND IMPORTANCE IN INTEGRATED PEST MANAGEMENT (IPM) AND INSECTICIDE RESISTANCE MANAGEMENT (IRM) PROGRAMS

L. Ishaaya & A. R. Horowitz, Dept. of Entomology, Agricultural Research Organization, The Volcani Center, Bet Dagan 50250, Israel, Fax: +972-3-968 3835, E-mail: vpisha@netvision.net.il,

In recent years, insect control by broad-spectrum insecticides has come under assault and scrutiny because of their undesirable effects on human health and the environment. Furthermore the rapidly developing resistance to conventional insecticides provides the impetus to study new alternatives and more ecologically acceptable methods as part of IPM and IRM programs. One of these approaches is the development of novel compounds affecting developmental processes in insects, such as chitin synthesis inhibitors, juvenile hormone mimics, and ecdysone agonists. In addition extensive efforts have been made to develop compounds acting selectively on some groups of insects by inhibiting or enhancing biochemical sites such as respiration (diafenthiuron), the nicotinyl acetyl choline receptors (imidacloprid and acetamiprid), and salivary glands of sucking pests (pymetrozine). Among the most recent novel insecticides with selective properties are the novaluron, thiamethoxam and spinosad. Novaluron (Rimon) is a novel benzoylphenyl urea that acts by both ingestion and contact. As such it is a powerful suppressor of lepidopteran larvae such as Spodoptera littoralis and Helicoverpa armigera (by ingestion) and of whiteflies such as *Bemisia tabaci* and *Trialeurodes vaporariorum* (by contact). Thiamethoxam (Actara) is a novel neonicotinoid acts specifically on aphids and whiteflies and spinosad (Tracer) acts on diversity of insect species and is considered an important agent for controlling the western flower thrips. The above compounds will be discussed in relation to their modes of action and their importance in IPM and IRM programs in various agricultural systems.

Key words: selective insecticides, benzoylphenyl ureas, juvenile hormone mimics, ecdysone agonists, biocontrol agents.

[1272] A GLOBAL PERSPECTIVE ON THE BIOLOGY AND FIELD PERFORMANCE OF SPINOSAD

P. Downard, G. Thompson, L. Pavan, R. Dutton, K. Kaneshi, A. Samsudin & P. Vergolas, Dow AgroSciences, Australia, USA, Brazil, England, Japan, Malyasia, and France.

Spinosad is a fermentation metabolite of the actinomycete Saccharopolyspora spinosa Mertz and Yao. Spinosad provides highly effective control of many Lepidoptera, Thysanoptera and Diptera insect pests while exhibiting large margins of selectivity for many beneficial insects, non-target organisms and applicators. Spinosad was one of the first products accepted into the U.S. Environmental Protection Agency reduced risk category. It has received rapid registrations and is currently registered on over 100 crops in over 20 countries as Tracer*, Success* and SpinTor* Naturalyte* Insect Control. This paper will focus on the field development program that enabled the rapid registration and adoption by agriculture. Special emphasis will be place on crops, pests, and use patterns in Australia, Japan, Southeast Asia, Latin America, USA and Europe. An overview of the philosophy and methods of the field development program as well as the biological response of Naturalyte Insect Control products in different environments will be provided.

[1273] BIOLOGICAL ACTIVITY AND FIELD PERFORMANCE OF METHOXYFENOZIDE: A CORNERSTONE FOR CONTROL OF LEPIDOPTEROUS PESTS

R. K. Jausson, Rohm and Haas Research Laboratories, 727 Norristown Road, Spring House, PA 19477-0904, USA, E-mail rahrkj@rohmhaas.com

Methoxyfenozide is a second-generation molt accelerating compound (MAC) in the diacylhydrazine family of chemistry discovered and developed by Rohm and Haas Co. This family also includes tebufenozide and halofenozide. Methoxyfenozide was discovered in 1990 and achieved its first commercial sales in 1999. Methoxyfenozide is binds to the receptor site for ecdysone and induces a premature and lethal molt. Like tebufenozide, methoxyfenozide is highly selective for lepidopterous pests, and is 3- to 10-fold more potent than tebufenozide against most lepidopterous pests. Methoxyfenozide is effective against a broader spectrum of pests than tebufenozide, it is safe to workers, loaders, applicators, consumers, birds, bees, natural enemies, and aquatic organisms. Because of its physiological selectivity for lepidopterous pests and its concomitant safety to beneficial arthropods, methoxyfenozide is well suited for integrated pest management programs. A pro-active resistance management platform was developed by Rohm and Haas Co. to prolong the longevity of methoxyfenozide and other MAC insecticide products in the marketplace.

Index terms: Methoxyfenozide, tebufenozide, ecdysone agonist

[1274] PERFORMANCE OF THIACLOPRID, A NEW FOLIAR APPLIED INSECTICIDE IN THE USA

R. Steffens & H. Lin, Research & Development, Agriculture Division, Bayer Corporation, 8400 Hawthorn Road, P.O. Box 4913, Kansas City, MO 64120, USA.

Thiacloprid, a new neo-nicotinoid (chloronicotinyl) insecticide, is being developed worldwide by Bayer for foliar application against a broad spectrum of sucking and biting insect Thiacloprid has excellent systemic activity and crop safety. It is effective at low nests. rates through contact and stomach activities. In the USA, Thiacloprid will be available in two products, CALYPSO® Flowable (4F) and CALYPSO® 70 WDG. The first registration application has been submitted to the US-EPA for use in apples, pears and cotton. The technical fit for use in additional crops is being investigated. Thiaeloprid has an excellent fit in pome fruits. In addition to post-bloom application, it can be applied prebloom because of its good safety to bees. On apples, it provides good to excellent control of leafminers, leafhoppers, mirid bugs, most aphids, codling moth and plum curculio. The control of other pests such apple maggot, scales, oriental fruit moth, glass wing moth, tuffed apple bud moth and others is under investigation. On pears, Thiacloprid offers excellent control of pear psylla in addition to leafminers, pear midge, aphids, and codling moth. Thiacloprid is soft on predatory mites, spiders and a number of beneficial insects. On cotton, Thiacloprid can be applied at low rates providing effective control of aphids, fleahoppers and other pests. It is particularly suitable for use before the start of pyrethroid sprays, due to its selectivity and IPM compatibility. For the control of whiteflies, including silverleaf whitefly, Thiacloprid offers an effective solution and an alternative to the frequently used tankmixes like Fenpropathrin plus Acephate. A favorable product profile and broad pest control spectrum make Thiacloprid an effective alternative for organophosphates and carbamates, and an attractive tool for resistance management in many situations.

Index Terms: Apples, Pears, Cotton, Codling moth, Pear psylla, Aphids

[1275] RECENT ADVANCES IN PESTICIDE RESISTANCE MANAGEMENT PROGRAMS IN BRAZIL

C. Omoto¹, R. N. C. Guedes² & L. A. Pavan³, ¹Depto, de Entomologia, Fitopatologia e Zoologia Agrícola, Escola Superior de Agricultura "Luiz de Queiroz", Av. Páduas Dias, 20010gia Agricola, Lecola, Sperior Soferior de Martine anticational activity and the second s AgroSciences, Caixa Postal 226, 13800-970 Mogi Mirim, SP, Brasil.

Almost 100 years have completed since the first detection of the resistance to a pesticide in a pest of economic importance and more than 500 cases of arthropod species resistant to the major classes of pesticides have already been documented around the world. However, researches on this subject gained importance in Brazil only in the last decade. The first Brazilian studies have focused on detection of the resistance after the documentation of frequent pest control failures with the use of a certain pesticide. Works have been done with some pests of stored products (Sitophilus zeamais and Rhyzopertha dominica), vegetables and ornamentals (Tetranychus urticae, Plutella xylosiella, Tuta absoluta and Bemisia tabaci), coffee (Leucoptera coffeellum), com (Spodoptera frugiperda), citrus (Brevipalpus phoenicis), among others. Researches on urban pests such as mosquitoes (Aedes aegypti and Culex spp.) and cockroaches (Blattella germanica) have also received attention. Besides detecting the resistance, some studies on genetics and mechanisms of the resistance have also been conducted. Not surprisingly, the most challenging step has been the implementation of the resistance management strategies in Brazil. A recent advance was the establishment of the Brazilian Insecticide Resistance Action Committee (IRAC-BR) in 1997 which is composed of professionals from 16 chemical companies, 2 consultants from universities and a representative from the Brazilian Ministry of Agriculture. The major activities of the IRAC-BR have been centered on research and educational programs. At moment, four research projects have been partially sponsored by IRAC-BR: Bemisia tabaci in vegetables, Spodoptera frugiperda in corn, Tuta absoluta in tomato and Alabama argillacea in cotton. After the implementation of this committee, studies on baseline susceptibility of the key pests to new chemical compounds that are launching in the market have also been emphasized for a proactive resistance management program. In this talk, progress on pesticide resistance management programs of Brevipalpus phoenicis in citrus and Spodoptera frugiperda in corn will be discussed.

Index terms: Brevipalpus phoenicis, Spodoptera frugiperda, chemical control.

[1276] SUCCESSES AND FUTURE CHALLENGES OF MANAGING WHITEFLY **RESISTANCE IN ARIZONA**

T. J. Dennehy & Y. S. Li, Extension Arthropod Resistance Management Laboratory, Dept. of Entomology, University of Arizona, Tucson, AZ 85721, USA, E-mail: tdennchy@ag.arizona.edu.

We will describe the successful management of whitefly resistance to synergized pyrethroid insecticides in Arizona cotton since 1995 and show how insecticide use against whiteflies has declined sharply since that time. Sustaining this success hinges on: 1) maintaining the effectiveness of buprofezin (Applaud®) and pyriproxyfen (Knack®), two insect growth regulators (IGRs) used in cotton; 2) averting more serious whitefly resistance to the insecticide imidacloprid (Admire®/Provado®) in winter vegetables and melons, and to two related neonicotinoid insecticides currently under development, acetamiprid and thiamethoxam; and 3) kceping highly resistant glasshouse whiteflies from spreading resistance to other commodities. While, imidacloprid continued to be used effectively against whiteflies on a very large proportion of Arizona melon and vegetable acreage, resistance levels have increased overall through time. The highest levels of resistance to imidacloprid were consistently detected in Arizona glasshouses and on poinsettias shipped to Arizona from other states. However, whiteflies from specific vegetable and melon fields displayed imidacaloprid resistance levels equal to those detected in glasshouses. Statewide levels of resistance to imidacloprid of whiteflies collected from cotton increased sharply from 1997 to 1998, but declined in 1999. The two newer neonicotinoid insecticides demonstrated significant but low order cross-resistance to imidaclprid. The IGRs, buprofezin and pyriproxyfen, provided the underpinning of the successful whitefly resistance management program implemented in cotton in 1996. Their use has been limited to a maximum of one treatment each in cotton. However, since 1996, less restrictive use of these insecticides has occured in glasshouses and on vegetables and melons. Both compounds continue to perform satisfactorily in cotton. However, the first evidence of reduced susceptibility to pyriproxyfen of whiteflies from Arizona cotton was obtained in 1999, and the populations least susceptible to pyriproxyfen or buprofezin were found in glasshouses and on melons. The future success of whitefly control in Arizona will be predicated on the degree to which use of neonicotinoid and IGR insecticides is limited and harmonized in these complex agricultural ecosystems.

Index terms: Bemisia argentifolii, imidacloprid, acetamiprid, thiamethoxam, resistance management.

1277] PROGRESSIVE INSECTICIDE RESISTANCE MANAGEMENT PROGRAMS IN THE ISRAELI AGRICULTURAL ECOSYSTEM

A. R. Horowitz¹, G. Forer², R. Ausher³, P. G. Weintraub³ & I. Ishaaya⁴, ¹Dept. of Entomology, ARO, Gilat Exp. Sta., M. P. Negev 85280, Israel, E-mail hrami@netvision.net.il; ²Cotton Production & Marketing Board, Herzliyya-B 46103, Israel; ³Dept. of Crop Prot., Ext. Service, Miniatry of Agric. & Rural Develop., P. O. Box 28, Bet Dagan 50250, Israel; ⁴Dept. of Entomology, ARO, The Volcani Center, Bet Dagan 50250, Israel Dagan, 50250, Israel.

Agriculture in the semi-arid Israeli climate has developed into intensive cropping systems including irrigated field crops, orchards and greenhouses. Israel has been plagued by many insect pest species that have seriously damaged yields, such as Bemisia tabaci, Spodoptera littoralis, Helicoverpa armigera, Pectinophora gossypiella and Frankliniella occidentalis, especially in cotton, vegetable and ornamental crops. Increasing failure to control B. tabaci with conventional insecticides led, in the late 1980s, to the introduction of a nationwide insecticide resistance management (IRM) strategy for cotton. One of its main objectives was to provide a means of exploiting and restricting newer chemicals, such as buprofezin, pyriproxyfen and other IGRs, to combat resistance along with other non-chemical measures. One of the achievements of this strategy is the reduction in insecticide use as well as in control costs. The Israeli strategy has since been adapted successfully to cotton in Arizona. Despite this success, however, outbreaks of resistance to newer insecticides have been observed in some cotton-growing areas of Israel. Recently, areawide pesticide management (APM) programs, covering most of the major agricultural crops has come under supervised control. Integrated pest management (IPM) and biological control practices have been introduced regionally. These programs have resulted in about a 30% reduction in the use of pesticides and, no doubt, have also improved the situation with regard to insecticide resistance. The progressing APM programs in such a diverse crop system will be discussed.

Index terms: Bemisia tabaci, Helicoverpa armigera, cotton, agricultural crops, IPM.

[1278] COMBATING INSECTICIDE RESISTANCE: ENMARIA AND THE EUROPEAN PERSPECTIVE

I. Denholm¹ & J. B. Jespersen², ¹Dept. of Entomology and Nematology, IACR-Rothamsted, Harpenden, Herts., AL5 2JQ, UK, E-mail ian.denholm@bbsrc.ac.uk; ²Danish Pest Infestation Laboratory, Skovbrynet 14, DK-2800 Lyngby, Denmark, E-mail j.b.jespersen@ssl.dk.

Insecticide resistance remains an important problem throughout Europe, reflecting a gradual accumulation of resistance mechanisms by some pests, and the greater diversity of species attacking valuable commodities, especially in the horticultural sector. Crop pests of particular concern include the aphids *Myzus persicae* and *Aphis gossypii*, the whiteflies *Trialeurodes vaporariorum* and *Bemisia tabaci*, the thrips *Frankliniella occidentalis*, the spider mites *Tetranychus urticae* and *Panonychus uni*, codling moth, *Cydia pomonella*, and the pear psylla, *Cacopsylla pyri*. In addition, resistance extends to coleopteran and mite pests of stored grain, and public health and livestock pests including mosquitoes, houseflies and occkroaches. ENMARIA (European Network for the Management of Arthropod Resistance to Insecticide and Acaricides) was launched four years ago as an EU-funded Concerted Action to promote the development and implementation of management strategies for insecticide and acaricide resistance throughout Europe. Patticipants in ENMARIA include scientists and advisors from 13 countries, as well as representatives of the agrochemical industry's Insecticide Resistance Action Committee (IRAC). The principal activities have been (i) compiling a database of known or suspected cases of resistance within Europe; (ii) convening workshops to promote the standardisation of techniques and the dissemination of management guidelines; (iii) sponsoring training visits between laboratories; and (iv) publicising the cause of resistance management at conferences, and through publications and a website. Some of these activities and their achievements will be presented and discussed.

Index terms: Insecticide resistance management, resistance monitoring, Europe.

[1279] PRO-ACTIVE RESISTANCE MANAGEMENT OF THIAMETHOXAM.

<u>P. Wyss</u>¹, **R. Senn**² & **M. Angsi**²Novartis Crop Protection AG, ¹Biology Research Insect Control, CH-4332 Stein, ²Werk Rosental, CH-4058 Basel, Switzerland. Email: peter.wyss@cp.novartis.com

Neonicotinoids are on the way to become the new leading class of insecticides. Among them, thiamethoxam is the first product of the second generation neonicotinoids. It has a broad spectrum combining high performance with low rates, thus contributes substantially to the economics of the farmers. this favourable cost /performance ratio will trigger an intensive use, as history has demonstrated, any type of over- or misuse of products results sooner or later in development of resistance. Learning from the past, a program is devised for thiamethoxam with the aim to assess the risk potential of developing resistance in target pests. Indeed, some of the target pests like whiteflies and colorado potato beetle are known and feared for their resistance genes. in some regions these pests are very hard to control and new active compounds have to be managed very carefully in order to maintain their efficacy. Therefore, resistance management does not start with the occurrence of resistance but much earlier and in several steps, as it is undertaken for thiamethoxam:

Experimental part:	Ativities/results with Thiamethoxam:
- Monitoring methodology:	Provokes a fast feeding stop. It takes a
	while until pests die. Mortality
- Cross-resistance tests:	Target pests resistant towards established insecticides are normal by
	sensitive to thiamethoxam.
	Field results indicate a X-resistance
	risk in whiteflies to neonicotinoids.
- Sensitivity of target pests:	World wide assessment of baselines and monitoring of sensitivity over time.
- Relevance of monitoring data:	Monitoring data are compared with field
	performance for calibration: resistance
is	i de la companya de la
	defined as a loss of field
	Serviciante.
- Life stage specific sensitivity:	nonulations is correlated with field

performance. Use recommendations according to IRM principles:

High resistance risk is expected in pests with short life cycles like aphids, whiteflies and cpb under long (soil application) or high (repeated foliar application) selection pressure. thiamethoxam should be used to control target pests not longer than half of the treatment period. In a block application system neonicotinoids should be placed in the same window. If thiamethoxam is used as long lasting soil application, products of other modes of action should be used as foliar spray if needed.

Index terms: Thiamethoxam, pest sensitivity, use recommendation.

[1280] DEVELOPMENT AND APPLICATION OF AN INSECTICIDE RESISTANCE IMPACT MINIMISATION STRATEGY FOR COTTON PEST CONTROL IN INDIA

D.A.Russell¹, K.Kranthi², D.Jadhav³, J.Singh⁴, A.Regupathy⁵, T.Surulivelu², ¹Natural Resources Inst., Chatham Maritime, ME4 4TB, UK. E-mail d.a.russell@gre.ac.uk ²Central Institute for Cotton Research, Nagpur, 440022 India. ³ICRISAT, Patancheru, 502324, India. ⁴Punjab Agric. Univ, Ludhiana, 141004, Punjab, India. ³Tamil Nadu Agric. Univ, Madurai, India

Significant resistance has been demonstrated in Spodoptera litura, Pectinophora gossypiella and Bemisi tabaci in India. However, Helicoverpa armigera is the major pest of cotton in India, contributing strongly to the average of 44% of cotton growing costs spent on insecticides. Pyrethroid resistance in H.armigera was first demonstrated in 1988 and national resistance laboratory network was set up to operate from 1993 using discriminating dose assays for major chemistries. This work has shown pyrethroid resistance to be high (e.g. averaging 80% survival of discriminating dose for feuvalerate) and stable and ubiquitous across the sub-continent, mediated by esterase and oxidative metabolic mechanisms and by nerve insensitivity and reduced cuticular penetration. In areas of Southern India where pyrethoid use is declining, resistance is falling. OP resistance (quinalphos) is more modest at around 20% in central India, with cyclodiene (endosulfan) resistance rising from c.20% to 40% across the season. When taken with poor insecticide quality and application practices, insecticide resistance in bollworms is a major production constraint. A consortium of research partners developed an insecticide resistance impact minimisation 'best bet' package from 1993-1996. The use of sucking pest tolerant genotypes and imidocloprid as a seed treatment allowed broad spectrum foliar applications to be delayed to at least 60 days from planting. With appropriate scouting practices and a careful sequence of bollworm chemistries (designed for efficacy, reduction of impact beneficial arthropods and resistance development minimisation) reduction of impact beneficial articropods and resistance development minimisation) applied in a fully village participatory framework it was possible to demonstrate very substantial benefits on an expanding scale, reaching over 1,200 farmers in 23 villages in 4 states in the Indian Union in 1998. Not only was insecticide use reduced by 44 to 95% and yields increased by 17 to 70% but there was a 30 to 98% reduction in the human health hazard associated with spraying across the states and very substantial profitability increases in all villages. As a consequence, the principles are being pursued under Indian government funding in the 25 districts which are the heaviest insecticide users in eight states in the 2000 cotton season and a major regional research project on resistance management for *Helicoverpa armigera* has commenced in India, China and Pakistan from 2000 under funding from the Common Fund for Commodities. Index terms: participatory, best-bet, Bemisia tabaci

[1281] INSECTICIDE RESISTANCE MANAGEMENT APPLICATION TO THE CONTROL OF MALARIA VECTORS

J. Hemingway', A.D. Rodriguez^{1,2}, R.P. Penilla^{1,2}, M. Rodriguez², ¹ Cardiff School of Biosciences 1, Main College Building, Cardiff University, Park Place, Cardiff, CF1 3TL, South Wales, U.K. ²National Institute of Public Health, Cuernevaca, Mexico.

Rotations and spatial mosaics of organophosphates, pyrethroids and carbamates have been compared to long-term single-use of DDT or a pyrethroid in an operational malaria control programme in Southern Mexico. The 4-year programme monitored resistance levels by bioassay and mechanistically pre-intervention, and over a 3-year treatment period. All treatments were duplicated. Resistance to DDT was high at the start of the project, while resistance to other insecticide classes could not be detected pre-intervention by bioassay, although An. Albimanus in Mexico has a history of broad-spectrum resistance through agricultural insecticide use in the 1970s. Resistance to DDT remained stable even in areas where this insecticide was no longer used. The rate of resistance development in the mosaic and rotation areas was slower than that in areas sprayed continuously with a pyrethroid. Results will be discussed in the broader context of long-term operational malaria control programmes.

Key words: Anopheles, pyrethroid, organophosphate

ABSTRACT BOOK I - XXI-International Congress of Entomology, Brazil, August 20-26, 2000

[1282] MANAGEMENT OF ACARICIDE RESISTANCE IN JAPAN

T. Miyata¹, K. Ohtani², M.E. Sato³, A. Kawai⁴ & O. Nakano³, ¹Lab. Appl. Entomol., Grad. School of Bioagr. Sci., Nagoya Univ., Chikusa, Nagoya, 464-8601 Japan, E-mail tmiyata@agr.nagoya-u.ac.jp; ²Mie Agr. Ext. Center, Kawakita, Ureshino, Mie-Pref., 515-2316 Japan; ³Biological Institute, Rod. Heitor Penteado km 3.5 - Caixa Postal 70, Campinas, SP, 13001-970 Brazil; ⁴Lab. Appl. Entomol., National Institute of Vegetable, Ornamental Plants and Tea, Kusaoi, Ano, Mie-Pref., 514-2392 Japan; ³Department of Entomology, Univ. of Sao Paulo, Av. Padua Dias, Piracicaba, SP, 13418-900 Brazil

Development of acaricide resistance in leaf spider mites is one of the most serious problems in the horticulture in Japan. Kanzawa spider mite, *Tetranychus kanzawai* is one of the most important pests for the pear production in Japan. Acaricides used to control Kanzawa spider mite have been replaced to newly introduced acaricide due to the development of resistance to acaricides. Generally, most of acaricide could be used to control Kanzawa spider mites for only few years. Thus, to prevent the development of acaricide resistance, pear growers were recommended to use acaricide by rotation. When we observed mite density in pear orchards, we found that the number of mite is larger in pear orchards where growers sprayed acaricides many times than in pear orchards where growers sprayed acaricide less times. Especially, in latter pear orchards, growers did not spray acaricides after August. We also found that in pear orchards where less acaricide application was performed, more number of predators such as six-spotted thrips, Scolothrips takahashii or predacious mite, Amblyseius womersleyi. were observed. When we tested acaricidal activity against Kanzawa spider mite, only few were effective as adulticidal (dicofol, milbemectin, brofenprox and chlorphenapyr) and ovicidal (dicofol, milbemectin, tetradifon, brofenprox chlorphenapyr and etoxazole) among acaricides tested. This result indicates many growers sprayed acaricides which were not effective due to the development of resistance. From above mentioned results, if we can wait to spray effective acaricides until the mite population increases and can preserve natural enemies, we can control Kanzawa spider mite in pear orchard in Japan. Usually we do not need to spray acaricides to control Kanzawa spider mite after August.

Index terms: Tetranychus kanzawai, Amblyseius womersleyi, Scolothrips takahashii

[1284] CHALLENGES WITH MANAGING INSECTICIDE RESISTANCE IN THE APHID, *MYZUS PERSICAE*

<u>S. P. Foster</u> & I. Denholm, Dept. of Biological & Ecological Chemistry, IACR-Rothamsted, Harpenden, Herts., AL5 2JQ, UK. E-mail: stephen.foster@bbsrc.ac.uk

The peach-potato aphid, Myzus persicae Sulzer, a major pest on a wide range of agricultural and horticultural crops, provides one of the clearest demonstrations of how genetic and ecological factors can interact to determine the dynamics of resistance and influence success with resistance management. Control of this species with insecticides is being threatened by an increasing diversity of resistance mechanisms, based on both enhanced detoxification of insecticides and modifications to their target sites. This is progressively eroding the supply of effective products, and highlights the importance of ensuring sufficient chemical variety and restricting the use of novel insecticides in order to sustain their effectiveness. Advances in understanding the different resistance mechanisms at the genotypic, biochemical and molecular levels have facilitated the development of rapid and precise methods for their detection. These methods are proving to be invaluable for monitoring changes in the incidence of several different resistance mechanisms in M. persicae populations around the world; a prerequisite for pest management. Resistance problems in UK *M. persicae* populations are enhanced by the predominance of year-round parthenogenesis, leading to non-random associations between mechanisms. In effect, they hitch-hike' together from generation to generation enjoying or suffering any fitness advantages or costs that each may confer. This has important implications for the rate at which resistance can accumulate in populations under selection by insecticides, and also for its decline through counter-acting selection when insecticides are not used. Recent investigations of fitness drawbacks associated with resistance have revealed that these are predominantly expressed during times of stress, such as during harsh winter weather. Furthermore, fitness studies of knock-down resistance (kdr) in M. persicae suggest that this mechanism imposes a direct negative pleiotropic effect on important aspects of behaviour, including response to aphid alarm pheromone. Indeed, there is growing evidence that insecticide-resistant M. persicae, in the UK at least, suffer adverse selection strong enough to maintain them at manageable frequencies in most seasons despite prolonged and often intense selection by insecticides.

Index terms: fitness advantage, fitness cost, maladaptive behaviour.

[1283] DEVELOPMENT OF A RESISTANCE MANAGEMENT STRATEGY FOR COLORADO BEETLE IN POLAND: A SUCCESSFUL IRAC-SPONSORED PROJECT

<u>R. Dutton</u>¹, M. Pawinska², A. Przybysz - Szczesna³ & P. Wengorek⁴, ¹ Dow AgroSciences, Wantage, OX12 9JT, UK; ² Institute of Plant Protection, 76-009 Bonin; ³ Institute of Organic Chemistry, ul Annopol 6, 03-236 Warsaw; ⁴ Institute of Plant Protection, ul Miczurina 20, Poznan, Poland

The IRAC (Insecticide Resistance Action Committee) Field Crops and Vegetables Working Group sponsored a project in Poland to define the extent of resistance of Colorado Potato Beetles (CPB) (Leptinotarsa decemlineata Say) following field failures with some organophosphate and pyrethroid products. DDT was the major product for control of CPB into the 1960's until resistance became widespread. Chlorfenvinphos was as effective for 15 years, but its use has been declining. Synthetic pyrethroids introduced in 1980 have been widely used, with resistance problems beginning in 1992. At present, bensultap is a favoured product. Potatoes are a major crop in Poland therefore it was important that the resistance situation be monitored and managed. The objectives of this IRAC-sponsored programme were: (a) to test the validity of a leaf-dip bioassay (IRAC # 7) on CPB larvae and compare this with topical application against adults, using chlorfenvinphos, cypermethrin and bensultap as representative standards from their respective chemical groups; (b) to develop the technique of using a 'discriminating dose' for resistance monitoring; and (c) to define a resistance management strategy for CPB, initially in Poland. Results have indicated that the IRAC #7 method is easy to use, produces consistent results for all the products, and that data can be used to define a discrimination dose. Within Poland there are 'hot spots' of resistance to both pyrethroid and organophosphate insecticides, associated with previous history of use. A resistance management strategy has been developed, communicated to farmers and advisors, and was published by the Plant Protection Institute in Poznan in 1998. The effectiveness of this strategy will be discussed.

Index terms: Leptinotarsa decemlineata, organophosphate; pyrethroid

(1285] INDUSTRIAL APPROACH FOR MANAGING RESISTANCE TO NOVEL INSECTICIDES A GLOBAL RESISTANCE MONITORING PROGRAM

D. A. Marsden & C. E. Clark, E.I. DuPont Co, P. O. Box 30, Newark, DE 19711, USA, Email David.A.Marsden-1@usa.dupont.com

With the large investment of time and the resources involved with the commercialization of a new insecticide, companies are developing resistance monitoring programs prior to the commercial launch of new products in order to better manage resistance and extend the life of this valuable new chemistry. An example of this type of pre-commercialization effort is the Global Resistance Monitoring Program developed and implemented by DuPont Ag. Products for the new insecticide, indoxacarb. DuPont has developed a bioassay monitoring technique which; closely resembles the mode of exposure of the insects to the insecticide in the field, is simple to perform, and provides informative data within a short period of time. This data can then be used for management decisions based on detected changes in susceptibility levela. This bioassay technique can be used to test several foliage feeding lepidopteran species notorious for resistance development including; Spodoptera exigua, Helicoverpa armigera, Heliothis virescens, and Plutella xylostella. This program has already been started in 16 countries, representing the major Ayronetta. This program has arready ocen started in to condities, representing the higher agricultural production regions of the world. Baseline susceptibility to Indoxacrib has been established for the 4 species listed above globally and for seven additional species of economical importance in specific regions. These include: *Tuta absoluta, Alabama argillacea, Spodoptera frugiperda* in Brazil; *Cydia pomonella, Phthorimaea operculella* in Europe; Erias sp., Spodoptera litura in Asia. By determining the baseline LC₃₀ and LC Europe, Erras sp., opodoptera titura in Assa. By determining the oasenine LC₉₀ and LC₉₀ values for Indoxacarb on key Lepidopteran pests in key regions of the world, a single discriminating concentration can be developed for routine monitoring of pest susceptibility. Slight changes in susceptibility will be a warning for intensified monitoring and significant changes in susceptibility will indicate the need for changing the use pattern of Indoxacarb before field performance problems occur; thus prolonging the effective use of this novel chemistry. In addition, the growing importance of resistance monitoring and baseline efficacy documentation is an area of increasing interest to regulatory authorities like the EU EPPO and the US EPA for new product registration, Currently, these agencies are viewing this type of testing as the responsibility of the industries developing the new pesticide. In the future, these voluntary programs may become part of the required registration package. The establishment of baseline susceptibility data for each species by geography before the commercial launch will be the foundation for indoxacarb's global monitoring program in years following its introduction. Index terms: indoxacarb, Lepidotera, bioassays

[1286] DEVELOPING PRACTICAL RECOMMENDATIONS FOR MANAGING INSECT RESISTANCE TO BT TRANSGENIC MAIZE

R. L. Hellmich¹, **R. A. Higgins³ & E. E. Ortman³**, ¹USDA-ARS, Corn Insects and Crop Genetics Research Unit and Dept. of Entomology, 109 Genetics Laboratory, c/o Insectary, Iowa State University, Ames, IA 50011, USA, E-mail rhhellmi@iastate.edu; ³Dept. of Entomology, Waters Hall, Kansas State University, Manhattan, KS 66506, USA; ³Agricultural Research Programs, 1140 Agriculture Administration Building, Purdue University, West Lafayette, IN 47907, USA

Managing resistance of insects to Bacillus thuringiensis (Bt) transgenic maize is necessary because Bt maize is valuable and all stakeholders want to preserve its efficacy. Currently, the high-dose/refuge strategy is the resistance management strategy of choice. There are potential problems with this strategy, yet research is underway to try to better define these problems and to offer solutions. A Regional Research Committee has fostered dialouge between industry, producers, academics and regulators. The NC205 committee formally addresses research on the AEcology and Management of European Corn Borer and Other Stalk-Boring Lepidoptera.@ For the past six years this committee has sponsored several meetings and symposia with industry and the Environmental Protection Agency to discuss insect resistance management issues. The NC205 Resistance Management meeting provides a forum for all parties to discuss general and specific issues concerning managing the resistance of European corn borer, Ostrinia nubilalis. The meetings have provided opportunities for sharing information, fine-tuning programs, establishing research priorities, reducing redundancies, and building understanding among participants. The dialogue has allowed the committee to identify science-based practical resistance management strategies. The importance of resistance management strategies that are practical cannot be overemphasized because NC205 recognizes that the ultimate stewards of the Bt technology are the growers. So the committee has tried, whenever possible and without compromising the scientific integrity of resistance management, to consider grower realities. Topics discussed include monitoring for insect resistance, education, extension, grower surveys, managing resistance of other insects (especially rootworm), ongoing research, and future needs for research.

Index terms: Ostrinia nubilalis, resistance management, NC205 committee.

[1287] BT RESISTANCE SURVEILLANCE AND DETECTION IN MAJOR MAIZE INSECT PESTS

B. D. Siegfried¹ & P. Marçon², ¹202 Plant Industry Bldg., Dept. of Entomology, University of Nebraska, Lincoln, NE 68583-0816, USA, E-mail bsiegfried1@unl.edu; ²DuPont Productos Agricolas, Estacao Experimental Agricola Rua Bortolo Ferro, No-500, Paulinia, SP 13140-000, BRAZIL

One of the most important operational research needs in resistance management programs for transgenic plants that express the insecticidal protein from Bacillus thuringiensis (Bt) is the development of techniques for detecting changes in susceptibility in key insect pest species. A number of techniques have been proposed to determine resistance frequencies, although each is associated with certain limitations that reduce sensitivity and precision of estimates. A standardized bioassay technique has been used for the last 5 years to measure susceptibility of European corn boyer, Ostrinia nubilalis (Hübner) populations to a number of Bt toxins. Neonate corn borer larvae are exposed to artificial diet treated with increasing Bt concentrations, and mortality and growth inhibition are evaluated after 7 days. The range of variation in Bt susceptibility indicated by growth inhibition is similar to that indicated by mortality. Although inter-population variation in susceptibility to both proteins has been observed, the magnitude of the differences is small (< 4-fold) and comparable to the variability observed among generations within a particular population (<3-fold). Additionally, there is no indication that Bt susceptibility is influenced by pheromone race, voltime ecotype, or geographic location. Diagnostic concentrations of Bt corresponding to the LC_{ss} for European corn borer were determined based on the previously described baseline data. Validation experiments using field-collected previously described baseline data. Validation experiments using field-collected populations from across North America showed that for Cry1Ab, a concentration corresponding to the upper limit of the 95% confidence interval of the LC_{99} , produced mortality > 99% for all populations tested. Development of Bt resistance monitoring programs that rely on diagnostic techniques will be discussed. Based on the results of dose-mortality assays and diagnostic bioassays, it is unlikely that the small differences in susceptibility are the result of prior selection and are more likely to have resulted from natural variability in susceptibility among populations. These results in combination indicate that in the four years of Bt corn availability, there has not been a detectable change in susceptibility among corn borer populations as a result of selective pressures resulting from the introduction of transgenic maize.

[1288] AN INDUSTRY INSECT RESISTANCE MANAGEMENT PLAN FOR BT CORN

<u>J. Stein</u>, Novartis Seeds, 3054 Cornwallis Road, Research Triangle Park, NC 27514 USA, jeff.stein@seeds.Novartis.com

Since the 1996 growing season, farmers in the United States have been planting corn hybrids that express a Bt protein that protects the plant against feeding damage caused by several lepidopteran pests, including the European corn borer. Prior to commercialization, biotechnology companies initiated research efforts directed towards the development of resistance management practices for this new Bt corn technology. This cooperative industry effort, jointly conducted with grower groups and other stakeholders, resulted in a plan that maximizes a grower's opportunity to benefit economically from Bt corn, while preserving the efficacy of this technology for the long term. Key elements of the plan include the requirement for the planting of a non-Bt corn refuge on every farm, a focused insect monitoring effort, and a comprehensive education program to promote grower adoption of the plan. In addition, mitigation measures have been developed in the unlikely event that target pest populations develop resistance towards the plant-expressed Bt protein. The industry group will continue to work with farmers to properly manage and protect the longevity of this important agricultural technology.

Index terms: transgenic plants, Bt corn, Ostrinia nubilalis

[1289] TRANSGENIC BT MAIZE AND RESISTANCE MANAGEMENT: FARMER ATTITUDES AND PRACTICES IN THE CORN BELT OF THE UNITED STATES

M. E. Rice, Department of Entomology, 103 Insectary, Iowa State University, Ames, IA 50011, USA, E-mail merice@iastate.edu

The European corn borer, Ostrinia nubilalis, is one of the most damaging pests of maize in North America. Farmers first planted transgenic Bt maize in 1996 to control this pest. Bt maize farmers were encouraged by seed companies to implement a resistance management plan by planting at least 20% of their acres as a refuge with non-Bt hybrids. The refuge concept is intended to help delay the development of resistance in the European corn borer to Bt maize. Following the third year (1998) of commercial production, written surveys were mailed to Bt maize farmers in 6 states (Illinois, Iowa, Kansas, Minnesota, Nebraska, and Pennsylvania) and 1,966 responses were returned. The objective of the survey was to evaluate farmer perceptions and practices regarding Bt maize, especially resistance management and insecticide use. Responses to several questions are presented. Survey Question: If a seed company, seed dealer, or Extension specialist recommended a *Question:* If a seed company, seed dealer, or Extension spectation recommended a resistance management strategy, would you follow it? 1. No, I have no interest in delaying European corn borer resistance to Bt maize (1.4%); 2. No, I don't think European corn borers will develop resistance to Bt maize (1.2%); 3. Yes, if the strategy can be easily worked into my farming operation (58.9%); 4. Yes, whatever the best strategy would be to delay resistance (25.5%); 5. I don't know (12.9%). A large majority (84.4%) of Bt maize farmers are willing to implement resistance management recommendations, while a very few (2.6%) are unwilling. Survey Question: What planting pattern did you use with your Bt maize hybrid? It was planted as: 1. a block in one field (46%); 2. several blocks in several fields (27%); 3. single or several rows alternated with single or several rows of a non-Bt maize hybrid (6%); 4. large strips alternated with large strips of a non-Bt maize hybrid (15%); 5. a seed mixture of Bt and non-Bt seed (<1%); 6. a border around a field of non-Bt maize (4%); 7. other (2%). Most farmers planted in blocks (73%) or large strips (15%), both of which are suggested for resistance management. A few farmers mixed seed and alternated rows of Bt and nonBt corn; these practices are thought to accelerate the development of insect resistance to Bt maize and are not recommended. Survey Question: Did insecticide use for European corn borer on your farm increase, stay the same, or decrease when compared to insecticide use during the previous five years? 1. Decreased (26.0%); 2. Stayed the same (17.9%); 3. Increased (2.4%); 4. Didn't use an insecticide (53.7%). Farmers planting Bt maize have reduced the amount of insecticide formerly applied to control this pest.

Index terms: transgenic plants, Bt corn, insect resistance management, Ostrinia nubilalis

[1290] STRATEGIES FOR MANAGEMENT OF RESISTANCE IN BT TRANSGENIC MAIZE IN BRAZIL

<u>I. Cruz</u>, Embrapa National Maize and Sorghum Research Center - P.O Box 151, 35700-970 Sete Lagoas, MG, Brazil – E-mail: ivancruz@cnpms.embrapa.br

The use of Bt transgenic plants can be a new and efficient approach to control some maize pests in Brazil. However, it should be considered the complexity of the pests and the diversity of climatic conditions that exist. An in-depth evaluation of the effect of the Bt transgenic plants over the main group of insect pests should be done. Even for the principal pest, S. frugiperda, the existence of genetic variability within its natural population related to the susceptibility of transgenic plant is possible. Plant-pest-natural enemy balance should be considered to prevent any disruption in favor of the pest, increasing the selection pressure over the transgenic plant and facilitating the build up of resistant pest strain. In order to make the transgenic plant last longer, strategies such as the constant monitoring (susceptible population from different locations should be maintained in the laboratory for comparison with advance field generations of pests subjected to transgenic plants) or the use of natural enemies should be encouraged. A good complementary action could be achieved by egg parasitoids such as Telenomus remus and Trichogramma spp. or predators such as the earwig Doru luteipes from natural population or even through artificial releases from laboratory culture. The successful of the transgenic technology also will depend upon joint action involving the private and governmental institutions working closely together with the farmer. These actions necessarily include the insteduction of integrated pest management concepts to be applied to those pest controlled by the transgenic plants as well as to other insects. The strategy to set up the distribution of refuse area depends on the production region and the level of technology used. In Brazil a large portion of farmers still use unimproved seed. Usually they are small farmers and the use of transgenic maize will probably depend upon seed prices. All these maize production regions could be considered as a natural refuse area. In the case that this new technology is adopted, one strategy should be the use a common area based on cooperative efforts from all farmers.

Index terms: Spodoptera frugiperda, Diatraea saccharalis, Helicoverpa zea, resistance management, biological control

[1292] EFFECT OF THE MICROENCAPSULATED FORMULATION OF LAMBDA-CYHALOTHRIN FOR THE CONTROL OF THE BLACK CUTWORM, AGROTIS IPSILON (LEPIDOPTERA: NOCTUIDAE), IN CORN

<u>F. J. Almeida¹</u>, F. J. Celoto¹ & G. Papa¹, ¹ Dept. of Biology, Univ. Estadual Paulista, Av. Brasil 56, Zip 15.385-000 - Ilha Solteira/SP, Brazil, E-mail: gpapa@bio.feis.unesp.br

Pests that are of sporadic occurrence on corn crop, and that use to stay under the soil, where the farmers cannot see them, are not given much attention from the farmers. Black cutworm, A. ipsilon, fits into this profile and when it occurs, it causes losses because it cuts the new plants, resulting in reduced stand. The increasing search for safer alternatives for pests control, which are less aggressive for the environment, has brought a significant development of new insecticide formulations, with possibilities of use in agricultural pest management, contributing to a safer and more efficient way of pest control. The objective of this work was to evaluate the performance of the microencapsulated formulation of lambda-cyhalothrin, for the control of black cutworm on corn crop. The experiment was established under field conditions, in Ilha Solteira/SP/Brazil, using the cultivar Ag-405. The design was of randomized blocks, with 9 treatments and 4 replicates. Each plot ocnsisted of 10 rows of crop, each row was 20m long, and the spaced 1m among each other, with the total of 160m². Two spray operations were conducted for each treatment, at 7-day intervals, using a knapsack sprayer at the volume of 300 l/ha. Spray operations were initiated as a preventive treatment, 13 days after sowing. The treatments consisted of the microencapsulated formulation of lambda-cyhalothrin at the concentrations of 5 and 25% Karate Zeon), at the doses of 15, 25 and 30g a.i./ha, carbaril as a concentrate suspension formulation (Sevin 480 SC) at the dose of 960g i/ha and chlorpyiriphos, as an emulsifiable concentrate formulation (Lorsban 480 BR), at the dose of 720g a.i./ha and control. Evaluations were done up 7 days after the second application, by counting the total number of plants attacked by the pest, observing all plants in each plot. Results showed that the microencapsulated formulation of lambda-cyhalothrin, at the doses of 25 and 30g a.i./ha, was efficient for the control of black cutworm, similar to the standard treatment with chlornvriphos.

Index terms: chemical control, pyrethroid, organophosphate, carbamate

[1291] INSECTICIDE RESISTANCE IN HELICOVERPA ARMIGERA AND STRATEGIES FOR ITS MANAGEMENT IN PAKISTAN

M. Ahmad, M. I. Arif & Z. Ahmad, Central Cotton Research Institute, PO Box 572, Multan, Pakistan, E-mail: mush_a@yahoo.com

The American bollworm, *Helicoverpa armigera* (Lepidoptera: Noctuidae) has become a major threat to cotton production in Pakistan. Regular monitoring since1991 reveals that there has been a development of high resistance to endosulfan and pyrethroids in this pest, which has led to control failures of these insecticides. However, resistance to some organophosphates and carbamates is still low to moderate, but it is also showing an increasing trend. To restore the economic viability of cotton crop in Pakistan, an insecticide resistance management strategy is being promoted. It emphasizes on the education of farmers in pest scouting, better pesticide application techniques, non-chemical control methods, conservation of beneficials by delaying the first spray and applying soft insecticides early in the season, and use of new chemistries with novel modes of action in rotation with the still-effective conventional chemistries. Index terms: *Helicoverpa armigera*, insecticide resistance, management, Pakistan

[1293] EFFECTS OF IVERMECTIN ON THE FAT BODY MORPHOLOGY OF CULEX QUINQUEFASCIATUS LARVAE

S.N. Alves¹, G. Mocelin³, A. L. Melo¹ & J. E. Serrão³, ¹Dept. of Parasitology, Federal Univ. of Minas Gerais, P.O. Box 486, Belo Horizonte, 30161-970, MG, Brazil. E-mail: snalves@icb.ufmg.br²Dept. of Chemical Eng., Federal Univ. of Parana, P. O. Box 19011, Curitiba, PR, Brazil. ³Dept. of General Biology, Federal Univ. of Viçosa, 36571-000, Viçosa, MG, Brazil. Support: CAPES, CNPq

Culex quinquefasciatus a cosmopolitan and a high anthropophylic mosquito is an important species for human and animal health. It is the main vector of Wuchereria bancrofti in Brazil. Nowadays chemical insecticides are regularly used to mosquito population control, but the development of species resistant to synthetic insecticides has now been described. Ivermectin is a chemical modification of avermectins, a macrocyclic lactone derived from Streptomyces avermitilis. It was previously tested to control mosquito larvae population in our laboratory. The aim of this present study was to observe effects of the ivermectin in the fat body of C. quinquefasciatus larvae. Groups of 3th instar were transferred to recipients containing a solution of ivermectin 1% w/v in a final concentration of 1 ppm during 30 minutes. Control groups were placed in recipients containing just dechlorinated water. After the period of the exposition, the larvae were rinsed with tap water and them fixed in 4% paraformaldehyde in phosphate buffer, pH 7.4, 0.1M, dehydrated in graded ethanol and embedded in historesin, five μ m thick sections were stained with toluidine blue. The larvae exposed to ivermectin lavae. There was also a decrease of lipid storage, what could be demonstrated by a more homogeneous staining of the cells, contrasting with a vacuolated cytoplasm in the control group. These results suggest a mobilization of stored resources (especially lipids) for a possible drug detoxification, which may be occur by enzymatic action, as has been reported for other

Index Terms: Culicidae, mosquito, avermectin.

[1294] EFFECT OF CHEMICAL CONTROL OF *BEMISIA ARGENTIFOLII* (HEMIPTERA: ALEYRODIDAE) ON THE INCIDENCE OF BEAN GOLDEN MOSAIC VIRUS IN COMMON BEANS AND ITS YIELD

<u>F. R. Barbosa</u>¹, K. M. M. Siqueira³, E. A. de Souza¹, W. A. Moreira¹, F. N. P. Ilaji¹ & J. A. de Alencar¹, ¹Embrapa Semi-Árido, Caixa Postal 23, CEP 56300-970, Petrolina-PE, E-mail: flavia@cpatsa.embrapa.br; ²UNEB. Dept. de Tecnologia e Ciências Sociais, CEP 48900-000, Juazeiro-BA.

The control of the silverleaf whitefly, Bemisia argentifolii, Bellows & Perring in common beans (Phaseolus vulgaris) and the incidence of bean golden mosaic virus (BGMV) were evaluated by using seed treatment with imidacloprid or thiamethoxam followed by four or six sprays with insecticide, at weekly intervals. The field experiment was carried out in an six sphars with insecticity, at weekly intervals. The field experiment was carried out an inter-irrigated area, at Petrolina-Pernambuco (Brazil). A randomized complete block design with four replicates was used and each plot had an area of 160 m^2 . The treatments, and concentration, in grams or millilitres of commercial product /100 kg of seeds or 100 litres of water, were: 1) imidacloprid 200 SC (200g), acephate 750 BR (100g), metamidophos 600 CS (125ml), imidacloprid 700 GRDA (20g), cartap 500 PS (300g); 2) imidacloprid 200 SC (200g), acephate 750 BR (100g), metamidophos 600 CS (125ml), imidacloprid 700 GRDA (20g), cartap 500 PS (300g), acephate 750 BR (100g), lambdacyhalothrin 50 CE (50ml); 3) thiamethoxam 700 WS (200g), acephate 750 BR (100g), metamidophos 600 CS (125ml), thiamethoxam 250 WG (200g), cartap 500 PS (300g); 4) thiamethoxam 700 WS (200g), acephate 750 BR (100g), metamidophos 600 CS (125ml), thiamethoxam 250 WG (200g), cartap 500 PS (300g), acephate 750 BR (100g), lambdacyhalothrin 50 CE (50ml); 5) control, without insecticide. The chemical control decreased significantly the number of eggs, nymphs and adults and also the percentage of infection by BGMV, ranging from 1.48 to 2.95% against 46.29% in the control treatment. Grain yields and the percentage of yield increase for treatments 1, 2, 3 and 4, were respectively: 1,930 kg/ha, 29.53%; 2,395 kg/ha, 60.74%; 2,180 kg/ha, 46.31% and 2,405 kg/ha, 61.40%, while in the control the yield was 1,490 kg/ha. There was no significant difference among number of pods per plant, number of seeds per pod and weight of 100 seeds. Index terms: Insecta, BGMV, vector, *Phaseolus vulgaris*

[1295] OBSOLETE INSECTICIDES IN LATIN AMERICA: WHAT TO DO WITH THEM?

<u>S. Barbosa</u>, Food and Agricultural Organization of The United Nations, P.O.Box 10095, Santiago, Chile.

country of Latin America, there are accumulations of unwanted, obsolete insecticide stocks which represent serious risks to human health and the environment. The great majority of these accumulations come from bulk government purchases or donations by the international community to control insect pest outbreaks in agriculture and public health. Because these insecticides were banned or had their use restricted by regulatory authorities or because they were not used within their validity dates, they can no longer be used and are considered obsolete. They are found in urban and rural areas, usually under very poor storage conditions, in corroding and leaking metal drums or ragged paper or plastic bags. Government authorities tend to deny that they exist and take bold decisions to dispose of them in landfills, giving them away as donations to other countries or keeping them under hidden storage. High temperature incineration in dedicated hazardous waste furnaces is the most recommended method for disposal of these obsolete insecticides and other pesticides but most countries of the region do not count with these facilities. Obsolete pesticides need to be repacked, including used containers and contaminated soil, and transported to facilities in the country or abroad where they can be properly disposed of. The cost of the entire operation is estimated by FAO to run between US\$ 3000 and US\$ 4500 per ton. Conservative estimates indicate that over 10 000 tons of obsolete pesticides exist in Latin America, needing to be urgently disposed of due to the human health and environmental problems they are causing. FAO is conducting a regional survey on the situation in order to present the problem and suggest possible solutions to the Latin American governments and to the international donor community. The author presents case stories of the situation of obsolete pesticides in some countries, discusses possible disposal action scenarios and elaborates on ways to prevent future accumulations. Index terms: toxic wastes, pesticide disposal

[1296] EFFECT OF THIAMETHOXAM (ACTARA® 250 WG) ON ENTOMOPATHOGENIC MICROORGANISMS

<u>A. Batista Filho¹</u>, J.E.M. Almeida¹, C. Lamas¹, ¹ Lab. Controle Biológico, Centro Exp. do Inst. Biológico, P.O. Box 70, Campinas, SP, 13001-970, Brazil, E-mail batistaf@dglnet.com.br

The compatibility of entomopathogenic microorganisms with thiamethoxam (Actara@ 250 WG) and other insecticides was studied in *in vitro* and field assays. The microorganisms tested were a bacterium (*Bacillus thuringiensis*), a virus [*Baculovirus anticarsia* (NPVAg)], and eight fungi (*Aschersonia aleyrodis*, *Beauveria bassiana*, *Hirsutella thompsonii, Metarhizium anisopliae*, Nomuraea rileyi, Paecilomyces farinosus, Sporothrix insectorum, and Verticillium lecanii). Two concentrations of each product were tested in the laboratory, based on the maximum and minimum recommended levels for application under field conditions. The products were added to specific culture medium for entomopathogen growth. Reproductive and vegetative growth was evaluated for fungi, and colony forming units (CFU) were evaluated for bacteria. For the field test, CFU were considered for both fungi and bacteria and caterpillar mortality of the NPV of Anticarsia genuntalis. The action of the pesticides on the vegetative growth and sporulation of the microbial species: (1) thiametoxam was compatible with all microorganisms studied; (2) endosulfan, monocrotophos and deltametrin were the insecticides that most affected *B. thuringiensis*, *B. bassiana*, *M. anisopliae* and *S. insectorum*; (3) thiametoxam did not affect the inoculum potential of *B. thuringiensis*, and (4) thiametoxam did not affect the efficiency of the nuclear polyhedral virus of *A. gemmatalis*. Index terms: Insecticide, microbial control, compatibility.

[1297] MIGRATION AND SELECTION AFFECTING INSECTICIDE RESISTANCE IN PSEUDOPLUSIA INCLUDENS

<u>M. E. Baur</u> & D. J. Boethel, Dept. of Entomology. Louisiana State University Agricultural Center, Baton Rouge, LA 70803, USA.

Pseudoplusia includens is a migratory insect that overwinters in southern Florida and Texas, the Caribbean Basin and Mesoamerica. Incapable of diapause, P. includenss migrates into the soybean growing regions in the Mid South. Insecticide resistance is a consistent problem with this insect in soybean agroecosystems, however the cause of the resistance remains a puzzle because insecticide usage in soybean agroecosystems is low. Therefore, this project set out to determine the relative contribution of migration from overwintering sites to resistance development and the relative contribution of local selection to resistance development. Data on the susceptibility to 6 insecticides and genetic markers from twenty-two populations of P. includens from sites in Puerto Rico, Florida, Texas and Louisiana were collected in 1998. The AFLP technique was used to detect genetic markers and insecticide susceptibility data were collected from diet overlay bioassays using discriminating doses of the insecticides. Analysis of the genetic data indicated that P. includens populations in Louisiana are derived from overwintering populations in Texas and Puerto Rico, but probably not southern Florida. The insecticide bioassay data showed abundant variation in susceptibility to thiodicarb, chlorfenapyr, B. thuringiensis, and spinosad between populations. The variation in susceptibility to permethrin and emarnectin benzoate between populations was low. The correlation between the genetic distances and insecticide susceptibility was moderate, suggesting that both local selection and migration contribute to resistance observed in the soybean agroecosystems in the Mid South. [1298] NUCLEOTIDE SEQUENCE & EXPRESSION OF A SECOND PUTATIVE ACETYLCHOLINESTERASE GENE FROM ORGANOPHOSPHATE (OP)-SUSCEPTIBLE AND OP-RESISTANT CATTLE TICKS

G. D. Baxter & <u>S. C. Barker</u>, Department of Microbiology & Parasitology, & Institute for Molecular Biosciences, University of Queensland, Brisbane, Australia. Email: s.barker@cmcb.uq.edu.au

Control of the cattle tick, *Boophilus microplus*, relies heavily on acaricides - this has led to resistance to these pesticides. It has been proposed that resistance to organophosphates (OPs) in *B. microplus* is conferred by an acetylcholinesterase (AChE) that is insensitive to the effects of OPs. In 1998 we isolated an AChE cDNA from *B. microplus* but we found that resistance to OPs in *B. microplus* from Australia was not conferred by point mutations in alleles at this locus. This contrasts with the only other two organisms for which a mechanism of resistance to OPs or carbamates that involves AChE insensitivity, has been described - point mutations in the coding region of the AChE gene of *Drosophila melanogaster* and *Leptinotarsa decemlineata* confer resistance to OPs in these insects. Recently, a second AChE gene was discovered in *B. microplus* and a Mexican strain that are resistant and susceptible to OPs. We also present data on the role of gene expression of AChEs.

[1300] EFFECTS OF SEVERAL FUNGICIDES ON THE PREDACIOUS MITE AMBLYSEIUS FALLACIS (GARMAN) (ACARI: PHYTOSEIIDAE) IN QUEBEC APPLE ORCHARDS

N. J. Bostanian & G. Racette, Hortic. Res. Dev. Centre. Agric. and Agri-Food Canada, St. Jean sur Richelieu, Quebec, CANADA J3B 3E6 E-mail: bostaniannj@em.agr.ca

Four fungicides currently used in apple orchards and the new compound Sovran[®] 50WG were evaluated for their toxic effects on the very important phytoseiid *Amblyseius fallacis*. The results indicate that of the five fungicides evaluated, mancozeb (Dithane[®] M-45) was toxic to nymphs and reduced egg eclosion by 26%. Captan (Captan[®] 80WP), myclobutanyl (Nova[®] 40WP) metiram (Polyram[®] 80WP) and kresoxim-methyl (Sovran[®] WG) had no effect on any of the growth stages of this predator. All tests were done at several concentrations including field rates. Index terms: Toxicity, pesticides

[1299] RELATIONSHIP BETWEEN EXPRESSION, AMPLIFICATION AND METHYLATION OF FE4 GENE IN *MYZUS PERSICAE* (IIOMOPTERA, APHIDIDAE)

D. Bizzaro, E. Barbolini, E. Mazzoni*, M. Mandrioli, G. C. Manicardi, P. Cravedi*, <u>R. Crema</u>, A.M. Pagliai, U. Bianchi, Dept. of Animal Biology, University of Modena & Reggio Emilia, Via Campi, 41100 Modena, Italy; *Institute of Entomology & Vegetal Pathology, Catholic University "Sacro Cuore", Via Emilia Parmense 84, 29100 Piacenza. E-mail: bizzaro@unimo.it

The peach potato aphid, Myzus persicae is an important pest on many crops, causing direct feeding damage as well as transmitting virus diseases. The wide use of insecticides characterised by an esteric group (organophosphorous, carbammate and pyrethroid finaccticides) selected resistant *R. persicae* populations This resistance mechanism arise from the overproduction of one of two closely related carboxylesterases (E4 and FE4). Both E4 and FE4 genes possess methylated CpG sites in the coding region or in nearest genomic areas. In populations with the amplification of E4 genes, the disappearance of resistance is associated with the loss of methylation in these genes, that is the direct opposite of the situation in vertebrates, where methylation correlates with genes silencing. In order to furnish information regarding this peculiar phenomenon, 22 Italian populations of *M. persicae*, all showing variable levels of FE4 genes amplification have been analysed. The estimation of gene copy number, carried out by densitometric scanning of dot and southern blots, show that the different populations possess a variable number of FE4 genes ranging from 4 to 104. Statistical analysis shows the existence of a high positive correlation between gene copy number and total esterase activity. The estimation of methylation levels, obtained by comparing *MspI* and *HpaII* RFLP, put in evidence that FE4 genes generally result fully methylated in populations possessing low gene copy number (4-8). On the contrary, in populations with many FE4 genes, when comparing clone possessing similar number of genes, it is possible to observe different levels of FE4 methylation, thus suggesting the lack of strict relationships between gene copy number, methylation and total esterase activity in these populations. In fact, populations possessing high levels of esterase activity show a percentage of unmethylated genes, which result independent from esterase activity levels. These data as a whole suggest that, contrary to what found for E4 genes, the expression of amplified FE4 genes is not directly related with methylation pattern.

[1301] EFFECTS OF SEVERAL PESTICIDES ON THE PREDACIOUS MITE AGISTEMUS FLESCHNERI (SUMMERS) (ACARI: STIGMAEIDAE) IN QUEBEC APPLE ORCHARDS

N. J. Bostanian & N. Laroque, Hortic. Res. Dev. Centre. Agric. and Agri-Food Canada, St. Jean sur Richelieu, Quebec, CANADA J3B 3E6. E-mail: bostaniannj@em.agr.ca

Extensive laboratory tests showed that the following fungicides: Trifloxystobine (Flint^{*} 50 WG), myclobutanyl (Nova^{*} 40WP), flusilazole (Nustar^{*} 50DF) and kresoxim-methyl (Sovran^{*} 50WG) were not toxic to the adults or the eggs of this predator. Among the insecticides evaluated pyridaben (Pyramite^{*} 75WG) caused 70% mortality of adult female predators. The remaining compounds, lambda-cyhalothrin (Warrior^{*}) and imidacloprid (Admire^{*}) were non toxic. All tests were done at several concentrations including field rates.

Index terms: fungicides, insecticides, toxicity

[1302] INDOXACARB (DPX-MP062) A NEW OXIDIAZINE INSECTICIDE - ITS POTENTIAL IN QUEBEC APPLE ORCHARDS

N. J. Bostanian, C. Vincent & N. Larocque, Hortic. Res. Dev. Centre. Agric. and Agri-Food Canada, St. Jean sur Richelieu, Quebec, CANADA J3B 3E6 E-mail: bostaniannj@em.agr.ca

This is a new insecticide especially active against Lepidoptera. The sodium channel is very sensitive to this compound and intoxicated insects quickly stop feeding and eventually die. In Quebec apple orchards, it was found to be effective against OP resistant strains of the obliquebanded leafroller, *Choristoneura rosaceana*. The predacious mirid *Hyaliodes vitripennis* is not affected by this compound. The toxic effects on the two predacious mites *Amblyseius fallacis* and *Agistemus fleschneri* are currently under study and will be presented.

Index terms: Toxicity, Hyaliodes vitripennis, Agistemus fleschneri, Amblyseius fallacis, Choristoneura rosaceana

[1304] INVOLVEMENT OF VOLTAGE-DEPENDENT SODIUM CHANNELS IN DELTAMETHRIN RESISTANCE IN A STRAIN OF CYDIA POMONELLA

A. Brun-Barale¹, J.C. Bouvier², D. Pauron¹, J.B. Berge¹ & <u>B. Sauphanor²</u>, ¹ Resistance aux Xenobiotiques et Ecotoxicologie, INRA, F 06606 Antibes, France; ² Unite de Zoologie-Apidologie - INRA, Agroparc, F 84914 Avignon Cedex, France

The codling moth, Cydia pomonella, a major pest of apple, has developed resistance to different classes of insecticides including pyrethroids such as deltamethrin and chitin synthesis inhibitors such as diflubenzuron. In many insect species, an important mechanism that confers resistance to pyrethroids is the knockdown resistance (kdr) which is linked to point mutations in the sequence of one voltage-dependent sodium channel gene. In order to study kdr in codling moth, PCR were performed to amplify the region of domain II containing putative kdr mutations. In many pyrethroid-resistant strains of insects, the kdr mutation is a leucine to phenylalanine replacement in the transmembrane segment IIS6 at position 1014. In a C. pomonella strain resistant to deltamethrin, a kdr mutation (TTT) was present at position 1014 and as expected neither in the susceptible strain nor in a strain resistant to diflubenzuron which both contain the susceptible codon (TTT. An intron located just 3' to the mutation was identified as reported for other orders of insects. These data allowed us to develop a PCR-based diagnostic test (PASA) to determine the presence or the absence of the kdr allele in pyrethroid-susceptible and pyrethroid-resistant strains of codling moth. This test will constitute a molecular tool to rapidly determine the frequency of the kdr allele in various populations of C. pomonella. Key words: codling moth, knock-down resistance, point mutation

[1303] EVALUATION OF TEMEPHOS SUSCEPTIBILITY IN AEDES AEGYPTI IN RIO DE JANEIRO, BRAZIL

A. K. R. Galardo¹, <u>I.A. Braga</u>² & S. S. Soares³, ¹ Aluno do Curso de Mestrado em Biologia Animal da Universidade Federal Rural do Rio de Janeiro, Biólogo do Centro de Controle de Zoonoses, Paracambi, RJ/FUNASA/RJ; ² MSc, Gerente de Entomologia e Pesquisa Operacional da Fundação Nacional de Saúde/M.S; ³ Fundação Nacional de Saúde/RJ

Temephos susceptibility was evaluated in 7 municipalities in the state of Rio de Janeiro. this insecticide has been used intensively to control dengue epidemics since 1986. *ae. aegypti* were collected and pooled from several locations in each community using enhanced cdc ovitraps and the fl generation were compared with a standard rockefeller strain using the diagnostic dosage of 0.012 mg ai/l. The results indicate the occurrence of resistance in all of the municipalities evaluated. The resulting mortalities were 23,5% for São Gonçalo; 32,5% for Rio de Janeiro; 34,6% for Niterói, 34,8% for Caxias , 44% for São João de Meriti, 58,2% for New Iguaçu and 74% for Campos. The Rockefeller Strain was had a mortality of 100%.

[1305] BOTANICAL EXTRACT EFFECT ON Anastrepha fraterculus (DIP., TEPHRITIDAE) BIOLOGY

N. A. Canal, E. Murillo & P. E. Galeano. Univ. Of Tolima, A.A. 546, Ibagué, Tol., Colombia. E-mail: Erro! Indicador não definido.

Colombian fruticulture is an important factor in the agricultural sector of the country and its producing is being mainly developed at small orchards. One of the main problems of these products is fruit flies. The following results are the first of a series of studies which were started at University of Tolima looking for easy, safe and efficient alternatives in fruit flies management by small farmers. Both, ethanolic and aqueous extracts of *Melia azederach* (Meliaceae) (m.a.), *Anona squamnosa* (Anonaceae) (a.s.), *Ocimun americanum* (Labiatae) (o.a.) and *Brunfelsia pauciflora* (Solanaceae) (b.p.) were evaluated on the southamerican fruit fly biology. Flies were obtained from an artificial rearing of ICA (Colombian Agricultural Institute) in Ibagué. Ten couples were put into cilindric cages of 20 cm high and with a diameter of 10 cm. Flies were exposed to 24 hours of inanition and then the extracts were given. After five days, mortality was found between 22% (control a 52% (a.s.) for ethanolic extracts and between 14% (o.a.) and 44% (b.p.) for aqueous extracts (control = 32%). Nevertheless no statistic difference was found among the treatments. Oviposition was favored by some ethanolic extracts, however larval development was reduced by these ones. Ethanolic extracts can reduce fruit fly population, increasing their mortality. Botanical extracts can reduce fruit fly population, increasing their mortality and decreasing the reproductive rata. Among these four treatments *Anona* shows itself to be potential for *Anastrepha fraterculus* management. Variation of obtained results and similarity with the ones gotten at the beginning with *A. obliqua* suggest the need of making adjustments to the work methodology in order to obtain

Index Terms: South American Fruit Fly, Botanical insecticides, Control

[1306] INSECTICIDAL PROPERTIES OF CANATOXIN, A TOXIC PROTEIN FROM CANAVALIA ENSIFORMIS SEEDS, AND ITS ENTOMOTOXIC PEPTIDES

C. R. Carlini, C. T. Ferreira-daSilva, & M.E.C. Gombarovits, Dept. Biophysics, Univ. Fed. Rio Grande do Sul, Porto Alegre, RS, CEP 91.501-970, Brazil. E-mail: ccarlini@vortex.ufrgs.br. Supported by CNPq, PRONEX 76.97.10.70.00

Canatoxin (CNTX), a toxic protein (dimer of 95 kDa) isolated from seeds of *Canavalia* ensiformis (Carlini & Guimarães,1981, Toxicon 19: 667), is lethal by oral route to a group of insects, being proteolitically "activated" by their digestive enzymes. No effects were seen in insects relaying on tripsin-like enzymes. In the other hand the bruchid beetle *C.* maculatus and the blood-sucking bug *R.* prolixus, are susceptible to CNTX (Carlini et al.,1997, J.Econ. Entomol. 90: 340). These insects present cathepsins of type B and D as their major digestive enzymes, which hydrolize CNTX to form entomotoxic peptides. A diet containing 0.25% w/w CNTX aborted larval growth in *C. maculatus*. In *R. prolixus* fed CNTX solutions (2,5 g/mg weight body), 100% lethality was recorded 72 hours after feeding and fragments of the toxin were found in haemolimph and the midgut of the insect by Western-blot analysis. When *R. prolixus* were fed CNTX "meals" containing either E-64 (2,0 M), Pepstatin-A (2,0 M) or both, the insects were partially protected against CNTX's lethal effect. In other studies, CNTX was digested *in vitro* with enzymes obtained from *C. maculatus*, and resulting peptides (8 to 15 kDa) were shown to be lethal to *R. prolixus* by oral or metathoracic administration. In this case, however, no protective effect was seen with the addition of catchepsin inhibitors to "meals" containing CNTX-derived peptides. CNTX did not show any inhibitory activity toward *C. maculatus or R. prolixus*. Additional studies on CNTX effects in other insects models, displaying either alkaline or acidic digestive processes, are under way in our laboratory in order to establish the biotechnological potentials of CNTX as a bioinsecticide.

Index terms: Callosobruchus maculatus – Rhodnius prolixus – cathepsins – proteinase inhibitors

[1307] SUSCEPTIBILITY TO CARTAP AND ABAMECTIN IN DIAMONDBACK MOTH STRAINS FROM BRAZIL

M. Castelo Branco & C.A. Melo, Embrapa Hortaliças, Caixa Postal 218, 70.359-970. Brasília, D.F. Brazil. e-mail: marina@cnph.embrapa.br.

Diamondback Moth strains collected in the Federal District, Minas Gerais and Ceará were evaluated in laboratory bioassays to determine their susceptibility to cartap and abamectin. The most susceptible strain to both insecticides was collected in the Federal District in a field where no insecticide was sprayed for at least four months. Levels of resistance to cartap was between 2.8 and 7.1 fold in relation to the susceptible strain. The most strain to cartap was collected in a field which was sprayed several times with the insecticide. Levels of resistance to abamectin was between 1.1 and 12.1 fold. The Diamondback Moth strain with the highest level of resistance to abamectin was obtained from a field in Minas Gerais where abamectin was never sprayed. This high level of resistance may be explained by the immigration of abamectin resistant genotypes into the area which may have affected the local level of resistance.

Index terms: Plutella xylostella, insecticide resistance

[1308] CAN THE RESISTANCE TO INSECTICIDAL TRANSGENIC PLANT PRODUCE NEW SPECIES OF INSECT PEST?: IMPLICATIONS OF DEVELOPMENT ASYNCHRONY OF RESISTENCE PEST TO BACILLUS THURINGIENSIS TRANSGENIC CROP

H.Cerda 1,2 & D. Wrigth ², ¹Universidad Simon Rodriguez, Caracas, Venezuela; ³Imperial College, Silwood Park, Ascot SL5 7PY, UK. E.mail h.cerda@ic.ac.uk. HC was supported by CONICYT and CDCIHT-UNESR of Venezuela.

Recently, Darby et al. (1999), Liu et al (1999) evidence studies on laboratory-selected insects show developmental asynchrony between Bt resistant and susceptible strains of diamondback moth (*Plutella xylostella*) and pink bollworm moth (*Pectinophora gossypiella*). Such developmental asynchrony could lead to non-random (assortative) mating among resistant insects and through interactions with season length, produce premating isolation. Assortative mating is one of the condition to have a sympatric speciation process (Dieckman and Doebeli, 1999). Three transgenic crop that produce Bt toxins were grown commercialy in the USA during 1997: nearly 3Mha of Bt maize, 1 Mha of Bt cotton 10 kha of Bt potato. With the widespread planting of Bt transgenic plants, individuals of many pest species are being exposed to intense selection process when the insect pest are under intense selection pressure.

[1309] METANOLIC EXTRACTS FROM DIMORPHANDRA MOLLIS (BARBATIMÃO) AND THEIR ACTIVITY IN WORKERS OF APIS MELLIFERA

Priscila Cintra¹, Osmar Malaspina¹, Odair Correa Bueno⁴, Fernando Petacci², João Batista Fernandes³, Paulo Cezar Vieira¹, Edson Rodrigues Filho⁴, Maria Fátima das Graças Fernandes da Silva³, ¹ Center of Study of Social Insects, Unesp, Av. 24-A, 1515, CEP 13506-900, Rio Claro, SP, malaspin@rc.unesp.br; ² Department of Chemistry-Ufscar, Rod. Whashington Luiz, Km 235, CP676, São Carlos, SP, petacci@dq.ufscar.br.Financial.FAPESP, CNPq, PRONEX/MCT/FINEP

In Brazil we have a different kind of vegetation called "cerrado" and this vegetation is already one of the most important areas to apiculturists. A native tree: Dimorphandra mollis (barbatimão) has flowers at the same time as the beekeepers observe a great mortality in their bees. The fenomenon is named by the beekepeers as the "fall evil". This fact occurs also when the tree is without its bark , which is commonly used to make teas because of its adstringent effects. These problems got scientists to study the *D. mollis* to obtain substances with potencial toxic action. Our study was done with the flowers and the bark of *D. mollis*. We did metanolic extracts and incorporated them in small percentages (0,2%, 0,5% and 1%) to the diet of bees. The diet were offered to three groups of twenty bees confined in little boxes (11 cmx11cmx7cm). At the same time we did the control group in wich the bees received just sugar and water daily. The results obtained were statistically significant. The mortality of metanolic extract from flowers to bees was 100% to treatment groups at 14° , 16° , and 20° days, at the concentrations of 1%, 0,5% and 0,2%, respectively. For the metanolic extracts from the bark the mortality was 100% to the treatment group on 10° , 16° , and 20° days. (concentrations: 1%, 0,5% and 0,2%). Both results suggest that the metanolic extracts from the bark and the flowers from *D. mollis* had an important role at the toxic effects pointed by the experiments. The knowledge of substances present in this specie and their action on bees is the aim of the solution to the "fall evil". More tests with other extracts made with parts from the tree are currently being done.

Index terms: Dimorphandra mollis, Apis mellifera, toxicity, metanolic extracts

[1310] IDENTIFICATION OF A CHEMICAL FRACTION FROM AROMATIC HERBS WITH INSECTICIDAL ACTIVITY AGAINST *TRIBOLIUM CASTANEUM* (COLEOPTERA, TENEBRIONIDAE)

S. Clemente¹, A. Broussalis¹, V. Martino², G. Ferraro² & G. Mareggiani¹, ¹ Cátedra Terapéutica Vegetal. Cátedra Zoología Agrícola. Facultad Agronomía. UBA. Av. San Martín 4453. (1417)Bs.As. Argentina. TE: 524-8066/524-8046. E-mail: clemente@mail.agro.uba.ar; ² Cátedra de Farmacognosia-IQUIMEFA (UBA-CONICET) Fac. de Farmacia y Biequímica. UBA. Junín 956, 2° piso (1113) Bs As. Argentina. TE/Fax: 508-3642.

At present, the use of natural agrochemicals is well accepted because of the necessity of new compounds useful for control pests but without environmental deleterious effects. Aromatic herbs, empirically used in interculture or foliar applications to keep horticultural crops free from insects, were selected to test their potential insecticide activity against Tribolium castaneum Herbst (Coleoptera, Tenebrionidae, CIPEIN strain),an important stored grains pest. Ten plants were tested: Rosmarinus officinalis L, Thymus vulgaris L, Origanum vulgare L, Ocimun bacilicum L, Lippia alda Mill, Urtica urens L, Lavandula spica L, Borago officinalis L, Mentha rotundifolia L and Artemisia absinthium L. Three extracts of different polarity (methylene chloride, methanol and aqueous extracts) from each plant were applied to the diet of T castaneum first instar larvae, evaluating their effect on development delay and mortality, until adult emergence, using ANoVA and Probit analysis (p≤0.05). The best results were achieved with Lavandula spica L non polar extracts, which produced a development delay of 40% compared with the control. When mortality produced by non polar L.spica extracts was compared with that caused by aqueous Lspica extracts, Lspica essential oil (containing 40% cineole), pure 1,8 cineole (as standard), results showed that methanolic extract treatment mortality was significantly different ($p \leq 0.05$) from the control, but similar to the standard treatment with 1,8 cineole. These results suggests that the biological activity here observed may be due to the presence of a secondary metabolite in the methanolic fraction of L. spica. Index terms: Lavandula spica, Natural Pest Control, Stored Grain Protection

[1311] CHARACTERISATION OF AMPLIFIED ALDEHYDE OXIDASES FROM INSECTICIDE RESISTANT Culex quinquefasciatus

"<u>M. Coleman¹</u>, L. M^{*}Carroll², J. G. Vontas³ & J. Hemingway⁴, ¹²⁴School of Bioscience J, Main College Building, Cardiff University, Park Place, Cardiff, CF1 3TL, South Wales, UK.

Organophosphorus insecticide resistance in *Culex quinquefasciatus* (Say), the major vector of filariasis, is due to the elevation of carboxylesterase activity. The underlying molecular basis of the enzyme's elevation is gene amplification. Two major phenotypes exist which involve either the co-amplification of esterases $est\alpha 2^{\prime}$ and $est\beta 2^{\prime}$, which accounts for 95% of resistant *Culex* species worldwide, or the amplification of $est\beta 1$. Since the $est\alpha 2^{\prime}$ / $est\beta 2^{\prime}$ amplicon is much bigger than the two genes alone, it was postulated that other genes may occur on the amplicon, and indeed, play a major role in insecticide resistance. Two further genes have now been identified. One has been fully cloned and sequenced in both genomic and cDNA, and both appear to code for functional aldehyde oxidase (ao). As AO plays a role in insecticide resistance. The deduced amino acid sequence of the fully sequenced *ao* encodes a 142 kDa protein of 1264 amino acid residues. A comparison of partial *ao* sequences from resistant and susceptible strains of *C. quinquefasciatus* demonstrates distinct allelic versions of the enzyme. By using quantitative PCR it has been possible to demonstrate that one of these alleles is amplified in the resistant but not the susceptible strain. In order to determine the role of AO in insecticide resistance, purified enzyme was characterised following over-expression in the baculovirus expression system. Index words: *PelRR, molybdenum, filariasis, baculovirus expression, esterase*

[1312] RESISTANCE MECHANISM TO BUPROFEZIN IN B-TYPE BEMISIA TABACI (HEMIPTERA: ALEYRODIDAE) IN AUSTRALIA

E.L.A Cottage¹ & R.V. Gunning², ¹Dept. of Agronomy & Soil Science, University of New England, Armidale, NSW, 2351, Australia; ³NSW Agriculture, Tamworth Centre for Crop Improvement, RMB 944 Calala Ln., Tamworth, NSW, 2340, Australia.

B-type Bemisia tabaci (Hemiptera: Aleyrodidae) in a serious insect pest of many horticultural, nursery and field crops internationally. The insect inflicts plant damage by virus transmission and honeydew production in addition to direct feeding. B-type B.tabaci was first detected in Australia in October 1994, and has since become widely spread across the country, posing a threat to many plant production industries. This insect is highly resistant to conventional insecticides, such as organophosphates and carbamates. Insecticides with novel modes of action, such as buprofezin, are being investigated for use in controlling this pest in Australia. Buprofezin acts by interfering with chitin deposition during moulting, causing the death of nymphs. The ability of buprofezin to bind to esterase iso-enzymes in B-type B.tabaci was investigated in a buprofezin susceptible strain and a strain that had been selected for buprofezin resistance. It is suggested that the resistance mechanism used is detoxification of buprofezin by esterases.

[1313] A SUSTAINABLE AND ECONOMICAL INSECTICIDAL MANAGEMENT PROGRAM ON COTTON IN BRAZIL

P. E. Degrande, J. S. Ribeiro, J. A. Staudt, R. V. Venturini & M. H. Cordellini. Caixa Postal 533, Dourados, Ms, Brazil, 79804-970. E-Mail: degrande@nin.ufms.br.

ITA-90 cotton is a virus-susceptible variety. This virus is transmitted by Aphis gossypii. Control of A. gossypii is based on very restricted threshold, varying of zero until 10% of attacked plants, from the establishment of the crop to 120 days after the germination (dag). The study objective to establish a program for a maintainable management of insecticides, minimizing problems of resistance of the pest and excessive use of insecticides mixtures. In Rondonopolis-MT during 1998/99 season, two treatments were compared ("System of Rotation" - SR versus "Conventional System"- CS). Each plot had 1,53 ha, with four replications. The pest monitoring followed principles of integrated pest management. Up to 64 dag insecticide applications were done by tractor (100 Lha⁴) later on aerial application (20 Lha⁴). "SR" consisted of the use of application blocks for mode of action of insecticides (1st = neonicotinoides: Cruiser* in seed treatment and Actara* in spraying; 2nd = carbamate/cyclodiene sprayed: carboaulfan + endosulfan; 3rd = carbamate/thiourea sprayed: carbosulfan + Polo[®]), "CS" based on the carbamate/cyclodiene use and organophosphate. The statistical analysis indicated significant differences in the viruses organophosphate. The statistical analysis indicated significant differences in the viruses incidence (SR=2,61% and CS=4,92%); smaller number of applications in SR (6) than CS (9,5); larger interval of applications in SR (17 days) than CS (10,27 days) [arger medium percentage of efficiency on aphids control in SR (73,68%) than CS (48,06%) and smaller in the virus of a particular term of the percentage of t cost of pest control by hectare in SR (US\$ 174,31) than CS (US\$ 207,30). We didn't find significant differences in the height of plants, bolls number per plant and weight of picked cotton among the two treatments. The results showed that in function of the readiness of mode of action of available insecticides for the control of the aphids in ITA-90 variety, should be used insecticides in blocks (mode of action based): neonicotinoides (first 35 dag), carbamate/cyclodiene (35-55 dag) and thiourea (after 55 dag). Index ternis: Aphis gossypii, ipm cotton, insecticide resistance, irm

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[1314] INSECTICIDES TOXICITY TO DIURAPHIS NOXIA (HOMOPTERA: APHIDIDAE)

L.R. Descamps¹, M.E. Reviriego¹, A. Ferrero¹ & <u>A.A. Suarez</u>², ¹Univ. Nac. Del Sur, San Andrés S/N, (8000) Bahía Blanca, Argentina, e-mail Errol Indicador não definido. ²E.E.A.INTA Anguil, Ruta Nac. N°5 Km 580, C.C. 11, (6326) Anguil, La Pampa, Argentina; e-mail asuarez@anguil.inta.gov.ar.

Aphids reared under laboratory conditions without insecticide applications background were used in this experiment. The organophosphate insecticides fenitotrion and clorpirifos and the pyrethroid deltametrin were used. FAO N°17 Method modified was used to determine the insecticides TL_{50} for *Diuraphis noxia*. Insecticides concentration were 0.1, 0.01 and 0.001 mg/ml. Mortality was determined using a computer program based on Finney method. Fenitotrion showed a TL_{50} of 12, 161 and 839 minutes for the 0.1, 0.01 and 0.001 mg/ml concentrations respectively. For clorpirifos TL_{50} of 5 (0.1 mg/ml), 44 (0.01 mg/ml) and 240 (0.001 mg/ml) minutes were observed. Deltametrin showed TL_{50} of 195 (0.1 mg/ml), 274 (0.01mg/ml) and 1030 (0.001 mg/ml) minutes. Results of this laboratory experiment showed that reduced concentrations of organophosphste insecticides are highly effective against Russian wheat aphid compared to deltametrin. Index terms: *Diuraphis noxia*, insecticides, TL_{50} .

[1316] RESPONSE OF PLUTELLA XYLOSTELLA (L.) (LEPIDOPTERA: PLUTELLIDAE) TO THE SELECTION WITH BACILLUS THURINGIENSIS

Ovidio Diaz-Gomez,¹ J. C. Rodriguez-M., ² A. M. Shelton, ³ A. Lagunes-T.,² M. Barcenas-O.,³ & R. Alatorre R.², ¹ Facultad de Agronomia, U.A.S.L.P. Alvaro Obregon 64, San Luis Potosi, S.L.P., C. P. 78000, MEXICO. 2 Inst. fitosanidad, C.P. Km 35.5 Carr. Mexico-Texcoco. Montecillo, Edo. Mexico.³ Entomology, Cornell Univ. NYSAES, Geneva, NY 14456 U.S.A.

In Mexico, the diamondback moth Plutella. xylostella (L.) is the major pest of crucifers plants. Its control depend largely on the use of Bacillus thuringiensis Berliner and organosynthetic insecticide. Therefore, it is important to take measures to prevent the further buildup of resistance. In this research, five populations of P. xylostella, collected in three states of Mexico, were selected with B. thuringiensis subspecies kurstaki (Dipel 2X), B. thuringiensis subspecies aizawai (Xentari), delta endotoxinas CryIC of B. thuringiensis subspecies aizawai (MC), and CryIA(c) of *B. thuringiensis* subspecies kurstaki (MVP), and finally, with the mixture of toxins contained in *B. thuringiensis* subspecies kurstaki and aizawai (Agree). Their responses were evaluated by leaf-dip bioassay. When it was compared a susceptible population with the response of those selected, in four out of five populations were obtained statistically significant differences. The most remarkable cases in resistance were detected to the delta endotoxinas Cry1A(c) and Cry1C, and in smaller degree to the complex of toxins contained in the subspecies *kurstaki*. With the subspecies aizawai and the mixture of subspecies kurstaki and aizawai the developed resistance levels were low. To ensure the continued performance of B. thuringiensis in field, we suggest that a resistance monitoring program be implemented to detect any changes in susceptibility to *B. thuring iensis* products and specific toxins; that their use be restricted to one generation per crop and that they be rotated with other groups of insecticides and incorporated in a integrated pest management program of cole crops. Also, we suggest the development and implementation of biological and cultural strategies in order to reduce overall population pressure so that fewer pesticidal treatments will be needed. This research demonstrates the existence of genes for resistance to B, thuringiensis in populations of P, xylostella collected in Mexico. This implies a strong risk to the dependence of B. thuringiensis for the control of P. xylostella, and also, to the introduction of crucífers transgénicas if they express a single delta endotoxina, mainly if appropriate strategies of management of the resistance are not implemented.

Key Words: Diamondback Moth, Microbial Insecticides, Resistance

[1315] TOXICITY OF DELTAMETRIN TO A STRAIN OF TRIBOLIUM CASTANEUM (COLEOPTERA: TENEBRIONIDAE)

L.R. Descamps¹, M.E. Reviriego¹, A. Ferrero¹ & <u>A.A. Suarez</u>¹, ¹Univ. Nac. Del Sur, San Andrés S/N, (8000) Bahía Blanca, Argentina, e-mail descamps@criba.edu.ar; ²E.E.A.INTA Anguil, Ruta Nac. N°5 Km 580, C.C. 11, (6326) Anguil, La Pampa, Argentina; e-mail asuarez@anguil.inta.gov.ar.

Surveys in the area of Puerto de Ingeniero White (Buenos Aires, Argentina) indicates that the more abundant stored-grain insect pests are: *Tribolium castaneum* and *Sitophilus spp.*. Also, deltametrin is one of the main insecticides used to control them. Several control failures reported by deltametrin aplicators, indicated the possibility of insecticide resistance development. Insect samples, from facilities with insecticide application background, were taken and the *Tribolium castaneum* strain obtained was named LIMA. To study the case, LIMA strain insecti severe compared to a strain, named ULP, without insecticide contact history. In laboratory, CL₅₀ for deltametrin, resistance factor, CL₅₀ for deltametrin + piperonyl butoxide (PB) and synergistic factor were determined using FAO method N° 15 modified. Toxicity parameters were analized by a computer program based on Finney method. Ours results indicates that LIMA (CL₅₀=87.88 µg/cm²) was more susceptible to deltametrin than ULP (CL₅₀=85.29 µg/cm²) for ULP and 1.04 µg/cm2 for LIMA. Sinergistic factors were 14.64 for ULP and 84.5 for LIMA. The suggest an important deltametrin degradation by mixed function oxidases.

Index terms: Tribolium castaneum, deltametrin, piperonyl butoxide, CL₃₀, mixed function oxidases.

[1317] INHERITANCE AND FITNESS COST OF RESISTANCE TO LAMBDA-CYHALOTHRIN IN SPODOPTERA FRUGIPERDA (LEPIDOPTERA: NOCTUIDAE)

G. I. Diez-Rodríguez & C. Omoto, Depto. de Entomologia, Fitopatologia e Zoologia Agrícola, Escola Superior de Agricultura "Luiz de Queiroz", Av. Páduas Dias, 11, 13418-900 Piracicaba, SP, Brasil, E-mail: celomoto@carpa.ciagri.usp.br.

Spodoptera frugiperda (J.E. Smith) is a major pest of corn and other vegetable crops in Brazil. An approximately 15-fold resistance was detected in a laboratory-selected resistant strain of *S. frugiperda* to the pyrethroid lambda-cyhalothrin. Inheritance and fitness consequences of resistance to lambda-cyhalothrin were investigated in this study. A series of crosses and backcrosses were performed between susceptible and resistant strains to determine the level of dominance and the number of genes involved in the resistance, respectively. Dose-response lines were obtained with third instars by using topical application bioassay. The analysis of the progenies of the reciprocal F₁ crosses indicated that the resistance was autossomal and conferred by an incompletely recessive gene. Chisquare analysis of responses of progenies from backcrosses suggested that the resistance was determinated by a single major gene under a influence of some minor genes. An isogenic-resistant strain was built to separate the major locus from modifiers genes, and then to evaluate the fitness cost of resistance to lambda-cyhalothrin in *S. frugiperda*. Fitness components (fecundity, viability, developmental time and pupal weight) were measured on the susceptible, heterozygous and isogenic-resistant strains. The relative fitness of heterozygous individuals was also studied because they are the most common individuals at the early stages of resistance evolution. Implications of these results for insecticide resistance management of *S. frugiperda* to lambda-cyhalothrin will be discussed

Index terms: fall armyworm, insecticide resistance, fitness cost, pyrethroid

[1318] BIOASSAY TO COMPARE THE SYSTEMIC ACTIVITY OF THREE NEONICOTINOIDS FOR CONTROL OF *IIETERONYCHUS ARATOR* (COLEOPTERA: SCARABAEIDAE), IN MAIZE

T.W. Drinkwater, ARC-Grain Crops Inst., Private Bag X1251, Potchefstroom, 2520, South Africa. E-mail: tomdrw@igg2.agric.za

Two neonicotinoid seed dressing insecticides (imidacloprid and thiamethoxam) are presently in use in South Africa for the control of black maize beetle, Heteronychus arator, in maize. However, these two compounds were tested and became registered in years when beetle numbers were relatively low and their performance in years when beetle numbers reach pest status is still uncertain. Since the systemically translocated repellent activity of neonicotinoids is an important means of controlling black maize beetle in maize, imidacloprid, thiamethoxam and acetamiprid were compared in laboratory feeding bioassays. In all trials, seed was planted on alternate days in 3.5 1 pots in a greenhouse. Sixteen days after planting, roots and leaves of seedlings were removed and thirty stems (40 nm in length) per treatment were placed singly in glass vials containing soil and one *H. arator* beetle. Beetles were provided with fresh seedlings and soil on alternate days for 10 days - a total of five stems per beetle. Damage to maize stems (rolled leaf sheaths) was recorded by determining the number of damaged sheaths, ranking from zero to six. Only the most severely damaged stem out of the five tested against each beetle was taken into account, demonstrating the ability of a beetle to damage treated seedlings. The compounds were tested at 1.75 g (registered dosage rate) and 0.88 g a.i. kg⁻¹ seed. In all trials imidacloprid proved to be the most effective in controlling black maize beetle, although differences were not always significant. However, the efficacy of the systemically translocated activity of this neonicotinoid (and others?) is affected by factors which are still unknown and which may relate to the reproductive status of the beetles. In twelve trials carried out with imidacloprid at a dosage rate of 1.75 g a.i. kg⁻¹ seed, the percentage of severely damaged stems varied from 3.3 to 60.0 % (n = 30). Therefore, in these type of trails, results with neonicotinoids should never be compared between, but always within trials.

Key words: Acetamiprid, imidacloprid, thiamethoxam, black maize beetle

[1319] DIFFERENT DOSAGES OF IMIDACLOPRID 60 FS (GAUCHO 60 FS) IN ONION SEED TREATMENT ON THE GERMINATION AND THE EMERGED PLANTS

A. C. Dughetti and D. L. De Carli, National Institute Technology Agriculture (INTA), Agric. Hilario Ascasubi Exp. Station, Hilario Ascasubi, Bs. As.- 8142, Argentina, E-mail adughetti@inta.gov.ar

The seed corn *Delia platura* and the onion maggot *Delia antiqua* larvaes are one of the most important problems in the implantation onion crops at direct seeding. The imidacloprid formulated for seed treatment is an alternative management less contaminates than soil treatments for these pests. The experiment objective was to test the imidacloprid's phytotoxicity on the onion's seed germination, in different dosages, by seed treatments. The treatments were the imidacloprid to 4, 6, 7.5 and 9 kg formulated product per 100 kg onion seeds, by slurry treatments; and the untreated check. Germination and phytotoxicity effect appraised through the germination power betten paper towel, in laboratory; and also for the emerged plants number, in experimental plots. In the laboratory's experiment, the igermination power's untreated check was more important than imidacloprid's treatments in different dosages, analyzed by Tukey test ($\alpha = 0.05$). In the field's experiment, the information was analyzed by the Friedman's test ($\alpha = 0.05$) in different dates. At the last date, the untreated check and treatments imidacloprid 4% and 6% the emerged plants resulted higher than imidacloprid 9%.

Index terms: Imidacloprid, seed treatment, phytotoxicity, onion, Delia sp.

[1320] AN RNA HELICASE OF THE "DEAD BOX" FAMILY CLONED FROM A LEPIDOPTERAN SPECIES, THE SPRUCE BUDWORM (CHORISTONEURA FUMIFERANA)

O.L. Feng¹, A. Retnakaran¹, T. R. Ladd¹, S.-C. Zheng¹, M. Primavera¹ & S. R. Palli², ¹Great Lakes Forestry Centre, Canadian Forest Service, P. O. Box 490, 1219 Queen Street East, Sault Ste. Marie, Ontario, Canada, P6A 5M7.E-mail: qfeng@nrcan.gc.ca;²Rohm and Haas Research Laboratories, 727 Norristown Rd. Spring House, PA 19477, USA.

Helicases are a family of enzymes that unwind nucleic acid duplexes, such as DNA/DNA, RNA/RNA and RNA/DNA, in a 3' to 5' direction to single-stranded polynucleotides. The function of helicases is involved in processes such as replication, DNA repair, recombination, transcription and translation. We screened CF-203 cell cDNA library using polyclonal antibodies produced against a methoprene-tolerant (*mel*) gene identified from *Drosophila melanogaster* and identified a clone that showed highest amino acid similarity with D. melanogaster helicase. This cDNA (CfrHel) was the first RNA helicase clone reported from lepidopteran species. The deduced protein had 555 amino acids and contained 8 domains that are conserved in the DEAD box family of RNA helicase, indicating that it was a member of this DEAD family. The cDNA has been expressed to produce an active protein with a molecular mass of 61kDa as expected from the deduced amino acid sequence. Developmental expression studies of CfrHel mRNA in *C. fumiferana* revealed that 1st instar larvae had the lowest background levels of mRNA, whereas diapausing 2th instar larvae showed the highest levels of mRNA and the 3rd-6th instar larvae and pupa also showed moderate levels of mRNA. Higher levels of CfrHel mRNA was detected in the fat body and midgut than in the epidermis of 6th instar larva. Female adults showed higher levels of CfrHel than male adults. The CfrHel mRNA expression pattern was similar to the maternally expressed *vasa* gene isolated from *D. melanogaster*.

Index terms: cDNA, cloning, expression, nucleic acid duplex

[1321] PEPPER WEEVIL CONTROL WITH ACTARA 25WG

J. S. Ferguson' & D. S. Lawson', 'Novartis Crop Protection Inc., 7145 58th Avenue, Vero Beach, FL 32967, USA, E-mail scott.ferguson@cp.novartis.com; ² Novartis Crop Protection Inc., P. O. Box 18300, Greensboro, NC 27419-8300, USA.

The pepper weevil, Anthonomus eugenii (Coleoptera: Curculionidae) is a severe pest of peppers in the Southern U.S.A., Mexico, Central America and several Caribbean Islands (most notably Puerto Rico). Adult female pepper weevils lay eggs on flowers, buds and fruit. Fruit infestation results in premature fruit drop and can result in crop losses of up to 50% or higher. Actara[®] 25WG (thiamethoxam, CGA 293343) is a new neonicotinoid insecticide under development by Novartis Crop Protection. In field trials, Actara[®] at 50 and 70 g ai/ha applied at 7-day intervals provided highly effective control of the pepper weevil in bell and jalapeno peppers, resulting in increased yields. Control was superior to that of the current standard, Vydate[®](oxamyl), at 1120-g ai/ha. Additionally, Actara[®]provides control of other pepper pests, including aphids, leafhoppers, stink bugs and whiteflies.

Index terms: Anthonomus eugenii, pepper weevil, Actara, thiamethoxam

M.C. Fernandes¹, S.A. De Bortoli² & R.J. Ferreira¹, ¹Depto. de Biologia, Univ. de São Paulo, CEP 14040-901, Ribeirão Preto, SP, Brasil. ²Depto. de Fitossanidade, Univ. Estadual Paulista, CEP 14870-000, Jaboticabal, SP, Brasil. E-mail: bortoli@fcav.unesp.br.

This work was aimed to evaluate the tolerance of lab populations of *Chrysoperla externa* to spinosad, clorpiryphos, lambdacyalothrin and abameetin, trying to improve the relationship between biological and chemical control. The trials were carried out in the Biology Lab at the University of Sao Paulo State, Jaboticabal, SP, Brasii.. The experimental conditions were: $25 \pm 2^{\circ}$ C, 14:10 (L:D) and $70 \pm 10\%$ R.H. The Bioassay 1 (immersion in the insecticides solutions) used 1^a instar larvae of *C. externa* with until 24 hours of age fastened on microscope slides. The insecticides solutions were: 12, 24 and 48 ppm (spinosad); 640 ppm (clorpiryphos); 30 ppm (lambdacyalothrin); and 3.3 ppm (abameetin). The evaluations, larvae mortality, were made 24, 48 and 72 hours after treatments by checking larvae mortality. To the Bioassay 2, the larvae's food (*Sitotroga cerealella* eggs) was treated by the same insecticides solutions during 5 seconds, and, after dried the larvae were exposed to the treated food, and checking the nortality at the same times. To the both bioassays were evaluated pupae period and adult viability, too. According to the results, *C. externa* larvae showed high tolerance to spinosad dosis tested and they had their life cycle completed forming perfect adults.

Index terms: crisopid, spinosad, clorpiryphos, lambdacyalothrin, abamectin

[1323] UPTAKE AND DISTRIBUTION OF THIAMETHOXAM AFTER SEED TREATMENT

W. Fischer & A. Steinemann, Novartis Crop Protection AG, CH-4058 Basel Switzerland, E-mail: willi. fischer@cp.novartis.com

Following application as seed treatment a crop protection agent will be taken up by the imbibing seed and the growing roots. A substantial part of the product will be removed from the seed by water and be partitioned into the soil. This part will behave like product applied by soil drench or other soil incorporation methods. Part of the product may be lost by soil degradation and washout by rainfall and part of the product will be taken up into the plant. Inside the plant the product will be redistributed, translocated and meabolized. The chemodynamic behavior of an active ingredient is determined by its chemical and physicochemical properties. These properties determine the use of the product and the environmental fate of the active ingredient. A low molecular weight, low

[1324] COMPARATIVE LARVICIDAL ACTIVITY OF THE ENDECTOCIDES, DORAMECTIN, EPRINOMECTIN, IVERMECTIN, AND MOXIDECTIN AGAINST THREE SPECIES OF PEST FLIES (DIPTERA: MUSCIDAE) IN DUNG OF TREATED CATTLE

K. D. Floate, R. W. Spooner & D. D. Colwell, Agriculture and Agri-Food Canada, Lethbridge Research Centre, P.O. Box 3000, Lethbridge, AB, Canada, T1J 4B1 E-mail: floatek@em.agr.ca.

Two experiments were performed to assess the larvicidal activity of endectocide residues in cattle dung against horn fly (*Haematobia irritans* (L.)), house fly (*Musca domestica* L.) and stable fly (Stomoxys calcitrans (L.)) (Diptera: Muscidae). In Experiment 1, cattle were treated with ivermectin, moxidectin, or left untreated. In Experiment 2, cattle were treated with doramectin, eprinomectin, ivermectin, or moxidectin. All treatments were applied in topical formulations at recommended dosages (500 mcg/kg body weight). Fresh dung was collected from cattle immediately before (0 wks) and one to nine weeks after application (Experiment 1), or one to four weeks after application (Experiment 2). Containers of dung were 'seeded' with eggs or first-instar larvae of horn fly, house fly or stable fly and held in the laboratory for adult emergence. Results identified horn fly as being most susceptible to endectocide residues, with reduced emergence in dung voided four to six weeks post-application. In contrast, emergence of house fly and of stable fly was not reduced in dung voided more than two weeks post-application. Ranked in descending order of larvicidal activity, doramectin > ivermectin = eprinomectin >> moxidectin. This study: 1) confirms previous reports that the larvicidal activity of ivermectin is greater than that of moxidectin, 2) is among the first to provide information on the larvicidal activity of doramectin and eprinomectin, and 3) is the first to perform simultaneous bioassays of the four endectocides currently available on the market against a group of important pest flies breeding in dung. Index terms: Haematobia irritans, Musca domestica, Stomoxys calcitrans, off-target effects octanol-water partition coefficient and relatively high water solubility characterize the neonicotinoid Thiamethoxam. All these parameters are favorable for an efficient uptake by the roots and for an efficient transport in the xylem. Thiamethoxam when applied as seed treatment on maize (Zea mays) is rapidly taken up into the seedling and young plant. Rather high concentrations of Thiamethoxam can be detected in all seed compartments and also the organs of the young seedling contained high amounts of the active ingredient 14 and 21 days after sowing: pericarp 30ppm, embryo 100ppm, endosperm 86ppm, coleoptile 33ppm, primary root 2.6ppm, and leaves 5.6ppm. Thiamethoxam was applied as seed treatment also on winter rape (*Brassica napus*) and on summer rape (*Brassica campestris*). A rapid and efficient uptake was found in both varieties over an extended time period. It was found that due to the high water solubility dry soil conditions did not impair uptake of Thiamethoxam. Uptake of the compound is significantly increased at higher temperatures. The rate of degradation in the plant is dependent on various factors, such as plant species, temperature, and humidity. Similar studies with cotton (Gossypium hirsutum) will be conducted. The results will be reported and discussed.

Index terms: Thiamethoxam, seed treatment, uptake, distribution.

[1325] EFFECT OF THIAMETHOXAN ON BEAN CROP DEVELOPMENT

M. J. Fornazier', D. S. Martins' & M. A. G. Ferrão', 'EMCAPER- Empresa Capixaba de Pesquisa, Assistência Técnica e Extensão Rural. BR-262, km 94, Venda Nova do Imigrante/ES, CEP 29375-000, Brazil, E-mail crdrcserrano@emcaper.com.br.

This experiment was carried out from November 1999 to February 2000 in the highlands of Espírito Santo State to determine the effects of different formulations and application methods of thiamethoxan (a neonicotinoid insecticide) on bean crops. A randomized complete block with sub-plots experimental design was used with three bean cultivars of different color groups: black, cream-beige solid and small dark red, and four insecticide treatments: granules (Actara 10GR*, 150 g a. i.fna), seed treatment (Cruiser 700 WS*, 105 g a. i.fna), plant row spray (Actara 250 WG*, 50 g a. i.fna) and untreated control. The experiment was irrigated three times every seven days in December and sprayed twice with tebuconazole (250 g a. i./ha) and six times with methamidophos (600 g a. i./ha) from November to January. Evaluations were done at 10, 16, 23 and 36 days after germination with the following parameters evaluated: number of leaves, fresh and dry leaf weight, fresh and dry root weight, total fresh and dry plant weight, plant height and number of Rhizobium nodules. There was an interaction between bean color group and thiamethoxan formulation. Actara 10GR had the greatest effect on black bean; Cruiser 700 WS in seed treatment on cream-beige solid group and Actara 250 WG plant row spray on small dark red group. Total plant weight was greater with thiamethoxan treatment initially but differences decreased from first to fourth evaluation showing effects of thiamethoxan on initial growth of bean crop. Number of Rhizobium nodules were not significantly reduced in any treatment by the use of thiamethoxan. Beneficial effects of thiamethoxan on beans in increasing initial crop development were noted.

Index terms: Phaseolus vulgaris, growth, neonicotinoid insecticide

[1326] EFFECTS OF TRANSGENIC HYBRID MAIZE ON ADULT WESTERN CORN ROOTWORM EMERGENCE AND ROOT RATINGS

B.W. French¹, L.D. Chandler², D. Hartman¹, D.W. Beck¹, P.M. Davis³, & J. Pershing⁴, ¹USDA, ARS, NGIRL, 2923 Medary Ave., Brookings, SD 57006, USA E-mail wfrench@ngirl.ars.usda.goy; ²USDA, ARS, RRVARC, 1307 N, 18^{*} Street, Fargo, ND 58105, USA; ³Monsanto Co., 3302 SE Convenience Blvd. Ankeny, IA 50021, USA; ⁴Monsanto Co., 800 N. Lindbergh Blvd., St. Louis, MO, 63167, USA.

The larvae of Diabrotica sp. feed on the roots of maize, which can cause plants to lodge and thus prevent harvesting. Each year in the United States, millions of hectares are treated with insecticides in attempts to reduce corn rootworm populations below economically damaging levels. No other agricultural pest accounts for as much insecticide application as do corn rootworms. The indiscriminant use of insecticides can have adverse effects on beneficial insects, wildlife, the environment, and humans. To reduce the amount of insecticide applied to maize, the Monsanto Co. has developed several varieties of maize that have a rootworm toxin-producing gene (Cry3Bb) inserted into the genome. This gene is derived from the soil bacterium Bacillus thuringiensis tenebrionis. In order to test the efficacy of these varietics against corn rootworms, we established a randomized complete block experimental design that included 9 maize varieties replicated 4 times. Seven varietal events (designated Event A-G) were transgenic corn. Two non-transgenic varieties acted as controls; one was treated with insecticide (Force 3G) (Control 1) and the other received no applied rootworm control method (Control 2). We infested each subplot with *D. virgifera virgifera* eggs at the V2-V3 growth stage. We then placed cages within the rows to capture the emerging beetles. At the end of beetle emergence, we rated the damage to roots caused by the larvae. Significantly more male beetles emerged than females, however, for both males and females, fewer beetles emerged from the transgenic maize plots than from either control. Events C-G were the most effective at reducing rootworm populations. The number of beetles emerging from insecticide-treated maize did not differ from the number emerging from plants not treated with insecticide. Root damage only exceeded economically damaging levels (3.0 rating) in the no treatment plots. These results are discussed in terms of management strategies for slowing the rate of resistance development in corn rootworms.

Index terms: Diabrotica, resistance management, agricultural landscapes.

OF IMIDACLOPRID, THIACLOPRID AND EVALUATION [1327] METHIOCARB TO CONTROL Myzus persicae (HOMOPTERA: APHIDIDADE) **ΙΝ ΡΟΤΑΤΟ**

R. S. Furiatti¹, P.R.V.S. Pereira¹ & A. R. Pinto Jr.², ¹ Depto de Fitotecnia e Fitossanidade, Univ. Est. de Ponta Grossa, Caixa Postal 992, 84100-970, Ponta Grossa, PR, e-mail: furiatti@centerline.com.br, prvalle@netpar.com.br; 2 Agrius Capac. e Análises Agronômicas, Curitiba, PR, e-mail: arpinto@netpar.com.br.

The efficacy of imidacloprid (nitroguanidine), thiacloprid (cloronicotinil) and methiocarb (carbamate) was determined against Myzus persicae (Sulzer, 1778) exposed to treated potato plants. The potato strain used was Atlantic, planted 0,3 m between lines and 0,75 m between plants. The doses of the insecticides tested were 0,07 kg a.i./ha (imidacloprid); 0,0336 and 0,048 I a.i./ha (thiacloprid) and 0,25 and 0,375 I a.i./ha (methiocarb). The statistical design was casualized plots with 4 replicates, the data was submitted to analysis of variance (ANOVA) and the mean number of data compared using Tukey's. The efficacy of the insecticides was evaluated by the number of live aphids/plant using the Ascombe's Three Leaves Method. The evaluations were done 1, 3, 7, 10 and 15 days after treatment, using 5 plants per replicate. The results showed that imidacloprid (0,07 kg a.i./ha) and thiacloprid (0,048 l a.i./ha) were efficient in all evaluations. Thiacloprid (0,0336] a.i./ha) was efficient after the third day after treatment. Index terms: Chemical control, potato, Myzus persicae

[1328] INSECTICIDE AND REPELLENT EFFECTS OF MELIA AZEDARACH EXTRACTS AGAINST AEDES AEGYPTI (DIPTERA: CULICIDAE)

Coria Genovese¹, F. Ludueña Almeida¹, W. R. Almirón¹ G. Valladares¹, S. Palacios², ¹Centro de Investigaciones Entomológicas de Córdoba. Facultad de Ciencias Exactas, Físicas y Naturales. Universidad Nacional de Córdoba. Avda. Vélez Sarfield 229. 5000 Córdoba. ²CEPROCOR. Av. Arenales 230. 5000 Córdoba. Argentina. E-mail: walmiron@onenet.com.ar

Dengue Fever cases have been recently reported from various provinces in Argentina the outbreak. The emphasis is currently on prevention and control programs aimed mainly against its vector. Aedes aegypti. Temephos and Bil are used to treat the mosquito breeding sites. In this study, extracts of Melia azedarach (Meliaceae) were tested against Ae. aegypti, thus aiming to provide a natural, easily obtainable, low-cost, and environmentally safe management tool. Larvicidal effects were investigated by analysing mortality rate and development time of larvae reared in water treated with *M. azedarach* leaf and fruit extracts. Three extract concentrations (1g/l, 0.75g/l, 0.50g/l) and five replications (each a cohort of 30 first instar larvae) were used for each extract. Ovitraps were used to evaluate oviposition deterrent activity of the extracts. Five females recently emerged and blood-fed were allowed to choose between ovitraps containing either 1 g/l or 0.50 g/l of leaf extract, 1 g/l or 0.50 g/l of ethanol, or just water. Treatments with fruit extracts included ovitraps with 1 g/l, 0.75 g/l, 0.50 g/l and a water control. Five replicates were conducted for each extract. The data were analysed by ANOVA and X⁴. Treatments with leaf extract resulted in 100% larval mortality at all the concentrations tested. Mortality and development time did not differ significantly between treatments with ethanol or water. In the treatments with fruit extract only the higher concentration (1 g/l) showed a significant increase in mortality rate (48%) and development time (17.7 d) in comparison with either lower concentrations of extracts or the water controls (about 14% mortality and 14 days to reach adult stage). When considering the extracts as repellents for oviposition, the leaf extract showed again the strongest activity, with significantly fewer (less than 7%) eggs being laid in ovitraps containing extract, in comparison with those containing either water or ethanol. The number of eggs was also significantly reduced in ovitraps with fruit extract, the latter receiving about six times fewer eggs than those with water. The number of eggs did not differ among ovitraps with different fruit extract concentrations. According to the results obtained, both leaf and fruit extracts of *M. azedarach* could provide an interesting tool for the management of Ae. aegypti, since they can negatively affect survival and development time of the mosquito, as well as inhibiting its oviposition.

[1329] EXPLORING THE INFLUENCE OF INSECTICIDE ON INSECT PEST-PREDATOR INTERACTIONS USING A THEORETICAL TWO-FIELD MODEL

P. F. Giordano¹, <u>E. V. Trumper</u>² & J. Holt³, 'Cátedra de Ecología, Fac. Cs. Exactas Fis. y Nat., U.N.C., Av. Vélez Sársfield 299, (5000) Córdoba, ARGENTINA. ³Sección y Nat., U.N.C., Av. Vélez Sársfield 299, (5000) Córdoba, ARGENTINA. ³Sección Entomología, E.E.A. Manfredi, INTA, Ruta Nacional 9 Km 636, (5988) Manfredi, Córdoba, ARGENTINA, E-Mail: etrumper@arnet.com.ar. ³Natural Resources Institute, University of Greenwich, Central Avenue, Chatham Maritime, Kent ME4 4TB UK.

Insect pest resurgence has been attributed to a variety of factors. One of the mechanisms most frequently invoked is the elimination of natural controls of pest populations, as a side-effect of pesticide applications. A modified Lotka-Volterra predator-prey model was proposed in which two fields where related through dispersal of both pest and predator. In proposed in which two fields where related intrough dispersion of both pest and predator in one of these fields insecticide spraying was represented. To investigate the influence of the predator functional response, alternative versions of the model employed type I, II and III functional response equations. The model was parameterised according to a survey of literature for the period 1984-1998. A sensitivity analysis was carried out to explore model behaviour. With certain parameter combinations, the consequence of spraying was a marked reduction in pest number. Pest population resurgence was found only in particular circumstances: no resurgence occurred in the sprayed field when an unselective insecticide was used, but in the unsprayed field, resurgence could occur. Resurgence was most apparent with a type III functional response and least apparent with a type II response, though these differences were relatively small. N general, simulated pest control outcomes were more sensitive to rates of predator assimilation and mortality than to rates of predator and pest dispersal. The relevance of these results is discussed in the context of general and pest unpersal. The relevance of interview and a second pest unpersal. The relevance of making. guidelines of pest management decision making. Index terms: ecotoxicology, pest resurgence, functional response, predation, simulation.

[1330] EFFECT OF VEGETAL AQUEOUS EXTRACTS ON IMMATURE STAGES AND FEMALES OF THE CASSAVA GREEN MITE *MONONYCHELUS TANAJOA*

M.E.C. Gonçalves¹, <u>I.V. Oliveira</u>¹, R. Barros & J.B. Torres¹, ¹Fitossanidade, Univ. Fed. Rural de Pernambuco, Av. Dom Manoel de Medeiros s/n, Dois Irmãos, 52171-900, Recife, PE. E-mail: jvolivei@elogica.com.br

It was studied the bio-activity of neem Azadirachta indica A. Juss., clove Syzigium aromaticum L. and cinnamon Melia azedarach L. aqueous extracts on immature stages and female mortality of the cassava green mite Mononychellus tanajoa (Bondar). The essays were carried at $27 \pm 0.5^{\circ}$ C, $69 \pm 4\%$ RH and photophase of 12 h. Egg treatment consisted of dipping cassava leaf discs with 30 eggs into each vegetal extract and concentrations. For treatment control, the leaf discs were dipped into destilled water. The treated and control leaf discs were dried for 30 min under environmental conditions. The effect on immature stages and females were studied by exposure of 40 individuals to each vegetal extract and concentrations. Neem extract at concentrations 0.5, 2.5 and 5% caused mortality of 16.8, 59.2 and 60% for embryonic stage, while the clove concentration 5% and control treatment caused mortality of 10.8 and 4.2%, respectively. Larvae, protonymphs and deutonymphs treated with neem extract at concentrations 2.5 and 5% showed mortality ranging from 57.5 to 100% and 85 to 100%, respectively. Neem extract at concentration 2.5% increased significantly protonymphs and deutonimphs mortality from 24 to 48 h evaluations, while for the later stage it was observed only to concentration 5%. The neem extract at 0.5% and clove at 5.0% did not show significant mortality for immature stages. Females of *M. tanajoa* treated with 2.5 and 5% of neem concentrations showed mortality of 97.5 and 100%, while the cinnamon and glove extracts at these concentrations, caused mortality of 5 and 7.5%, and 5 and 12.5%, respectively. Index terms: Phytophagous mite, cassava pest, plant extract, natural insecticide.

[1332] METABOLIC RESISTANCE TO PYRETHROIDS IN AUSTRALIAN HELICOVERPA SPECIES

R. V. Gunning¹, G. D. Moores² & A. L. Devonshire³, ¹NSW Agriculture, Tamworth Centre for Crop Improvement, RMB 944, Calala Lane, Tamworth, NSW, Australia, 2340; ²³ IACR-Rothamsted, Harpenden, Herts., AL5 2JQ, UK.

Helicoverpa armigera (Hübner) and Helicoverpa punctigera (Wallengren), are major pests of cotton, and other crops in Australia. H. armigera (Wallegera (balance), are major insecticide resistance (DDT, pyrethroids, carbamates, organophosphates and endosulfan.) Some populations of H. punctigera are resistant to pyrethroids, carbamates and endosulfan. Chemical insecticides are considered essential for control of H. armigera and H. punctigera on cotton and, due to the variable performance of transgenic cotton, are likely to remain an important component of control strategies for the foreseeable future. Insecticide resistance has greatly increased over recent years and is a major threat to the economic production of cotton in Australia. Pyrethroids were first introduced for control of Helicoverpa spp. in Australia the late 1970's and resistance was first diagnosed in H. armigera, in late 1983. The initial pyrethroid resistance mechanism, a massive nerve insensitivity was associated with a severe fitness deficit and was quickly replaced in the field by a metabolic mechanism. This mechanism could be partially suppressed by piperonyl butoxide (PBO). Pyrethroid synergism by PBO, led to a widely held assumption, that pytethroids were metabolised by monooxygenases in *H. amigera*. However, it has become increasingly clear that instead, an overproduction of esterase isoenzymes is responsible for pytethroid resistance in *H. armigera*. The esterases sequester and metabolise pyrethroids and furthermore, biochemical studies showed that PBO was an esterase inhibitor in H. armigera. Some organophosphates are effective esterase inhibitors and can restore pyrethroid susceptibility. Pyrethroid/ esterase binding studies showed that pyrethroids which contained a halogenated benzyl group bound more readily to *H. armigera* esterases and were more resisted, in comparison to pyrethroids, where the benzyl ring was replaced by a dihalogenated aliphatic entity. Pyrethroid resistance in H. punctigera was also shown to be the result of an esterase mediated resistance mechanism.

[1331] INFLUENCE OF INSECTICIDES ON THE SPIDERS COMMUNITY IN A SOY CULTIVATION (BUENOS AIRES, ARGENTINA)

A. González, E. Minervino, D. Castro, A. Armendano & S. González, Cepave. 2 nº 584, 1900 La Plata, Argentina. alda@netverk.com.ar

There is experimental evidence on the action of spiders as regulators of populations of plague insects in agriculture, so as on the need of biocontrol agents (Greenstone, 1999). Indiscriminate use of agrochemical favors the elimination of natural enemies (Kajak, 1978). The aim of this paper is to determine the effects produced by insecticides on the spider population of soy cultivation and relate density fluctuations to those of the plague groups. The work was carried out in two parcels, one without treatment, and the other with two fumigations (on middle of February and end of March). 40 samples were taken weekly, randomly, on plant packaging from January to March. Diversity (equitability and Shannon & Weaver indexes) and density of spiders and plagues of the fumigated parcel was compared with those of that not fumigated (test t). The weekly net increase of spiders (i) was calculated for both parcels. Diversity and density of spiders were significantly lower in the treated parcel (only 50% of the families appeared), being low the diversity index and high the equitability index. The first fumigation occurred when the area was not completely colonized. This fact prevents the settlement of some spider species on one hand, and the elimination of most preys, on the other. After fumigation, density of spiders became zero, for fifteen days, then the colonization began again, as at the beginning of cultivation, but with less diversity and density. The weekly increasing rate shows similar trends in both parcels in the first three weeks. In the parcel not treated, density increased, but in the funigated parcel was zero (weeks 3 and 4). This situation repeated after the second funigation (weeks 7 and 9). Later it was similar in both parcels. Comparing spider and prey defoliators and drillers densities, preys appear in the first weeks, together with the spiders, but then, defoliators are drastically affected by fumigation, as spiders, while in the not treated parcel they reached high densities and then decreased, surely affected by natural enemies. Drillers are not highly affected by fumigation, and when spiders disappear, they show a high peak in density. In the not treated parcel, the permanence of factors of natural mortality probably prevented the second peak. Index terms: Spiders, soy culture, insecticides.

[1333] METABOLIC MECHANISM OF RESISTANCE TO IMIDACLOPRID IN BEMISIA TABACI, IN AUSTRALIA

R. V. Gunning, NSW Agriculture, Tamworth Centre for Crop Improvement, RMB 944, Calala Lane, Tamworth, NSW, Australia, 2340

B-biotype Bemisia tabaci is a serious pest of cotton and horticultural pests world wide. This insect has spread thought the world via the international trade in poinsettia cuttings. B-biotype B. tabaci was first discovered in Australia in 1994 and since, has become widely distributed. This whitefly has already achieved a major pest status in some horticultural crops in Australia. Imidacloprid is one of the newer insecticides developed for the control of sucking insects, including whiteflies. Imidacloprid is registered for whitefly control in Australia. Initially bioassays showed that B-type Benisia tabaci in Australia were susceptible to imidacloprid. However, since then, there have been some problems with field control of B. tabaci in Queensland using imidacloprid. Bioassays showed a rapid development of resistance. Biochemical studies indicated that imidacloprid bound readily to esterase isoenzymes in resistant B. tabaci. Detoxification of imidacloprid by esterases is suggested as a mechanism of resistance in Australian populations of B. tabaci.

Symposium and Poster Session

[1334] EFFECT OF WHEAT CURL MITE SOURCES ON TRANSMISSION OF HIGH PLAINS VIRUS

T.L. Harvey' & D.L. Seifers', 'Dept. of Entomology, Kansas St. Univ., Manhattan, KS 66506, e-mail tharvey@oz.oznet.ksu.edu; 'Kansas St. Univ., Agricultural Research Center-Hays, Hays, KS 67601, e-mail dseifers@oz.oznet.ksu.edu.

The High Plains virus (HPV) is vectored by the wheat curl mite (Aceria toshichella) (WCM). This study was done to determine if differences exist among sources of WCM in vectoring of HPV isolates. WCM were obtained from five states and cultures free of wheat streak mosaic virus (WSMV) were established by raising the WCM from eggs on wheat free of HPV and WSMV. WCM from each location were then separately maintained on healthy and WSMV-infected wheat. HPV isolates were isolated from infected corn from five states and were maintained free of WSMV in corn by vascular puncture of the embryonic tissue of corn seed. Each WCM culture (viruliferous and aviruliferous) was tested against each HPV isolate for ability to vector HPV. WCM from Kansas, South Dakota, and Texas were not able to transmit any HPV isolate. However, WCM from Montana and Nebraska could vector all HPV isolates in all experiments in both viruliferous and aviruliferous culture.

[1335] ANALYSIS OF THE PROMOTERS OF THE β ESTERASE GENES ASSOCIATED WITH ORGANOPHOSPHATE-RESISTANCE AND – SUSCEPTIBILITY IN TWO STRAINS OF CULEX QUINQUEFASCIATUS

<u>N. J. Hawkes</u> & J. Hemingway. School of Biosciences, Cardiff Univ., Main College, Museum Avenue, Cardiff, CF10 3TL, UK e-mail:- sabnh@cf.ac.uk

The mosquito Culex quinquefasciatus is a major vector of filariasis and arboviruses. Widespread resistance to organophosphate insecticides is primarily due to the over-expression of non-specific carboxylesterases which sequester the insecticide. Excess esterase production is usually caused by amplification of the structural esterase gene(s). Co-amplification (1:1) of two genes on a single amplicon, $est\alpha 2'$ and $est\beta 2'$, is the most common genotype (~95%). In the resistant strain Pel RR $est\alpha 2'$ and $est\beta 2'$ are oriented head-to-head, and separated by 2.7 kbp of intergenic sequence, whereas in the susceptible strain Pel SS the intergenic spacer between the corresponding genes $est\alpha\beta^{\prime}$ and $est\beta l^{\prime}$ is only 1.8 kbp.. This spacer DNA must, therefore, contain the promoter elements for divergent transcription of both esterases, and the additional sequence in the resistant spacer may affect transcriptional control. We are studying these four esterase promoters (RRA2, RRB2, SSA3, SSB1) using transient transfection of luciferase reporter gene constructs into a C. quinquefasciatus cell line. After optimisation of transfection conditions, it was necessary to construct a β-galactosidase vector control, as a commercially available plasmid was insufficiently expressed. The B-galactosidase gene was ligated into a plasmid containing the Drosophila actin 5c promoter (derived from a vector kindly supplied by P. Eggleston). This construct was expressed at acceptable levels by the Culex cells. Transfection of equimolar amounts of the four promoter-luciferase constructs showed that both resistant and susceptible β -esterase promoters were highly active in these Culex cells (150x and 130x relative to a promoter-less control) but that both α promoters were essentially inactive (0.4x and 0.3x as active as the same control). This inactivity may be due to the requirement for tissue-specific factors or induction, or conversely the \beta-esterase promoters may contain constitutively-regulated promoter elements lacking in the α promoters. Panels of progressive promoter deletions were created by exonuclease III deletion and PCR for both RRB2 and SSB1 promoters. Transfection assays have revealed several regions in both promoters where binding sites for positive and negative transcriptional regulators may be located; for example the 230bp of DNA proximal to the initiating Met retains ~25% of the transcriptional activity of the full-length promoter, but deleting a further 60bp closer towards the ATG reduces this activity to \sim 5%. In addition, mutagenesis studies have revealed that the arthropod initiator site TCAGT 130bp upstream of the ATG, which is perfectly conserved in both B-esterase promoters, is essential for directing transcription.

Key words: Culex quinquefasciatus, resistance, esterase, promoter, initiator

[1336] DIAZINON AND PYRETHROID RESISTANCE TO THE HORN FLY IN TEXAS

C. E. Hoelscher', D. M. Kammlah², & D.C. Sheppard³, ¹Dept. of Entomology, Texas A&M Univ. Heep Center, College Station, TX 77843, USA, E-mail c-hoelsch@tamu.edu; ³USDA Knipling-Bushland US Livestock Insect Research Lab. Kerrville, TX, USA; ³Dept. of Entomology, Univ. of Georgia, Tifton, GA, USA.

The horn fly, Haematobia irritans irritans (L.) is the major insect pest of livestock in Texas. This blood feeding biting fly occurs in all livestock producing regions of the state. Horn fly populations on beef cattle normally exceed established economic thresholds of 200-250 flies per animal in spring and fall periods. Economically damaging populations cause significant reduction in the thrift and vigor of the host animals. Blood loss caused reduced milk production thus the weaning weight of calves is reduced. Producers use a variety of whole body sprays, pour-on formulations, and self-treatment devices to control the horn fly. Self-treatment devices such as insecticide impregnated ear tags put daily selection pressure on the fly population. Routine treatment can lead to the development of insecticide resistant populations. The treatment dosage is high when the tags are attached to the animal's ear and decrease with age of tag. Pyrethroid resistance was documented in the horn fly in Texas in the early 1980's. Cross-resistance was observed to all pyrethroid insecticides labeled for use on beef cattle. Resistance to diazinon was documented in Robertson County, TX in September 1996. Horn flies were approximately 16x resistant to diazinon in September 1996. Resistance levels were determined by the treated filter paper method for both classes of insecticide. Patriot® car tags contain 40% diazinon. These insecticide impregnated ear tags failed to provide satisfactory control of the target fly population. Data will be presented on the management of resistant flies to lower resistant gene levels in field populations. Avermectin pour-on provided the best reduction of fly population for the control of resistant horn flies

Index terms ...matobia irritans irritans (L.), insecticide resistance, horn fly and livestock.

[1337] THIAMETHOXAM (CRUISER[®]) AS SEED TREATMENT – VALUE BEYOND INSECT CONTROL

D. Hofer, F. Brandl, L. Zang & A. Fougeroux, Novartis Crop Protection AG, CH-4058 Basel Switzerland, E-mail: dieter.hofer @cp.novartis.com.

Thiamethoxam (CGA 293'343) is a novel broad-spectrum insecticide currently under worldwide development by Novartis Crop Protection. The molecule belongs to a new chemical class - the neonicotinoids. Neonicotinoids have a new mode of action interfering with the nicotinic acetylcholine receptor of the nervous system of insects. CRUISER® is highly active on a broad spectrum of insects. Compared to the most important competitor in the same chemical class, CRUISER® can be used at lower dose rate to achieve the same or even higher level control effects with longer lasting activity. Furthermore, the unique technical advantages of CRUISER® may be separated into 3 general areas: Robust performance under different elimatic conditions; strong initial crop vigor which results in increased yield effects; and carryover of treated seed. Each of these unique technical advantages provides added value to crop genetics, farmers and environment. The constant performance of CRUISER® is due to the water solubility designed to perform well under most different climatic conditions. CRUISER® is well distributed in the soil and taken up by the plants under very dry up to wet conditions. This feature gives CRUISER® a clear advantage over the current available solutions. CRUISER® treated seeds benefit from robust crop vigor due to crop safety, rapid systemic uptake into young seedlings, highly consistent activity, and broad-spectrum insect control. Strong early season crop vigor leads to fast and uniform stand establishment, early uniform crop ripening, and therefore maximized potential for yield increase. CRUISER® shows excellent performance of seed safety on seeds carried over from one season into the next. Canola seed for example can be stored for at least 18 months without loosing viability and germination power.

Index terms: Thiamethoxam, Cruiser, seed treatment

MANAGING INSECTICIDE RESISTANCE IN AUSTRALIAN [1338] HELICOVERPA ARMIGERA

J. W. Holloway' & N. W. Forrester', 'NSW Agriculture, Australian Cotton Research Institute, Narrabri, NSW, Australia, 2390, E-mail jonathanh@mv.pi.csiro.au; ²Deltapine International, P.O. Box 196, Narrabri, NSW, Australia, 2390.

Components of the Australian cotton Insecticide Resistance Management (IRM) strategy for monitoring and managing insecticide resistance in *H. armigera* are discussed, including chemical and non-chemical approaches. This species currently has high frequencies of resistance to members of several of the older insecticide groups, including the pyrethroids, carbamates, endosulfan and organophosphates. A hackground of resistance and cross-resistance to older groups places increased pressure on newer chemistry and emphasises the need for pro-active resistance management. Chemical approaches include separation of the target pest species and insecticide selection pressure in time (rotations or window strategies) and separation of the target pest species and insecticide selection pressure in space (alternation or mosaic strategies), use of synergists or mixtures to overcome metabolic resistance and restrictions in the total number of applications of a particular insecticide group used. The success of these approaches will depend on the range (and cost) of chemical groups available, their impact on the major beneficial insect and the resistance status, major resistance mechanisms and ecology of the pest. Complementary non-chemical approaches empasise a systems approach to help to reduce pest population pressure and insecticide use. This includes matching the variety and its agronomic management to the region, optimising planting windows, realistic early season thresholds, an understanding of the crops compensatory capacity for damage, classical or genetically modified host plant resistance, use of trap crops to concentrate pests for management, refuges for preservation of susceptible genes, physical destruction of over-wintering pupae and area-wide management. These components have been incorporated into integrated pest management guidelines designed to complement and support IRM and to reduce the risk of selection for resistance being channeled toward any single component. The challenges encountered in integrating these approaches into a coordinated strategy and regularly updating this strategy to cope with the dynamic nature of the problem will be discussed using the Australian Cotton Insecticide Resistance Management (IRM) Strategy as an example.

Index terms: Bolloworm, cotton, management.

[1339] THE STUDIES OF THE INSECTICIDE SUSCEPTIBILITY AND DETOXIFICATION ENZYMES OF APIS CERANA AND APIS MELLIFERA

E. L. Hsu & S. S. Liu, Dept. of Entomology, Natl. Taiwan University, Taipei (112), Taiwan, ROC, E-mail elhsu@ccms.ntu.edu.tw.

Both apis cerana and apis mellifera are important species for apiculture industry in taiwan. Due to taiwan is located in subtropical area with hot and humid weather. insect pests are seriously damaged the crops. Pesticides are necessary used in crop protection. Honeybees are frequently contaminated by insecticides. Topical appli-cation and feeding method were used for insecticides susceptibility test. Ten insecti-cides, carbaryl, coumaphos, dimethoate, mevinphos, thiometon, phenothrin, perme-thrin, cypermethrin, decamethrin and avermectin were tested in this experiment. Coumaphos was low hazard to apis cerana eighter apis mellifera. Both species were very susceptible to dimethoate and avermectin, moderately susceptible to synthetic pyrethroids. Apis mellifera was more susceptible to insecticides in comparison with apis cerana. The specific activities of microsomal oxygenases such as aldrin epoxidase, n-demethylase and o-demethylase of apis cerana were higher then apis mellifera. This could be the reason why apis cerana more tolerate to insecticides then apis mellifera.

Index terms: Apis cerana, Apis mellifera, insecticides, detoxification enzyme

[1340] OSTRINIA NUBILALIS ADULT MOVEMENT AND RESISTANCE MANAGEMENT

T.E. Hunt' & L.G. Higley', 'Dept. of Entomology, Univ. of Nebraska, 202 Plant Industry Bldg., Lincoln NE, 68583, USA.

The European corn borer, Ostrinia nubilalis (Hubner), is a significant pest of corn. (Zea mays L.). Current modeling efforts that address the management of European corn borer resistance to Bt transgenic corn require information on adult corn borer dispersal and factors affecting such movement. In 1996 through 1998 we conducted mark-releaserecapture, release-recapture, and mating studies to directly measure and compare dispersal patterns of European corn borer moths from corn of different phenological stages and in and around irrigated and rain-fed cornfields. Releases of marked moths were made corresponding to the first and second flight of European corn borer in eastern Nebraska. Moths were recaptured in blacklight traps positioned around the release fields. Dispersal was random with respect to direction for males and females on both release dates. Dispersal models fit a negative exponential decay, but could not be generalized by using a common model. Release date, corn phenology, agronomic practice (irrigated or rain-fed), sex, and mating status contributed to the variability observed in adult dispersal. Mean recapture distance during the June release was greater than that of the August release, greater at unattractive than attractive (with respect to ovipositional preference) cornfields, and greater for males than the females. Over 95% of the unmated females recaptured were recaptured within 48.0.6 m from their release site. Moth dispersal was significantly different between irrigated and rain-fed cornfields. Released moths tended to remain in and near irrigated cornfields, and disperse out of and away from rain-fed cornfields. Mating efficiency in a late-season cornfield was not significantly different than in dense variables and their interaction with European corn borer life history. The poor The poor predictability of dispersal reflects the importance of local conditions, such as plant community and microclimate, to designing resistance management protocols and identifying areas that may have a higher risk of resistance developing.

Index terms: Ostrinia nubilalis, Zea mays, transgenic, resistance management

[1341] DETECTION OF INSECTICIDE RESISTANCE IN PEACH POTATO APHIDS MYZUS PERSICAE AND IN TOBACCO APHIDS MYZUS NICOTIANAE BLACKMAN

P. M. Ioannidis, Hellenic Sugar Industry S.A., Plant Protection Department, 59032, Plati Imathias, GREECE

The Myzus persicae is considered as a serious pest in peach orchards and sugarbeets, and Myzus nicotianae in tobacco in Greece. Laboratory bioassays were conducted to evaluate the LC₃₀, using the dip-test method recommended by FAO with assessment of mortality after 24 hours. The most commonly applied insecticides by farmers, pirimicarb, methamidophos, carbosulfan, L-cyhalothrin and imidacloprid were used. Both the species were very resistant to pirimicarb and methamidophos. These two insecticides have been used extensively for controlling these insects. Some populations of the tested species were tolerant to imidacloprid with 5 tol1 resistance ratio (RR) and some had 12 to 25 RR. This tolerance to chloronicotinyls in certain populations of Myzus spp. can be considered as a natural variation in response due to the nature of the insecticide or can be considered as resistance because in some bioassays the x^2 (chi square) values were high showing heterogenicity in the response of the population to imidaeloprid. More research is needed to clarify this situation. The average LC_{26} for susceptible *Myzus persicae* was 0,63 ppm. And for *Myzus nicotianae* 4,18 ppm. Consistently the *M. persicae* has lower values of LC_{26} the method of the method. LC., than the susceptible M.nicotianae . Despite that the distinction between the two species is very difficult. Recently these two species are considered as two biotypes of the same species. All the tested populations of *M.nicotianae* were resistant to carbosulfan with values from 37. To 125 ppm. While some population of M. persicae were LC,00 LC₃₀ values from 5.7. To L25 pm. White some parameters of the LC₃₀ values from 0.63 to 33 ppm. Pyrethroids are sprayed usually to the above mentioned crops for controlling lepidoptera. As a consequence a selection pressure to aphids is applied and some resistance to L-cyhalothrin had been noticed with 6 RR. From the regression equations which have been established for the susceptible populations the discriminating doses which kill the 99% of the susceptible population can be detected.

Index terms : carbosulfan, pirimicarb, imidacloprid.methamidophos

[1342] NOVALURON (RIMON EC-10), A NOVEL IGR FOR CONTROLLING AGRICULTURAL INSECT PESTS

I. Ishaaya, S. Kontsedalov, D. Masirov & A. R. Horowitz, Dept. of Entomology, Agricultural Research Organization, The Volcani Center, Bet Dagan 50250, Israel, E-mail: vpisha@netvision.net.il, Fax: +972-3-9683835.

Novaluron (Rimon Ec-10),1-[3-Chloro-4(1,1,2-Trifluoro-2-Trifluoro-Methoxyethoxy) phenyl]-3-(2,6-difluorobenzoyl)urea, is a novel benzoylphenyl urea that acts by both ingestion and contact. As such it is a powerful suppressor of lepidopteran larvae such as Spodoptera littoralis, S. exigua, S. frugiperda, Helicoverpa armigera and Tuta absoluta attacking field crops such as cotton, corn and vegetables. It is also a powerful toxicant against whiteflies such as *Bemisia tabaci* and *Trialeurodes vaporariorum* and leafminers such as Liriomyza huidobrensis and Perileucoptera cofeella. Our studies indicated that the LC-50 value of Rimon on 3rd-instar S. littoralis fed on treated castor bean leaves is ~0.1 mg a.i./litre. This value resembles that of Atabron (chlorfluazuron) and is about 10-fold lower than that of Nomolt (teflubenzuron). An application of 250 g a.i./ha in a cotton field resulted in 100% mortality of both S. littoralis and H. armigera larvae upon exposure to treated leaves, up to day 8 after application and about 60% and 30% mortality, respectively, at day 15. Novaluron affects to a much greater extent larvae of B. tabaci than chlorfluazuron and teflubenzuron. Total larval mortality was obtained by dipping infested cotton seedlings in 1mg a.i./litre Rimon. Artificial rain at a rate of 40 mm/h applied 5 and 24 h after treatment in cotton field had no appreciable effect on the potency of Rimon on S. littoralis larvae. Hence Rimon can be used in tropical areas and in rainy seasons. Rimon has similar potency on susceptible and pyriproxyfen and buprofezin resistant B. tabaci strain indicating that no cross resistance occurs between Rimon and other leading compounds against whiteflies. Rimon has no effect on parasitoids such as *Encarsia formosa* and is considered to *have* a relatively mild effect on other natural enemies. As such it is an important addition to be used in integrated pest management (IPM) and insecticide resistant management (IRM) for controlling pests in various field crops, vegetables and ornamentals.

Key words: Benzoylphenyl urea, selective insecticide, whiteflies, lepidopteran pests

[1344] HOW TO BE OPTIMAL UNDER TOXICANT STRESS: OPTIMAL ENERGY ALLOCATION AND ECOTOXICOLOGY OF INSECTS AND OTHER ARTHROPODS

M.K. Janczur, Institute For Environmental Sciences. Jagiellonian University, Ul. Oleandry 2a, 30-063 Kraków, Poland, E-Mail: Maj@Datasys.Com.Mx.

Among terrestrial arthropods, some organisms (e.g. beetles) are known for maintaining low concentrations of toxicants in their bodies, while other (e.g. spiders) exhibit high concentrations. Some toxicants (like metals) are non-degradable so their decontamination is a two-stage process: first they are converted to less toxic forms (e.g. metalothioneins) and then removed outside the organism. I present an optimal energy allocation model, which takes into account both internal properties of an organism and its demography. Using the dynamic programming procedure i find the optimal fractions of energy allocated to growth, reproduction, heavy toxicant immobilisation and removal in order to maximise the lifespan reproductive success. Toxicants are absorbed from food with the rate proportional to the assimilation rate. i consider two models: Toxicant affect 1) mortality, and 2) both mortality ant the assimilation rate. Optimal energy allocation determines such characteristics as toxicant concentration in the body, optimal lifespan, age at maturity and adult body size. I obtained three qualitatively different solutions: 1) allocation to growth, reproduction, toxicant immobilisation and removal, 2) allocation to growth, reproduction and metal immobilisation, 3) allocation to growth and reproduction only. Higher allocation to decontamination results in a lower energy allocation to growth and/or reproduction which is paid back by a longer lifespan due to a reduced toxicant-dependent mortality. The model predicts that animals living under higher external mortality pressure accumulate higher toxicant concentration in the body. The predictions of the model concerning interdependence among life-history traits are consistent with experimental and field results obtained on such arthropods as chironomus riparius (diptera: chironomidae), folsomia candida (collembola: isotomidae), orchesella cincta (collembola: entombryidae), porcelio scaber (isopoda: porcellionidae), poecilius cupreus (coleoptera: carabidae). Results concerning the effect of intrinsic properties on decontamination pattern are consistent with empirical studies carried out on ephemeropterans. The model is also consistent with some studies concerning insect (and other arthropods) abundance (inter- and intraspecific) along the toxicant concentration gradient. The model explains some results of experimental and/or field studies that were not fully understood by their authors. Additionally it allows to put forward accurate null hypotheses for future empirical work. It seems to predict particularly well the optimal decontamination strategies in insects and in other invertebrates.

Index terms: carabidae, chironomidae, collembola, porcelionidae, optimal energy allocation, decontamination, matematical model

[1344] CONTROL OF DIAMONDBACK MOTH (*PLUTELLA XYLOSTELLA*) BY SPINOSAD AND ITS INFLUENCE ON PARASITIC WASPS

K. Kaneshi¹, H. Himei¹, G. Nakamura¹, K. Morita¹ & T. Noda².¹ Dow Chemical Japan Ltd. Dow AgroSciences division, Tennoz Central Tower 2-24, Higashi Shinagawa 2chome Shinagawa-ku, Tokyo 140-8617, Japan; ² Tohoku National Agricultural Experiment Station, Laboratory of Insect Pest Control, 4 Akahira, Shimo-Kuriyagawa, Morioka, Iwate 020-0123, Japan.

Plutella xylostella is one of the most troublesome pests in Cole crops. It has developed resistance to a wide range of chemicals and management of this insect has been a challenge since 1960s in Japan. Various integrated pest management (IPM) methods to control P. xylostella have been proposed but chemical application is still the most popular way to control this insect among Japanese cabbage growers. Spinosad is the first insect control agent from NATURALYTE* class of naturally derived product from Dow Spinosad is produced by fermentation by a novel actinomycete AgroSciences. Saccharopolyspora spinosa. Spinosad has high activity to mainly Lepidopteran and Thysanopteran insects but also has favorable mammalian and environmental characters. More than 50 field studies conducted from 1995 to 1998 in Japan showed that spinosad as 25% WDG at 2.5gai/hl provided excellent control of P. xylostella. Spinosad was also tested against two indigenous parasitic wasps of P. xylostella, Cotesia plutellae and Comyzus sokolowskii, and an introduced natural enemy, Diadegma semiclausum in lab and semi field conditions. Even though spinosad was toxic to adults of these parasitoids with direct contact, its toxicity was reduced on cocoons and on adults in semi-field conditions. Cocoons of the parasitoids showed a high survival rate even with direct spray and there was no significant difference in mortality of adults between the treated and untreated plots. This result suggests that spinosad can preserve populations of these parasitoids in the field and play an important role in IPM for control of *P. xylostella*. Index terms: spinosad, Plutella xylostella , parasitic wasps

[1345] STATUS OF INSECTICIDE RESISTANCE IN HELICOVERPA ARMIGERA POPULATIONS FROM AREAS WITH DIFFERENT INSECTICIDE-USE REGIMES

V. Kathuria¹, R. K. Saini² and P. Ram³, Department of Entomology, College of Agriculture, Ch. Charan Singh Haryana Agricultural Univ., Hissar 125 004, Haryana, India; 'Present address: Tata Energy Research Institute, Darbari Seth Block, Habitat Place, Lodhi Road, New Delhi 110 003, India, e-mail: vanitk@teri.res.in

Bioassay studies on relative susceptibility of Helicoverpa armigera populations from three districts (viz. Hissar, Sirsa and Bhiwani) of Haryana, following cotton-chickpea crop rotation but with a different insecticide-use pattern, were conducted during 1998-99 at CCS Haryana Agricultural University situated at Hissar. The other two districts were 90 and 50 km away from the central district (i.e. Hissar). Larval populations were collected from chickpea fields in 15 km radius of each district headquarter and reared separately on chickpea foliage to obtain moths. Apart from this, with a view to expose a wider gene pool to different insecticides, moths were collected during different nights with the help of artificial light from at least three locations from each of the three districts to supplement the moths obtained from laboratory rearing of the pest. First instar larvae from the three populations were exposed to dry films of different insecticides on glass surface and mortality was recorded after four hours. The whole experiment was repeated three times. On the basis of LC_{30} values for each of the three populations, it was found that population from Bhiwani was the most susceptible one to all the insecticides tested, while that from Sirsa exhibited the highest resistance to these insecticides. Population from Sirsa had developed 4.0-, 3.8-, 3.8-, 2.5- and 1.6-fold resistance to monocrotophos, cypermethrin, endosulfan, quinalphos and fenvalerate, respectively, as compared to population from Bhiwani. On the other hand, population from Hissar manifested 1.9-, 2.8-, 1.9-, 1.1- and 1.9-fold resistance to the above insecticides, respectively, vis-à-vis population from Bhiwani. Greater insecticidal tolerance in population from Sirsa, followed by that from Hissar, closely corresponded with the pattern and intensity of insecticide use in these districts. It was concluded that areawise control strategy for this pest would be more useful in view of the differential susceptibility of the populations from different districts. Keywords: Helicoverpa armigera, insecticide, resistance

[1346] SUSCEPTIBILITY OF HELICOVERPA ARMIGERA EGGS TO SOME COMMONLY USED INSECTICIDES

<u>V Kathuria</u>¹, R K Saini² & P Ram³, Department of Entomology, College of Agriculture, Ch. Charan Singh Haryana Agricultural Univ., Hissar 125 004, Haryana, India; ¹Present address: Tata Energy Research Institute, Darbari Seth Block, Habitat Place, Lodhi Road, New Delhi 110 003, India. e-mail: vanitk@teri.res.in

Laboratory studies on the ovicidal activity of different insecticides against Helicoverpa amigera populations from Hissar district of Haryana were conducted during 1998-99 at CCS Haryana Agricultural University, Hissar. Nine commonly used insecticides were evaluated by egg dipping method taking eggs of different ages. Synthetic pyrethroids, namely, fenvalerate and cypermethrin gave the highest egg mortality (>80%) followed by methomyl and triazophos (>75%). The next group of promising insecticides included quinalphos, monocrotophos and endosulfan (60 – 70%) while carbaryl and malathion constituted the inferior category, though quite significant (>50%) egg mortality was afforded by them. One-day-old (0-24h) eggs exhibited greater susceptibility to all the insecticides followed by two-day-old (24-48h) and three-day-old (48-72h) eggs. In the young (0-24h) eggs, much of the ovicidal action by most of the insecticides was recorded within the first 12h after the treatment. However, methomyl and quinalphos showed significant incremental egg mortality during the next 12h also. This tread was less pronounced in the older eggs. No additional mortality was recorded after 36h of treatment. It is concluded that insecticides with good ovicidal action may be selected for inclusion in the control programmes involving insecticides and their application must be synchronised with the peak ovigosition period of the pest in the field.

Keywords: Helicoverpa armigera, insecticide, ovicidal action

Symposium and Poster Session

[1348] TICK CONTROL: EVIDENCE TO SUPPORT RESISTANCE MANAGEMENT RECOMMENDTIONS

D.H. Kemp¹, R. Thullner² & N.N. Jonsson³, ¹CSIRO Tropical Agriculture, Molecular Animal Genetics Centre, Gehrman Bldg., Univ. of Queensland, Brisbane, Australia 4072, e-MAIL David.Kemp@tag.csiro.au. ²Alte Obervolkacherstr. 9, D-97332 Volkach, Germany. ³Dept. of Veterinary Clinical Studies, Univ. Glasgow, Bearsden Rd., Glasagow G61 1QH, UK.

The cattle tick, boophilus microplus, is a serious problem in many tropical countries and it has developed resistance to all except for the newest acaricides. Modeling of resistance management has been limited and experiments and field trials are almost non-existent so it is difficult to make recommendations on particular resistance management strategies. Modeling has suggested that increasing treatment frequency will promote the emergence of resistance and this was confirmed in a recent field survey. An earlier survey showed fewer cases of sp resistance in regions where introduction of tick immune cattle (zebu) reduced the need for acaricides. Recommendations for greater use of immune cattle, introduction of the recombinant anti-tick vaccines and other biological control methods to delay acaricide resistance are probably justified. Trials with a combination of macrocyclic lactones and the tickgard anti-tick vaccine showed some synergistic effects and this may also have potential to delay resistance. Mixtures of acaricides/insecticides are used in some countries for improved control of ticks and insects but there is no information on potential risks or benefits for managing resistance. Likewise, recommended saturation strategies with high concentrations of acaricides or alternatively, strategies that use concentrations lower than currently recommended, have not been tested. Recent trials on dominance of tick resistance to amitraz, a commonly used acaricide, suggest that higher concentrations would not be successful. This needs to be checked for each group of acaricides. Rotation of an op and sp acaricide did delay the establishment of resistance in a laboratory trial and this can be recommended for field testing. New initiatives are needed by companies, government authorities and farmer organisations to protect the valuable acaricides that are available.

Index terms: boophilus microplus, resistance management, recommendations

[1347] EFFECTS OF EUCALYPTUS AND CALLISTEMON LEAF EXTRACTS ON HELICOVERPA ARMIGERA LARVAE

<u>N Kaushik</u>, Bioresources and Biotechnology Division. TERI, Habitat Place, Lodhi Road. New Delhi 110 003, India. e-mail: kaushikn@teri.res.in

Helicoverpa armigera is one of the major insect pest in India. It attacks many economically important crop species viz. cotton, pigeonpea, chickpea, tomato, sunflower, etc. Currently, it is the most difficult species to control because of emergence of resistance to commercially available insecticides. This necessitates search for newer molecules to control the pest population. Plant biodiversity is of immense importance in this regard offering a wide range of biomolecules. In present study, extracts obtained from Eucalyptus and Callistemon leaves in different solvents were tested against Harmigera larvae using feeding bioassays. Preliminary bioassays were conducted by feeding the insects on the diet having the crude leaf powder of Eucalyptus and Callistemon. The larval development, molting, pupal weight and survival rate were studied from 1" instar larvae upto emergence of adults. Further bioefficacy experiments were conducted with different levels of the leaf powder in the artificial diet. Slow growth and development of larvae was observed. The powder in the automatical state of the stat deformity in adults. Leaf extract of *Eucalyptus* and *Callistemon* were prepare in different solvents. First instar larvae was released into the diet treated with the extract and rate of survival, development time, molting disorders, larval weight on 7th day were recorded as performance variables. Among various extracts maximum activity was recorded in alcohol extract. About 88 per cent growth inhibition was recorded in H.armigera larvae treated with the alcohol extract of the Eucalyptus leaves. All the larvae died without reaching pupation with stunted growth. Whereas, in the case of Callistemon leaf extract 20 per cent survival was recorded till pupation. Further studies related to bioassay mediated fractionation of the extracts are in progress.

[1349] INSECT ANTIESTERASE ACTIVITY OF NOVEL ORGANO-PHOSPHORUS COMPOUNDS AND CHANGES OF ENZYME LEVEL IN FIELD RESISTANT POPULATIONS *MUSCA DOMESTICA*

A.V. Khrunin & <u>O.Yu. Eremina</u>, Dep.of Entomology, Inst. of Disinfectology, Nauchny pr.,18, Moscow, 117246, Russia, E-mail: eremin@bochvar.ru

The insecticide effect, combined action of pyrethroids and potential synergists from two groups of organophosphate (OP) compounds: derivatives of 1,3,2 oxazaphosphorinan and derivatives of phosphorothio- and dithio acids containing fragments of N-carbalcoxylated glycine or --alanine, were studied. Interaction of novel potential synergists with cholinesterases (ChE) (housefly *Musca domestica* heads ChE, cockroach *Periplaneta americana* nerve cord ChE) and carboxylesterases (CE) (housefly CE, cockroach CE) were investigated by Ellman, Van Asperen and PAAG methods. It was determined 1,6 and k, and shown, that O-analogues has more anti-ChE activity, than S-analogues, and they have a combined or reversible type of inhibitory action in connection with their chemical structures. We compared novel compounds with paraoxon, GD-42, eserine wich have irreversible type of ChE inhibition. Nonspecific esterases (NE) activity was studied in five populations of houseflies *Musca domestica* from regions with different levels of industrial and pesticide pollution. Quantitative differences between total activity and esterase spectra of ChE and CE from heads and abdomens of houseflies were revealed. Both NE activity (determined according to Van Asperen) and activities of individual esterases proved to be highly resistant to OP, which may reflect the adaptation of flies to pesticide pollution. An increase in the activity of esterases from heads correlated with the high level of OPresistance, and from abdomen – the same to pyrethroid-resistance in fly populations. Changes in acid phosphatase activity were observed too, and we connected its change with environmental pollution.

Index terms: Periplaneta americana, Musca domestica, enzyme activity, synergism, OP, pyrethroids

[1350] BAS 620 H - A NEW GRAMINICIDE FOR POST-EMERGENCE GRASS CONTROL IN BROADLEAF CROPS

E. Kibler¹, M. Landes¹, <u>H. D. Briz¹</u>, H. Hosaka⁴, ¹BASF Agricultural Center, D-67114 Limburgerhof, Germany, ²Nippon Soda Co. Ltd., Chiyoda-ku, Tokyo 180, Japan

BAS 620 H is a new cyclohexenone herbicide of Nisso BASF Agro Ltd. containing the new active ingredient tepraloxydim (= proposed ISO common name). BAS 620 H is developed for broad spectrum post-emergence grass weed control in broadleaf crops. BAS 620 H is an inhibitor of the acetyl-CoA carboxylase (ACCase), which is responsible for the formation of lipids required for cell growth. The broadleaf crop selectivity is based largely on the lack of activity of BAS 620 H on this target site. Extensive field research conducted world wide 1990 - 1998 confirmed the excellent selectivity of BAS 620 H in all major broadleaf crops and vegetables at herbicidal use rates. At a use rate of 50 - 75 g a.i./ha, BAS 620 H controls very good all economically important annual grasses (e.g. Avena fatua, Brachiaria plantaginea, Digitaria sanguinalis, Echinochloa crus-galli) as well as volunteer small grains. BAS 620 H, at 75 - 100 g a.i./ha, is particularly strong on *Poa annua* and volunteer corn. At 100 g a.i./ha, BAS 620 H controls perennial grasses such as Sorghum halepense and Agropyron repeats and supresses Cynodon dactylon. Investigations showed that some annual grass biotypes with metabolism based ACCase inhibitor resistance are still sensitive to BAS 620 H. The standard formulation of BAS 620 H is a 200 g/litre EC formulation for use with an additive (e. g. DASH HC[®], oil concentrate) in soybeans, cotton, canola, peas, beans, mustard and flax. An adjuvant builtin formulation is under development in Europe for use in winter oil seed rape, sugarbeet, potatoes, cole and pulse crops. BAS 620 H has a favorable environmental and toxicological profile. First registrations of BAS 620 H (Tradename: ARAMO®) were granted in 1999 with the worldwide market introduction planned from 2000 onwards.

Key words: weed spectrum; does rate; crop spectrum; acetyl-CoA carboxylase inhibitor; sensitivity;

[1351] BAS 620 II - A NEW GRAMINICIDE FOR POST-EMERGENCE GRASS CONTROL IN BROADLEAF CROPS

E. Kibler', M. Landes', & H. Hosaka¹, 'Nippon Soda Co, Ltd., Chiyoda-ku, Tokyo 180, ² Japan; BASF Agricultural Center, D-67114 Limburgerhof, Germany.

BAS 620 H is a new cyclohexenone herbicide of Nisso BASF Agro Ltd. containing the new active ingredient tepraloxydim (= proposed ISO common name). BAS 620 H is developed for broad spectrum post-emergence grass weed control in broadleaf crops. BAS 620 H is an inhibitor of the acetyl-CoA carboxylase (ACCase), which is responsible for the formation of lipids required for cell growth. The broadleaf crop selectivity is based largely on the lack of activity of BAS 620 H on this target site. Worldwide extensive field earch conducted world wide 1990 - 1998 confirmed the excellent selectivity of BAS 620 H in all major broadleaf crops and vegetables at herbicidal use rates. At a use rate of 520 - 75 g a.i./ha, BAS 620 H controls very good all economically important annual grasses (e.g. Avena fatua, Brachiaria plantaginea, Digitaria sanguinalis, Echinochloa crus-galli) as well as volunteer small grains. BAS 620 H, at 75 - 100 g a.i./ha, is particularly strong on Poa annua and volunteer corn. At 100 g a.i./ha, BAS 620 H controls perennial grasses such as Sorghum halepense and Agropyron repens and supresses Cynodon dactylon. Investigations showed that some annual grass biotypes with metabolism based ACCase inhibitor resistance are still sensitive to BAS 620 H. The standard formulation of BAS 620 H is a 200 g/litre EC formulation for use with an additive (e. g. DASH HC[®], oil concentrate) in soybeans, cotton, canola, peas, beans, mustard and flax. An adjuvant builtin formulation is under development in Europe for use in winter oil seed rape, sugarbeet, potatoes, cole and pulse crops. BAS 620 H has a favorable environmental and toxicological profile. First registrations of BAS 620 H (Tradename: ARAMO[®]) were granted in 1999 with the worldwide market introduction planned from 2000 onwards.

Key words: grass control; BAS 620 H; post-emergence; weed spectrum; does rate; crop spectrum

[1352] CAN CAFFEINE BE USED AS AN AUXILIARY AGENT IN THE CONTROL OF AEDES AEGYPTI ?

A. T. Laranja & H. E. M. C. Bicudo. IBILCE/UNESP. Rua: Cristóvão Colombo, 2265-CEP: 15054-000 - São José do Rio Preto - SP - Brasil.

After being eradicated for a long time Aedes aegypti reinvaded Brazil in the last 15 years giving rise to a great deal of concern. The reason is that this mosquito is an important vector of dengue and yellow fever and has shown devastating effects in many places of de world. Public Health Service (SUCEN = Superintendência de Controle de Endemias do Estado de São Paulo) is doing campaigns and is trying to maintain mosquito population size within acceptable levels using insecticides that are sprayed in the streets of towns for killing adult mosquitoes. Larval and pupal stages are controlled by using grain shaped organophosphorous insecticides. The consequences for life and environment of using insecticides are well known from data in literature. Thus, the finding of alternative control agents would be very interesting. Data obtained in Drosophila studies performed in our laboratory showed that caffeine decreases fertility and longevity of flies, and increases development time. Such results suggested the present study in which different concentrations of caffeine were used for raising Aedes aegypti from eggs to adult stage. Treatments with 1,000 µg/mL and 2,000 µg/mL of caffeine and 0.025 g/mL (a tea spoon) of used ground coffee in water showed 85% of first stage larvae yielded in the control (only water), 88% in 1,000 µg/mL caffeine, 21% in 2,000 µg/mL caffeine and 52% in the form and 6% of the total number of eggs that were used in these experiments, respectively). We also observed a delay on developmental time in both caffeine concentrations and also in the ground coffee containing medium. Decreasing the caffeine concentrations to 200 μ g/mL and 500 μ g/mL, some adults were obtained in the first but not in the second treatment. Mortality larva-adult, developmental time and longevity are being analyzed in detail. As previously found for *Drosophila*, the effects of caffeine on these characteristics are dose dependent. (CAPES)

Index terms: diseases vector, alternative control, drug toxicity

[1353] MATRICAP®: NOVEL SYSTEMS FOR CONTROLLED DELIVERY OF PESTICIDES IN AQUATIC OR TERRESTRIAL HABITATS

R. Levy, M.A. Nichols & W.R. Opp LCMCD Technology Development Center, P.O. Box 60005, Fort Myers, FL 33906, USA, E-mail levy@lcmcd.org

Matricap@ controlled-delivery systems are based on the use of patented coating or coating complex formulations composed of one or more fatty acids, fatty alcohols or fatty acid esters, with or without one or more polymer binders and adjuvants to regulate the release rate and release profile of bioactive agents from solid carrier matrices (U.S. and overseas patents pending). Selection of a coating or coating complex is dependent on the type of aquatic or terrestrial habitat, the physicochemical characteristics of the bioactive agent, and the surface or subsurface orientation of the target pest. Specific gravity, solubility, hydrolysis, and biodegradation interactions of the coating(s), carrier, and bioactive agent(s) in an admixture are utilized to design specific Matricap@ compositions for aquatic or terrestrial pest-management applications. If the formulation components are properly matched, a Matricap® composition can deliver a bioactive agent to specific surface and/or subsurface areas of an aquatic or terrestrial habitat to target the orientation and/or feeding patterns of pest populations for prolonged periods. Matricap@ powdered, granular, or agglomerated matrices composed of materials such as silica, cellulose, clay, corn cob, sand, PVA or MHPC were initially designed for controlled delivery of insect corn cob, sand, PVA or MHPC were initially designed for controlled adivery of insect growth regulators (e.g., methoprene or pyriproxyfen), biolarvicides (e.g., Bacillus *huringiensis* var. israelensis or Bacillus sphaericus) or central nervous system inhibitors (e.g., temephos, chlorpyrifos, or phenyl-pyrazole). Matricap@ compositions were initially evaluated against mosquitoes and coekroaches. Controlled delivery of bioactive agents used to control mosquito larvae in surface (Anopheles spp.) or subsurface (Aedes or Culex com) argue column surface the phenomena of the tune and/or concentration spp.) areas of a water column were shown to be functions of the type and/or concentration of coating agents incorporated into a Matricap® composition. For example, slight variations in the ratio of fatty acid ester coatings in a coating complex were observed to significantly increase or decrease the duration of delivery from a solid matrix as well as alter the controlled-release profile and positional distribution of a bioactive agent in an aquatic habitat. The rate and duration of controlled delivery of bioactive agents used to control German cockroaches were dependent on the type and concentration of fatty acid ester(s) and polymers (e.g., PVA and/or MHPC) utilized to fabricate coated, extruded, or continuous film bait stations

Index terms: coatings, targeted release, insecticides, mosquitoes, cockroaches

[1354] TIMING INSECTICIDE APPLICATIONS FOR DUSKY SAP BEETLE (COLEOPTERA: NITIDULIDAE) CONTROL IN BT SWEET CORN

J. J. Linduska¹, G. P. Dively¹, M. Ross¹, M. Embrey¹, and T. Patton¹, 'LESREC, 27664 Nanticoke Rd., Salisbury, MD 21801-8437, USA, e-mail jl43@umail.umd.edu; 2Dept. of Entomology, Plant Sciences Bldg., Univ. of MD, College Park, MD 20742-4452, USA; WREC, P. O. Box 169, Queenstown, MD 21658-0169, USA.

CrylA(b) protein-expressing Attribute sweet corn developed by Novartis Seeds provides exceptional control of ear-invading lepidopteran pests. However, in the mid-Atlantic area, the dusky sap beetle, Carpophilus lugubris Murr., is a secondary pest of sweet corn and is not affected by CrylA(b) expression. Consequently, insecticide applications targeted specifically for sap beetles are necessary to meet ear quality standards for both fresh market and processing. The objective of this study was to determine the optimum timing and number of insecticide applications required to control sap beetles in Attribute sweet corn grown for processing. All experiments were conducted over 3-years in late plantings of Attribute GH-0937 sweet corn (hybrid 'Bonus') using different timings of lambdacyhalothrin (Warrior® 1CS) for control of sap beetle. Spray schedules were initiated at various plant growth stages varying from late tassel up thru the brown silk stage. The number of insecticide applications also varied from 1-4 treatments. The results of these trials showed that insecticide treatments initiated at the early silk stage (50% fresh silk) provided the best control of sap beetle and repeated applications (two applications) spread 4 days apart were generally more effective than a single application. Schedules involving greater than two treatments did not consistently result in increased control efficacy. Control efficacy was dependent on the infestation level which can vary greatly between fields and also on the method of insecticide application.

Index terms: Bt sweet corn, Carpophilus lugubris Murr, pesticide timing, pesticide efficacy

113561 AGRONOMIC EFFICIENCY OF NEW MOLECULES FOR CONTROL OF THE FIELD BEAN WHITE FLY

M. B. Lucas', D. R. Batista', C. A. Silveira' & B. V. Lucas', ' Instituto de Ciências Agrárias da Universidade Federal de Uberlândia - UFU, Av. Pará, 1720, CEP: 38.400-902 - Umuarama, Phone/Fax: (0xx34) 212-5566, E-mail carmeng@umuarama.ufu.br. ² Bayer S. A., Phone: (0xx11) 5694-5277. ³ Escola de Educação Básica da Universidade Federal de Uberlândia-MG, ESEBA-UFU, Phone: (0xx34) 218-2903.

The recognition by the scientific community that the complex Bemisia sp. (Biotypes A and B) has been one of the major crop pests of this century and also that presently there is no unique, efficient and universal method for its control, justified the assembling and conduction of this experiment which objective was to evaluate the agronomic efficiency of new insecticides on controlling this insect. The trial was conducted in the location of Uberlândia, MG, Brazil, during March and April 1999, using the cultivar "Perola" ("carioca" type) under irrigation (a self-propelled sprinkler system). The experimental design used was a randomized complete-block, with 7 treatments in four replications, with plots of 12.25 cm². Means were compared with Tukey's test at 5% probability level and agronomic efficiency was calculated by the formula used by Abbott. One day after seed treatment with the fungicide Euparen M 500PM, the following insecticide treatments were applied to seed: imidacloprid (Gaucho 700 PM – 0.2kg/100 kg seed) in some of the treatments, while the insecticides initial/oprin (Provado 2005C - 100g a.i./ha), thiacloprid (Calypso 480SC - 96g a.i./ha) betacyflutrin (Turbo 50CE - 5g a.i./ha) - 100g and methamidofos (Tamaron BR - 480g a.i./ha), were applied in a curative basis in four sprays per week using a manual pump sprayer with average flow rate of 4001 of solution per hectare. In the conditions in which this experiment was conducted, regardless the method of application, it was concluded that the insecticides imidacloprid (Provado 200 SC), metamidophos (Tamarom BR) and thiacloprid (Calypso 480 SC) added after seed treatment with imidacloprid (Gaucho 700 PM), confer excellent (>90%) efficiency for the control of the white fly biotype B (*Bernsia argentifolli*) on field bear crop. Seed treatment obly with imidacloprid (Gaucho 700PM) it is not effective. Independently of seed treatment with imidacloprid (Gaucho 700PM), betacyflutrin (Turbo 50CE) and thiacloprid (Calypso 480SC) both confer a good (80 - 90%) agronomic efficiency for the control of the fly. Regardless of method of application and for the doses tested, it was not evident any problems of phytotoxicity of the products.

Index terms; Bemisia argentifolli, vector, viruses, insecticides.

[1355] MOLECULAR BASIS OF INSECTICIDE RESISTANCE IN THE HOUSE **OFLY**. Musca domestica

N. Liu., Dept. of Entomology and Plant Pathology, Auburn University, 301 Funchess Hall, Auburn, AL 36849-5413, USA, E-mail nliu@acesag.auburn.edu.

A house fly strain, ALHF, was collected from a poultry farm in north Alabama, USA, with an initial 260-fold level of resistance to permethrin compared to a susceptible strain, aabys. After 5-generation selection with permethrin in the laboratory, resistance level was increased to 1,800-fold. We have found that ALHF has a great ability to develop resistance and cross-resistance to different insecticides. The possible genes involved in resistance in ALHF have been investigated by differential display. As a result, whereas most cDNA bands were equally detected from both ALHF and aabys strains, some were unique to samples from the ALHF strain. Five genes that specifically expressed in ALHF strain have been identified. One of them is consecutively expressed and others are induced by the treatment with permethrin. The possible roles of the genes in resistance in ALHF will be discussed.

Index terms: Musca domestica, insecticide resistance, differential display

[1357] AGRONOMIC EFFICIENCY OF THE INSECTICIDE THIAMETHOXAN FOR CONTROL OF THE PINEAPPLE MEALYBUG AND THE TERMITE

M. B. Lucas', D. R. Batista', J. S. Aizawa' & B. V. Lucas', 'Instituto de Ciências Agrárias da Universidade Federal de Uberlândia - UFU, Av. Pará, 1720, CEP: 38,400-902 - Umuarama, Fone/Fax: (0xx34) 212-5566, E-mail carmeng@umuarama.ufu.br. 'Novartis Biociências S. A., 'Escola de Educação Básica da Universidade Federal de Uberlândia, MG, ESEBA-UFU, Fone: (0xx34) 218-2903.

The pineapple constitutes a fruit of great internal commercial acceptance and importance for export purposes, and it has already its place in Brazilian economy, demanding a special sort of cultivation, in order to be economically viable. Apart from the cultivar used and considering it as a tropical culture, the presence of the termite *Procomiterms striatus* and the mealybug Dysmicoccus brevipes, have been the two major plagues seriously affecting the production, thus justifying this research. The experiment was conducted in the location of Capinópolis M.G. Brazil, using the cultivar *Smooth cayenne* 180 days after planting. The experimental design used was a randomized complete-block with six treatments in four replications. Each experimental block was comprised of two double lines with 100 plants in each plot, where the plants were pre-evaluated and later on, effective evaluations were made after 30, 60, 90 and 120 days after treatment. For this purpose, five plants were randomly taken per plot. The insecticide thiamethoxan (Actara Biodae 1% Gr - 100, 150 and 200 gr. a.i./h.a) was applied in two rows along the crop, while the insecticides thiamethoxan (Actara 25WG - 15g a.i./ha) and methyl parathion (Folidol 600 - 600ga.i./ha) were sprayed in the base of the plants. Under the conditions tested, using the Tukey's procedure at 5% probability level to compare means and the biologic efficiency calculate by Henderson & Tilton's formula, it was concluded that the insecticide thiamethoxan, regardless of the method of application, concentration, formulation and doses tested, did not present any evidence of phytotoxicity and also conferred an agronomy efficiency up to 90 days after application, with biologic results superior to the minimum demanded (70%) for soil plagues. It was also found that the granulated formulation presented a higher performance when comparing to the WG formulation at 150g a.i./ha was more economical and conferred agronomic results superior to the insecticide methyl parathion (Folidol 600) up to 120 days after application. Index terms: Dysmicoccus brevipes, Procorniterms striatus, Smooth cayenne,

thiamethoxan.

[1358] AGRONOMIC EFFICIENCY OF NEW MITICIDES FOR CONTROL OF THE COFFEE LEPROSIS

M. B. Lucas¹, F.F.M. Marra¹, A. C. Rezende¹ & R. V. Lucas², ¹ Instituto de Ciências Agrárias da Universidade Federal de Uberlândia - UFU, Av. Pará, 1720, CEP: 38.400-902 - Umuarama, Phone/Fax: (0xx34) 212-5566, E-mail carmeng@umuarama.ufu.br. ² Escola de Educação Básica da Universidade Federal de Uberlândia-MG, ESEBA-UFU, Phone: (0xx34) 218-2903.

The mite Brevipalpus phoenicis (Geijskes, 1939) (Acari: Tenuipalpidae) is a polyphagous pest and is associated to the ring spot disease or coffee leprosis. The increasingly incidence of this disease in the regions of the "Triângulo Mineiro" and "Alto Paranaíba" in the State of Minas Gerais, has already seriously threatened yields of coffee crops in 1995 and 1996 and therefore it is focus of great concern by producers in such regions, justifying the need of new research efforts for the control of the disease. This experiment was conducted with the objective of evaluating the biologic or agronomic efficiency of new miticides for the control of this pest, and it was located in the middle of a coffce plantation, in Uberlândia, MG. The cultivars "Mundo Novo" and "Catuaí-amarelo" were planted in alternated rows, under high plant density and irrigated by a drip system. The design used was a randomized complete-block with seven treatments and four replicates in which the plots were comprised by 80 plants. The Tukey procedure at 5% probability level was utilized to compare means and the biologic efficiency was calculated by the Henderson & Tilton formula. The miticides tested and their doses were: ketaenole (BAJ2740 - 240SC) - 48,60 and 72g. a.i./ha, azocyclotin (Peropal 500SC and Peropal 250PM) - 375g. a.i./ha; and dicofol + tetradifon (Carbax CE) - 400 + 150g. a.i./ha. They were applied twice, in a 60-day interval, with a motorized mist sprayer, allowing a flow rate of 1.2001 of solution per hectare. Under the conditions tested, it was concluded that the infestation levels on the treated plots were very low, conferring an excellent (>90%) agronomic efficiency of all products and doses tested for the control of the mite Brevipalpus phoenicis on leaves and branches of the coffee trees up to 60 days after the application. No visible signs of phytotoxicity were detected.

Index terms: leprosis, coffee, Brevipalpus phoenicis, miticides.

Symposium and Poster Session

[1360] TONIC EFFECT OF THIAMETHOXAN ON GROWTH OF DRY BEAN PLANT

D. S. Martins¹ & M. J. Fornazier¹, 'EMCAPER- Empresa Capixaba de Pesquisa, Assistência Técnica e Extensão Rural-Rua Afonso Sarlo, 160, Bento Ferreira, Vitória/ES, CEP 29052-010, Brazil, E-mail davidmartins@emcaper.com.br.

Dry bean (Phaseokus vulgaris L.) plants in early stages are damaged by some pests that cause direct and indirect very important losses as reduction of the stand and vectors of viruses. Some insecticides, in determined doses, can cause phytotoxic or tonic effects on plants when used on the control of the pests. A randomized complet block design experiment with 7 treatments and 4 replications was carried out during the rain season on the highland Region of Espírito Santo State to evaluate the possible effects of three doses of insecticide thiamethoxan (group neonicotinoid) two formulations under two aplication methods, soil spout and seed treatment, on the growth of dry bean plants cv. Xamego (black bean). Experimental plots had 6 rows of 3,0m apart and 0,5m into row, with 12 seeds/m. Thiamethoxan treatments were: Actara 250 WG at 100; 125 and 150g a.i./ha, spouled in the soil on botton the plants 3 days after seeds germination, and irrigated immediately; Cruiser 700 WS at 70, 140 and 240g a.i./100kg seeds as seed treatment; and untreated control. At 10, 17, 24 and 38 days after germination were evaluated: number of leaves, plant height, fresh and dry weight of vegetative part (leaves and stems) and roots, number of Rhizobium nodules and number of pods of 5 plants harvested by plot. The experiment was irrigated and sprayed with methamidophos insecticide and tebuconozole fungicide to uniformize and avoid pests and diseases interference at the experimental area. There were no significant differences to the number of *Rhizobium* nodules and number of pods (P+0.05). Plants treated with the two thiamethoxan formulations had greater in fresh pous (1903), realist dealed with the two infanctional tormonators had greater in fresh and dry weight, comparatively to the untreated plants, showing an tonic effect caused by the thiamethoxan, that was more evident with Cruiser 700 WG formulation on the early stages of plant development. With the growth of plants, the difference of this effect, among the two formulations, was decreasing until to make equal. All doses of both formulations, in growth early stages, were superior values to the untreated plants too; the best plant development were observed on the highest doses. At floweing time was not observed significantly difference on treated and untreated plots.

Index terms: Phaseolus vulgaris, neonicotinoid insecticide, development

[1359] TIME-DEPENDENT VARIATIONS IN ESTERASE 9b FREQUENCY AND MALATHION-RESISTANCE OF THE DIAMONDBACK MOTH (PLUTELLA **XYLOSTELLA) IN TAIWAN**

Maa, Can-Jen William, Institute of Zoology, Academia Sinica, Taipei, Taiwan, 115, ROC.

EST 9b was recognized as an esterase allozyme associated with malathion resistance in the diamondback moth (DBM), *Plutella xylostella L.*. In 1987, Geou-Fang DBM population was significantly (P < 0.05) differentiated from other 14 local DBM populations in Taiwan based on EST 9b frequency. Meanwhile, Geou-Fang DBM was the most susceptible population found in Taiwan. Two years later Geou-Fang DBM was no longer being differentiated from other DBM populations based on the EST 9b frequency. In fact, EST 9b frequency of Geou-Fang DBM increased from 13% to 35% within the two years of 1987~1989; and no insecticide was applied in Geou-Fang area during that time period. A statistically significant (P < 0.02) linear regression was existed between the EST 9b frequency and malathion resistance of the 14 DBM populations, and this correlation lasted till 1991. Although the two regression lines of 1989 and 1991, respectively, showed different slopes, they shared the same interception point to the horizontal axis of EST 9b frequency. This phenomenon implicated that EST 9b frequency of Taiwan DBM might vary from year to year, and accordingly, resistance of DBM might also fluctuate from time to time. So the EST 9b frequency could be suggested as an indicator protein for monitoring malathion resistance in the DBM. However, by 1997 the regression line between EST 9b frequency and resistance of the DBM was neither statistically significant nor sharing the same interception point with that of 1991 and 1989. This might implicated some variations between the EST 9b frequency and the resistant mechanism from 1989 to 1997. In view of these consecutive accounts of the variation in EST 9b frequency and malathion resistance through the passed ten years, significance of the above mentioned events was discussed. The adaptive phenomenon of the DBM to the changing circumstance in Taiwan was also discussed.

Index terms: Plutella xylostella L., esterase 9b, malathion-resistance, variation, adaptation

[1361] EFFICIENCY OF SEEDS TREATMENTS WITH THIAMETHOXAM TO CONTROL BEMISIA ARGENTIFOLII ON COTTON CROP

J.C. Martins' & G. Nakamura², 'Fundação Faculdade de Agronomia "Luiz Meneghel", P.O. Box 261, Area Code 86360-000 – Bandeirantes – Paraná – Brazil, E-mail jeelso@ffalm.br; ³Novartis Diociências – São Paulo – São Paulo – Brazil.

Recently found on cotton crop, *Bemisia argentifolii* specie is the responsible of "sticky" beyond transmitton of virotical diseases. This present trial was conducted in Miguelópolis City – São Paulo State – during summer crop of 98/99. With the purpose to evaluate efficiency and agromical use of seeds treatments with thiamethoxam in order control nimphs and adults of B. argentifolii on cotton crop, Deitapine cultivar, it were evaluated following treatments, which doses are on g a.i.Jkg of seeds; thiamethoxam (Cruiser 700 WS – 140, 210 and 280); furathiocarb (Promet 400 CS – 800); imidaeloprid (Gaucho 700 WS - 210) and control (with no insecticide). The experimental design was randomized blocks with 6 treatments and 4 replications, using Tukey's test for medium comparing and Abbott's formula to obtain efficiency percentage. On seeds treatments, done in plastic bags, it were added 5 ml of water per seeds kilogramme. At evaluations, done at 18 d.a.e. for adults, it was used a pitfall "witch-hat" type, counting catched adults on 15 randomized plants/plot, and at 28 d.a.e. for nymphs collected on 15 randomized plants/plot, taken one planespiot, and a zo date for hydrons corected on 15 function plants plot, taken one leaf at inferior third. Leaves were removed to laboratory and with a esteroscopic microscopic with 15 times of magnifications, it were counted alive nymphs number. Insecticide thiamethoxam, at doses 210 and 280 g a.i./100 kg of seeds was the most efficient on *B. argentifolii* control, with more than 85%, for nymphs and adults. Index terms: Bemisia argentifolii, chemical insecticide, cotton.

[1362] SELECTIVITY OF GROWTH REGULATORS, PHOSPHORATES AND PYRETROIDS UPON NATURAL ENEMIES OF PESTS ON SOYBEAN CROP

LC. Martins⁴, E. Nascimento³ & L.F. Weber³, ¹Fundação Faculdade de Agronomia "Luiz Meneghel", P.O. Box 261, Area Code 86360-000 – Bandeirantes – Paraná State – Brazil (FFALM), E-mail jcelso@ffalm.br; ²Agronomy Student at FFALM. ³Bayer S/A – Londrina City –Paraná State – Brazil.

With the purpose to reduce the effects of insecticides use, it is necessary to find methods for pests control that causes no damage on ambience and insecticide selectivity to preserve natural enemies. This trial was conducted in Bandeirantes City - Paraná State, during summer crop of 98/99. With the purpose to evaluate selectivity and agronomical uses of the insecticides: betacyfluthrin, triflumuron, chlorpyrifos and prophephos upon pest predators on soybean crop, BR-4 cultivar, it were evaluated following treatments, which doses are on g a.i./ha: betacyfluthrin (Turbo 50 CE - 2,5); triflumuron (Alystin 480 SC -14,4), chlorpyrifos (Astro 450 E - 112,5); betacyfluthrin (Bulldock 125 SC - 2,5); prophenophos (Curacron 500 -80) and control (with no insecticide). Used experimental design was randomized blocks with 6 treatments and 4 replications. It were used Tukey's tests for medium comparing and Abbott's formula to obtain efficiency percentage. For to insecticides applications, when plants were on stagium $R_{s,i}$ it was used a sprayer with constant pression equiped with $D_{s,i}$, nozzle, pression of 5,5 Bar and volume of 150 l/ha. At evaluations, on pre-applications and at 2, 4 and 7 d.a.a. it was used cloth method, with 4 randomized shakes/plot, doing identifications and remarks of alive predators number Insecticide betacyfluthrin 50 and chlorpyrifos, after shock effect, showed found. selectivity from 4 d.a.a. Although showing fluctuation on reduction percentage, triflumuron was selective at 7 d.a.a.

Index terms: selectivity, natural enemies, soybean, predators.

[1364] RESISTANCE IN NORWAY SPRUCE AGAINST THE GREEN SPRUCE APHID

F. Midtgaard, T. Skrøppa, G. Ogner A. Lønneborg. Norwegian Forest Research Institute, Dept. of Entomology, Høgskoleveien 12, N-1432 Ås, Norway.

Infestation experiments were performed in three clonal trials with Norway spruce planted Norway and Denmark. These trials belong to a joint Nordic series of clonal tests of 240 clones from 20 families planted at 9 sites in Norway, Sweden, Finland and Denmark in a randomised block design with 6 replicates in single 'ee plots at 2 m. spacing. Twenty-four clones were selected to be included in the green spruce aphid infestation experiment, 4 from each of 6 full-sib families, and from each clone 3 or 4 replicates. The families and clones were selected on the basis of earlier measurements in the experimental series. They represent all three categories of crosses, cover the range of variation in the timing of spring flushing and shoot growth cessation and had earlier shown different levels of attack after natural infestation of the spruce gall aphids in two experimental plantations. The mean tree height at the start of the experiment in the spring of 1997 were 162 cm, and in 1998 it was 209 cm. The mean tree height in Kaupanger spring 1998 was 157 cm. Samples for chemical analyses was taken in 1997, and for enzyme analyses in 1997 and 1998. Infestations were done in 1997 (2), in 1998 (2), and in 1999 (3). The results show a good fit between biochemical and enzyme results and genetics, but there is a great random variation in the aphid population development data. In spite of this , significant variation is present among families. One family has in particular high number of aphids, and another consistently low number of aphids. Interactions seem to be present between families and sites/years. The results indicate that there are genetic differences in survival of aphids on families of Norway spruce. These differences may to some extent depend on the site conditions.

Index terms: Elatobium abietinum, clones, host resistance

[1363] DIFFERENT FORMULATIONS OF THIAMETHOXAM USED TO CONTROL LARVAE AND ADULTS OF *DIABROTICA SPECIOSA* ON SMALL POTATO CROP

<u>I.C. Martins</u>¹, G. Nakamura¹, ¹Fundação Faculdade de Agronomia "Luiz Meneghel", P.O. Box 261, Area Code 86360-000 – Bandeirantes – Paraná – Brazil, E-mail jcelso@ffalm.br; ²Novartis Biociências – São Paulo – São Paulo – Brazil.

Among different insect-pests on small potato crop there are some coleopterous and one of them, *Diabrotica speciosa* (Coleoptera-Chrysomelidae) has the main economic significance. This trial was conducted in Guarapuava City-PR, during summer crop 98/99. Treatments on g a.i./ha, with thiamethoxam (Actara 25 WG – 150 and 200); thiamethoxam (Actara 10 G – 150 and 200); phorate and aldicarb (Granutox 5 G – 2000 and Temik 15 G – 2025); thiamethoxam (Actara 25 WG – 150 and Actara 10 G – 150 and Actara 25 WG – 150 and Actara 10 G – 150 and Actara 25 WG – 150 and Actara 10 G – 150 and Actara 25 WG – 200) and control (with no insecticide) were applied on different periods of plants development, with the purpose to evaluate efficiency and agronomical use to control larvae and adults of *D. speciosa* on small potato crop, Monalisa cultivar. Experimental-design was randomized blocks with 6 treatments and 4 replications using Tukey's test for medium comparing and Abbott's formula to obtain efficiency percentage. In order to apply liquid insecticides on treatments 1, 4 and 5, done at planting furrow and at plants before heaping, it was used a back manual sprayed with constant pression of 4,1 Bar, nozzle 11002, and 200 l/ha of volume. Granulated insecticides were handly applied on treatments 2, 3, 4 and 5, on planting furrow and asplied on treatments 2, 5, 4 and 5, one at platutions were done at 15 and 20 d.a.e. for adults, using 50 randomized leaves per plot and counting of found perforation. Just combination of thiamethoxan 10 G – 150 g a.i./ha applied on planting furrow with thiamethoxan 25 WG – 200 g a.i./ha applied before heaping did no reach 80% of efficiency.

Index terms: Diabrotica speciosa, chemical insecticide, small potato.

[1365] INSECTICIDE PROPERTIES OF ETHANOLIC EXTRACT ISOLATED FROM SEEDS OF PIPER TUBERCULATUM SEEDS (PIPERACEAE) ON DIATRAEA SACCHARALIS (LEPIDOPTERA: PYRALI DAE)

J. E. Miranda¹, A. T. Murata², H. M. D. Navickiene³, M. J. Kato⁴, V. S. Bolzani³, G. E. D. Paredes⁵, M. Furlan³ & S. A. De Bortoli¹, ¹Dept. de Fitossanidade, Unv. Estadual Paulista, 14884-900, Jaboticabal, SP, Brasil (Bolsista Fapesp), E-mail: miranda@fcav.unesp.br; ²Dept. de Biologia, Fac. Filosofia, Ciências e Letras de Ribeirão Preto, Univ. de São Paulo, Av. dos Bandeirantes, 3900, 14040-901, Ribeirão Preto, SP, Brasil (Bolsista Fapesp), ; ³Dept. Química Orgânica, Instituto de Química, Unesp, Araraquara, SP, Brasil; ⁴Dept. Química Fundamental, IQ, USP, SP, Brasil; ³FCB, Univ. Nacional Pedro Ruiz Gallo, Lambayeque, Peru.

Plants of the family Piperaceae, are broadly used in the pharmacology and alimentary industries. The genus of larger importance is *Piper*. Reports have been mentioned that some species of the genus Piper has been used as insecticide and molluscide. The leaves of *Piper tutokatsura*, originated from Taiwan and Japan are known as deterrents of feeding *Spodoptera litura*. The specie *Piper tuberculatum* Jacq. was collected at the Campus of INPA - Manaus, in July of 1998. The seed (24.33 g) were doubled extracted in CH2CI2: MeOH (2:1). The evaluations were made at 24, 36 and 48 hours after the application. The relationships answer-dose was compared by the analysis of Probit to determine the susceptibility rate, measured in mg i.a./insect. The test consisted of the topical application of the compounds on caterpillars of 3th instar. The concentrations tested were 100,000ppm 10,000ppm, 1,000ppm and 10 ppm. In relation to answer-dose obtained by the analysis of Probit, it can be observed that the value of DL50 was 9.57mg i.a./insect. It could be concluded that this extract presents insecticide potential. A trial of the substances of the seed extract of *P. tuberculatum* and, from de isolated substances, new susceptibility tests to found the active insecticide substance, are suggested.

Index terms: Diatraea saccharalis, susceptibility test, amide, insect control

[1366] RELATIVE TOXICITY OF INSECTICIDES TO COTTON LEAFIIOPPER POPULATIONS FROM VARIED ENVIRONMENTS

S.Mohankumar^{1,2} & M.S.Venugopal², ¹ CSES Dept., Virginia Tech, Blacksburg, VA24061, USA, ²TamilNadu Agricultural University, Coimbatore-641003, INDIA, E-mail: smk65@hotmail.com

Cotton leafhopper, Amrasca devastans (Distant) occurs as a potential pest in major agroclimatalogical cotton tracts namely winter irrigated, summer irrigated, rice fallows and ranifed environments. Foliar application of several insecticides belonging to different chemical groups (monocrotophos, methyl-o-demeton, dimethoate, phosphamidon, endosulfan, quinalphos, synthetic pyrethroids, botanical insecticides) were observed to be effective against *A.devastans*. But during recent years, the cotton leafhopper population showed a progressive increase with less susceptibility to various insecticides and hence it has become a problem to cotton cultivation in Tamil Nadu. The heavy incidence of leafhopper along with reduced effectiveness of commonly used insecticides has become a serious problem. Hence, the present study aims to determine the variability in toxicity of different insecticides against *A.devastans* population collected from five agro-climatic regions of Tamil Nadu. Leafhoppers collected from different agroclimatic regions of Tamil Nadu (Coimbatore, Theni, Srivilliputhur, Koilpatti and Madurai) were conditioned through maintaining in susceptible variety (LRA 5166). The insecticides namely dimethoate, methyl-o-demeton, monocrotophos, endosulfam, quinalphos, neem oil, neem seed kernel extract were tested for their efficacy against different populations separately by standard spray residue method. The LC50 values were worked out and with the base line as LC50 value of most susceptible population, the resistance ratio was worked out. The results revealed that the leafhoppers collected from Theni were least susceptible to methyl-o-demeton, dimethoate, endosulfan, quinalphos, fenvalerate and neem seed Kernel extract where as Srivilliputhur for phosphamidon and Coimbatore for monocrotophos and neem o'l . In general, Madurai population was highly susceptible to all insecticides except phosphamidon and botanicals. Koilpatti, Srivilliputhur and Coimbatore populations were highly susceptible for phosphamidon and fenvalerate, neem and neem seed kernel extract respectively. This generation of base line data pave the way for stressing the need for detailed studies on resistance development in cotton leafhopper.

Index terms: Amrasca devastans, population variation, resistance development

[1367] PRO-ACTIVE MANAGEMENT OF BEET ARMYWORM (SPODOPTERA EXIGUA) RESISTANCE TO THE IGRS, TEBUFENOZIDE AND METHOXYFENOZIDE

J. K. Moulton, D. A. Pepper, & T. J. Dennehy, Dept. of Entomology, Extension Arthropod Resistance Management Laboratory, 1140 E. South Campus Dr., Univ. of Arizona, Tucson, AZ 85721, USA, E-mail: kmoulton@ag.arizona.edu.

Susceptibility to tebufenozide and methoxyfenozide of beet armyworm (Spodoptera exigua) from the southern United States and Thailand was determined through exposure of first and third instar larvae to dipped cotton leaves. LC_{s_0} estimates of first instar larvae ranged from 0.377 to 32.7 micrograms of tebufenozide per milliliter and 0.034 to 11.5 micrograms of methoxyfenozide per milliliter. LC_{s_0} estimates of third instar larvae ranged from 4.37 to 715 micrograms of tebufenozide per milliliter and 0.393 to 47.4 micrograms of methoxyfenozide per milliliter. First and third instar larvae of a Thailand strain selected with these compounds were up to 87- and 164-fold less susceptible to tebufenozide and 338- and 121-fold less susceptible to methoxyfenozide, relative to the most susceptible of the strains evaluated. Among the United States field populations evaluated, a collection from Belle Glade, Florida, was the most susceptible and one taken near Parker, Arizona, was the least susceptible to bth IGRs. Selection of the Thailand population with tebufenozide or methoxyfenozide synergized tebufenozide and methoxyfenozide to approximately the same degree in a methoxyfenozide-selected Thailand strain. These results indicate a common mechanism of resistance. Crossing experiments between the methoxyfenozide-selected Thailand strain indicated multigenic and incompletely dominant inheritance. These findings and further isolation and characterization of resistance to tebufenozide and methoxyfenozide will provide helpful information for pro-active management of resistance to this valuable group of insecticides in the United States.

Index terms: Spodoptera exigua, tebufenozide, methoxyfenozide, resistance

Symposium and Poster Session

[1368] INSECTS ENEMIES OF THE BLACK SCALE, SAISSETIA OLEAE (BERNAD) ON OLIVE IN ARGENTINA

<u>G. Murúa</u> & P. Fidalgo, Instituto Superior de Entomología (INSUE) - Fundación Miguel Lillo, Miguel Lillo № 205, San Miguel of Tucumán, CP(4000), Tucumán -Argentina. E-mail: gmurua@yahoo.com.

Saissetia oleae is a poliphagous species widely distributed over the tropical and subtropical regions of the world and is a serious pest in citrus and olive trees. In Mendoza and San Juan provinces (Argentina) it is the most important pest together with Pollinia pollinii, while in La Rioja and Catamarca it is found with Parlatoria oleae. The parasitoids Metaphycus helvolus, M. Lounsburyi and Coccophagus caridei, were introduced in Mendoza in 1969 from Chile for it control. These species were recovered in very small percentages, and their establishment and were not evaluated. According to the bibliography, five species of parasitoids of S. oleae were registered in Argentina, but a study of the enemies of the pest was never carried out in olive. Collections of insects enemies of black scale on olive groves at La Rioja were carried out during January and October of 1999 and February of 2000. The materials colleted were observed in the laboratory and the insets obtained were identified and deposited as "vouceher specimenes" at the FML's collections. Four species of parasitoids and two species of predators were registered. The parasitods were: Lecaniobius utilis, Coccophagus caridei, Metaphycus stanleyi and Brasema sp.. The last two species were not found previously in Argentina. The predators obtained were the coccinellid Azya bioculata and Chrysopidae sp.. The parasites associated with black scale is not enaugh able to prevent the pest status attained in Argentina by S. oleae. The introduction of additional enemies is therefore highly recommended. In the world the encyrtid Diversinervus elegans (Silvestri) is the most important and efficient parasitoid in the control of S. oleae, but is not present in Argentina. The introduction of this species would be very important to obtain a complete biological control of this pest in olive.

Index word: natural enemies, Saissetia oleae, olive, Diversinervus elegans.

[1369] INSECTICIDES FOR PSEUDALETIA SEQUAX CONTROL IN WHEAT TRITICUM AESTIVUM.

Pedro Neves'; M.U. Ventura' & A. Pasini'. 'Depto. Agronomia, Univ. de Londrina, C.P. 6001, Londrina, PR 86051-970, Brazil. E-mail pmojneve@uel.br

The worm *Pseudaletia sequax* is an important pest in wheat in Brazil. This worm eats the leaves and the spikes of the plants. Damages to production can be bigger than 30%. This experiment was carried out to evaluate *P. sequax* control efficiency of some insecticides. Cultivar Igapó was used. Plots size were (6 m X 4.5 m) 27.00 m⁴ (4 replications). The experiment, in blocks, was carried out at Fischer farm in Rolândia-PR Brazil. Spraying volume was 190 l/ha. The treatments were: lambdacyalothrin (Karate 50CS Zeon) 5 g. a.i./ha, lambdacyalothrin (Karate 50CE) 5 g a.i. /ha, permetrim (Ambush 500 CE) 25 g a.i. /ha, the standard metamidophos (Tamaron BR) 180 g. a.i. /ha and a control (only water). The assessment were made 3 and 7 days after spraying by counting the worm number in the soil under the plants during 6 minutes. In all assessment treatments differed statistically from the control with efficiency levels greater than 80% (Abbott) except for Tamaron BR. For this treatment the efficiency was 59 and 27% respectively for the 3 and 7 days after spraying. Index terms: lambdacyalothrin, permetrin, chemical control.
[1370] BUTTERFLY DIVERSITY IN SERRA DO CIPÓ, BRAZIL: A PRELIMINARY SURVEY

<u>E. G. Oliveira</u>¹ & G. W. Fernandes¹, ¹Departamento de Biologia Geral, Instituto de Ciências Biológicas, Universidade Federal de Minas Gerais, 30161-970, Belo Horizonte, MG, Brazil, E-mail evandro@mono.icb.ufmg.br.

Serra do Cipó is located in the southernmost portion of the Espinhaço Mountains, a high altitude mountain range in southeastern Brazil. It harbors one of the most diverse ecosystems in the world with high degree of floral endemism and morphological convergence. Low soil fertility, prolonged dry season, strong winds, and other harsh environmental conditions, which strongly influence its flora and fauna, characterize the region. In this scenario, we would expect to find a relatively poor butterfly fauna. On the other hand, due to its speciose flora and because the region has never been properly surveyed, we would also expect to find rare and new species. In an attempt to address these questions, for the first time we have sampled the butterflies in the region by (i) direct netting and (ii) trapping using rotting fruits as bait. We have also recorded migration (i.e., unidirectional flight) events, which had not been previously studied in the region. During the first three months of this study, we have collected butterflies belonging to all common families, and the preliminary list of species suggests that its diversity may be higher than previously postulated. Migration of Pieridae was observed in several occasions indicating that this is a common phenomenon in the region.

Index terms: Lepidoptera, species composition, mountain habitat, migration

[1372] INTERCROPPING SYSTEM AND THIAMETHOXAM SPRAYING FOR EMPOASCA KRAEMERI (HEMIPTERA: CICADELLIDAE) CONTROL IN COWPEA

J.V. Oliveira, M.S. Braga¹, M.P.L. Lima¹ & P.R. Machado¹, ¹Fitossanidade, Univ. Fed. Rural de Pernambuco, Av. Dom Manoel de Medeiros s/n, Dois Irmãos 52171-900 Recife, PE. E-mail: jolivei@elogica.com.br

The effect of intercropping system cowpea-corn with and without application of inseciticide for *Empoasca kraemeri* control was studied. The experiment was set up at Experimental Station of Empresa Pernambucana de Pesquisa Agropecuária, in Vitória de Santo Antão County, State of Pernambuco, Brazil in a randomized complete block with four treatments and five replicates. Each plot was consisted of 30 m² with plants spaced 0.5 m within row and 1.0 m between row with cowpea cultivar Sempre Verde and corn cultivar BR-476 planted in monoculture or in intercropping. For intercropping plots was used three lines of cowpea was surrounded by two corn lines. The insecticide thiamethoxam at rate of 37.5 a.i./ha and deltamethrin at rate of 12.5 a.i./ha were sprayed 20, 35 and 50 days after seeding. Nymphs of *E. kraemeri* were sampled on 36 trifoliate leaves before each spraying. Nymphs of 20 days after seeding lower *E. kraemeri* nymphs population was observed in cowpea treated plots and cultivated either in nonoculture or in intercropping. Likewise, in intercropping treated system was 98.5 and 98.4% lower than in untreated plots. Likewise, in intercropping treated system reduction of *E. kraemeri* was 98.4 and 99.3% in relation to untreated plots Independent of cropping system thiamethoxam reduced significantly *E. kraemeri* population. In addition, larvae, pupae and adults of ladybird predator *Cycloneda sanguinea* (Coleoptera: Coccinellidae) population was greater on untreated monoculture and intercropping plots accounting to 51.4 and 38.2, respectively. This predators occurrence was verified on the black aphid. Aphis cracicivora (Homoptera: Aphidiae) population. In Addition, Index terms: Cultural control, leafhopper, insecticide, predator.

[1371] CONTROL OF BEAN LEAFHOPPER *EMPOASCA KRAEMERI* (HEMIPTERA: CICADELLIDAE) WITH THIAMETHOXAM ON COWPEA

<u>J. V. Oliveira</u>¹, M. P.L. Lima¹, M.E.C. Gonçalves¹, P. R. Machado¹ & M.A.A. Mattos¹, ¹Fitossanidade, Universidade Federal. Rural de Pernambuco, Av. Dom Manoel de Medeiros, s/n, Dois Irmãos 52171-900 Recife, PE.

This research was carried out at the Luiz Jorge da Gama Wanderley Experimental Station, Empresa Pernambucana de Pesquisa Agropecuária, in Vitória de Santo Antão, PE. The objective was to test the insecticide thiamethoxam for control of *Empoasca kraemeri* nymphs on cowpea by using seed treatment (Cruiser 700 WS - 150 g/kg of seeds), seed treatment + spraying (Actara 250 WG - 150 g c.p. /ha) e spraying in comparison to monocrotophos pattern spraying (Agrophos 400 - 1, 0 1 c.p. /ha), and control. Seeds of the cowpea cultivar Sempre Verde were sowed in a 1,0x0,5m spacing and the plants irrigated through sprinkling. The plot area was 30m² and composed by five rows with the lateral ones used as borders. A randomized design was adopted with five treatments and our replications. The insecticide sprayings was made with a 20 liter costal sprayer and took place at 24, 46, and 60 days after sowing. Before each spraying, samples of *E. kraemeri* nymphs were observed under the leaf bottom side of 42 trifoliate leaves per plot. At 24 and 46 days after sowing it was observed a black aphid, *Aphis craccivora*, infestation followed by a larval, pupal and, adult incidence of the ladybird, *Cycloneda sanguinea* (Colcoptera: Coccinellidae). The results were analyzed statistically and the means compared by Tukey test (P < 0,05). The insecticide efficiency was measured with nymphal counting data available at 46 and 60 days by using Abbott's formula. The following efficiency percentages were obtained: 44.4 and 26.2% for thiamethoxam by using seed treatment; 94.4 and 97.2% for seed treatment + spraying; 64.8 and 100% for thiamethoxam spraying and 61.1, and 93.1% for monocrotophos spraying at 46 and 60 days after sowing, respectively.

Index terms: Insecta, Homoptera, chemical control, Vigna unguiculata.

[1373] SAFETY OF TWO TRACTOR CABINS IN APPLICATION OF INSECTICIDE AND ACARICIDE BY TRACTOR-TRAILED AIR-CARRIED SPRAYER IN CITRUS (Citrus sinensis)

M. L. Oliveira¹ & J. G. Machado Neto¹, ¹Dept. de Fitossanidade, FCAV/UNESP – Câmpus de Jaboticabal, 14.870-000, Jaboticabal, SP, Brazil. E-mail oliveiraml@hotmail.com; joaquim@fcav.unesp.br.

Pesticides applications in citrus by tractor-trailed air-carried sprayer provide low spray retention in plants and high environmental contamination and occupational risk. Safety of tractor driver in these applications can be achieved by the use of tractor cabins. In present work safety was evaluated calculating the margin of safety (MOS) from data of NOEL of pesticides and occupational exposure in a 6 hours work day. Working conditions of tractor driver (DE) was evaluated using or not two types of cabins (Real and Agroleite) spraying with Arbus 2000 Valência tractor-trailed air-carried sprayer in orchard of the Cambuhy Agrícola Farm, Matão-SP, Brazil in november/99. Cu⁻² of a cupric fungicide was used as tracer of spray. DE was quantified directly on long sleeved white overall, on hood and on cotton gloves. Exposure of face was evaluated on female sanitary pads attached on disposable face masks and exposure of feet was on same type of pads attached on upper part of rubber boots. DE in three working conditions were evaluated in ten replications for each activity during 30 to 40 minutes. After the exposure overalls were divided into parts and were immersed in solution of HCl (0.1 N) for extraction of the tracer. Same procedure was carried out on pads. Quantification of Cu⁻² was by atomic absorption spectrophotometer. The values of Cu⁻³ recovered in spray collectors and concentration of the tracer in the spray solution were used to estimate the DE. Dermal exposure of pesticides. These data were used to calculate MOS with the following equation: MOS = [NOEL x 70] / [1.1 DE]. The DE without cabin was of 496.8 mL/day. Using the Real cabin it was 25.3 mL/day and using the Agroleite cabin was 71.9 mL/day with 94.9% and 83.6% were classified as safe (MOS ≥ 1) without tractor cabin, 62.4% with the Agroleite cabin.

Index terms: sprayer, pesticides, tractor-trailed air-carried sprayer, tractor cabins, safety

[1374] SAFETY OF PROTECTIVE CLOTHING AND SEMI-CABIN IN INSECTICIDES AND ACARICIDES APPLICATIONS BY TRACTOR-TRAILED HAND GUN SPRAYER IN CITRUS

M. L. Oliveira¹ & J. G. Machado Neto', 'Dept. de Fitossanidade, FCAV/UNESP – Campus de Jaboticabal, 14.870-000, Jaboticabal, SP, Brazil. E-mail oliveiraml@hotmail.com; joaquim@fcav.unesp.br.

The safety of the tractor driver and spraymen applying pesticides in citrus by tractortrailed hand gun sprayer was evaluated calculating margin of safety (MOS) from data of NOEL of pesticides and occupational exposure in a 6 hours work day. Working condition of workers was classified as safe (if MOS ≥ 1) or unsafe (if MOS <1). Dermal exposure (DE) of tractor driver was evaluated with and without protective clothing (AZR clothing) and semi-cabin and of spraymen with and without protective clothing (AZR and Roupa UNESP clothing). AZR protective clothing was composed by AZR clothing (hood, long sleeve jacket, pants and acetate face visor). Roupa UNESP protective clothing was composed by the Roupa UNESP clothing (impervious garment protecting only the frontal part of body and opened in the back). Both protective clothing were completed by nitrila gloves, rubber boots and charcoal treated disposable respirator. For Roupa UNESP it was added straw hat. Evaluations were carried out using Rolanzir high pressure sprayer in citrus orchard of Marchesan Agroindustrial e Pastoril Farm – Fazenda Cambuhy, Matão-SP, Brazil, during august/99. Cu² of a cupric fungicide was used as tracer in spray. Dermal exposure were assessed in ten replications in each activity during 30 to 40 Derma exposure were assessed in the representation in deer deer deer a solution of HCI (0.1 N) for minutes. After the exposure, spray collectors were immersed in solution of HCI (0.1 N) for extraction of the tracer. The values of Cu² recovered in the spray collectors and the concentration of the tracer in the spray solution were used to estimate the DE. Dermal exposure to 135 recommended pesticides were estimated with DE to spray and the dose of pesticides. MOS were calculated by the equation: MOS = [NOEL x 70] / [1.1 DE]. The DE of the tractor driver working with tractor without semi-cabin and AZR protective clothing was 57.2 mL/day. Wearing AZR protective clothing the DE was 12.7 mL/day, and using semi-cabin, 55.7 mL/day, with 77.8% and 2.6% efficiences. DE of spraymen meas 356.5 mL/day with 77.8% and 2.6% efficiences. DE of spraymen were 356.7 mL/day without protective clothing, 24.7mL/day with AZR (93.1% efficiency) and 77.3mL/day with Roupa UNESP (78.3% efficiency). Among 135 recommended insecticides and acaricides 64.4% were safe for the tractor driver working without protective clothing and semi-cabin, 89.1% were safe if tractor driver used AZR and 64.4% when the semi-cabin was used. For spraymen without protection 43.6% of applications were safe. Wearing Roupa UNESP 59.4 % were safe and 82.2% were with AZR.

Index terms: spray, pesticides, safety, protective clothing, semi-cabin

[1375] BASES FOR AN INSECTICIDE RESISTANCE MANAGEMENT OF SPODOPTERA FRUGIPERDA IN CORN IN BRAZIL

C. Omoto¹, F. B. Schmidt¹, R. B. Silva¹, T. D. Zucchi¹, M. D. M. Risco¹, C. Travalini¹, T. Thomazini¹ & S. C. Trakaki², 'Depto. de Entomologia, Fitopatologia e Zoologia Agrícola, Escola Superior de Agricultura "Luiz de Queiroz", Av. Páduas Dias, 11, 13418-900 Piracicaba, SP, Brasil, E-mail: celomoto@carpa.ciagri.usp.br; ²Dow AgroSciences, Rua Alexandre Dumas, 1671, 04717-903 São Paulo, SP, Brasil.

Corn is one of the most important crop in Brazil with about 12 million hectares of cultivated area per year. This crop has been cultivated all the year round with up to 3 different growing seasons in some regions. Therefore, the problem of pests attacking corn has also increased. The fall armyworm (*Spodoptera frugiperda*) is one of the most important corn pests in Brazil. Approximately 60 million US dollars were spent with insectides in corn in 1998; and about 40% of this amount was to control fall armyworm. Field failures have been reported frequently with the use of conventional insecticides for controlling this pest. Then, a survey of the susceptibility of *S. frugiperda* to commonly used insecticides such as the organophosphate chlorpyrifos ethyl and the pyrethroids lambda-cyhalothrin and zetacypermethrin was conducted in 1996/1997. Populations of *S. frugiperda* were collected from some corn-growing regions located in the State of Paraná, São Paulo, Minas Gerais and Goiás. The frequency of the resistance to these compounds varied from <1% to >35%. A 16-fold resistance was detected to chorpyrifos and lambda-cyhalothrin have increased in a stair-step fashion through time. In response to these results, another survey of susceptibility of *S. frugiperda* was conducted in 1999/2000 to evalue the extent of the problem to other compounds such as thiodicard, spinosad, methoxyfenozide and lufenuron. In this paper, we will also present the baseline suceptibility data of *S. frugiperda* in Brazilian cornfields will be presented. Index terms: fall armyworm, for the resistance ethyl, lambda-cyhalothrin survey of succeptibility of such such as thodicard, spinosad methoxyfenozide and tufenuron. In this paper, we will also present the baseline suceptibility data of *S. frugiperda* in Brazilian cornfields will be presented. Index terms: fall armyworm, for the resistance they for an insecticide resistance management of *S. frugiperda* in Brazilian cornfields will be presented.

[1376] DDT- AND ORGANOPHOSPHATE-RESISTANCE IN ANOPHELES GAMBIAE MEDIATED BY GLUTATHIONE S-TRANSFERASE GENES

F. Ortelli, H. Ranson, N. Roberts & <u>J. Hemingway.</u> Dept. of Biosciences, Univ. of Wales Cardiff, P.O. Box 915, Cardiff CF10 3TL, UK, E-mail: Hemingway@cardiff.ac.uk.

Anopheles gambiae represents an important Sub-Saharan malaria vector. The extensive use of insecticides in agriculture and for anti-malarial purposes, selected for resistant strains. Three complex mechanisms underlying insecticide resistance are known: cuticular resistance, metabolic resistance (carboxylesterases, glutathione S-transferases (GST), mixed-function oxidases) and target site insensitivity.¹ GSTs are a large family of enzymes, which protect the cell from reactive electrophilic compounds by enhancing their solubility and aiding their excretion from the cell. GSTs are also competent for the dehydrochlorination of DDT and dealkylation of organophosphates (OP) insecticides¹², modulating the resistance level in insects. DDT- and OP-resistance in An. gambiae is mediated by stage-specific GSTs,³ where an increase in gene expression is responsible for resistance.³ Recent work on An. gambiae has demonstrated the diversity of GST enzymes present in this insect. Most class I GSTs are located together on a single chromosome and sequencing of this DNA revealed two full-length genes and five GSTs-like sequences. The first of these has high levels of identity to the 5' end of insect class I GSTs, while the other four are truncated at their 5' ends but have high sequence identities to the 3' region of GSTs. Expression studies show that this is an alternately splice gene with four different protein products. The factors determining the choice of the 3' splice site are still unknown, but they seem to be stage and tissue dependent. This gene splicing mechanism is responsible for some of the high GST variation in this insect class. Characterisation of the factors contributing to the choice of 3' splice site should lead to a better understanding of these enzymes, their role in insecticide resistance, and splicing systems in insect vectors. Index terms: gene over-expression, promoter analysis, reactive electrophilic compounds

[1377] EFFECT OF A SPECIAL THERMONEBULIZATION FORMICIDE FORMULATION FOR THE CONTROL OF THE LEAF-CUTTING ANT, ATTA CAPIGUARA (HYMENOPTERA:FORMICIDAE)

<u>G. Papa</u>¹, F. J. Celoto¹ & F. J. Almeida¹, ¹ Dept. of Biology, Univ. Estadual Paulista, Av. Brasil 56, Zip 15.385-000 - Ilha Solteira/SP, Brazil, E-mail: gpapa@bio.feis.unesp.br

Leaf-cutting ants of the genus Atta excel over the remaining groups of insects which cause damage to plants since they are highly active social insects that cause great losses to farmers in Brazil. The control methods used today present limitations that may compromise their control. Bait formulations require good soil conditions and low humidity, otherwise they will not be efficient. Applying water-based insecticides is not possible in large areas as well as fogging, which demands engine-propelled equipment that require constant maintenance, increasing the treatment cost. New approaches such as an insecticide formulation of a fumigant paste that produces a fog after being ignited and that exempt the use of fogging equipment, may offer a better solution for the control of leaf-cutting ants. The objectives of the present paper were to evaluate the results of a special formulation of fumigant paste for the control of Atta capiguara. The experiment was performed under field conditions, in a pasture area, from November 1999 through January 2000. The design was completely randomized, consisting of 5 treatments and 8 replications. Each parcel consisted of one colony (anthill). The sizes of the colonies varied from 6 to 40 m² of area of loose soil. The insecticide was applied introducing already lighted up tubes containing the funigant paste plus the insecticide into the active openings of the colonies. Each tube contained 65 g of the paste and 4.3 g of cypermethrin. The treatments consisted of one tube (FUMACÉ) per each 6, 8 and 10 m² of loose soil, one standard treatment with the conventional insecticide in a formulation in order to verify the soil removal and ant activities in each anthill. Colonies were classified as active, inactive or disturbed. The analysis of the results showed that the fungant paste applied at the dosage of 100 ml c.p.A of diesel oil with a back fogger and a control freatment. The explained shows control insecticide in a formulation in order to verify the soil removal and ant activities in ea

[1378] EFFECT OF CHEMIGATION THROUGH CENTRAL PIVOT. FOR THE CONTROL OF THE FALL ARMYWORM, SPODOPTERA FRUGIPERDA, (LEPIDOPTERA: NOCTUIDAE), IN CORN

G. Papa', <u>M. Rotundo'</u> & G. V. Tomquelski', ' Dept. of Biology, Univ. Estadual Paulista, Av. Brasil 56, Zip: 15.385-000 - Ilha Solteira/SP, Brazil, E-mail: gpapa@bio.feis.unesp.br

Among the main factors that affect corn production in Brazil, pests such as Spodoptera frugiperda constitute the greatest problem to farmers. As the areas irrigated by aspersion (central pivot) increase in Brazil, chemigation has become one of the most important mode of application of insecticides. However, there are only a few options of products recommended for this mode of application. The increasing search for safer alternatives for pests control, which are less aggressive for the environment, has brought a significant development of new insecticide formulations, with possibilities of use in agricultural pest management. Therefore, the current technological advancement in chemistry leads to safer and more adequate insecticides, contributing to a safer and more efficient way of control pests. The objective of this work was to evaluate the performance of the microencapsulated formulation of Lambda-cyhalothrin, applied through central pivot, for the control of the main corn pest in Brazil, S. frugiperda. The experiment was established under field conditions, during the period of May to August/99. The design used was in strips, with 11 treatments and 4 sub-plots. Each plot consisted of an area of 5 ha, subdivided to 4 equal sub-plots. Two applications were made through central pivot and injection pump. The pivot worked at full speed and at a pressure of 1.42 kg/cm^3 , distributing a water deep of 4.75 mm. The treatments consisted of a microencapsulated formulation of lambda-cyhalothrin at the concentration of 5 and 25% (Karate Zeon), lambda-cyhalothrin as an emulsifiable concentrate formulation (Karate 50 CE) at the doses of 7.5 and 12.5 g a.i./ha, chlorpyriphos (Lorsban 480 BR), lufenuron (Match CE), spinosad (Tracer) and zeta-cypermethrin (Fury 200 EW), at the doses of 288, 15, 24 and 20 g a.J.Aa, respectively, and control. Evaluations were done up to 15 days after each application, by checking the number of larvae found in 15 plants/sub-plot, with a total of 60 plants per treatment. Yield evaluation was conducted by harvesting all plants from two rows of 10m in length in each sub-plot and weighing stem + leaves + cob. Results showed that both formulations and concentrations of lambda-cyhalothrin were efficient for the control of *S. frugiperda* and provided for an increase in yield similar to the standard treatments (chlorpyriphos, lufenuron spinosad and zeta-cypermethrin).

Index terms: lambda-cyhalothrin, microencapsulated, chemical control

[1380] RESISTANCE OF COMMON BEAN GENOTYPES TO Diabrotica speciosa (Germar) (COLEOPTERA: CHRYSOMELIDAE) ADULTS

M. J. F. O. Paron¹, F. M. Lara¹ & M. Yokovama², 'Dento, de Fitossanidade, Univ. Estadual Paulista, Faculdade de Ciências Agrárias e Veterinárias, Via de Acesso Paulo D. Castellane s/n, 14884-900, Jaboticabal, SP, Brazil. E-mail fmlara@fcav.unesp.br;² Centro Nacional de Pesquisa de Arroz e Feijão, EMBRAPA, C.P. 179, 74001-970, Goiânia, GO, Brazil

The gene pool of common bean (Phaseolus vulgaris L.) is related with two major domestication centers, the Middle American (MA) and Andean (AN). In this work, we use representative genotypes from these groups to determine their resistance to Diabrotica speciosa. Feeding non-preference in field and cages (26 genotypes) were evaluated in free choice tests, in 1997 and 1998, at the farm of UNESP-FCAV, Jaboticabal, SP, Brazil. The results of these tests showed different attack levels on the genotypes, and for the subsequent tests six genotypes were selected: Goiano Precoce, Jalo Precoce, PR 95105146, PR 95105142 (AN), Engopa 201 Ouro and IAPAR 57 (MA). The bean genotypes were planted in pots, covered with voil cages, and when 20 day-old, leaflets were collected. Foliar disks of 25,4-mm-diameter were taken out of each genotype for the tests. Two trials, a no choice test and a free choice test, were set up in BOD at temperature of 25°C, 70% air RH, photoperiod of 12:12 (L: D). The experimental unit of the free choice test was 2 disks of each genotype kept in a 140-mm-diameter Petri dish (total of 12 disks), where 12 adults were confined. The study was carried out in a completely randomized design with 15 replications. Consumption was determined after 24 hours or until 80% leaf area was destroyed from one of the genotypes. No choice test was conducted with the same genotypes. The experimental unit was a 60-mm-diameter Petri dish with 2 disks of one genotype and 2 insects, the evaluation and environmental conditions were according to the method described earlier. Another field experiment was conducted planting the 6 genotypes on June 10, 1999, in randomized blocks with five replications using normally recommended culture and fertilizing conditions. Fifteen leaflets per plot were collected 30 days after planting and the leaf area consumption was evaluated. On screening tests, Middle American genotypes were more preferred. The genotypes Emgopa 201 Ouro and IAPAR 57 (both MA) were the most preferred on feeding preference tests conducted at BOD, while the genotypes PR 95105146 and PR 95105142 (AN) were less damaged. The genotypes Emgopa 201 Ouro and IAPAR 57 also were the most preferred on field experiment, while Jalo Precoce (AN) had the lowest damage, and had not showed difference from the others AN genotypes. Index terms: Phaseolus vulgaris, feeding nonpreference, host plant resistance

[1379] STRATEGIES FOR THE USE OF THIAMETHOXAM ON THE MANAGEMENT OF THE APHID APHIS GOSSYPH IN COTTON

G. Papa¹, G. V. Tomquelski⁴ & R. B. Silva¹, 'Dept. of Biology/UNESP, Av. Brasil 56, CEP: 15.385-000 Ilha Solteira/SP E-mail: gpapa@bio.feis.unesp.br

The objective of this work was to evaluate the performance of thiamethoxam, in different dosagens, formulations and application strategies, aiming the aphid management and the reduction of foliar applications in cotton. Two experiments were deployed, the first in the 98/99 season and the second in the 99/00 season, both in the Brazilian cerrado, and with the cotton cultivar Delta Pine Ita-90. The design was of randomized blocks, with 8 treatments and 4 replications. Plot size was 12 rows by 15m length (162m²). In the first experiment the treatments consisted of: thiamethoxam (Cruiser 700 WS) applied as a seed treatment at the dose of 300 g c.p./100 kg of seeds + thiamethoxam (Actins 1 of M), applied at covering (granulated) at the doses of 15 and 20 kg c.p./ha, 35 and 45 days after planting; thiamethoxam (Actara 10 GR), at the doses of 15 and 20 kg c.p./ha and aldicarb (Temik 150) at 8kg p.c. /ha, applied in-furrow. In the second experiment the treatments consisted of: thiamethoxam (Cruiser 700 WS) applied as a seed treatment at the dose of 300 g c.p./100 kg of seeds + thiamethoxam (Actara 10 GR), applied at covering (granulated) at the dose of 20 kg c.p./ha, in different times for each treatment (at 10, 15, 20 and 30 days after planting); thiamethoxam (Actara 10 GR), at the dose of 20 kg c.p.. /ha, aldicarb (Temik 150) at 8 kg c.p./ha, applied in-furrow and imidacloprid (Gaucho 700 PM) applied as a seed treatment at 500 g c.p./100 kg + carbosulfan (Marshal 200) in foliar applications at 10-day interval, at dose of 600 ml c.p./ha. Results showed that the combination: seed treatment + application of granulated at covering was efficient for the control of the cotton aphid, and it reduced the number of diseased plants and it provided increment in the productivity in relation to the control treatment, being viable as a part of the cotton aphid management, as a replacement to sequential foliar applications. Index terms: mosaic, chemical control, IPM

[1381] RESISTANCE MECHANISMS IN ANOPHELES ALBIMANUS DURING A LARGE-SCALE FIELD TRIAL USING A SINGLE INSECTICIDE, ROTATION AND MOSAIC STRATEGIES IN MEXICO

R.P. Penilla^t, A.D. Rodríguez^t, J. Hemingway², A.D. López¹ & M.H. Rodríguez¹, ¹Infectious Diseases Research Center/Malaria Research Center, National Inst. of Public Health, P.O.Box. 537, Tapachula, 30700, Chiapas, México. School of Biosciences, Univ. of Wales, P.O.Box. 915, Cardiff CF10 3TL, Wales UK.

A three-year large-scale field trial for the evaluation of insecticide resistance management was conducted in Southern Mexico and the resistance gene frequencies of. Anopheles albimanus populations were investigated. Before the intervention, a broad-spectrum resistance to DDT, PYR (pyrethroids), OP (organophosphorus) and CAR (carbamates) was detected by WHO bioassays. Biochemical assays showed that such resistance was conferred by GST (Glutathione S-transferase), elevated esterases and AChE -based mechanisms (Penilla et al., 1998). Resistance gene frequencies in the distinct enzymes assayed were significantly different between villages and collection methods, suggesting the presence of sub-populations with different levels of resistance to the insecticides. During the three years evaluation significant variations in the enzymatic levels of this species between the different resistance management strategies were detected. GST activity increased after the 2rd and the 3rd year in villages under continuous DDT pressure, and in villages under the rotation strategy during the 2^{ad} year of treatment when a PYR was sprayed. Elevated esterases were detected during the 2^{ad} year in villages under the rotation strategy and through the three years study in some villages under the continuous PYR pressure. PYR apparently selected for monooxygenases (MFO) and esterases-based mechanisms, since both showed similar gene frequency patterns. Differences in gender also were detected in MFO and GST gene frequencies, with higher levels in females and males, respectively. Altered AChE gene frequencies decreased in villages under the PYR and rotation strategies by the 3rd year of intervention. The rotation of insecticides prevented MFO and GST levels to increase, while elevated esterases were observed in much low frequencies.

[1382] RESISTANCE TO THE TOMATO PINWORM, TUTA ABSOLUTA, BY INTERSPECIFIC GENETIC CROSSES OF TOMATO PLANTS

<u>N.E. Pereira'</u>, N.R. Leal', M.G. Pereira' & R. I. Samuels', 'Laboratório de Melhoramento Genético Vegetal, Universidade Estadual do Norte Fluminense, Campos dos Goytacazes, RJ, Brasil. ² Laboratório de Proteção de Plantas, Universidade Estadual do Norte Fluminense. E-mail norma@uenf.br;

The South America tomato pinworm, Tuta absoluta, is one of the major pests of the tomato crop in Brazil. The use of chemical pesticides is the most common method of controlling this insect. However, chemical control is expensive and causes environmental pollution. Genetic resistance to this insect is not seen in cultivated tomato species, but it is known to occur in wild/undomesticated species which are related to the cultivated tomato. This research studied the genetic resistance to Tuta absoluta in Lycopersicon esculentum cv IPA-6 and L. hirsutum f. glabratum Pl 134418 crosses. The parental, F_1 and F_2 generations were evaluated under greenhouse conditions. Artificial infestations of Tula absoluta were achieved by placing 1st instar larvae on the adaxial surface of the leaflets, which were then confined with dialysis tubing. The degree of insect damage was evaluated in relation to leaf area consumed. Larval development was also evaluated during the 15 days period following artificial infestation. Resistance was observed in the form of antibiosis. *Tuta absoluta* larvae showed abnormal development when exposed to wild/undomesticated parental and F, foliage. Larvae feeding on cultivated parental (L-esculentum) plants, completed their development within 15 days of infestation. A generation means analysis showed that the results can not be explained by a simple additive-dominant model, suggesting that the distortion could be due to interspecific incongruity or epistatic effects.

Index terms: Lepidoptera, plant breeding.

[1384] RELATION DOSE-LETHALITY OF THREE PESTICIDES ON VARROA AND APIS MELLIFERA VARROIDAE) JACOBSONI (GAMASIDA: (HYMENOPTERA: APIDAE): COMPARISON OF TWO ADMINISTRATION METHODS

G. Pérez-Santiago¹, G. Otero-Colina², D. Mota S²., M. E. Ramírez³ G. & R. Vandame⁴, 1.-Instituto Politécnico Nacional, CIIDIR Unidad Durango. A.P. 112, 34890 Vicente Guerrero, Dgo., México. Becario Cofaa. E-mail: gperezs@yahoo.com. 2.-Colegio de Postgraduados, Instituto de Fitosanidad, 3.- Instituto de Socioeconomia 56230, Montecillo, Méx. México & 4.- Université Claude Bernard-Lyon I. Institut d'Analyse des Systémes Biologiques et Socio-Economiques, Lyon France.

Two methods of toxicological bioassays were tested to determine the response doselethality of amitraz, flumethrin and fluvalinate on Varroa jacobsoni and Apis mellifera. The first bioassay method was aspersion by means of the Potter-Bourgerjon's tower; its results are expressed in mean lethal concentrations (LC_{a0}). The second one was topical application by means of microsyringe and manual applicator; its results are expressed in mean lethal doses (LD₅₀). In the study on varroa, values of LC₅₀ (mg L^{-1}) were the following: amitraz 0.23, flumethrin $8.75*10^{-4}$, fluvalinate 0.19. Values of LD₂₉ per individual mite (pg) were: amitraz 1.7, flumethrin 0.46, fluvalinate 15.42. Values of LC₃₉ (mg L⁻¹) in honeybees were: amitraz 1636, flumethrin 46.87, fluvalinate 1601. Values of

(ing L.) in noneypees were: anitraz 10.50, numerarin 40.67, nuvainate 1001, values of LD_{50} per honey bee specimen were: anitraz 2.55 *g, flumethrin 0.05 pg, fluvalinate 0.97 *g. Both LC_{50} and LD_{50} were considerably higher in varioa mites than in honey bees, showing that a wide security margin exists between effective doses against mites and dangerous doses for honey bees. Both methods gave similar confidence intervals; they showed a comparable sensivity to changes in dose or concentration of pesticides. Key words: amitraz, bioassays, flumethrin, fluvalinate, toxicity.

[1383] TOWARDS APHID RESISTANCE IN TRANSGENIC LUPINS

M. R. Perera & M. G. K. Jones, Western Australian State Agricultural Biotechnology entre, School of Biological Sciences and Biotechnology, Murdoch University, Perth, WA 6150, Australia. E-mail: mperera@central.murdoch.edu.au

The Australian pulse industry is worth about \$400 million per annum. Plant sucking insects such as aphids are serious pests of pulses which reduce crop yield and transmit phytopathogenic viruses. The new yellow lupin (*Lupinus luteus*) variety Wodjil is particularly susceptible to aphid damage, and this may limit its potential use. In Western Australia aphids are also vectors of two serious lupin viruses: cucumber mosaic virus (CMV) and bean yellow mosaic virus (BYMV). Aphid species, which frequently attack pulse crops in Western Australia such as cowpea aphid (Aphis craccivora), green peach aphid (Myzus persicae), bluegreen aphid (Acyrthosiphon kondoi) and potato aphid (Macrosiphum euphorbie) are the main focus of this project. The control of these pests currently relies heavily on cultural methods and applications of chemical pesticides. Some green peach aphid populations have resistance to organo-phosphorus and carbamate groups of insecticides. There is an opportunity for novel approaches to aphid control such as transgene-mediated resistance. The aim of this project is to develop transgenic legumes resistance to aphids. This project has several parts: (1) to develop different plant expression cassettes using constitutive, wound-inducible and tissue specific promoters; (2) to clone insect resistance genes into plant expression cassettes and generate stable transgenic lines expressing the insect resistant genes; (3) to assess the effectiveness of aphid resistance conferred by the introduced genes. The aim of this paper is to outline investigations that are being carried out and to describe the strategies that might be used to Investigations use are being carried off and to describe the strategies that might be dised to develop transgenic plants resistant to aphids. This research is in collaboration with the Centre for Legumes in Mediterranean Agriculture (CLIMA)), Agriculture WA (AGWEST) and KEYGENE N.V., Wageningen, The Netherlands, and financially supported by the Australian Grains Research and Development Corporation (GRDC). Index terms: Acyrthosiphon kondoi, Myzus persicae, Aphis craccivora, Macrosiphum euphorbie, Lupinus luteus.

[1385] DETECTION AND MONITORING OF INSECTICIDE RESISTANCE IN TRIATOMA INFESTANS AND RHODNIUS PROLIXUS

M. I. Picollo; C. Vassena; & E. Zerba, Centro de Investigaciones de Plagas e Insecticidas (CIPEIN/CITEFA-CONICET), Zufriategui 4380, (1603) Villa Martelli, Buenos Aires, Argentina. E-mail: cipein@citefa.gov.ar. This investigation received financial support from UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases.

Despite prolonged and intensive use of insecticides for the control of Chagas Disease Despite prolonged and intensive use of insecticides for the control of Chagas Disease vectors, few studies have been made on the possible development of insecticide resistance in Triatomines. We evaluated deltamethrin susceptibility in field populations of T. infestans and R. prolixus, for resistance detection and documentation. Sampling sites, sample size, life stage of collected insects were standardized in order to optimize sampling. Deltamethrin was chosen for the laboratory bioassays, as it was the major insecticide used in control campaigns from Argentina. The application of the World Health Organization (WHO 1994) protocol to determine resistance in T. infestans, and determine of the restored by R medium allowed the determination of LD, and adaptation of that protocol to R. prolixus, allowed the determination of LD_g and discriminating dose (DD) for the susceptible CIPEIN strains. The values obtained were userminating dose (DD) for the susceptible CIPEIN strains. The values obtained were LD_{sc} : 0.1 ng/insect and DD: 1.98 ng/i for *T. infestans*, and LD_{sc} : 0.01 ng/i and DD: 0.059 ng/i for *R. prolixus*. Topical application of DD on first nymphs obtained from field collected insects, were made on 123 *T. infestans* samples from 13 provinces from Argentina, 1 *T. infestans* sample from Brazil, 3 *R. prolixus* samples from Venezuela and 1 R. prolixus sample from Colombia. We found 100% mortality in field colonies collected in a province of Argentina, but number found in S. provinces of Argentina but number found in S. provinces. *k. protixus* sample from Colombia. We found 100% instanty in field colomes concrete in 8 provinces of Argentina, but survival was found in 5 provinces: San Luis, La Rioja, Mendoza, Catamarca and Salta. We also found survival insects in all *R. prolixus* field colonies collected in Venezuela. Resistant ratios for Argentinean colonies ranged from 3.0 to 4,8 and the same for Brazilian colony was 7. Resistant ratios for Venezuelan colonies ranged from 3,4 to 11.4. These results showed initial detection of resistance in field strains of Triatomines, and would allow the adoption of preventive resistance management tactics.

Index terms: Triatoma infestans, Rhodnius prolixus, field strains, monitoring insecticide resistance

[1386] THIAMETHOXAM TO CONTROL CITRUS LEAFMINER IN TANGOR MURCOTT

A. Raga, M.E. Sato, M.F. Souza Filho & R.C. Siloto, Biological Institute Experiment Center, P.O. 70, Campinas, SP 13001-970, Brazil, E-mail adalton@dglnet.com.br.

A field experiment was conducted on 'Tangor Murcott' spring flushes during 1999 to control citrus leafminer (CLM) *Phyllocnistis citrella* (Lepidoptera: Gracillariidae) in Cordeirópolis County, State of São Paulo, Brazil. Insecticides and respectively concentrations (g IA/100 liters of water) used were thiamethoxam 250 WG (3.0; 4.0 and 5.0) *thick and the sectore* 5.0), thiamethoxam (4.0) + petroleum oil (PO) 80EC (200.0), abametin 18EC (0.54) + PO (200.0), lufenuron 50EC (3.75) + PO (200.0), pyridaphention 400EC (30.0), pyridaphention (30.0) + PO (200.0) and PO (200.0 and 800.0). Two foliar sprays were made at interval of ten days. At 3 days after the 1st application, abamectin + PO and mate at interval of ten days. At 3 days after the 1st application, anametin + PO and lufenuron + PO, both considered as standards, provide significantly greater CLM larval mortality, with 86.8% and 93.3% of reduction, respectively. In the same date, only lufenuron + PO gave good control of larvae + pupae (86.2%). For all insecticide treatments, with the exception of thiamethoxam at 3.0g and 4.0g, the number of larvae per flush was lower than for untreated control at 7 days after the 1st application, ranging from 57.4% (PO - 200.0g) to 98.9% of reduction (abameetin + PO). In this evaluation, abameetin + PO caused the highest reduction (87.2%), thiamethoxam (5.0) provided good control (74.0%) while pyridaphention treatments were not significantly different from the check, based on the number of CLM larvae + pupae. At 5 days after the 2nd application, only abameetin + PO provided significant reduction in larva (93.9%) and larva + pupa (95.0%) populations. In the same date, lufenuron + PO showed significantly lower larva + pupa density per flush (75.4% of reduction). Although thiamethoxam + PO had been inferior to standard insecticides at 5 days after the 2nd application, the number of CLM larvae was reduced in 63.0%. At 11 days after the 2nd application no significant differences in larval or larval + pupal infestation were detected among treatments. The results suggest that studies with thiamethoxam to control P. citrella should be developed at 2.0 g AI/100 liter of water or higher doses with the addition of PO.

Index terms: citrus, Phyllocnistis citrella, Gracillariidae, chemical control.

[1388] EFFICACY OF GROWTH REGULATOR INSECTICIDES FOR THE CONTROL OF RACHIPLUSIA NU (LEPIDOPTERA - NOCTUIDAE) ON SOYBEAN

LL. Reichert¹ & J.C.L. Barbosa², ¹Lab. Entomology, College of Agronomy & Veterinary Medicine, Univ. Passo Fundo, P.O. Box 611, ZIP 99001-970 Passo Fundo -Brasil. E-mail Reichert @ upf.tche.br; 2 Agronomy Graduate Student

Rachiplusia nu is a major insect pest of flax, soybean, and sunflower in Southern Brazil. An experiment was carried out in the growth chamber, adjusted to 23±2°C and 14-hour photophase, to evaluate the efficacy of growth regulators insecticides on the control of *R*. *nu*. The following insecticides were tested: Novaluron 10 g a.i./ha; Lufenuron 10 g; Teflubenzuron 9 g; Methoxyfenozide 21.6 g; Chlorfluazuron 15 g, Triflumuron 14.4 g, and Diflubenzuron 10 g. The insecticides were applied onto experimental plots (3 m wide × 10 m long) by means of a CO, backpack sprayer adjusted to deliver 200 L/ha at a 45-PSI pressure. The larvae used in this test were from a stock population. The experimental units were arranged in a complete randomized design with eight treatments and five replications. Each replication consisted of 10 larvae (1-2 cm) kept in plastic containers $(11 \text{ w} \times 11 \text{ I} \times 3 \text{ cm h})$. The larvae were fed with leaves from the insecticide sprayed area. Insecticide efficacy was calculated according to the Abbott's formula at three, five, and seven days after insecticide application. For statistical analyses, data were transformed by $\sqrt{(x+0.5)}$. Teflubenzuron and Chlorfluazuron showed a strong initial effect over the young larvae and reached control efficacy of 87.7 and 86.6% at the first assessment. Lufenuron and Triflumuron provided control higher than 60%. All insecticides but Diflubenzuron showed control efficacy at five (> 85%) and seven days (100%). At 10 days, even Diflubenzuron controlled 100%. Overall, the control of young *R. nu* larvae was obtained by all insecticides, especially Teflubenzuron and Chlorfluazuron because of their quick effect. Diflubenzuron should not be recommended because it has a slow initial effect while R. nu is voracious and has a short larval phase.

Index terms: Rachiplusia nu, growth regulator insecticides, chemical control

[1387] GENETIC MAPPING OF LOCI AFFECTING RESISTANCE TO INSECTICIDES IN ANOPHELES GAMBIAE

H. Ranson¹, B. Jensen², J. Hemingway¹ & F.H. Collins², 'School of Biosciences, Cardiff Univ., PO Box 915, Cardiff, Wales, CF1 3TL, UK. ³Dept. of Biological Sciences, Univ. of Notre Dame, Notre Dame, IN 46556-0369, USA.

Malaria is the most debilitating vector-borne disease in the world today. Hundreds of millions are infected and more than 2 million are killed every year, mostly children and infants in Africa. Chemical control of the mosquito vectors is an integral part of malaria control campaigns but the emergence of insecticide resistance, is a continual threat to these control efforts. The two major insecticides employed in malaria control today are DDT and permethrin. Resistance to DDT is widespread and, in many areas, house spraying with this insecticide has been replaced by the use of permethrin impregnated bednets. However, permethrin resistance has already been detected in malaria vectors and, given the predicted increase in bednet usage, there are fears that this resistance could have a severe impact on this promising new malaria control method. We have used microsatellite markers to scan the genome of the major African malaria vector, Anopheles gambiae, for loci linked to resistance to DDT and permethrin. We have identified 2 major quantitative trait loci (QTL) associated with resistance to DDT in the ZAN/U strain from Zanzibar and two distinct QTL associated with permethrin resistance in a Kenyan strain of An. gambiae. Resistance in both these strains is associated with increased metabolism of the insecticide, catalysed by glutathione S-transferases (GSTs) in the case of DDT resistance or cytochrome P450s in the case of permethin resistance. An additional resistance mechanism, a point mutation in the voltage-gated sodium channel, the target site of both these insecticides, confers a low level of resistance in the permethrin resistance strain. We have cloned and physically mapped the target site gene and several members of the GST and P450 enzyme families to *An. gambiae* polytene chromosomes. By integrating the physical and genetic maps we can assess the role of these candidate genes in conferring resistance to insecticides. However, a major advantage of the genetic mapping approach is that it can detect novel resistance genes that would be difficult to isolate by functional based cloning. We are therefore isolating additional genetic markers to enable the isolation of the resistance genes by positional cloning.

Index terms: malaria, OTL, permethrin, DDT

[1389] EVALUATION OF GROWTH REGULATOR INSECTICIDES ON THE CONTROL OF RACHIPLUSIA NU (LEPIDOPTERA - NOCTUIDAE) ON SOYBEAN

J.L. Reichert', J.C.L. Barbosa² & R.D. Tanabe², 'Lab. Entomology, College of Agronomy & Veterinary Medicine, Univ. Passo Fundo, P.O. Box 611, ZIP 99001-970 Passo Fundo - Brasil. E-mail Reichert @ upf.tche.br; ² Agronomy Graduate Students

Rachiplusia nu is a major insect pest of soybean in Southern Brazil. An experiment was carried out in the growth chamber, adjusted to $23\pm2^{\circ}$ C and 14-hour photophase, to evaluate the efficacy of growth regulators insecticides on the control of *R. nu*. The evaluate the efficacy of growth regulators insecticides on the control of R. nu. The following insecticides were tested: Novaluron 10 g a.i./ha; Lufenuron 10 g; Methoxyfenozide 21.6 g; Triflumuron 14.4 g, and Diflubenzuron 10 g. The insecticides were applied onto experimental plots (3 m wide x 10 m long) by means of a CO, backpack sprayer adjusted to deliver 200 L/ha at a 45-PSI pressure. The larvae used in this test were from a stock population. The experimental units were arranged in a complete randomized design with eight treatments and five replications. Each replication consisted of 10 mature larvae (> 2 cm) kept in plastic containers (11 w \times 11 | \times 3 cm h). The larvae were fed with leaves from the insecticide sprayed area. Insecticide efficacy was calculated according the Abbott's formula at three, five, and seven days after insecticide spray. For statistical analyses, data were transformed by $\sqrt{(x+0.5)}$. At the first assessment, Novaluron provided coutrol of 86.3%, followed by Lufenuron (62.7%). At assessment, rowattron provided control of 80.3%, followed by Lufention (62.7%). At five days, the efficacy of Lufenuron reached 98%, followed by Triflumuron and Novaluron, both with insect control above 90%. At seven days, all insecticides but Diflubenzuron reached 100% control efficacy. At this evaluation, the pre-pupa living population was 52.9% for Diflubenzuron and 47.8% for the control treatment. At the last assessment, on the 10th day, 95.3% of the living population (control treatment) was in the pupal stage. At this point, Diflubenzuron presented a 95% efficacy over the pupal ecdysis. Index terms: Rachiplusia nu, growth regulator insecticides, chemical control

[1390] SULFOTINE[™], A NEW ACTIVE FOR BAITS AGAINST COCKROACHES AND PHARAOH'S ANTS

F. Retlich & V.Rupes, Nat. Inst. of Public Health (NIPH), Srobarova 48, Prague 10, 100 42 Czech Republic, E-mail: rettich@szu.cz , rupes@szu.cz . Research funded by SC Johnson, Inc.-NIPH joint scientific project

Lithium perfluorooctanesulfonate (LPOS, Sulfotine[™]) is an isomeric mixture containing Lamin performately 70% of linear isomer and 30% of branched isomers. Molecular formula for LPOS is C_1F_1 ,LiO,S, and acute oral LD₃₀ for rat is greater than 5,000mg/kg. LPOS exhibits promising oral efficacy to various domestic insect pests, mainly cockroaches and ants. An experimental solid bait (against cockroaches) and liquid bait mounted in plastic boxes (against Pharaoh's ants), both containning 1% a.i., have been used for laboratory and field tests. The solid bait has been evaluated against laboratory (susceptible) and wild strains (pyrethoids tolerant) of the German cockroach, Blattella germanica (L.) and succeptible Oriental and American cockroaches, Blatta orientalis L., Periplaneta americana (L.). The liquid bait has been evaluated against 18 small (totalling 68 females, 8,800 workers and broot) laboratory colonies of Pharaoh's ant (Monomorium pharaonis a_{5000} workers and broot latoratory colonies of Pharaon's and (*Monorium pharaonis* L.). LT₅₀ and LT₅₀ values for *Blattella germanica* ranged from 0.4 to 1.4 and 2.2-5.5 days, respectively. LT₅₆ for *B.orientalis* and *P.americana* ranged from 1.1 to 3.0 and 0.8 days, respectively. The LPOS bait exhibited a single feeding feature. When males and females of *B.germanica*, *B.orientalis* and *P.americana* were fed bait for 2 hrs (and then the baits were removed), mortality was 100%, 92-100% and 100% respectively, after a 5-7 day holding period. LPOS exhibited distinct secondary kill. Pharaoh's ant colonies were destroyed and all members killed, within 4 or 9 weeks (after 5.1 weeks on the average). When the liquid bait boxes were opened and aged at room temperature for 30 days before exposition, only 8 colonies from 10 exposed were destroyed within 5 to 14 weeks (after 7.6 weeks on the average). Two other colonies survived at least 35 weeks with limited numbers of workers but with doubled numbers of females and males of the new generation. In the field, cockroach solid bait has been tested in hospital kitchens infested by B.germanica using doses of 4-5 baits per 10 square meters of area. Ant liquid bait has been tested in apartments using 6 baits per apartment. Reduction of B.germanica (based on sticky trap counts) a week A.T.reached 90 or more%. Reduction ranging from 92% to 100% were observed during a one year post-treatment period. A total of 108 apartments at 6 apartment blocks all infested by Pharaoh's ants, were free of insects (check based on youlk trap counts) 27-128 days A.T., 96.3 days on average. Index terms: Lithium perfluorooctanesulfonate, Blattella germanica, Blatta orientalis,

Periplaneta americana, Monomorium pharaonis, baiting

[1391] EXTRACTS OF CHRYSANTHEMUM CINERARIAEFOLIUM AND QUASSIA AMARA: EVALUATION OF EFICIENCE AND EFFECT ON SITOPHILUS ORYZAE (COLEOPTERA:CURCULIONIDAE)

S. M Rodriguez¹, V. M Frigidi¹, S. Delfino³ & A E.Pelicano⁴, ¹Cátedra de Zoología Agrícola,² Cátedra de Estadística. Fac. de Agronomía, Univ. de Buenos Aires. Av. San Martín 4453 (1417). Bs. As. Argtentina. E-mail: silro@mail.agro.uba.ar

Insecticide and sinergic effects of water and alcohol natural extracts of Chrysanthemum cinerariaefolium and Quassia amara were analized. Two concentrations (10% and 20%) for the first sample were considered. Seven treaments with four repetitions each were evaluated: T1: control: water, T2: Q .amara bark extract solution 10%; T3: C. evaluated: 11: control: water, 12: Q . amara bark exhat solution 10%, 13: C. cinerariaefolium flowers extract solution 10%: T4: the same quantity of C. cinerariaefolium and Q. amara 10%; T5: Q. amara bark extract solution 20%; T6: C. cinerariaefolium flowers extract solution 20%. For the second trial, only one concentration (20%) was considered. Four treaments with four repetitions each were evaluated: T1: control: alcohol. Filter paper humidified with 1 ml of different solutions and over each one of them 10 weevils were placed. Died weevils percentage was considered at 30°, 6, 24 and 48 hours. The analysis of the data was made throught an ANVA and Tukey comparation, applying a significance level of 5%. The water extracts at 20% had the higher insecticide power at 24 hours. A low weevils mortality was detected on T7. There were not differences between treaments at 30' to 24 hours. However, there was mortality to 48 hours (averages: to C. cinerariaefolium was 0,75; to Q. amara was 0,25 and to the mixture of Q. amara and C. cinerariaefolium was 0,25). Significant differences were not registered. Index terms: weevils, sinergic effect, water natural extract, alcohol natural extract.

[1392] THE EFFICACY OF SOME AROMATIC PLANTS AGAINST STORED PRODUCT INSECTS

V. Rozman¹ & I. Kalinovi¹, 'Facul. of Agriculture, Univ.J.J. Strossmayer in Osijek, P. O. Box 719, 31000 Osijek, Croatia, E-mail vrozman@suncokret.pfos.hr.

This research has been carried out to investigate insecticidal activity of some Mediterranean herbs in Croatia against stored product insects, in order to use them as Recological and natural insecticides. Mercantile and seed wheat was infested by adults of *Rhyzopertha dominica* and *Sitophilus granarius* which were treated by *Lavandula* officinalis, Laurus nobilis, Rosmarinus officinalis and Thymus vulgaris with application in two forma: essential oils and plant powder. The insecticidal effect was observed by exposition of time up to 100% mortality of adults. The efficiency of the plant materials was compared to chemical insecticide based on dichlorovos, and to control with no treatment. Complete research was carried out under laboratory and storage conditions treatment. Complete research was called our and in and instance M and M a efficacy against S. granarius showed T. vulgaris essential oils, while L. officinalis and L. nobilis had very good results in powder form. After completed analysis, the quality of mercantile and seed wheat was tested. Mercantile wheat was assayed by using ekstenzograph, farinograph and amilograph determining the quality of flour and it was not changed. The quality of seed wheat was tested by analyses of energy of germination and germination itself. No significant statistical differences were founded among the control semination user, to significant statistical unterences were founded among the control without application and treatments in both characteristics. In general, all investigated aromatic plants (*L. officinalis*, *L. nobilis*, *R. officinalis* and *T. vulgaris*) in forms of essential oils and plant powder showed insecticidal activity against *R. dominica* and *S.* granarius on mercantile and seed wheat under laboratory and storage conditions. In praxis, synthetic insecticides can be partly replaced by these plant products for less quantity of stored wheat and decrease contamination of food and environment.

Index terms: Rhyzopertha dominica, Sitophilus granarius, herbs, stored wheat, control.

[1393] MECHANISMS OF RESISTANCE TO THE INSECTICIDE METHIDATHION IN Amblyseius womersleyi (ACARI: PHYTOSEIIDAE)

M. E. Sato¹⁴, T. Miyata¹, A. Kawai³ & O. Nakano³, ¹Lab. of Applied Entomology, Graduate School of Bioagricultural Sciences, Nagoya Univ., Nagoya 464-8601, Japan; National Inst. of Vegetables, Ornamental Plants and Tea, Aki, Mie 514-2392, Japan; ²ESALQ, USP, CP 9, Piracicaba, SP, 13418-900, Brazil; ²Present address: Inst. Biológico, CP 70, Campinas, SP, 13001-970, Brazil, E-mail mesato@dgInet.com.br, Scholar of CNPa.

The predaceous mite Amblyseius womersleyi is an important natural enemy of Kanzawa spider mite *Tetranychus kanzawai*, which is considered a key pest of tea in Japan. In order to study the mechanisms of methidathion in this phytoseiid mite, a resistant strain of *A. womersleyi* was selected for resistance; and along with this selection, a susceptible strain was selected for susceptibility to methidathion. After four selections for resistance and three selections for susceptibility, the resistance ratio (R/S) at the LC₃₀ increased from 16 to 342 times. The effect of some synergists (PBO, DEM, and DEF) was investigated on the toxicity of methidathion in *A. womersleyi*. The highest synergistic ratio (SR: LC₃₀ without synergist/LC₃₀ with synergist) was observed for piperonyl butoxide (inhibitor of mfo, mixed function oxidases), which increased 12.3 times the toxicity of the insecticide in the resistant population. A second test was carried out using PBO and PTPE (inhibitor of mfo) as synergists. The highest SR was observed for PTPE. mite Tetranychus kanzawai, which is considered a key pest of tea in Japan. In order to study the PTPE, with 59.3 times in the R strain. The results suggest that an increase in oxidative metabolism is involved in this resistance. In another experiment, an insensitive acetylcholinesterase was observed to have some effect on this resistance, however this acetylcholinesterase was thought to be a minor factor for resistance. Cuticular penetration of acceptationintestriate was analyzed, and the results obtained indicate that the penetration is not a methidathion was also analyzed, and the results obtained indicate that the penetration is not a factor involved in this resistance. Another study was about "in vitro" metabolism of methidathion, using different subcellular fractions of the predaceous mile. The degradation of MADPH I"Cl-methidathion by the microsomal fraction of resistant mite, in the presence of NADPH, was 48% higher than that obtained for the susceptible strain, corroborating observations that was 4656 night than that obtained for the susceptible shain, corroborating observations that mfo are involved in this resistance. In a final experiment, the toxicity of eight pesticides was evaluated in the R and S strains of this phytoseiid mite. The R strain was more resistant to all compounds with the exception of bifenthrin. The highest resistance ratios were observed for the insecticides methidathion, acephate, and malathion, for which the R strain was respectively 311, 20.4, and 13.1 times more resistant than the S strain. In the case of the pyrethroid bifenthrin, no cross-resistance was observed for this chemical. Index terms: Predaceous mite, synergist, cross-resistance

ABSTRACT BOOK I - XXI-International Congress of Entomology, Brazil, August 20-26, 2000

[1394] MECHANISMS OF AZINPHOS-METHYL RESISTANCE IN A STRAIN **OF CYDIA POMONELLA FROM SOUTHERN EUROPE**

B. Sauphanor¹, J.C. Bouvier¹, D. Beslay¹, D. Bosch² & J. Avilla², ¹Unite de Zoologie-Apidologie - INRA, Agroparc, F 84914 Avignon Cedex, France; ²Centro UdL - IRTA de R+D de Lleida. Rovira Roure 177, E-25198 Lleida

A population of Cydia pomonella (Re) was collected in 1997 at Torrefarrera (NE of Spain) from a pear orchard chemically sprayed with organophosphates (mainly azinphos-methyl). Damage at harvest that year was greater than 30%. This population was found to be resistant to several insecticides. The neonates of the F1 generation exhibited a 10-fold resistance to azinphos-methyl compared to a French laboratory susceptible strain (S). This population was kept without selection for four generations to ensure its acclimatization to the laboratory conditions. The resistance to azinphos-methyl reverted to 2.3 fold during this period. A selection pressure with this compound was then applied, which resulted in a This period. A selection pressure with this compound was then applied, which resulted in a 13-fold resistance in the F9 generation. The enzymatic detoxication systems were analysed in the neonates of Re strain and of two strains previously selected for resistance to diffubenzuron (Rt) or to deltamethrin (Rv), and compared with those of the S strain. A 7.8, 7.6 and 9.4 increase of the mixed function oxidase activity was measured in Rt, Rv and Re strains, respectively. The difference between Re and the two other resistant strains was significant. The Re strain also exhibited a significant increase in glutathion-transferase (2.7 fold) and non specific esterase (3.8-fold) activity, while Rt and Rv did not. Moreover, a 5-fold decrease of the sensitivity of acetylcholinesterase to azinphos-methyl oxon occured in Re strain. Further studies are required to determine the involvement of each mechanism in the resistance to azinphos-methyl. Selection with this compound was found to increase the activity of detoxication mechanisms, which could explain the cross resistances frequently observed between azinphos-methyl and insecticides of different classes in C. pomonella.

Key words: codling moth, insecticide, metabolism, acetylcholinesterase

[1396] POPULATION DYNAMICS OF ODONATES IN AGRICULTURAL LANDSCAPES: A LARGE-SCALE ECOTOXICOLOGICAL PERSPECTIVE

T.N. Sherratt, K.F. Conrad & C.J. Thomas, Dept. of Biological Sciences, Univ. of Durham, South Road, Durham, DH1 3LE, UK, E-mail T.N.Sherrati

There is now a general awareness amongst ecologists that many natural populations of insects are most appropriately viewed not as single homogenous units, but as more complex structures, consisting of local semi-autonomous populations, linked to each other by dispersal. This "metapopulation" perspective is particularly important when one has a specific interest in estimating the rate of recovery of a population following the local application of a pesticide. In this paper, we present the results of an extensive markrecapture study of seven species of odonate (dragonflies and damselflies) in a British agricultural landscape. The population densities of odonates recorded around certain ponds fell dramatically when posticides were applied in the surrounding fields. Furthermore, while odonate species differed significantly in their overall rates of dispersal, we found that the probability of individuals of all the species moving between ponds all declined in a simple exponential manner with the distance between ponds. On the basis of these results we quantified the attributes of every pond above 10 m² in the Counties of Cheshire and Durham, using a Geographical Information System (GIS) based on Ordnance Survey 1:2500 scale digital vector map data. By incorporating the observed dispersal characteristics of odonates into this GIS, we have developed a tool which is capable of estimating the rate of immigration of odonates into any pond within these counties. Furthermore, by combining this information with a simple stage-structured population model, we have been able to crudely predict the rate of recovery of any local odonate population, after a pesticide is applied around a given pond within a real landscape. The development of tools and approaches such as these are important if we are to find practical ways of integrating more ecology into the risk assessment process. Index terms: damselflies, dispersal, pesticide, recovery.

[1395] INJECTION OF INSECTICIDES INTO TREE TRUNK FOR CONTROL **OF CITRUS PESTS**

A. A. Seraj, Plant Protection Department, Shahid Chamran University, Ahvaz, I. I. Iran. E-mail: aseraj@ahvazuni.neda.net.ir

One experiment was undertaken to determine the effect of injection of metasystox into Inne tree trunk citrus aurantifolia in spring 1997. Mean percent of citrus leaf mined areas *Phyllocnistis citrella* (Lepidoptera: Gracillaridae) per leaf of 1, 5 and 20 year old trees respectively treatment: 45,43 and 35%. Mean number of citrus oriental mite Eutetranychus orientalis (Acarina: Tetranychidae) per leaf of 5 and 20 year old tree were as follows: Injected treatment were as follows (first week after injection): Injection treatment: 4, 3.5 and 6.2%. Control: 0, 0. And mean number of southern mealybag Nipaecoccus viridis (Homoptera: Diaspididae) were as follows: Injection treatment: 0, 0. Control treatment: 2.5, 1, and 1. The treatments showed little effect of phytotoxicity. The injection of insecticide was more effect on young trees than old ones. A technique for injecting water-soluble insecticides such as metasystox into citrus tree trunks to control citrus pest is described. Ordinary disposable plastic syringes, which can be used repeatly, are used. The advantages of this type of treatment compared to conventional spray techniques can be summarized as follows: 1- The application and absorption of the required dosage of insecticide for pest control takes only a few minutes per tree. 2- as the entire plant system is poisoned all insects, including those in the most concealed hiding places, can be reached. In this way it should be possible with selected chemicals to control special pests and diseases. 3- there is no reason why a tree should not be fully sterile after treatment. In the case of certain pests the chances of reinfestation after treatment should be reduced considerably as survival of some individuals after normal spraying is usually the enemics will be able to attack the pest unhindered as no insecticide residues will be present on the tree.

Index terms: Injection, lime, citrus leaf miner, Eutetranychus citrella

[1397] CONTROL OF "WHITE FLY", Bemisia argentifolii WITE THE INSECTICIDES THIACLOPRID 480 SC; IMIDACLOPRID 700 GRDA AND IMIDACLOPRID 200 SC, IN CUCUMBER PLANTATION.

A.C. Silva'; L. O'. Salgado; J. Gitirana Neto' & M. A. R. Alvarenga'1 - Agroteste Pesquisa e Consultoria Praça Leonardo Venerando, 284 C.P 201 Lavras/MG 37.200-000 Brazil E-mail agrotest@ufla.br; 2 Universidade Federal de Lavras/UFLA C.P 37 Lavras/MG 37.200-000 Brazil

The "White fly" this is the pest more important in Brazil actually. The trial was realized in Uberlândia/Minas Gerais State – Brazil. The cultivate utilized was "Hibrido Safira" planted in $1,0 \ge 0.75$ m spacing. The experimental design used was randomized blocks, with 9 treatments and 4 replications, each plot with 18 m^2 . The treatments were applied 3 times in 24/06/99; 01/07/99 and 08/07/99. The treatments were applied in spray method with volume of 800L/ha. The insecticides tested (Formulated Product/ha) were: 1.Thiacloprid 480 SC - 100 ml; 2. Thiacloprid 480 SC - 150 ml; 3. Thiacloprid 480 SC - 200 ml; 4. Imidacloprid 700 GRDA - 200g; 5. Imidacloprid 700 GRDA - 300 g; 6. Imidacloprid 200 SC - 700 ml; 7. Imidacloprid 200 SC - 1000 ml; 8. Methamidophos 600 CE - 1000 ml and 9. Check. Were realized 3 evaluations weekly at 01/07/99 - 11/08/99; and more 5 evaluations in 15/07/99; 18/07/99; 23/07/99; 29/07/99 and 07/08/99. Evaluated 10 leaves/plot established the number of nymphs and pupas living. The means Evaluated to iterate statistics the number of hymphs and pupas living. The means were separate with Tukey test (p<0,05) and the efficiency established with Abbott formula. The insecticide Thiacloprid 480 SC showed an efficiency between 71,52 and 100,00% until 14 DAA (Days after the last application). Imidacloprid 700 GRDA showed an efficiency between 70,55 and 100,00% until 21 DAA. Imidacloprid 200 SC showed an efficiency between 70,55 and 92,38% until 30 DAA. Index terms: *Remising argentifolii* white fly character cumumber area

Index terms: Bemisia argentifolii, white fly, chemical control, cucumber crop.

[1398] PATTERNS OF ANSWER OF THE ENTOMOFAUNA OF THE CANOPY OF THE BEAN PLANT TO THE IMIDACLOPRID APPLICATION

<u>F.M. Silva¹</u>, M. Picanço¹, R. N. C. Guedes¹, E.J.G. Pereira¹, L. Bacci¹, ¹ Dept. de Biol. Animal, Univ. Fed. de Viçosa, CEP 36571-000, Viçosa, MG, Brazil, E-mail: marquini@alunos.mail.ufv.br.

This research was carried out from december 1998 to February 1999 in Coimbra, Mina Gerais State, Brazil with the objective evaluating the spacial and temporal effect of the neonicotinoid insecticide imidacloprid on the insect comunity associated with bean plant canopy. The experiment was established in a 20 days old bean plantation. The cultivated area had 1.9 ha and it was divided in two parts. The first was sprayed with 147g i.a/ha with a 700 GrDA formulation of imidacloprid. The second part constituted the control treatment where insecticide was not applied. Three transects were marked crossing from one area no another and sampling points 10 m apart from each other were establish in each transect starting from the intersection among the areas treated and not treated. Before the application of the imidacloprid and 3, 8, 14, 22, 29, 37 and 44 days after wards, the densities of the herbivore insects, predators, parasitoids and Collembola were evaluated in the canopy of nine plants. The imidacloprid controlled until the 22^e day after your application the total number of arthropods, total of insects fitossuccivoros, numbers of *Thrips tabaci* (Thysanoptera: Thripidae). *Caliothrips brasiliensis* (Thysanoptera: Thripidae) and *Empoasca kraemeri* (Homoptera: Cicadellidae) until 22 days after the insecticide applications, besides impeding the increase in Collembola (Insecta) density. There were higher densities of *E kraemeri* in the extremes of the treated area which Noctuidae) and *Frankliniella* sp. (Thysanoptera: Thripidae), which present larger densities by mid and end of the cultivation period. Imidacloprid also did not show effect on the number of mines and adults of *Lirionyza* spp. (Diptera: Agromyzidae), total of chewing insects (Homoptera: Aleyrodidae), which present larger densities by mid and end of the cultivation period. Imidacloprid also did not show effect on the number of mines and adults of Lirionyza spp. (Diptera: Agromyzidae), total of chewing insects and *Bemisia tabaci* (Homoptera: Aleyrodid

Index terms: Impact of insecticide, neonicotinoid, Phaseolus vulgaris

[1400] EFFECT OF A NEW FORMULATION OF LAMBDA-CYHALOTHRIN FOR THE CONTROL OF THE BOLL WEEVIL, ANTHONOMUS GRANDIS (COLEOPTERA: CURCULIONIDAE), IN COTTON

<u>R. B. Silva¹, M. Rotundo¹ & G. Papa¹, ¹ Dept. of Biology</u>, Univ. Estadual Paulista, Av. Brasil 56, Zip 15.385-000 - Ilha Solteira/SP, Brazil, E-mail: gpapa@bio.feis.unesp.br

The cotton boll weevil was found in Brazil for the first time in 1982, and even since it is causing considerable losses to the crop. The increasing search for safer alternatives for pest control, which are less aggressive to the environment, has brought a significant development of new insecticide formulations, with possibilities of use in agricultural pest management and contributing to a safer and more efficient way of pest control. The objective of this work was to evaluate the performance of the microencapsulated formulation of lambda-cyhalothrin for the control of the boll weevil, which is one of the main cotton pests in Brazil. The experiment was established under field conditions, in Ilha Solteira/SP/Brazil, using the cultivar IAC-22. The design was of randomized blocks, with 6 treatments and 4 replicates. Each plot consisted of 8 rows of the crop. Each row 10m long, and spaced 1m among each other, and total of 80 m². Five spray operations were conducted for each treatment, at 7-day interval, using a knapsack sprayer at the volume of 300 l/ha. Spray operations were initiated when the infestation level reached 5% of attacked flowering buds. The treatments consisted of a microencapsulated formulation of lambda-cyhalothrin at the concentrations of 5 and 25% (Karate Zeon) and Lambda-cyhalothrin as an emulsifiable concentrate formulation (Karate 50 CE), at the dose of 15g a.i./ha, deltamethrin, as an emulsifiable concentrate (Decis 25 CE) and a concentrate suspension (Decis 50 SC) formulations, at the dose of 10g a.i./ha and control. Evaluations were conducted 7 days after each application, by counting the number of attacked bud flowers (feeding and/or laying) out of 50 randomly picked buds, in each plot. Results showed that the microencapsulated formulation of lambda-cyhalothrin was efficient in controlling the of boll weevil at the two concentrations tested, and that it was similar to the standard treatment with deltamethrin as a concentrate suspension formulation, and better than the treatments with the emulsifiable concentrate formulations. Index terms: microencapsulated, chemical control, pyrethroid

[1399] REPELLENCY OF VEGETABLE OILS ON ADULTS OF ZABROTES SUBFASCIATUS (COLEOPTERA: BRUCHIDAE) IN BEAN GRAINS

G.J. R. Silva¹, <u>I.V. Oliveira¹</u>, R.L.B.C. Coitinho¹ & P.R. Machado¹, ¹Fitossanidade, Univ. Fed. Rural de Pernambuco, Av. Dom Manoel de Medeiros s/n, Dois Irmãos, 52171-900, Recife, P.E. E-mail: jvolivei@elogica.com.br

In the present work it was studied the repellent effect of oils of floral buttons of clove Syzigium aromaticum, leaves of eucalyptus Eucaliptus citriodora, bark of cinnamon Cinnamonum zeylanicuum, and eugenol on adults of Z subfasciatus in bean grains. Arenas formed by three plastic circular recipients were used in the tests. The central recipient was symmetrically connected to the two lateral recipients by plastic tubes. Ten couples of Z subfasciatus with 0-24 hours of age were placed into the central recipient, and 20 g of bean, treated and non-treated with oil, was placed into each one of the lateral recipients. Each oil dose was tested, separately, in ten arenas. The repellency was calculated 24 hours after the confinement of the insects, through the formula: PR = (NC-NT) / (NC + NT) x 100, being PR, percentage of repellency; NC, total of insects attracted in the control; NT, total of insects attracted in each treatment with oil. The number of adults attracted was reduced, and the repellency percentages increased with the oil doses. The eugenol was the most efficient, causing repellency of 93.9 and 86.6%, followed for cinnamon 91.8 and 62.7%, eucalyptus 74.1 and 55.2%, and clove 71.4 and 67.3%, at the doses of 2.5 and 0.5 ml/kg of bean grains, respectively.

Index terms: Insecta, bean weevil, natural insecticide, stored bean pest.

[1401] CARTAP RESISTANCE AND SYNERGISM IN POPULATIONS OF TUTA ABSOLUTA (LEPIDOPTERA: GELECHIIDAE)

H. A. A. Siqueira¹, <u>R. N. C. Guedes¹</u>, <u>M. Picanço¹ & E. E. Oliveira¹</u>, 'Dept. of Animal Biology, Federal Univ. of Viçosa, Viçosa, MG 36571-000, Brazil, E-mail: guedes@mail.ufv.br.

Control failures of cartap used against the tomato leafminer *Tuta absoluta* in Brazil and a recent report of cartap resistance in Brazilian populations of this pest-species led to the investigation of the possible involvement of detoxification enzymes on this phenomenon using insecticide synergists. The insect populations were collected from seven different sites in the states of Minas Gerais, Rio de Janeiro and São Paulo. These populations were subjected to insecticide-impregnated filter paper assays. The concentration-mortality assays were carried out for cartap alone and in mixture (1 cartap: 10 synergist) with the synergists diethyl maleate, piperonyl butoxide and triphenylphosphate which respectively inhibit the enzymes glutathion-S-transferases, cytochrome P450-dependent monooxygenases and esterases. Resistance to cartap was observed in all populations when compared with the standard susceptible population, with resistance ratios ranging from 2.3- to 21.9-fold. Piperonyl butoxide was the most efficient synergist with cartap synergism ratios ranging from 1.3- to 21.0-fold and nearly completely suppressing the resistance to cartap in all populations studied suggesting a major involvement of cytochrome P450-dependent monooxygenases as a cartap resistance mechanism in these populations of *T. absoluta*. Diethyl maleate and triphenylphosphate also synergized cartap in nearly every population, and they still provided partial suppression of cartap resistance in the leafminer populations studied. Therefore, glutathion-S-transferases and esterases seem to play a secondary role on cartap resistance in Brazilian populations of *T. absoluta*. Index terms: Tomato leafminer, insecticide resistance, insecticide synergism, diethyl maleate, piperonyl butoxide, triphenylphosphate

[1402] INSECTICIDE RESISTANCE IN POPULATIONS OF TUTA ABSOLUTA (LEPIDOPTERA: GELECHIIDAE)

H. A. A. Siqueira¹, R. N. C. Guedes¹, M. Picanço¹ & L. C. Magalhães¹, Dept. of Animal Biology, Federal Univ. of Viçosa, Viçosa, MG 36571-000, Brazil, E-mail: guedes@mail.ufv.br.

Control failures of insecticides used against the tomato leafminer Tuta absoluta (Lepidoptera: Gelechiidae) in Brazil led to the investigation of the possible occurrence of resistance of this insect-pest to abamectin, cartap, methamidophos and permethrin. The insect populations were collected from seven sites in the states of Minas Gerais, Rio de Janeiro, and São Paulo. These populations were subjected to insecticide-impregnated filter paper method for concentration-mortality bioassays. We were unable to obtain a single population which provided a susceptibility standard for all insecticides tested. Therefore, the resistance levels were estimated in relation to the most susceptible population to each insecticide. Resistance to abamectin and cartap were observed in all populations when compared with the susceptible standard population, with resistance ratios ranging from 5.2- to 9.4-fold and from 2.2- to 21.9-fold for abameetin and cartap respectively. Resistance to permethrin was observed in five populations with resistance ratios ranging from 1.9- to 6.6-fold, while resistance to methamidophos was observed in four populations with resistance ratios ranging from 2.6- to 4.2-fold. The long period and high frequency of use of these insecticides against this insect-pest suggest that the evolution of insecticide resistance on them has been relatively slow. Alternatively, the phenomenon might be widespread among Brazilian populations of T. absoluta making the finding of suitable standard susceptible populations difficult and leading to an underestimation of the insecticide resistance levels in this pest. Higher levels of resistance to abamectin, cartap, and permethrin are correlated with greater use of these compounds by growers. This finding suggests that local variation in insecticide use was an important cause of variation in susceptibility.

Index terms: Tomato leafminer, abamectin, cartap, methamidophos, permethrin.

[1404] INSECTICIDAL ACTIVITY AND MOLECULAR TARGETS OF LEGUME LECTINS ON THE PEA APHID, ACYRTHOSIPHON PISUM

F. A. M. Sousa¹², G. Duport¹, T.B. Grangeiro², Y. Rahbé¹ & B. S. Cavada², ¹Biologie Fonctionnelle, Insectes et Interactions - UMR INRA/INSA de Lyon, INSA Bäliment 406, 69621 Villeurbanne cedex, France ; ²Dept. de Bioquímica, Univ. Federal do Ceará, Caixa Postal 6033, CEP 60.451-970, Fortaleza, Brasil. This work was supported by a CAPES-COFECUB project (261/98).

In recent years, the insecticidal activity of plant lectins against many insect species, including those in Coleoptera and Homoptera, has been widely reported. Together with advances in transgenic technology and the availability of lectin genes, genetically modified plants are becoming increasingly common in human food products. The mechanism of lectin toxicity seems to be mediated by lectin binding to glycoprotein receptors in the insect midgut epithelium or in the peritrophic matrix. However, little is known about the subcellular and molecular effects of plant lectins on insect physiological systems and their specific molecular targets. In order to study the effects of leguminous lectins on the pea aphid, in vitro toxicity tests against larvae were carried out using ten lectins from the Diocleinae subtribe. This subtribe comprises a group of homologous lectins with mannose/glucose specificity. Statistical comparisons of mortality and growth inhibition curves showed that all the lectins tested exerted concentration-dependent toxic effects on the normal development of the insect. Canavalia brasiliensis (Con Br), *C.bonariensis*, *C.sp.aff.bolivianna*, *Dioclea rostrata* and *D.virgata* lectins were among the more toxic, decreasing the weight of the adult aphid by 50 % at doses between 99 and 122 μ g/ml. Lectin Blot analysis with biotin-labeled Con Br, *Cratylia floribunda* and *D.violacea* lectins were performed on solubilized-protein extracts from the aphid digestive-tube: while all these lectins were shown to share with Con A and GNA many common membrane-protein targets, their binding affinities varied significantly. In order to isolate and characterize a common "receptor" for the Diocleinae subtribe, possibly involved in their toxic mechanism, Con Br-agarose affinity chromatography and other biochemical techniques were performed. Index terms: Lectin, toxicity, Con Br, midgut

[1403] SIGNIFICANCE OF UPTAKE AND BINDING IN LEPIDOPTERA AND COLEOPTERA ON TOXICITY OF DIBENZOYLHYDRAZINE ECDYSONE AGONISTS

G. Smagghe, B. Carton, A. Heirman, W. Wesemael, I., Decombel & L. Tirry, Lab. Of Agrozoology, Dept. Of Crop Protection, Faculty of Agricultural and Applied Biological Sciences, Ghent Univ., Coupure Links 653, B-9000 Ghent, Belgium.

Dibenzoylhydrazine ecdysone agonists are a new group of insect growth regulators (IGRs) causing specifically premature, lethal larval molting, especially in Lepidoptera and Coleoptera. Toxicity bioassays were performed with four agonists, RH-5849, tebufenozide (RH-5992), methoxyfenozide (RH-2485) and halofenozide (RH-0345) against last-instar larvae of the beet armyworm, Spodoptera exigua (Hubner), the cotton leafworm, Spodoptera littoralis (Boisduval), and the Colorado potato beetle, Leptinotarsa decemlineata (Say). Methoxyfenozide was the most toxic against both caterpillar pests, whereas halofenozide showed the lowest LC_{ss} s in the Colorado potato beetle. Subsequently, uptake and excretion of ["C]labeled compound were studied after ingestion together with the distribution pattern in the insect body. In addition, the activity of the ecdysone agonists in terms of their potency to induce evagination in cultured imaginal discs and to bind the target receptors in whole discs in competition with [3H]labeled ponasterone A as compared to the natural molting hormone 20-hydroxyecdysone, was determined. The results obtained discuss the pharmacokinetics and dynamics for binding in relation to the toxicity, especially the difference between both insect orders, for this new group of IGRs.

Index terms: Spodoptera exigua, Spodoptera littoralis, Leptinotarsa decemlineata

[1405] BIOCHEMICAL MECHANISMS OF RESISTANCE IN TETRANYCHUS URTICAE

N. Stumpf & R. Nauen, Bayer AG, Agrochemicals Division, Research Insecticides, D-51368 Leverkusen, Germany, E-mail: ralf.nauen.rn@bayer-ag.de

The two-spotted spider mite, Tetranychus urticae (Acarina: Tetranychidae), is a worldwide pest of a vast range of crop and ornamental plants. T. urticae has developed resistance to numerous acaricidal compounds, but due to its small size the underlying biochemical mechanisms conferring resistance are difficult to study in detail. investigated the toxicology of several acaricides with different modes of action on different developmental stages of several laboratory and field strains of T. urticae. The efficacy of these acaricides on laboratory selected and field strains was compared to a strain supposed to be susceptible to organophosphates and all other chemical groups of commercial acaricides. Biochemical mechanisms of resistance investigated include insensitive acetylcholinesterase, glutathione S-transferase, esterases and cytochrome P-450-dependent reactions. Virtually all field derived strains of T. urticae seem to be resistant to organophosphate insecticides. Therefore acetylcholinesterase polymorphism has been studies in detail in individual spider mite equivalents using a microtiter plate bioassay and fluorescence detection.

Index terms: acaricides, spider mites, acetylcholinesterase

[1406] NEEM DERIVATIVES AGAINST CRAWLERS AND ADULT COCCIDS

S. Suresh, K.Kumar, K.Geetha, Department of Agricultural Entomology, Tamilnadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India.

Many of the insecticides recommended for the control of coccids were also found to be toxic to natural enemies. To over come this a serious of plant derivatives were tested against the crawlers and adult females of Saissetia oleae, Pulvinaria psidii, Ferrisia virgata and Planococcus citri both in the field and in the lab. In the field the insecticides were srayed @ Imil/litre and plant derivatives @1&2%. Pre and post treatment counts were taken on the number of live and dead insects in ten randomly selected trees (5flushes from each) 1,3 and 7days after treatment and arrived at a percentage. In the lab, a leaf /stem disc of 5cm diamater was taken and dipped in the respective concentrations of plant derivatives and standard insecticides for a minute and shade dried and then placed in petriplates with moistened filter paper in three replications. Observations on the mortality of coccids were made similar to field treatment. Results indicated that, Tamil Nadu Agricultural University (TNAU) neem formulations viz., TNAU NO(A) 60EC @ 2%,TNAU NO(C) 2%,TNAU NOPO (C)2% were equally effective in reducing the F. virgata , P. citri,S. oleae and P. psidii population within three days resulting in 90 per cent control 7 days after treatment as that of Neem oil 2%, Fish Oil Rosin Soap 20 & 25g/l and other organic insecticides

Index terms: Ferrisia virgata, Saissetia oleae, Planococcus, citri and Pulvinaria .psidii.

[1408] EFFICIENCY OF INSECTICIDES TO STERNECHUS SUBSIGNATUS ON SOYBEAN

G. L. Tonet, Embrapa – National Wheat Research Center, BR 285, km 174, 99001-970 Passo Fundo, RS, Brazil. E-mail: gabriela@ cnpt.embrapa.br.

Since 1973, Sternechus subsignatus (Col., Curculionidae) was found as a secondary pest on soybean in the State of Rio Grande do Sul, southern Brazil. The increase in extensively cropped areas and the monoculture system, together with no-tillage practices, benefited the insect population. Nowadays it reached the status of major pest. It is an insect that causes damages on seedlings and young soybean plants and moves to different cropping areas searching for host plants to feed on. Damages are caused both by adults and larvae. The adults feed on the branches, surrounding them with scares and scratches, frequently killing the plants, and larvae penetrate the branches. Population of the pest can be reduced by alternative hosts sprayed with insecticides on the border of the main cropping areas. Aiming to test new efficient insecticides to control the pest, an experiment was done at Embrapa-National Wheat Research Center, in Coxilha, RS, Brazil, in a farmer site in 1998/1999 crop season. Three doses of the insecticide thiamethoxam and two doses of thiamethoxam + profenophos were compared with one dose of metamidophos and one of The results showed that thiamethoxam 5 g a.i./ha and thiamethoxam + deltamethrin. profenophos 144 g a.i./ha were the most efficient treatments up to 8 days after treatment, with 84.2 % and 89.5 % of adult control, respectively, although there was no significant statistical difference from the other insecticides and doses tested, which reached up to 80 % of minimum level accepted. Reduction of the insect population resulted in lower number of damaged plants to 36.2 % and 35.2 %, respectively. The test plots showed a rate of 96.9 % damaged soybean plants, eight days after treatment. It is concluded that only thiamethoxam + profenophos showed a control rate higher than 80.0 %, at 11 days after treatment, and no insecticide dose tested reached that rate of control 17 days after treatment.

Index terms: Chemical control, thiamethoxam, metamidophos, deltamethrin, soybean pest

[1407] PERFORMANCE OF THE MICROENCAPSULATED FORMULATION OF LAMBDA-CYHALOTIIRIN FOR THE CONTROL OF THE WHITEFLY, BEMISIA TABACI (BIOTYPE B) (HEMIPTERA: ALEYRODIDAE), IN BEANS

G. V. Tomquelski, F. J. Celoto' & G. Papa', 'Dept. of Biology, Univ. Estadual Paulista, Av. Brasil 56, Zip 15.385-000 - Ilha Solteira/SP, Brazil, E-mail: gpapa@bio.feis.unesp.br

In Brazil, the problems with the new strain of whitefly began in 1991 when high infestations in beans, cotton and soybeans crop occurred, as well in cucurbitaceae and solanaceae. The increasing search for safer alternatives for pests control, which are less aggressive for the environment, has brought a significant development of new insecticide formulations, with possibilities of use in agricultural pest management and contributing to a safer and more efficient way of pest control. The objective of this work was to evaluate the performance of the microencapsulated formulation of lambda-cyhalothrin, at weekly applications and alternated with parathion methyl, for the control of one of the main beans pests in Brazil, B. tabaci. The experiment was established under field conditions, in Ilha Solteira/SP/Brazil, using the cultivar carioca. The design was of randomized blocks, with 14 treatments and 4 replicates. Each plot consisted of 10 rows of the crop, each row 10m long, and spaced 1m among each other, with a total of 50m². Four spray operations were conducted for each treatment, at 7-day intervals, using a knapsack sprayer at the volume of 200 L/ha. Spray operations were initiated as a preventive treatment. The treatments consisted of a microencapsulated formulation of lambda-cyhalothrin at the concentrations of 5 and 25% (Karate Zeon) and lambda-cyhalothrin as an emulsifiable concentrate formulation (Karate 50 CE), at the doses of 10, 20 and 30g a.i./ha, applied as a sequential treatment each 7 days and as alternate applications with parathion methyl (Tamaron BR), at the doses of 10 g a.i./ha of lambda-cyhalothrin and 750 g a.i./ha of parathion methyl and control. Evaluations were conducted 7 days after each application, by counting the number of ninphs and adults whitefly in 30 leaves per plot. To count the ninphs, the leaves were taken to the laboratory and the counts were conducted with an stereoscopy microscopy. The counts of adults were conducted in the field, during the first hours of the morning because at this time the flies do not use to fly, which makes counting easier. Results showed that all formulations and concentrations of lambda-cyhalothrin were efficient for the control of whitefly at the dose of 30g a.i./ha and at the dose of 10 g a.i./ha, in alternate applications with parathion methyl, at the dose of 750 g a.i./ha. Index terms: chemical control, pyrethroid, organophosphate

[1409] DELTAMETHRIN RESIDUES ON/INCORN AND POPCORN GRAINS AND IN SOME OF THEIR PROCESSED PRODUCTS DETERMINED BY GAS CHROMATOGRAPHY

L.R.P. Trevizan¹, <u>G.C. de Baptista</u>¹ & O. Bahia Filho¹, ¹ Departamento de Entomologia, Fitopatologia e Zoologia Agrícola, ESALQ/USP, Av. Pádua Dias, 11, 13418-900 Piracicaba, SP Brazil, E-mail gcbaptis@carpa.ciagri.usp.br.

This study had the objective of evaluating the degradation/persistence of the residues of the pyrethroid insecticide deltamethrin on/in corn and popcorn grains and in some of their processed products, such as: corn: grain, wranjica", "farelinho" and "biju" (corn flour); popcorn: grain and popcorn. The grains were treated with the recommended dose of 0.35 mg . kg^d (ppm) of a.i. deltamethrin for the control of the lesser grain borer (*Rhyzopertha dominica*) and weevils (*Sitophilus* spp.), with the use of K-Obiol 25 CE (25 g deltamethrin + 250 g PBO/L) commercial product, with three replicates. Samples were taken at zero, 15, 30, 60 and 90 days after treatment. The analytical method consisted of extraction of residues with a mixture of hexane + ethyl ether (1/1, v/v), clean-up by partition with acetonitrile/hexane and silica gel column chromatography eluted with a mixture of hexane + ethyl ether (9/1, v/v). Quantitative measurements were made by gas chromatography, equipped with an electron capture detector (μ - ECD, Ni⁴⁵). A total of 210 samples (60 grains and 150 processed products) was analyzed. The limits of the method quantitation were different for the various matrices ranging from 0.01 mg . kg⁻¹ to 0.05 mg . kg⁻¹. Deltamethrin residues were persistent and stable in both kind of grains during the entire storage period (90 days). In corn processed products they remained mostly in the bran (3.5 times higher than in grain); very low residues were found in the endosperm, from which "canjica", "farelinho" and "biju" are obtained; popcorn has a trend of residue concentration 50% higher than in grain).

Index terms: Rhyzopertha dominica, Sitophilus spp., lesser grain borer, weevil

[1410] PULVERIZATIONS WITH THIAMETHOXAM TO CONTROL ADULTS OF *DIABROTICA SPECIOSA* ON SMALL POTATO CROP

M.A. Valério¹, <u>I.C. Martins¹</u>, M. Nishimura³, ¹Fundação Faculdade de Agronomia "Luiz Meneghel", P.O. Box 261, Area Code 86360-000 – Bandeirantes – Paraná – Brazil, E-mail jcelso@ffalm.br; ²Novartis Biociências – São Paulo – São Paulo – Brazil.

Although small potato its not large cultivated, it has important place among agricultural regions in Brazil, sheltering pests as *Diabrotica speciosa* (Coleoptera – Crysomelidae) doing high economical losts. This trial was conducted in Guarapuava City – Paraaf State, during summer crop 98/99, with the purpose to check efficiency and agronomical use of thiamethoxam as insecticide, applied by pulverization, in order to control adults of *D. speciosa* on small potato crop, Atlantic cultivar. It were used following treatments and doses in g a.i./ha: thiamethoxam (Actara 25 WG – 10, 12,5 and 15); deltamethrin (Decis 25 CE – 8); methamidophos (Tamaron BR – 480) and control (with no insecticide). Experimental design was randomized blocks with 6 treatments and 4 replications, using Tukey's test for medium comparing and Abbott's formula to obtain efficiency percentage. For both insecticides applications it was used, with an interval of 7 days, a back manual sprayer with constant pression of 4,1 Bar, equiped with a plain jet 11002 and 200 l/ha of volume. At evaluations, doing at 7 d.a.a.¹ and 7 d.a.a.² it were taken 25 randomized leaves/plot and counting found perforations number done by the insect. Higher doses of thiamethoxam were very efficient, given more than 80% to control adults of *D. speciosa* at all evaluations.

Index terms: Diabrotica speciosa, chemical control, small potato.é

[1411] INSECTICIDE THIAMETHOXAM USED ON DIFFERENT FORMULATIONS TO CONTROL MYZUS PERSICAE ON SMALL POTATO CROP

M.A. Valério'; <u>J.C. Martins'</u> & G. Nakamura', 'Fundação Faculdade de Agronomia "Luiz Meneghel", P.O. Box 261, Area Code 86360-000 – Bandeirantes – Paraná – Brazil, E-mail jcelso@ffalm.br; 'Novartis Biociências – São Paulo – São Paulo – Brazil.

Aphids are responsable for economical damages on small potato crop, due by transmission of virotical diseases. This trial was conducted in Guarapuava City, Paraná State, during summer crop 98/99. With the purpose to check efficiency and agnomical use of thiamethoxam, on different formulations, applied on different periods, in order to control Myzus persicae on small potato crop, Monalisa cultivar, it were used following treatments and doses at g a.i./ha: thiamethoxam (Actara 25 WG – 150 – 200); thiamethoxam (Actara 10 G – 150 – 200); phorate and aldicarb (Granutox 5 G – 2000 and Temik 15 G – 2025); thiamethoxam (Actara 25 WG – 150 and Actara 25 WG – 150 and Actara 10 G – 150 and Actara 25 WG – 200) and control (with no insecticide). The experimental design was randomized blocks with 6 treatments and 4 replications, using Tukey's test for medium comparing and Abbott's formula to obtain efficiency percentage. Liquid insecticides were applied on planting furrow and on plants before heaping at treatments 1, 2 and 5 with a back sprayer equiped with a 11002 nozzle, pression of 4,1 Bar and 200 *l*/ha diveloume. Granulated insecticides were handly applied on treatments 2, 3, 4 and 5 on planting furrow and at soil, besides plants before heaping. At evaluations, at 15, 30 and 45 d.a.e., it was taken a single randomized leaf on 20 randomized plants/plot and counting alive found aphids. Insecticide thiamethoxam 25 WG applied on pulverization, was the most efficient, upper than 80% at all evaluations on aphids control. Index terms: *Myzus persicae*, chemical insecticides, small potato.

[1412] THE EFFECT OF AQUEOUS EXTRACT OF AZADIRACHTA INDICA LEAVES ON THE CONTROL OF SPODOPTERA FRUGIPERDA FED WITH CORN LEAVES

P. A. Viana¹, H. T. Prates¹, I. Cruz¹ & J. M. Waquil¹, ¹Embrapa Milho e Sorgo, Caixa Postal 151, Sete Lagoas, MG 35701-970, Brazil, E-mail: pviana@cnpms.embrapa.br.

The fall armyworm, Spodoptera frugiperda is considered one of the most important corn pests. The control of this insect has been accomplished with synthetic insecticides, generally of high cost and with unknown molecules for the farmers, increasing the risks of toxicity and environmental contamination. The use of plant extracts may reduce the use of synthetic insecticides. The neem plant (Azadirachta indica) has shown insecticide activity for several species of insects. Aqueous extract of neem leaves was evaluated for its insectidal action against newly hatched S. frugiperda larvae. Corn leaves were submerged in this extract (10.000 μ g mL⁻¹) in laboratory or sprayed in the field with a CO, sprayer (80.03 flat nozzle, 40 p.s.i.) and placed in 50 ml plastic cups with 25 larvae each. The corn leaves were changed every other day. Twenty-five cups were used for each treatment. One group of larvae placed into the cups was sprayed with the extract and other group was not sprayed. The control treatments were made of corn leaves without the neem extract and infested with larvae not sprayed. Three and ten days after the beginning of the experiment, the number of live larvae was evaluated in each cup. At the 12th day, the effect of the extract was evaluated on the development of the live larvae (larva length, weight and width of the head capsule). There was low control efficiency, varying from 6.2 to 13.9%, three days after the application of the neem extract. At ten days the control efficiency varied from 12.6 to 94.4%, where the submerged leaves and larvae sprayed with the extract had 94,4% control, submerged larvae and larvae without spraying had 87,3% control, leaves and larvae sprayed had 32,2% control, and leaves without extract and larvae not sprayed had 12,6% control. The larvae fed on leaves submerged in the extract of neem stopped feeding after the first food change, causing the death of the larvae. The surviving larvae suffered a strong negative effect on its development. Larvae fed with leaves submerged in the extract were 5,8 mm long, weighed 5,0 mg and had a head capsule width of 0,9 mm, whereas the larvae in the check treatment were 24,6 mm long, weighed 205,0 mg and had a head capsule width of 2,5 mm. It was observed that the spraying on the larvae did not show efficiency in controlling the larva and the uniform covering of the leaf with the extract was an essential condition for the effectiveness of control.

Index terms: fall armyworm, neem, natural insecticide, insecta, Zea mays

[1413] RECLAMAL[†] N OF SELENIUM-CONTAMINATED SITES: RESPONSE OF SPODOPTERA EXIGUA (LEPIDOPTERA: NOCTUIDAE) TO CONTAMINATED ALFALFA AND ATRIPLEX PLANTS

D. B. Vickerman & J. T. Trumble, Department of Entomology, University of California, Riverside, CA 92521, USA.

Selenium (Se) is a significant pollutant associated with irrigation in nearly every Pacific Rim country. Many organisms have been severely affected, including fish, birds, and The primary effect appears to be the replacement of sulfur with selenium in mammals. amino acids resulting in nonfunctional proteins and enzymes. Very little information is known about the impact of selenium on insects, or how insects might affect biomagnification and remediation of selenium. Alfalfa, Medicago sativa, and several Atriplex spp. have been proposed as suitable plants for reclamation of selenium-contaminated sites. Our previous studies using artificial diet demonstrated form and concentration of selenium (Se) significantly influence development and survival of Spodoptera exigua (Lepidoptera: Noctuidae) in no-choice tests. Choice tests demonstrated a preference for control diet over sodium selenate treatments and sodium selenite treatments, but no preference between selenocystine or selenomethionine and untreated controls. Since all forms of selenium tested are toxic to these insects, this differential detection has the potential to affect both the distribution and diversity of terrestrial herbivores in both agricultural and natural systems. Both feeding and oviposition preferences will be critical to the use of plants in reclamation. For nearby growers, there may be a tradeoff; these plants can become a potential winter harborage for the important pest, or a 'sink' in which oviposition occurs, but development is inhibited. Development, survival and behavioral response of S. exigua to Se treated plants will be discussed.

Index terms: sodium selenate, Medicago sativa, biomagnification

[1414] THIACLOPRID - FIRST EXPERIENCES WITH THE NOVEL INSECTICIDE IN BRAZIL

I.Wetcholowsky 1, J.A.Geraldes 2, P.Calegaro 2, J.Kühnhold 1, 1 BAYER AG, PF-E-BE, Landwirtschaftszentrum Monheim, Geb. 6100, 40789 Monheim, Germany, Email Ingo Wetcholowsky.IWI@bayer-ag.de; 2 BAYER S.A., Proteção das Plantas, Rua Domingos Jorge, 1100; B. Socorro, 04779-900, São Paulo, S.P., Brazil, Email Jose.Geraldes.JG@bayer.com.br

The novel insectide Thiacloprid, launched in Brazil under the commercial name "Calypso", belongs to the chemical group of the Chloronicotinyls. Due to its properties it shows an unique activity. Its action is based on an interference with the transmission of impulses in the nerve system of insects. The product's effect is due to a disorder of the nervous system and, as a consequence, in death of the treated insects. On account on this mechanism of action, it is effective against strains of pests which are resistant to conventional products. Thiacloprid acts as an acute contact and stomach poison. The systemic activity is excellent which is combined at comparable low rates of application. Thiacloprid has a broad spectrum of activity, particularily against sucking insects, but also some species of coleoptera and lepidoptera. The product is safe on bees and many beneficial insects and therefore fits well into the IPM-concept. At present Thiacloprid has registrations in 14 different crops in Brazil. With rates between 48 and 96 g/ha a.i. it performs excellent against aphids, whiteflies, bugs and some coleoptera. In several years of trials with various formulations in numerous crops, Thiacloprid showed excellent crop compatibility.

Index terms: Thiacloprid, Calypso, Chloronicotinyl, Aphids, Thrips, Bugs, Coleoptera, Lepidoptera, IPM

[1416] COMPARISON OF ROTENONE CONTENT AND INSECT BIOACTIVITY BETWEEN ROOTS AND CALLUS CULTURES OF DERRIS ELLIPTICA

X. N. Zeng¹, J. T. Coll², J. J. Xie¹, X. Q. Liu¹ & F. D. Camps², ¹Lab. of Insect Toxicology, South China Agric. Univ., Guangzhou 510642, P. R. China; ²Inst. for Chemical and Environmental Research of Barcelona, CSIC, Barcelona 08034, Spain. The financial support from The National Natural Sciences Foundation of China (No: 29672001) and The Natural Sciences Foundation of Guangdong Province (No: 970027) to the present research is greatly acknowledged.

The rotenone content and insect bioactivity between roots and callus cultures of D. elliptica were compared in the laboratory. Root samples (<0.8mm in diameter) were collected from fields and the callus cultures were obtained by sub-cultivation of callus initially induced from leaves on revised MS media (Zeng et al. 1998). Samples were extracted twice with 10 times (V/W) 9:1 CHCL/MeOH for 24 h. under room temperature, purified by gradient filtration of the C-18 reversed-phase column and analyzed by HPLC using 70:30 MeOH/H₂O as mobile phase. The results showed that the roots and callus contained 2721.1 and 559.7 μ g/g rotenone, respectively. Bioassays of acetone extracts were conducted against cabbage worm, *Pieris rapea*. At the same rate of rotenone might play some role in the bioactivity. However, no significant difference can be seen between the bioactivity of roots and callus. All samples did not show repellence of egg deposition. Index Terms: botanical insecticide, *Pieris rapea*, bioassay

[1415] INFLUENCE OF SPINOSAD ON SOME HYMENOPTEROUS NATURAL ENEMIES OF AVOCADO, CITRUS AND OTHER ORCHARD PESTS

<u>M. Wysoki</u>, S. Rene, M. Eliahu & D. Blumberg, Dept. of Entomology, Institute of Plant Protection, ARO, The Volcani Center, Bet Dagan, 50250 Israel; e -mail: manesw@netvision.net.il

Spinosad under the trade name Tracer® a mixture of spinosyn A & D, produced by Saccharopolyspora spinosa (Actinomycetes), is used in Israel against the recently introduced orchid thrips, Chaetanaphothrips orchidii (Moulton)(Thysanoptera :Thripidae). Since many parasitoids of citrus and avocado pests where introduced and well established in Israel, influence of this product on some of the local and introduced natural enemies was evaluated. Two concentrations of the commercial product: 0.02 % (the recommended) and 0.01% were tested in laboratory trials and in preliminary field trials. Trials were performed on the influence of Spinosad on natural enemies, of pseudococcid citrus pests: Anagyrus pseudococci Girault and Leptomastix dactylopii (Howard)(Hymenoptera : Encyrtidae), a parasitoids of citrus mealybug, Planococcus citri (Risso); L. algirica Triapitzin (Hymenoptera : Encyrtidae), a parasitoid of citriculus mealybug, Pseudococcus Cryptus Hempel and on Thripobius semiluteus Boucek (Hymenoptera: Eulophidae), a well established parasitoid successfully controlling the greenhouse thrips, Heliothrips haemorrhoidalis (Bouche') (Thysanoptera :Thripidae) and on Metaphycus stanleyi Compere (Hymenoptera: Encyrtidae) the most abundant parasitoid of the pyriform scale, Protopulvinaria pyriformis Cockerell (Homoptera: Coccidae). Additionally was evaluated the influence on Mastrus ridibundus (Gravenhorst) (Hymenoptera: Ichneumonidae) a parasitoid of an apple pest, the codling moth, Carpocapsa pomonella (L.)(Lepidoptera: Tortricidae). This product shows detrimental influence on hymenopterous parasitoid is both concentrations in laboratory trials and long persistence in preliminary field trials.

[1417] TRITROPHIC IMPACT OF HOST PLANT RESISTANCE - SOME POTENTIAL PITFALLS FOR GENETICALLY MODIFIED CROPS

H. F. van Emden, Dept. of Agriculture, Univ. of Reading, Earley Gate, Reading. RG6 6AT, UK, E-mail h.f.vanemden@reading.ac.uk

Of the various ways in which plants can influence the natural enemies of herbivorous insects, three are relevant to pest resistant crop varieties, whether produced by conventional or transgenic methods. One relates to the responses of beneficial insects, particularly parasitoids, to volatiles from the host plant. There may be problems if the odour of a new variety is greatly different from that of other widely grown varieties of the crop. Secondly, if toxic allelochemicals are the basis of the pest resistance, there is the potential for mortality or sterility of natural enemies. The transfer to a crop variety of a single insect-toxic allelochemical is exactly the approach used in genetic modification (GM). This is in contrast to more broadly-based plant resistance, which often shows valuable synergism with biological control. Explanations of this synergism (which may be crop-specific or very generally applicable) do not involve the presence of allelochemicals. Thirdly, host plant resistance can effect the susceptibility of the pest to insecticide, and through this the differential mortality of pests as compared with their natural enemies. The smaller, stressed pests on resistant varieties are usually more susceptible to insecticide. The reduced dose then possible is increasingly selective to the degree that natural enemies do not, or at least to a lesser extent, show a similar shift in susceptibility. There are even cases where natural enemies become more tolerant of insecticide on pest-resistant varieties. However, pests may also become more resistant to pesticide where there is an allelochemical basis of a plant resistance. Allelochemicals in plants can raise the level of detoxifying enzymes in pests and reduce their mortality when insecticides are applied. Such induced tolerance to insecticides can be expected with GM crops as well as with conventionally-bred varieties with enhanced levels of secondary compounds. Just as natural enemies have a zero or lower shift than pests to greater susceptibility on many resistant varieties, so they are unlikely to show a shift towards pesticide-tolerance when the resistance is allelochemically based. With raised concentrations of insecticide then required against the pests, damage to biological control will increase. These three interactions between plant resistance and the third trophic level make a comparison with conventionally-bred pest-resistant varieties unfavourable for GM crops. However, host plant resistance is not often the technology for controlling pests that GM is designed to replace; much more usually it is use of insecticides. Then GM crops compare very favourably.

Index terms: Allelochemicals, biological control, insecticides.

[1418] TRANSGENIC INSECT RESISTANT PLANTS AND NATURAL ENEMIES

T. H. Schuler, Dept. of Entomology & Nematology, IACR-Rothamsted, Harpenden, AL5 2JQ, UK, E-mail Tanja, Schuler@bbsrc.ac.uk.

All currently commercialized insect resistant transgenic plants express δ -endotoxin genes from Bacillus thuringiensis (Bt). Parasitoids and predators are important natural enemies of pest insects and potential side effects of Bt plants on these beneficial insects are being studied. Direct negative effects of Bt crops have so far only been observed with one predatory insect but Bt plants will have indirect (or host-mediated) effects on both groups of natural enemies when compared to unsprayed crops. Current commercial Bt crops will cause host depletion for natural enemies specializing in highly susceptible target pests since the Bt crops cause close to 100% mortality of first instar larvae of such pests (e.g. European cornborer, Colorado potato beetle). Local survival of populations of specialists natural enemies will depend on the availability of other suitable food plants for their hosts, either weeds or other crops, in the vicinity of the Bt crop. In addition to target pests, crops also support other herbivores (the non-target pests) which are not susceptible to the Bt toxins or only susceptible to a limited degree. The supply of hosts for more generalist natural enemies will therefore be less dramatically reduced. The farming system and the general crop management, by controlling the presence of alternative food plants, will strongly influence the presence and size of natural enemy populations. However, the side effects of Bt plants have to be seen in context. Current conventional farming relies largely on broad spectrum insecticides for pest control which not only reduce host availability to parasitoids and predators but in addition indiscriminately kill the natural enemies of both target and non-target herbivores via direct contact activity. Bt plants should be used as a component within Integrated Pest Management (IPM) programmes which take into account beneficial insects. Natural enemies present useful tools to control non-target pests in crops and potentially can also assist with delaying the buildup of resistant pest populations. There is a strong case to be made for managing Bt crops as to encourage natural enemy populations if the promise that Bt crops will result in a long term reduction in insecticide use is to be realized.

Index terms: Bacillus thuringiensis, Bt crops, environmental risk assessment, parasitoids, predators

[1419] PLANTS KNOW HOW TO BE SWEET: PATTERNS OF EXTRAFLORAL NECTAR PRODUCTION OPTIMIZE INDIRECT DEFENSE

F. L. Wäckers, Dept. of Entomology, PO Box 8031, 6700 EH Wageningen, the Netherlands. NIOO CTO, PO Box 40, 6666 ZG Heteren, the Netherlands. E-mail: waeckers@cto.nioo.knaw.nl.

Extrafloral nectaries are commonly found in a broad range of plant taxa. Rather than serving a role in pollination, these nectaries are believed to represent a type of indirect plant defense. It is believed that the secretion of extrafloral nectar enables plants to attract and retain predaceous insects (e.g. ants and parasitoids), which in turn can guard the plant against herbivore attacks. Here I will test this putative defensive function, by addressing whether the temporal and spatial distribution of extrafloral nectar production fits predictions from the optimal defense theory. Patterns of extrafloral nectar production in castor (*Ricinus communis*), cotton (*Gossypium herbaceum*), and faba bean (*Vicia faba*) are compared. It could be demonstrated that extrafloral nectar production can be both constitutive, and inducible. The mechanism of induction was elucidated and it will be discussed how this mechanism differs from induction mechanisms known from other plant defenses. Finally, the effect of nectar distribution on ant recruitment is elucidated. Index terms: *Gossypium herbaceum*, induction, *Spodoptera littoralis*, sugar, ant

[1420] PLANTS CRY FOR HELP: DO PLANT BREEDERS AND BIOCONTROL COMPANIES LISTEN?

Marcel Dicke, Olga Krips & Conny Schütte, Lab. of Entomology, Wageningen Univ., P.O. Box 8031, NL-6700 EH Wageningen, The Netherlands. E-mail: marcel.dicke@users.ento.wag-ur.nl.

Host-plant resistance and biological control are highly valuable components of environmentfriendly pest control. However, these two components are not a priori compatible. The biological control agents are active on the plant and are thus affected by a wide range of plant traits that can influence their effectiveness either directly or through interactions with the pest organism. In order to develop an integrated pest management program that incorporates both methods of pest control, we should consider how the crop affects the beneficial organisms. Ideally we should incorporate the impact of plants on beneficial organisms both in selection procedures that select for the best plant cultivar for agriculture and in selection procedures that select for beneficial organisms that are most suitable for biological control of pest organisms. This will be illustrated with the example of herbivore-induced plant volatiles. These chemicals are produced by plants in response to herbivory and attract carnivorous enemies of the herbivores and may be considered a chemical 'cry for help'. This plant trait has never been selected for during plant breeding. Yet, it is still present in a large number of crop species, although it may be that the trait is more pronounced in wild relatives. In this presentation I will show how plant breeders can select for crops that have maximal attraction of biocontrol agents and how biocontrol practitioners need to consider intraspecific variation in the ability of the biocontrol agent to respond to the volatiles. An integrated approach should increase the options for environmentally-friendly pest control.

Index: resistance, predators, parasitoids, tritrophic interactions, infochemicals

Session 08 - ENTOMOPHAGOUS INSECTS AND BIOLOGICAL CONTROL

[1421] APHID-INDUCED PLANT VOLATILES INFLUENCING PARASITOID BEHAVIOUR

<u>G. M. Poppy</u>¹ W. Powell¹, E. Guerrieri² & F. Pennacchio³, ¹Dept Entomology & Nematology, IACR Rothamsted, Harpenden, AL5 2JQ, UK, Email: poppy@bbsrc.ac.uk; ²Centro CNR per lo Studio delle Tecniche di Lotta Biologica (CETELOBI), via Iuniversita, 100, 80055 Portici (NA), Italy; ³Dipartimento di Biologia, Difesa e Biotecnologie Agro_Forestali, Universita della Basilicata, via N. Sauro, 85, 85100, Potenza, Italy.

The braconid, Aphidius ervi, is an endophagous parasitoid of several aphid species of economic importance, and is a commercially available biological control agent. Research in our labs has focussed on the chemical and behavioural ecology of this important species in a model tritrophic system involving Vicia faba and Acyrthosiphon pisum. In a windtunnel we have shown that females undertake in-flight orientation towards bean plants, Vicia faba, infested with their host aphid Acyrthosiphon pisum. This response to a plant produced "signal" is induced systemically throughout the plant. We have also demonstrated a relationship between the attractiveness of infested plants and the number of aphids feeding, and the duration of the aphid infestation. The parasitoid can also differentiate between plants infested with A. pisum and plants infested with the non-host Aphis fabae. The lack of response to plants infested with A. fabae, may be due to a missing or different component in the "signal" or changes in the ratio of components. This talk will focus on recent developments in our understanding of aphid-induced plant signals. Current research involves attempts to elucidate the mechanisms of the production of the signal within the plant and the role of aphid feeding and/or saliva in this process. We have also expanded our studies into a glasshouse so as to add more spatial complexity to our bioassays. These experiments involve placing "baited" plants in a complex matrix of uninfested plants. Both "baited" plants are infested with a cohort of 50 A. pisum coming from the same clone. However, one of these plants has previously been infested for 72 hours by hundreds of aphids (removed just before the new infestation), whereas the other plant has never been previously infested with aphids. Thus the only difference between the "baited" plants is their previous history of infestation. Twenty mated parasitoids are released into the glasshouse, and the "baited" plants removed after 24 hours and the numbers of mummies recorded over the next two weeks. These experiments demostrate that female parasitoids utilise plant signals to locate aphids in a more spatially complex environment than a windtunnel and that the duration of the infestation is important is attracting parasitoids to attack aphids.

Index terms: Aphidius ervi, Tritrophic interactions, Plant signalling, Indirect defence

[1422] IS IT FEASIBLE TO INCREASE THE ATTRACTIVENESS OF CROP PLANTS TO PARASITOIDS?

T. Turlings, M. E. Fritzsche, S. Gouinguené, C. Tamò & T. Degen, Inst. of Zoology, Univ. of Neuchâtel, Case Postale 2, CH-2007, Neuchatel, Switzerland, Email: Ted.Turlings@zool.unine.ch

Herbivory causes many plants to emit specific volatiles. Parasitoids use the resulting odour to locate their herbivorous prey. We study ways to exploit this phenomenon in order to increase the attractiveness of crop plants to these beneficial insects. Our model plant is maize, which shows a particularly fast reaction to caterpillar attack. Within hours it emits a blend of volatiles consisting mainly of terpenoids. We have found considerable variation among maize genotypes, both in terms of total amounts and specific compounds that are emitted. This variation allows us to test the potential of "creating" maize varieties that are particularly efficient in attracting parasitoids. A complicating, but fascinating factor is the learning ability of parasitoids, which largely determines their responsiveness to specific odour blends. Results of laboratory and field tests are presented and discussed in the context of breeding crop plants to enhance pest control. Index terms: plant synomones, host location, biological control

ABSTRACT BOOK I – XXI-International Congress of Entomology, Brazil, August 20-26, 2000

[1423] HERBIVORE AND NATURAL ENEMY ASSEMBLAGE STRUCTURE: INFLUENCE ON TRI-TROPHIC INTERACTIONS AND BIOLOGICAL CONTROL

<u>P. Barbosa¹</u> & A. Caldas¹, ¹Dept. of Entomology, Univ. of Maryland, Plant Sciences Bldg., College Park, MD, 20742, USA, E-mail pb5@umail.umd.edu and ac182@umail.umd.edu.

Larval free-feeding macrolepidoptera of two riparian trees Salix nigra (black willow) and Acer negundo (box elder) were sampled and sorted by species and abundance. Both relative and absolute sampling has provided insights into patterns of parasitism, and of abundance, diversity, and persistence of macrolepidopteran species. The species on these two trees constitute two macrolepidopteran assemblages in which one to three species were numerically dominant. Using a theoretical model to describe the abundance distribution of species in an assemblage is an effective tool for both describing these assemblages and allowing comparisons among them. The log-series and the log-normal distributions are among the most common theoretical distributions used in community studies. Theoretically, a log-normal distribution is expected to arise in most natural community studies because it is more likely that multiple factors are determining the distribution of that community or assemblage. A log-series distribution, on the other hand, suggests that one or a few factors determine the abundance distribution To verify the commonness of the log-series distribution among insects, we used 36 sampling datasets of different sizes to generate rank-abundance distribution curves. Our analysis indicated that the assemblages on box elder and black willow were best described by a log-series distribution, reflecting the fact that most species were scarce. To verify the commonness of the log-series distribution among insects, we used 36 sampling datasets of different sizes to generate rank-abundance distribution curves. These analyses suggest that the logseries distribution is widespread among Diptera, Lepidoptera, Coleoptera, and many other invertebrate groups. If indeed, the log-series distribution is widespread it should have a significant influence on the interactions among and between natural enemies and their herbivore prey. The implications of the structure of assemblages of herbivore prey/hosts and their natural enemies on the ecology and evolution of three trophic interactions are discussed. Further, potential outcomes of classical and conservation biological control given the assemblage structures noted above are discussed.

Index terms: Assemblage structure, parasitoids, predators, biological control

[1424] ADDING FLORAL RESOURCES TO AGRO-ECOSYSTEMS: MANAGING THE CONSEQUENCES FOR THIRD AND FOURTH TROPHIC LEVELS

<u>S. D. Wratten¹</u>, G. Gurr², L. Berndt¹ & N. Irvin¹, ¹Ecology & Entomology Group, Soil, Plant & Ecological Sciences Division, P.O. Box 84, Lincoln University, Canterbury, New Zealand: ²Orange Agricultural College, The University of Sydney, PO Box 883, Orange, NSW, Australia 2800.

Current debate in "classical" biological control includes concerns about non-target species being affected by released agents. In "conservation biological control", a similar potential exists for unpredicted and unwanted effects. Many predators and parasitoids, whether introduced as "classical" agents or as part of an existing natural enemy community, require pollen and nectar to enhance fecundity, longevity and general fitness. However, adding certain flowering plants to agro-ecosystems can lead to a suite of negative effects. For example, the targeted pest may feed on or shelter in the added resource. Secondly, other predators and parasitoids may benefit from the resource and this may lead to fourth trophic level effects whereby natural enemies of the targeted biological control agent or of other beneficial species in the system may be advantaged. The dynamics and complexity of these effects need to be understood and managed. Examples will be given of case studies that have begun to unravel the consequences of adding floral diversity to enhance biological control.

[1425] CASE STUDIES - TRITROPHIC ASPECTS OF INTEGRATED PEST MANAGEMENT FOR CRUCIFER PESTS IN THE FIELD

R. H. J. Verkerk & D. J. Wright, Imperial College of Science, Technology & Medicine, Biology Dept., Silwood Park, Ascot, Berkshire SL5 7PY, UK E-mail: d.wright@ic.ac.uk

Can an understanding of the complex and dynamic interactions between plants, insect pests and their natural enemies over the crop cycle provide the basis for robust pest management solutions? For example, host plant resistance is not always compatible with biological control and it can vary with growth stage and environmental conditions. In contrast, laboratory studies have shown that host plant quality or cultivar can have an effect on parasitism success, suggesting that cultivar manipulation could be a way of enhancing parasitism in the field. Using examples of crucifer-pest-natural enemy systems in South East Asia (diamondback moth-parasitoid), the United Kingdom and Kenya (cabbage aphid-syrphid/parasitoid), we consider various interventionist approaches. Field studies on cabbage aphid systems will be used to illustrate why modeling techniques can provide improved understanding of applied tritrophic systems compared with conventional methods of data analysis.

Index terms: Plutella, Myzus, Brevicoryne, biocontrol, resistance

[1427] REARING HYMENOPTEROUS LARVAL PARASITOIDS OF APHIDS ON ARTIFICIAL DIETS

<u>F. Pennacchio¹</u>, **R. Farneti¹**, **M. C. Digilio¹**, **P. Fanti¹** & **M. de Eguileor²**, 1Dipartimento di Biologia, Difesa e Biotecnologie Agro-Forestali, Università della Basilicata, via N. Sauro, 85, 85100 Potenza, Italy, E-mail pennacchio@unibas.it; 2Dipartimento di Biologia Strutturale e Funzionale, Università dell'Insubria, via Dunant, 3, 21100 Varese, Italy.

Aphidiines (Hymenontera, Braconidae) are important biological control agents of aphids. The development of artificial diets to rear these parasitoids in vitro would reduce their production costs and would provide a new tool for studying their physiology outside of the host. Recent research work aimed at defining suitable media for the aphid parasitoid Aphidius ervi Haliday, a model species widely used also for behavioural and physiological studies, will be presented. The media formulated until now, on a simple empirical basis, were unable to support the complete development of the pre-imaginal stages of A. ervi. This failure and the general, even though unsupported, hypothesis that endophagous Hymenoptera may have peculiar nutritional and/or physiological requirements stimulated experimental work in vivo on A. ervi nutritional physiology. The pea aphid, Acyrthosiphon pisum (Harris) (Hemiptera, Aphididae), was used as a model host. Parasitism-induced biochemical changes in the host haemolymph were measured and the associated physiological and molecular regulations investigated. Functional morphology and anatomy of A. ervi larvae were studied to identify the major routes and mechanisms involved in nutrient absorption. Artificial diet refinement was carried out, based on these in vivo observations. The oviposition behaviour and the major cues regulating the egg release in aphid dummies were also considered, in order to develop protocols for continuous in vitro rearing of A. ervi.

Index terms: host regulation, physiological interactions, nutrition, Aphidiinae

[1426] ARTIFICIAL DIETS FOR REARING PREDATORS AND PARASITOIDS OF GREENHOUSE PEST INSECTS

<u>S. Grenier</u>¹, P. De Clercq², A. Ferran³, F. Pennacchio⁴, C. Castañe⁵ & F. Kabiri⁴, ¹Labo. Biologie Appliquée, UA INRA 203, INSA Bât. 406, 20 av. Einstein, 69621 Villeurbanne France, E-mail sgrenier@jouy.inra.fr; ²Lab. Agrozoology, Dept Crop Protection, Ghent Univ., Coupure Links 653, 9000 Ghent, Belgium; ³Entomologie Lutte Biologique, SPE, INRA BP 2078, 06606 Antibes, France; ⁴Univ. degli Studi della Basilicata, Dipt di Biologia, Difesa e Biotecnologie Agro-Forestali, Via Sauro 85, 85100 Potenza, Italy; ⁵IRTA, Unitat d'Entomologia Aplicada, Carretera de Cabrils, 08348 Cabrils, Spain; ⁶Biotop, Rte de Biot, 06560 Valbonne, France.

In Europe, biological control is fairly developed in greenhouses. Some predators (the coccinellid Harmonia axyridis, and the heteropterans Orius laevigatus and Dicyphus tamaninii) and parasitoids (Aphidius ervi) are important biocontrol agents which are already used in various greenhouse crops against aphids, aleyrodids, and thrips. Efforts to shorten the production line have been performed by using alternative hosts/prey or artificial diets, but in many cases empirically established artificial diets, if any, are not suited for good quality production of entomophagous insects. Researches were developed to try to define artificial diets for the in vitro production of these natural enemies, based on an analytical and rational approach. The final objectives are different according to the species. We can expect, a diet for mass production for H. axyridis, diets that support the whole life cycle for O. laevigatus and D. tamaninii, and basic information for experimental diets for A. ervi. The predators feed on aphids as natural food and can be produced on Ephestia kuehniella eggs as substitution food. In a first step we analyzed the 2 kinds of food (biochemical analyses of the main nutrients, proteins, lipids, carbohydrates) to determine the nutritional needs. *E. kuehniella* eggs as well as young aphids are rich in amino acids (12% of the fresh weight), but E. kuehniella eggs are 3 times richer in lipids than aphids. Some other medium components such as feeding stimulants, consistency agents, preservative agents and other physiological needs will be defined. In a second step, according to available substrates, different diets suited to each species will be formulated partly by computation. Quality of entomophages obtained on newly developed diets or on adjustments of available diets will be compared with that of control entomophages reared on natural food by using different quality parameters, including biochemical, physiological, and behavioral traits. The differences between insects obtained on natural and artificial foods, will allow to further modify and improve the artificial diets. These researches are conducted in the framework and with the support of the European Commission via contract FAIR6 CT98- 4322. Index terms: Harmonia, Orius, Dicyphus, Aphidius, entomophage.

[1428] IN VITRO REARING OF PARASITOIDS IN BRAZIL: AN OVERVIEW

J. R. P. Parra¹, F. L. Cônsoli² & S. R. Magro¹, ¹Dep. Entomol., Fitop. e Zool. Agrícola, ESALQ-USP, 13418-900, Piracicaba-SP, Brasil, E-mail jrpparra@carpa.ciagri.usp.br; ²Dep. Entomology, Texas A&M University, College Station-TX, 77843-2457, USA.

Researches on *in vitro* rearing of parasitoids in Brazil began in the 1990s at the Department of Entomology of ESALQ/USP, in Piracicaba, SP, with species *Trichogramma pretiosum* Riley, 1879 (Hymenoptera: Trichogrammatidae). At the beginning, pupal viability was low and major deformation of adult abdomen and wings were observed with a diet based on Helicoverpa zea hemolymph (40%), egg yolk (40%), milk suspension (20%) and streptomycin (0.02%). Then, diet adjustments to rear T. pretiosum and T. galloi Zucchi were performed, with the latter never being reared under artificial diet. We made progress on rearing of the 2 species, obtaining the viabilities equal to those in countries which dominate the in vitro rearing technology, with 51% and 26%, respectively. The proportion of the components - hemolymph, egg yolk, bovine fetal serum and anticontaminants - is variable and dependable upon the species. Milk was not considered essential and H. zea hemolymph was very suitable for diets of both species. Although with the same size, the same longevity, the same host preference and having no deformation of the reproductive system, the insects produced in vitro were less fecund than those produced in vivo. Quantitative differences of free amino acids in the components of the diets interfere with the biological behavior of *Trichogramma* spp. Studies on chorion, volume of host egg and behavioral characteristics have improved the in vitro rearing techniques. High-density plastic polyethylene films of 7-8 and 9-10 µm thickness were suitable for making artificial eggs and the texture of the egg by the technical process of deformation was efficient to promote parasitization. Artificial 5 mmdiameter eggs and the proportion of 6 parasitoid females per artificial egg were the best combination for in vitro rearing of two species presenting distinct nutritional requirements. However, these proportions vary according to the strain of the Trichogramma. The diets with pupal holotissues of Diatraea saccharalis (65%), egg yolk (18%), bovine fetal serum (8.5%) or yeast extract solution (8.5%) lactalbumin hydrolysate (8.5%) and anticontaminants (0.3%) provided the best development of *T. pretiosum* and *T. galloi*. Adults obtained from this diet presented behavior and biological characteristics similar to the insects reared in vivo. For the past 2 years, the parasitoid Bracon hebetor (Hymenoptera: Braconidae) has been reared under artificial diet set on parafilm, with a diet similar to that used for T. galloi and T. pretiosum. The viabilities were high for the diet mentioned, although lower than those reared on Anagasta kuehniella host. The spinning of cocoons showed some differences among the diets. Index terms: biological control, artificial diets

[1429] WILL ARTIFIAL REARING SYSTEMS CAUSE A REAL BREAKTHROUGH IN BIOLOGICAL CONTROL? NA INDUSTRY VIEWPOINT

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ABSTRACT NOT RECEIVED

[1431] IN VITRO REARING OF TRICHOGRAMMA OSTRINIAE PANG ET CHEN

Shichou Han, Wenhui Liu, <u>Living Li</u>, Qiaoxian Chen & Bingkun Zeng, Guangdong Entomological Institute, Xingang West Road 105, Guangzhou 510260, China. E-mail gzgeii@publicl.guangzhou.gd.cn

Asian corn borer, Ostrinia furnacalis (Guenee), is the main insect pest of corn in China. Trichogramma is used widely for biological control of O. furnacalis in North China with about 0.6 million hectare annually. Usually, T. dendrolimi was the species for mass production and releases. But. laboratory experiments showed that T. ostriniae was more effective than T. dendrolimi for parasitizing the eggs of O. furnacalis. In some provinces, T. ostriniae is the dominant trichogrammatid species in the corn fields. The difficulty in mass rearing T. ostrinias with the eggs of Antheraea pernyi limits its wide use in controlling O. furnacalis. In 1985-1986, some species of Trichogramma, including T. ostriniae, were reared in laboratory with in vitro rearing method. But, because it was difficult to attract T. ostriniae to lay eggs into the artificial "host-eggs" (with artificial medium, composed of pupal hemolymph of A. pernyi 40%, 10% malt solution 30%, chicken yolk 20%, Neisenheimer's salt solution 10%400 unit.ml of penicillium & streptomycin) through polypropylene "chorion", the parasitism of artificial "host-eggs" was low. Laboratory experiments showed significant stimulating function of polyvinyl alcohol. The percentages of artificial "host-eggs" (with a 85.79% respectively, while in control (without stimulant) they were 28.18%, 18.56% and 23.60% respectively. Recently, a newly improved machine for automatically making artificial "host-eggs" was designed and manufactured by the Guangdong Entomological Institute and Guangzhou Electronic Research Institute. The productivity of this machine is 1.3 million wasps per hour.

Index terns: Ostrinia furnacalis (Guenee), Trichogramma ostriniae Pang et Chen, in vitro rearing, ovipositional stimulant, polyvinyl alcohol.

[1432] RECENT ADVANCES IN THE DEVELOPMENT OF ARTIFICIAL DIET

D. A. Nordlund¹ & Z. X. Wu², ¹USDA, REE, ARS, MSA, Biological Control and Mass Rearing Research Unit, P. O. Box 5367, Mississippi State, MS 39762-5367, USA, E-mail

donn@ra.msstate.edu; ²Dept. of Entomology and Plant Patholgy, Mississippi State University, P. O. Box 9775, Mississippi State, MS 39762-9775, USA, E-mail

Egg parasitoids are, potentially, among our most valuable biological control agents, in part because they kill the insect pest before it causes any damage. However, egg parasitoids tend to be small, live a relatively short time, and require releases of very large numbers to be effective. Thus, an ability to produce very large numbers of high-quality parasitoids at a low cost is essential to their practical use. Considerable progress has been made in the development of artificial diet based systems for rearing *Trichogramma* spp. More recently, there has been progress in the development an artificial diet based system for *Anaphes iole*. From these two models, we are begining to develop an understanding of what is required to develop both artificial diets and practical artificial diet based mass rearing systems for egg parasitoids. For example, in addition to a high-quality diet, there must exist systems/procedures for collecting large numbers of parasitoid eggs, mixing those eggs with the artificial diet, holding the diet/egg mixture for development, and for harvesting/releasing the adults. In a rearing system capable of producing billions or trillions on insects, most of these steps will require high levels of automation and sanitation. Recent findings, and their implications for system development, will be reviewed and discussed. The development of automated artificial diet based systems for mass rearing of egg parasitoids will have a significant impact on augmentative biological

BASED MASS REARING SYSTEMS FOR EGG PARASITOIDS

Index terms: Trichogramma minutum, Anaphes iole, biological control

zwu824@ra.msstate.edu.

[1430] PRODUCTION AND EFFICACY OF CATOLACCUS GRANDIS, A HYMENOPTEROUS LARVAL PARASITOID OF THE BOLL WEEVIL

King, E. G.,

ABSTRACT NOT RECEIVED

control.

[1433] PRODUCTION OF PREDATORY BUGS ON ARTIFICIAL AND FACTITIOUS FOODS AND THEIR USE IN GREENHOUSE PEST MANAGEMENT

P. De Clerca, Y. Arijs, S. Walgraef, F. Merlevede & V. R. Chocorosqui, Lab. of Agrozoology, Dept. of Crop Protection, Ghent University, Coupure Links 653, B-9000 Ghent, Belgium, E-mail: Patrick.DeClercq@rug.ac.be.

Several heteropteran predators are commercially available for biological control of a variety of insect pests in European greenhouses. The anthocorid Orius laevigatus has been routinely used for the control of western flower thrips, Frankliniella occidentalis, since the early nincties. Because mass rearing of this anthocorid on eggs of Ephestia kuehniella is relatively expensive, the suitability of different factitious and artificial foods was assessed. Successful development and reproduction of O. laevigatus was noted on hydrated cysts of the brine shrimp, Artemia spp. Also, the predator could be reared on meat-based artificial diets with similar developmental and reproductive success as on E. kuehniella eggs. Podisus maculiventris is a pentatomid predator that is commercially available in The Netherlands since 1997 as an additional asset to suppress outbreaks of noctuid caterpillars in greenhouse vegetables and ornamentals. This pentatomid is easily reared on several factitious hosts, including Tenebrio molitor and Galleria mellonella. Although development is similar on both of these prey types, fecundity on T. molitor is only about half of that on G. mellonella. Mass production of these relatively large predators is hampered by their voracity, necessitating large cultures of prey and forcing up labour costs. Artificial diets based on bovine meat proved to be suitable for the production of Podisus bugs, although development is slightly prolonged and achieved body weights and fecundity are lower. Perillus bioculatus is a pentatomid predator of mainly chrysomelid prey that has potential for the biological control the Colorado potato beetle, Leptinotarsa decemlineata. P. bioculatus was able to develop on bovine meat diets, but the results were inferior to those obtained on larvae of the cotton leafworm, Spodoptera littoralis.

Index terms: Orius laevigatus, Podisus maculiventris, Perillus bioculatus, mass rearing, diet

[1434] LABORATORY PRODUCTION AND FIELD EVALUATION OF HYMEMOPTEROUS ECTOPARASITOIDS REARED ON ARTIFICIAL DIETS

J. E. Carptenter¹, P. D. Greany², S. M. Ferkovich³, & D. B. Gelman⁴, ¹USDA-ARS, Crop Protection Management Research Unit, P.O. Box 738, Tifton, GA 31793; ²USDA-ARS (retired), Tallassee, FL; ³USDA-ARS, CMAVE, Gainesville, FL 32604; ⁴USDA-ARS, Insect Biocontrol Laboratory, Beltsville, MD 20705.

Diapetimorpha introita (Hymenoptera: Ichneumonidae), a native ectoparasitoid of Spodoptera spp. pupae was reared in the laboratory on an artificial diet devoid of any insect host components. Diet-reared wasps demonstrated a propensity to search for and parasitize natural hosts in a field cage trial. Longevity of the diet-reared wasps was comparable with the longevity of wasps reared on host pupae. Survival rate of D. introita was 67.3% when reared on diet and 76.3% when reared on host pupae. Developmental time was significantly longer for wasps reared on the artificial diet than for wasps reared on host pupae. Reduced fecundity and reduced wasp weight were characteristics of dietreared D. introita. Efforts to improve wasp weight, developmental time, fecundity and longevity have included the use of culture media conditioned by insect cell lines, additional nutrients in the diet, and diets supplemented with lipid extracts from host pupae. These efforts resulted in some improvement in wasp weight and fecundity. Other studies comparing molting hormone titers of diet-reared and host-reared D. introita were undertaken to elucidate factors responsible for the reduced emergence of diet-reared wasps. After the initiation of cocooning, there were six stages of development in which hemolymph ecdysteroid titers were significantly higher in host-reared than diet-reared wasps. Thus, insufficient ecdysteroid in the hemolymph during metamorphosis may contribute to the higher percentage mortality that occurred in wasps reared on the artificial diet. Because the wasps can be reared on the artificial diet without any exposure to host kairomones, we investigated the role of preimaginal and imaginal exposure to host kairomones on the acceptance and preference of different host species. We found that rearing D. introita on artificial diet (in the absence of host kairomones) did not significantly influence female oviposition response in choosing a preferred host. Also, our results indicate that there is limited opportunity to manipulate the host preference of D. introita by preimaginal or imaginal exposure to host or non-host kairomones.

Index terms: Diapetimorpha introita, Spodoptera, in vitro rearing, kairomone, entomophagous

(1435) SCIENTIFIC, SOCIAL, POLITICAL AND ETHICAL ISSUES FOR CLASSICAL BIOLOGICAL CONTROL IN THE COMING MILLENNIUM

Mariorie A. Hov1, 1Dept. of Entomology and Nematology, University of Florida, P.O. Box 110620, Gainesville, FL 32611-0620 USA

Since 1992, three serious pests of citrus have invaded Florida. The first was the citrus leafminer (CLM), Phyllocnistis citrella. The CLM rapidly colonized all of Florida and caused significant damage, especially in nurseries. A classical biological control program was initiated and, with the assistance of scientists in Australia, Thailand and Taiwan, two populations of the encyrtid parasitoid Ageniaspis citricola were imported and released. A. citricola established and spread, colonizing all of Florida's citrus. This parasitoid, in combination with native natural enemies, has reduced CLM populations to the point that few groves are treated for the CLM. Unfortunately, this parasitoid appears to do best in humid tropical and subtropical climates and has failed to perform well in Mediterranean climates. The second invader was the brown citrus aphid (BCA), Toxoptera citricida. This pest caused direct damage to flushes and also is an efficient vector of citrus tristeza virus. During 1999, we obtained a colony of Lipolexis scutellaris (Aphidiidae) with the assistance of Ross Miller in Guam. L. scutellaris has been evaluated in quarantine and we hope to release it in Florida during the 2000 growing season. The third pest was the Asian citrus psylla, Diaphorina citri, which is a direct pest and also a vector of citrus greening disease. Two parasitoids were imported from Taiwan and Vietnam, Tamarixia radiata (Eulophidae) and Diaphorencyrtus aligarhensis Encyrtidae). T. radiata was released during the 1999 growing season and we hope to release D. aligarhensis during the 2000 growing season. Risk assessments conducted for these releases will be discussed, and some thoughts presented regarding the social, political and ethical issues facing classsical biological control workers.

[1436] PARASITOIDS OF CITRUS PESTS IN REUNION ISLAND (INDIAN OCEAN)

S. Ouilici, CIRAD-FLHOR Réunion, Laboratoire d'Entomologie, BP180, 97455, Saint-Pierre Cedex, France. E-mail quilici@cirad.fr

Reunion Island is a French overseas department in the west of the Indian Ocean. Citrus crops, which have been developped there since the last thirty years, are attacked by a variety of pests. The Citrus Greening Disease (CGD) has long been a major limiting factor of citrus growing. Until the 1980's, it was transmitted by the african psylla Trioza erytreae and the asian psylla Diaphorina citri. Among major pests are aphids transmitting the CTV (Citrus Tristeza Virus), particularly Toxoptera citricidus and Aphis gossypii, different species of fruit flies (Ceratitis rosa and C. capitata), the Citrus Rust Mite (Phyllocoptruta oleivora), the South African Citrus Thrips (Scirtothrips aurantii), the Citrus Flower Moth (Prays citri), and various species of scale insects. More recently, the Citrus Leafminer (Phyllocnistis citrella), has been recorded in the island. The Wooly Whitefly, Aleurothrixus floccosus, for a long time a major pest, has been successfully controlled biologically. During the last thirty years, parasitoids have been used in classical biological control programs conducted by CIRAD scientists against citrus pests. The programme against the vectors of CGD can be considered a case-study of successful biocontrol in an island. While the introduction of the eulophid Tamarixia dryi (1974) allowed the eradication of T. erytreae at the beginning of the 80's, the introduction of Tamarixia radiata (1978) led to a drastic reduction in the populations of the asian psylla. A very favorable biological equilibrium also followed the introduction of Cales noacki against the Wooly Whitefly in 1976. More recently, the successful introduction of Ageniaspis citricola in 1997 enabled us to improve the natural control of the Citrus Leafminer. Indigenous parasitoids may play a prominent role in the natural control of various citrus pests, as in the case of the large parasitoid complexes associated with lecanid or diaspid scales. The Margarodidae Icerya seychellarum is under very good control by the combined action of the ladybird Rodolia chermesina and the dipteran parasitoid Cryptochetum sp... Five indigenous parasitoids play a major role in the control of the Citrus Leafminer. Aphids are also attacked by various species of Aphidiidae and Aphelinidae, with a variable degree of control. In other cases, the contribution of parasitoids to the natural control of the pest seems much less effective, like for fruit flies, for which parasitoids contribute as a minor mortality factor on wild host-plants. The possible side-effects of classical biocontrol must be thoroughly considered before any operation, particularly in the case of fragile island ecosystems. Current and future programmes will only consider the possibility of using parasitoids with the narrowest possible host-range. In the meantime, the knowledge of the local entomofauna has considerably progressed, allowing a better prevision of possible side-effects.

ABSTRACT BOOK I - XXI-International Congress of Entomology, Brazil, August 20-26, 2000

[1437] AUGMENTATION OF PARASITOIDS FOR CONTROL OF CITRUS PESTS IN SOUTHERN AFRICA

<u>S. D. Moore¹</u>, V. Hattingh², B. A. Tate² & A. B. Ware², ¹Capespan, P.O. Box 12531, Centrahil 6006, South Africa, E-mail: sean_moore@capespan.co.za; ²Outspan Citrus Centre, P.O. Box 28, Nelspruit 1200, South Africa, E-mail: vaughan_hattingh@capespan.co.za

The southern African citrus industry is committed to an approach of bio-intensive integrated pest management (IPM). In an effort to reduce the use of chemical insecticides, augmentation of natural enemies of certain key pests has been investigated over several years. This involves the mass production and inundative release of large numbers of parasitoids, resulting in an earlier peak in parasitism levels, an earlier decline in pest levels, and hopefully a lower pest presence at harvest. Intensive trials have indicated the value of this approach, particularly with Coccidoxenoides peregrinus, a parasitoid of citrus mealybug, Planococcus citri. In cases of low to moderate P. citri infestation, releases of 100 000 C. peregrinus per hectare per season over a five month period, have proved adequate. Greater release intensities were necessary against high levels of mealybug. Higher levels of parasitism of mealybug were recorded in release orchards than in adjacent control orchards, up to nine weeks after release. This showed that C. peregrinus disperses at a rate of approximately 100m per month. Mealybug came under commercial control biologically in well over 90% of 250ha in which semi-commercial releases were conducted. Lack of control could be blamed on injudicious use of pesticides and ant activity. A similar programme has been adopted with California red scale, Aonidiella aurantii, using Aphytis lingnanensis. The aim is to release 120 000 A. lingnanensis per hectare per season. This is however more difficult to implement than the mealybug biocontrol programme, due to problems with mass production, disruption by thripicides and ants, a low export tolerance for red scale, and uncertainty whether A. lingnanensis is the best species for certain areas. Currently, augmentation of the egg parasitoid, Trichogrammatoidea cryptophlebiae, is also being investigated, for control of lepidopteran pests. Initially a total of only 20 000 parasitoids were released per hectare per season. In one case, level of parasitism was increased by 40% and consequently fruit loss was reduced by 41%, compared to an adjoining non-release orchard. During a second season, 150 000 parasitoids were released per hectare. Early season evaluations indicate a higher level of parasitism and a lower level of fruit damage since parasitoids have been released, than in adjoining non-release orchards. As a consequence of the positive results achieved with these augmentation initiatives, a total of nine insectaries have been established in citrus producing regions throughout South Africa.

Index terms: Coccidoxenoides peregrinus, Aphytis lingnanensis, Trichogrammatoidea cryptophlebiae, Planococcus citri, Aonidiella aurantii.

[1438] MYMARID PARASITOIDS OF THE GLASSY-WINGED SHARPSHOOTER IN SOUTHERN CALIFORNIA CITRUS

<u>P. A. Phillips</u>, Cooperative Extension, Univ. of California, 669 County Square Dr. #100, Ventura, CA 93003, USA, E-mail paphillips@ucdavis.edu.

The glassy-winged sharpshooter (GWSS), Homalodisca coagulata, was introduced into Southern California from the southeastern US around 1990. Increasing populations of this bacterial plant pathogen vector pose a significant threat to several of California's valuable agricultural industries, including citrus, grapes, stone fruits, and almonds. Endemic species of parasitoids (family; Mymaridae; genus, Gonatocerus) have been consistently recovered during field biology studies of the GWSS in commercial citrus orchards in Ventura County. Of the four species recovered (G. ashmeadi, G. morilli, G. incomptu, and G. novifasciatus), G. ashmeadi has accounted for more than 95% of all recorded parasitism. Annual fluctuations in parasitoid activity, as measured by yellow sticky traps and GWSS egg collections, are synchronized with the two periods of GWSS oviposition each year. Parasitism of first generation GWSS egg masses, occurring in the late winter through spring, is very low compared to second generation egg mass parasitism occurring from late summer through early fall. First generation GWSS egg mass parasitism was higher in 1999 than in the previous two years. Despite parasitism rates averaging 40% and ranging from 10 to 85% on second generation GWSS egg masses, GWSS populations continue to increase in Ventura County citrus orchards. In April 1999, a foreign exploration trip was conducted into NE Mexico in search of a more effective parasitoid of first generation GWSS egg masses. Another Mymarid, G. triguttatus was recovered from GWSS eggs in both lemon and peach foliage. Current plans are to import this species through UC quarantine facilities for release into California citrus.

Index terms: Gonatocerus ashmeadi, Gonatocerus triguttatus, parasitism, lemon, vector

[1439] INFLUENCE OF *SPINOSAD* ON SOME HYMENOPTEROUS NATURAL ENEMIES OF AVOCADO, CITRUS AND OTHER ORCHARD PESTS

M. Wysoki, S. Rene, M. Eliahu & D. Blumberg, Dept. of Entomology, Institute of Plant Protection, ARO, The Volcani Center, Bet Dagan, 50250 Israel; e -mail: manesw@netvision.net.il

Spinosad under the trade name Tracer® a mixture of spinosyn A & D, produced by Saccharopolyspora spinosa (Actinomycetes), is used in Israel against the recently introduced orchid thrips, Chaetanaphothrips orchidii (Moulton)(Thysanoptera :Thripidae). Since many parasitoids of citrus and avocado pests where introduced and well established in Israel, influence of this product on some of the local and introduced natural enemies was evaluated. Two concentrations of the commercial product: 0.02 % (the recommended) and 0.01% were tested in laboratory trials and in preliminary field trials. Trials were performed on the influence of Spinosad on natural enemies, of pseudococcid citrus pests: Anagyrus pseudococci Girault and Leptomastix dactylopii (Howard)(Hymenoptera : Encyrtidae), a parasitoids of citrus mealybug, Planococcus citri (Risso); L. algirica Triapitzin (Hymenoptera : Encyrtidae), a parasitoid of citriculus mealybug, Pseudococcus cryptus Hempel and on Thripobius semiluteus Boucek (Hymenoptera: Eulophidae), a well established parasitoid successfully controlling the greenhouse thrips, Heliothrips haemorrhoidalis (Bouche') (Thysanoptera :Thripidae) and on Metaphycus stanleyi Compere (Hymenoptera: Encyrtidae) the most abundant parasitoid of the pyriform scale, Protopulvinaria pyriformis Cockerell (Homoptera: Coccidae). Additionally was evaluated the influence on Mastrus ridibundus (Gravenhorst) (Hymenoptera: Ichneumonidae) a parasitoid of an apple pest, the codling moth, Carpocapsa pomonella (L.)(Lepidoptera: Tortricidae). This product shows detrimental influence on hymenopterous parasitoids in both concentrations in laboratory trials and long persistence in preliminary field trials.

[1440] AUTOMATION IN MASS REARING - MAKING THINGS POSSIBLE

D. A. Nordlund, USDA, REE, ARS, MSA, Biological Control and Mass Rearing Research Unit, P. O. Box 5367, Mississippi State, MS 39762-5367, USA, E-mail donn@ra.msstate.edu.

Insect rearing is essential to much entomological research and for certain pest management approaches. Rearing systems range from research level cultures, producing a few hundred insect per generation cycle, to systems for sterile insect technique or augmentative biological control programs that may require billions/trillions of insects per day. As production capacity increases, the need for automation increases. Mass rearing, defined by Mackauer as "the rearing, per generation cycle, of one million times the mean number of offspring per female," though possible, is not generally practical without a significant level of automation in the system. Automation is use of, more or less, automatically Benefits of automation controlled mechanical devices to perform rearing operations. Benefits of automation include: a reduction in the labor required to perform an operation, performance of an operation at a higher rate, performance of multiple operations at one time, performance of an operation for long periods without interruption, and increased uniformity with which operations are performed; resulting in increased production capacity, improved quality, and reduced production costs. Pest management techniques, such as the sterile insect technique and augmentative biological control, even at the research stage, may require the production of millions of high-quality insects, or more, per day. From the implementation stand point, it is essential that these insects be produced at a low cost, or the technique will not be competitive with alternative management practices. Automation of insect rearing systems makes such pest management approaches possible.

Index terms: insects, biological control, sterile insect technique

Symposium and Poster Session

[1441] RESULTS OF THE DEVELOPMENT AND INTRODUCTION OF ENGENEERING TECHNOLOGIES FOR THE MASS REARING OF ENTOMOPHAGES AND ACARIPHAGES IN THE EASTERN PALEARCTIC REAGION

I. P. Starchevsky¹ & <u>E. A. Sadomov²</u>, ¹Engineering-Technological Institute «Biotechnica», Odessa, 65012, Ukraine, E-mail: biotech@te.net.ua; ² IOBC/EPRS Secretariat, Moscow 107807 Russia, 095 915-7212.

Per 90 years the agriculture and plants protection of the countries by East Palearctic is experienced by deep changes. The economic and legal conditions have changed. Last years the new strategy of organization of an agriculture is created, switching and plant protection. In these countries are available agroregions, differing on ecological and economic conditions requiring for different technologies of protection. By their development we should adhere to principles of steady development, first of all of biological method with preferable use of the natural factors of suppression harmful organisms, organization-economical and agrotechnical methods, steady grades and biological means. It is provided three-stage the decision of a task on a substantiation of prospects of development of a biomethod in conditions of market economy. The special role in biological protection against the wreckers in an open ground is removed Trichogramma and Bracon, which manufacture is mastered practically in all countries by East Palearctic. Taking into account high efficiency of application and rather low cost of these insects the special attention is given to modernization of technological lines on an operating time in view of last engineering development. In practice of biological protection of the closed ground the greatest distribution has received application of predators and parasites greenhouse whitefly, web ticks and decay. In hothouses and seedbeds use of a biological method decides a practical task of cultivation of ecologically clean production in hothouse facilities of Russia, Ukraine, Hungary, Poland, Moldova, Bulgaria etc. In biolaboratories hothouse combines produce necessary volumes encarsia, phitoseiulus, ambliseius, dall-fly, aphidius and others entomo-acariphages, which in conditions of the closed ground, work more effectively in comparison with chemical means of protection of plants. In institute "Biotechnica" (Ukraine) is developed the universal equipment for an operating time entomo-acariphages of the closed ground. The biological laboratory by the industrial area about 90 M² is capable to let out of production for protection 3 ha of hothouses. At the same time it is necessary to note also that the major factor is the reconsideration and possible change of all factors of protection of plants and even plantwork, that the planned purpose, that is restoration and preservation of a biovariety ecosistems could be carried out. Index terms: biometod, plant protection.

[1442] THE ENTOMOLOGICAL INDUSTRY IN THE UKRAINE: CONDITIONS AND PROSPECTS FOR DEVELOPMENT

<u>I.P. Starchevsky</u>, Y.C. Samoilov & LN. Bespalov, Engineering-Technological Institute «Biotechnica», Odessa, 65012, Ukraine, E-mail biotech@te.net.ua

The ecological and economic situation which has been usual in Ukraine has defined formation at a qualitatively new level of official state scientific and technical and industrial politics in the field of biotechnologies as priority strategic direction of scientific and technical progress and its integral component - biologization of agriculture. Thus the task of achievement by Ukraine scientifically - is proved of level of replacement chemical pesticides on biological pesticides much earlier is put, than it will be achieved in the conducting agrarian states of the world. In area entomological of methods of plant protection the basic attention is given to restoration and development on a qualitatively new basis of volumes of manufactures and application trichogramma. The original complex of the equipment ensuring necessary conditions for the contents and an operating time of parties maternal cultures of local races trichogramma is created that has basic importance for maintenance of appropriate quality commodity trichogramma. Besides the idea about creation of new generation of a technological line for mass cultivation Sitotroga, mechanization, distinguished by a high level, of labour-consuming technological operations is realized. Represent also practical interest results of researches on development of technologies and creation of the equipment for mass cultivation Brakon, Dibrahis, Metaseiulus (Institute "Biotechnica", Ukrainian Research station of plant quarantine, Research station of quarantine of a grapes and fruit cultures of institute of plant protection, institute of plant protection Republic Moldova). The complete set of the unified equipment for mass cultivation of a complex entomoacariphages of the protected ground is created. The technology of complex biological protection of hothouse cultures is developed resource saving. Its basic difference consists in maintenance during all vegetation period of dynamic balance of community entomoacariphages and phitophages, that provides essential reduction of need in means of plant protection (institute "Biotechnica").

Index terms: biological pesticide, plant protection, technological line.

[1443] UNIFICATION OF INDUSTRIAL LINES OPERATING TIME ENTOMOPHAGES

K.A. Asanov¹, A.I.Goncharuk² & V.M. Belchenko², ¹Uzbecian Research Institute Plant Protection, Tashkent, 700017, Uzbekistan; ²Engineering-Technological Institute «Biotechnica», Odessa, 65012, Ukraine, E-mail: biotech@te.net.ua.

Task of industrial cultivation entomophages is the operating time of the certain assortment is artificial reproduced parasitoids for suppression harming phitophages. A question on development of criteria of selection of kinds, general principles of their cultivation and designing of lines of flexible manufacture in this connection is lifted. According to a task, criterion of a selection entomophages is accepted a ecological-biological generality of kinds given in one type location, owners, connected to determined ecological group, in certain ontogenetical to a phase consuming a resource by one way. The ecologicalbiological generality assumes the similar ecological standard of kinds, and it means that the life-support in technogenic environment at their artificial cultivation submits to the general technological circuit with the amendments on ecological features of kinds, them trophical specialization. Stated is a basis for offered classification of types of the technological circuits. So, we distinguish 2 such as industrial complexes. In one case focused on the owners, which reproduced on rough forages, in second - on juicy. The industrial complexes include a line of lines differentiated on concrete ecological-biological group of the owners. Each line on cultivation of the owner or their group includes technologies of cultivation egg's egg-larva's, larva's, vimph's the parasites. And, the technology of cultivation egg's, egg's-larva's of the parasites is under construction in view of features eggs laging by the owner. Same concerns to features of technology of cultivation larva's parazitoides freely and the latently lived the owners. Offered criteria of selection of kinds and, system, connected to it, of technological lines allows to hope for exception of long research by a trial and error method, and assortment entomophages is provided not with a casual set of kinds, but purposeful methodical selection. Index terms: selection of kinds, cultivation, reproduction.

[1444] REDUCTION OF PARAMETRICAL SPACE DIMENSION AS A BASIS OF INSECT'S REPRODUCTION AUTOMATIC SYSTEMS CONSTRUCTION

A.V.Chernikov, Engineering-Technological Institute (ITI) "Biotechnica", Odessa, 65012, Ukraine, E-mail: biotech@te.net.ua

The reproduction cycle of an artificial insect's population can be view as object of control. Input parameter at that is the an "quality" of initial generation Q_0 , and output parameter – an "quality" of posterity Q1. The deflective of meaning Q1 factors we shall share into two groups - constant of cycle k and variable of cycle W. A constant of cycle k unites the some deflective factors, which meanings should not appreciably change during a cycle (including Q₀). To not taken into account by a component of a constant of cycle ξ_k carry petty and unknown factors. A variable of cycle W unites deflective of artificial environment (AE), which can be operated. To not taken into account by a component of a variable of cycle Ew carry petty and unknown AE components. Current informative parameters of a cycle can be, for example, meanings of a gas exchange: consumption of oxygen ΔO_2 and allocation of carbon dioxide ΔCO_2 . The basic formula of a cycle is $Q_1 =$ $(k + \xi_k)$ f (W + ξ_w) It is known, that the final "quality" of insect's artificial culture Q₁ can be expressed by one number (Greenberg, 1990). Then the basic task becomes development of a method integrated estimation of the current meaning of a variable of cycle W by the real non-negative number, which will be understood as "AE quality". At numerical control this task has discrete character. For its decision such sequence of actions is propose: physical measurements - normalization - convolution - metrization - cluster analysis classification - resultant number from a range [0;1]. Mathematical modeling very simple AE with dimension n=5 for 3 meanings of each parameter (243 alternative condition) have shown, that there is at least 5 close to optimum by criterion "metabolism level" state of insect's vital functions. Also begins possible to construct usual bivariate diagram of dependence, for example, metabolism level of an artificial insect's population in technocenosis conditions from set of the taken into account factors of a variable of cycle W. Such approach to a problem can be a basis of construction of automatic control systems for biotechnical systems of insect's mass rearing.

Index terms: quality, artificial environment, mass rearing, deflective factors

[1445] DEVELOPMENT AND ORGANIZATION OF MANUFACTURE VIRUS PREPARATION VIRIN

Y.C. Samoilov¹ & V.B. Mitrophanov², ¹Engineering-Technological Institute (ITI) "Biotechnica", Odessa, 65043, Ukraine, E-mail biotech@te.net.ua; ²All-Russia institute of plant protection (UIPP), St.-Petersburg, 189620, Russia

The large-scale application of granulosis viruses for struggle with codling moth restrains by difficulties arising at mechanization and automation of mass cultivation of insects for an operating time of plenties of virus bioweight. There are some alternative ways of real increase of release of a biopreparation on the same industrial areas and at identical expenses for its manufacturing: a) Increase of an output of virus bioweight from one nimph by influence of the various factors on growth of an insect in a stage caterpillar and selection of lines codling moth with higher weight caterpillars; b) Selection virulence strains of a granulosis virus, giving raised output of virus bioweight. On these directions the positive results in ITI "Biotechnica" and UIPP are received. Together with URPP ITI "Biotechnica" has developed and has tested a complete set of the equipment for trial For the equipment of the equipment of a line of manufacture virin $-\Gamma SIII$. The development of the equipment of a line of manufacture virin $-\Gamma SIII$ was conducted in view of the technological rules describing all stages and operation of an operating time of a preparation at each stage. Each of operations of an operating time larva of bioweight is important and requires implicit observance of the technological rules. Especially important the requirement on observance of ecological parameters (temperature and humidity of air, air exchange, mobility of air, duration of light day, light exposure etc.) is. It is especially important for a line maternal of culture. The board of management of all system includes (individual) systems of maintenance of light exposure, sterility of air given temperature and humidity varying within day, and allows distation operate the listed parameters. The system provides regulation of parameters during all cycle of development of insects. The developed system of regulation of ecological parameters can be used by development of lines of mass cultivation of various insects, which untroduce on an artificial medium. The received preparation was applied to struggle with polyvoltine (2-3 and more generations for a season) populations codling moth in Crimea. The technical efficiency virin - ГЯП has made from 70 up to 94 % depending on climatic conditions. Also it is necessary to note, that these preparations are not toxic and are not produced in organism thorough-bred and in cultures of crates. Epidemical danger do not represent. Index terms: granuloses virus, codling moth, larva.

[1446] TECHNOLOGY TRANSFER IN AUGMENTATIVE BIOLOGICAL CONTROL: AUTOMATION FOR COMMERCIAL PRODUCTION AND APPLICATION OF NATURAL ENEMIES

N. C. Leppla⁴, E. S. Delfosse² & F. Ferrer³, ¹Dept. of Entomology and Nematology, Univ. of Florida, P. O. Box 110630, Gainesville, FL 32611-0630, USA, E-mail ncl@gnv.ifas.ufl.edu; ²USDA, ARS, Room 218, Bldg. 005, BARC-WEST, 10300 Baltimore Boulevard, Beltsville, MD 20705-2350, USA, E-mail esd@ars.usda.gov; ³Servicio Biologico, Carrera 5 N0 4-76 Urbanizacion del Este, Barquisimeto - Estado Lara, Venezuela, E-mail fferrer@telcel.net.ve.

Basic principles exist for moving an invention or discovery from research to implementation as a new technology. Inventions or discoveries may include useful machinery, manufactured articles, chemical compositions, processes and organisms. In augmentation biological control, these respective categories encompass rearing and handling equipment, materials for manipulating the organisms, diets and processing chemicals, rearing and application methods, and certain natural enemies. These technologies may be new or significant improvements that can be patented in individual countries, disseminated through the scientific literature or kept secret. Patents disclose the details of a technology but protect the owner from illegal infringement, requiring payment of licensing fees for access. Technology is often provided free of charge by government researchers but most commercial biological control producers do not reveal their advancements. An interesting example of these technology transfer principles is the entomopathogenic nematode, Steinernema scapterisci, originally collected in Uruguay for importation into the United States and patented by the University of Florida. A company patented processes and equipment for mass producing this nematode in liquid culture, storing infective juveniles for long periods, and shipping and releasing them for mole cricket control. This company independently collected and imported S. scapterisci from South America but was not allowed to sell it in the United States without a licensing agreement with the University of Florida. Historically, however, methods for large-scale production and application of natural enemies have been developed by public sector researchers and freely contributed for the advancement of biological control. Notable examples are production of Trichogramma spp., Chrysoperla carnea, Phytoseiulus spp., Muscidifurax spp. and Catolaccus grandis. A recent innovation is to combine patented artificial diets with industrial food processing technology and produce packaged rearing and delivery systems for predators. This kind of system is being tested for Geocoris spp., Orius spp., Cryptolaemus montrouzieri, Hippodamia convergens, Harmonia axyridis and other commercially produced species.

Index terms: Steinernema scapterisci, insect rearing, biological control, patenting and licensing, mass production of natural enemies

[1447] DEVELOPMENT AND IMPLEMENTATION OF AN AUTOMATED SYSTEM FOR MASS REARING PINK BOLLWORM (PECTINOPHORA GOSSYPIELLA)

<u>E. Miller¹</u>, F. Stewart², J. Ploski² & R. Edwards³, ¹USDA-APHIS PPQ PPPC 3645 E Wier Av., Phoenix, Az, USA² USDA-APHIS-PPQ PBWRF 3645 E Chipman Av., Phoenix, Az, USA³USDA ARS Western Region Research Center, Albany Ca.,USA

Since 1995 significant changes have been made in the methodology used to mass rear Pink Bollworm Pectinophora gossypiella (PBW) as the use of sterile PBW release shifts from a 29 year old exclusion program in the San Joaquin valley of California to an Area Wide Management Program for PBW. Production demands for the Pink Bollworm Rearing Facility (PBWRF) will increase from 5 million moths per day to 32 million moths per day in the expanded program. The 32 million per day production schedule is tentatively scheduled for the year 2002. In 1991 work on developing new technology for mass rearing PBW began. Actual implementation of this technology into PBW mass rearing was initiated in 1995. The objective of this change was to reduce labor costs through automation of labor intensive rearing tasks, improve utilization of rearing space and improve rearing efficiency through higher yields per unit of diet. These goals were accomplished with the following developments and implementations: 1) A thermoformed on site rearing container made of PVC plastic film replaced the 32 oz paper convocan. 2) A Twin-Screw Extruder (TSE) continuous diet processing system with ancillary support equipment that employ technology adopted from the food processing industry replaced the steam kettle diet batch making system. 3) The original diet formula was modified 4) The method of disinfecting eggs prior to implant in the diet was changed. These combined changes in the PBWRF have resulted in a 1999 pupal production yield of 9.4 pupae per gram of diet. This is a 42.4 % increase in yield (9.4 versus 6.6 pupae per gram of diet) when compared to the highest production yield (1994) obtained from the old mass rearing methodology. Implementation of the new technology has reduced labor costs by 20%. Total production costs have been reduced from \$3.00 per 1000 moths to \$ 1.85 per 1000 moths in a 1X facility. These savings will increase appreciably as production increases in the facility.

[1448] QUALITY CONTROL IN AUTOMATED MASS REARING

S. M. Greenberg¹ & D. A. Nordlund², ¹Integrated Farming & Natural Resources Research Unit, Kika de la Garza Subtropical Agricultural Research Center, USDA-ARS, Weslaco, TX 78596, USA, E-mail: sgreenbe@weslaco.ars.usda.gov; ²Biological Control & Mass Rearing Research Unit, USDA-ARS, P. O. Box 5367, Mississippi State, MS 39762, USA, E-mail: donn@ra.msstate.edu.

Insect mass rearing systems involve selection of the target population, strain development, establishment of an initial culture, mass production, short- and long term storage, shipment to users, and release in the field. All these steps are mediated by process and product Mass rearing should be preceded by the development of quality control procedures. control methods. This allows pursuit of promising avenues of research related to mass rearing techniques, as well as allows producers to undertake an organized effort to improve the quality of the insects. According to modern notions of quality, the quality index of mass reared insects must be based on their ability to perform the function for which they are produced. Thus, criteria for evaluating the quality of mass reared insects may best be based on vitality and productivity. The development of global indices is preferable. Quality control assessment methods must also be quick and reliable. Original methods for standardized assessment of quality classes of Trichogramma spp. and methods for standardized assessment of quality classes of *Trenogramma* spin and *Catolaccus grandis*, and a device for determining a global index for *Trichogramma*, as related to field efficacy, will be discussed. The methodology for determining related to field efficacy, will be discussed. The methodology for determining Trichogramma release rates, and prediction of generalized criteria of effectiveness based on pest density, the quality of released wasps, weather conditions, and plant phenology also will be presented.

Index terms: Trichogramma spp., Catolaccus grandis, global indices.

[1449] BRAZILIAN LEGISLATION IN THE EXCHANGE BENEFICIAL ORGANISM/CONVENTION ON BIOLOGICAL DIVERSITY

Dias, B. F. S.

ABSTRACT NOT RECEIVED

Symposium and Poster Session

[1451] HOST SELECTION STRATEGIES BY THE APHID PARASITOID APHIDIUS ERVI

<u>F. Pennacchio</u>¹, D. Battaglia¹, E. Guerrieri², G. Poppy³, W. Powell³, A. Romano¹ & A. Tranfaglia¹, ¹Dipartimento di Biologia, Difesa e Biotecnologie Agro-Forestali, Università della Basilicata, via N. Sauro, 85, 85100, Potenza, Italy, E-mail pennacchio@unibas.it; ²Centro C.N.R. per lo Studio delle Tecniche di Lotta Biologica (CETELOBI), via Università, 100, 80055 Portici (NA), Italy; ³IACR Rothamsted Experimental Station, AL5 2JQ Harpenden, UK.

The braconid Aphidius ervi Haliday (Hymenoptera, Braconidae) is an endophagous parasitoid of several aphid species of economic importance. This parasitoid has been widely used as a model species for both behavioural and physiological studies. The present contribution summarizes the most recent findings on chemical ecology and behavioural physiology aspects that play a key role in the regulation of host location and recognition in the experimental system A. ervi – Acyrthosiphon pisum (Harris) (Hemiptera, Aphididae). The roles played by plant-derived synomones and by host associated cues, both chemical and physical, are taken into consideration. Broad bean (Vicia faba L.) plants infested by the pea aphid produce and release synomones used by A. ervi females for inflight orientation. These plant volatiles are aphid specific and systemically inducible by aphid feeding, when a minimal threshold of infestation level is exceeded. Plant attractiveness to the female parasitoids can be significantly enhanced in uninfested broad bean plants by their hydroponic co-culture with pea aphid infested plants. This would suggest the occurrence of helicitors that can be translocated throughout the plant, which may affect its secondary metabolism. A considerable degree of plant genetic variation in the attractiveness to parasitoids of aphid-infested plants has been detected among different broad bean cultivars. These have been characterized from a behavioural, chemical and genetical point of view. Short range and contact cues regulating the final steps of the host selection process are both physical and chemical. Colour vision plays a pivotal role in stimulating an oviposition attack. The rate of attack of physically suitable aphid dummics can be enhanced when experimental females are also exposed to host cuticular kairomones. The final egg laying is controlled by internal host cues detected via the ovipositor. The purification and characterization of both external and internal kairomones has been undertaken. A. ervi behavioural plasticity, as a result of learning, is also considered and its influence on host selection is discussed.

Index terms: Braconidae; pea aphid; behaviour; aphid parasitoids; synomones

[1450] FOREIGN EXPLORATION FOR NATURAL ENEMIES OF THE WEEVIL DIAPREPES ABBREVIATUS (COLEOPTERA: CURCULIONIDAE) A SERIOUS PEST OF CITRUS IN FLORIDA

<u>J. E. Pena</u>, University of Florida, IFAS Tropical Research and Education Center, Homestead, FL 33031 USA

The west Indian sugarcane roostalk borer weevil, Diaprepes abbreviatus (L.), originated in the Caribbean region, is an important pest of several crops (i. e., citrus, sugarcane, vegetables, ornamentals) in Florida for over 30 years. However, until today, very little effort has been made to include the use of entonophagous insects in the whole management program for Diaprepes abbreviatus. An exploratory program for egg parasitoids of this species, has been initiated in the Caribbean and Colombia. Several egg parasitoids of this species, has been initiated in the Caribbean and Colombia. Several egg parasitoids (Ceratogramma etiennei, Quadrastichus haltiensis, Aprostocetus vaquilarum,) have been introduced from the Caribbean Region, in cooperation with entomologists and authorities of each country. The taxonomical position of some of the parasitoids have been re-evaluated and determined by systematists from USDA, Beltsville, MNH, UK, and UC, Riverside. One of the introduced, parasitoids, Ceratogramma etiennei (Hymenoptera: Trichogrammatidae) from Guadeloupe was tested for specificity, against lepidopteran eggs of native butterfly species, weevils released for biological control of weeds and close related weevils (i.e., Pachnaeus sp.). All other introduced species, are been screened for specificity and potential as hyperparasitoids. The important aspect in all these introductions will not only be to make available pertinent information to researchers from the country where exploration takes place, but also to share the results of different studies on augmentation and mass production of the introduced species. [1452] POST-EMERGENCE HOST MANIPULATION BEHAVIOR BY LARVAE OF THE SOLITARY ENDOPARASITOID COTESIA MARGINIVENTRIS (HYMENOPTERA: BRACONIDAE)

M. E. Fritzsche-Hoballah & T. C. J. Turlings, Institute of Zoology, University of Neuchatel, Rue Emile-Argand 11, CH-2007, Neuchatel, Switzerland. Email ted.turlings@zool.unine.ch.

Cotesia marginiventris (Hymenoptera: Braconidae) is a solitary endoparasitoid of many lepidopteran larvae. We observed a unique behavior of the parasitoid larva during emergence, which we think is typical for this Cotesia species and has not been described before. The larva emerges when it has completed its third and final instar. As soon as it has exited the host halfway, the parasitoid larva begins to spin the bottom half of its cocoon. Interestingly, the parasitoid not only employs the silk to spin the bottom half of its cocoon. Interestingly, the parasitoid not only employs the silk to spin the bottom half of the social tach itself and the host to the surface of the leaf. Once the first half of the cocoon is built, the parasitoid larva emerges completely from the host, and it positions itself firmly in the coccoon. At this time the larva first uses its mouth parts to detach the host from the leaf surface and then its head to push the host until it falls to the ground, where it dies within 24 hours. The parasitoid larva, free of its host, then finishes to spin its coccon and pupates. This post-emergence behavior was not observed in other solitary endoparasitoids that we study. Several hypotheses concerning the function of this unique behavior were tested and the results are discussed.

[1453] ORIENTATION BY SELF-PRODUCED VIBRATIONS: HOW PUPAL PARASITOIDS HUNT FOR HIDING HOSTS

F. L. Wäckers, Dept. of Entomology, PO Box 8031, 6700 EH Wageningen, the Netherlands. NIOO CTO, PO Box 40, 6666 ZG Heteren, the Netherlands. E-mail: waeckers@cto.nioo.knaw.nl.

Parasitoids which lay their eggs in insect pupae face the problem that their hosts do not feed or move. In comparison to parasitoids of larval stages this constrains the range of stimuli by which the parasitoid can locate their hosts. We were able to demonstrate that the pupal parasitoid *Pimpla turionellae* can circumvent this problem by using self generated vibrations to investigate potential oviposition sites. During this vibrational sounding the parasitoid creates vibrations in the substrate and uses the resonance of the reverberating substrate to decide where to insert its ovipositor. Here I will address the following aspects of this unique host location mechanism:

- The method of vibration production.

- The mechanism of vibration transmission, in particular the description of specific antennal structures which could facilitate this process.

- Description of the subgenual organ (mechanoreceptor) and behavioral evidence for its involvement in vibrational sounding.

- The effect of parasitoid size on the efficacy of vibrational sounding

Index terms: *Pimpla turionellae*, vibrational sounding, echolocation, sensory orientation, mechanoreceptor

[1455] LOCAL ADAPTATION OF PARASITOID POPULATIONS: WHAT DOES LEARNING HAVE TO DO WITH IT?

K.M. Kester¹ & H. R. Royaltey², 1. Department of Biology, Virginia Commonwealth University, 816 Park Ave., Richmond, Va . 23284-2012.2. Dept. Biology, Univ. California-Santa Cruz, CA 95064. Email kmkester@saturn.vcu.edu

Foraging behavior of parasitoids is modified by both post-emergence and ovipositional experiences with plants. Post-emergence experience induces positive responses to the plant experienced at emergence and generalized responses, either positive or inhibitory, to other plants. Ovipositional experience induces a positive response to the plant on which oviposition occurs. In a series of laboratory experiments with *Cotesia congregata* (Say) [Hymenoptera: Braconidae], a gregarious endoparasitoid of *Manduca sexta* L. [Lepidoptera: Sphingidae], we tested the effects of post-emergence experience followed by ovipositional experience with both typical and novel host foodplants on searching responses, offspring allocation and sex ratios of resulting offspring. Implications of these responses for local adaptation of parasitoid populations to host food plants were explored using an individual-based simulation model.

[1454] FINDING HOSTS IN A COMPLEX ENVIRONMENT: THE ROLE OF PLANT COMMUNICATION

C.M. De Moraes & J.H. Tumlinson, USDA-ARS-CMAVE, P. O. Box 14565, Gainesville, FL 32604, USA Email: CDeMoraes@gainesville.usda.ufl.edu

tritrophic plant-herbivore-parasitoid interactions are often complex and tightly interwoven, chemical signaling by plants has profound implications for parasitoid foraging efficiency and plant defense. plant-derived chemical cues are the dominant long-range cues used by parasitoids to locate cryptic, highly dispersed hosts within a complex physical and chemical environment. it is well documented that volatile chemical signals produced and released by plants specifically in response to herbivore feeding play an important roll in parasitoid foraging. these volatile semiochemicals are produced by several biosynthetic pathways. although some volatile compounds are released from storage when damage occurs, others are synthesized *de novo* in response to herbivore attack. plants release these induced compounds from undamaged as well as damaged leaves. new evidence suggests that in addition to being easily detectable and reliable indicators of herbivore presence, herbivore-induced plant volatiles may convey herbivore-specific information that allows parasitoids to discriminate even closely related herbivore species at long range. in this presentation we discuss recent developments in the investigation of plant-parasitoid interactions and the potential significance of these developments.

index terms: tritrophic interactions, parasitoids, plant chemicals, host location.

1456] SPIRACULAR GLANDS OF *DROSOPHILA MELANOGASTER* PUPARIA ELICIT RECOGNITION RESPONSE IN *TRICHOPRIA DROSOPHILAE*

N. Isidoro¹, R. Romani¹, S. B. Vinson² and <u>F. Bin¹</u>, ¹Department of Arboriculture and Plant Protection – Entomology, University of Perugia, Borgo XX Giugno, Perugia 06121, Italy, E-mail: fbin@unipg.it; ²Department of Entomology, Texas A&M University, College Station, Texas, 77843-2475.

The recognition process takes place usually mediated by physical and chemical stimuli perceived on contact by antennal sensory structures. The diapriid *Trichopria drosophilae* recognizes *Drosophila melanogaster* pupae using two types of multiporous gustatory sensilla (MGS). MGS type I are about 60 arranged in patches on the last two antennomeres. MGS type II consist of 5-6 basiconic sensilla with porous shaft located in a pit on the apical antennomere. Bioassays are carried out using altered females (one or two apical antennomeres removed) with intact puparia or intact females with host horned spiracles of both ends covered with wax or removed. Host recognition does not occur if the apical antennomere is removed or when intact female cannot antennate spiracular horns. The tips of these are covered with an oily secretion which oozes from associated glands. Morphological and behavioural data indicate that MGS type I and II are likely used to detect kairomone/s from different sources, i.e. the puparium body and the respiratory horns, respectively. However, while the former sensilla type may not be relevant, the latter always triggers the recognition response. Some more examples of MGS type I and II are shown in other diapriids

Index terms: antennal gustatory sensilla, oily secretion, recognition kairomone

Symposium and Poster Session

[1457] EGG PARASITOIDS ATTACKING HOMOLOGOUS HOSTS: EQUIVALENCES AND DIFFERENCES BETWEEN TWO ALLOPATRIC CABBAGE BUGS

E. Conti¹, <u>F. Bin¹</u>, S. B. Vinson² & H. J. Williams³, ¹Department of Arboriculture and Plant Protection – Entomology, University of Perugia, Borgo XX Giugno, Perugia 06121, Italy, E-mail: fbin@unipg.it; ²Department of Entomology, Texas A&M University, College Station, Texas, 77843-2475; ³Department of Chemistry, Texas A&M University, College Station, Texas, 77843-2475.

Two allopatric pentatomids, the European Harlequin Bug (EHB), Eurydema ventrale Klt., and the American Harlequin Bug (AHB), Murgantia histrionica (Hahn) (Heteroptera: Pentatomidae), present several similarities. These include using the same host plants (Cruciferae and Capparidaceae, both rich in mustard oil glycosides), having similar life cycles, adult size, warning coloration, oviposition sites, and clustered eggs (12 eggs in two rows). In addition, their eggs are attacked, respectively, by the European Trissolcus simoni (Mayr) and the American Trissolcus brochymenae (Ashm.). (Hymenoptera: Scelionidae). Because of such similarities, it could be expected that these parasitoids would easily switch hosts and, as a result, produce a new association sheding light on specificity and having potential in biological control. Possible host switches were therefore evaluated in terms of host location, recognition and suitability in laboratory conditions. However, host switches are non-reciprocal as T. simoni attacks and develops in AHB while T. brochymenae does not recognize EHB. In order to fully understand the mechanism, studies on the other aspects of the host selection process are in progress. Results are discussed in terms of ecological and physiological equivalences or differences in order to gain further insight into the attributes that determine host range of parasitoids used in biological control.

Index terms: Eurydema ventrale, Murgantia histrionica, Trissolcus simoni, Trissolcus brochymenae, host switch

[1459] SPECIES INTERACTIONS IN MULTI-SPECIES BIOLOGICAL PEST MANAGEMENT SYSTEMS: DO THEY ENHANCE OR DETER BIOLOGICAL CONTROL?

M. P. Parrella, Department of Entomology; University of California, Davis, California 95616, USA. E-mail: mpparrella@ucdavis.edu

Biological control developed in glasshouses around the world with repetitive releases of a single species of natural enemy. While this methodology has been a model for success, particularly with Encarsia formosa whitefly control and Phytoseiulus persimilis for control of two-spotted spider mites, it is being replaced by an approach which utilizes multiple natural enemies for the same target pest. This evolution has occurrred because of the advent of new polyphagous pests in the glasshouse (eg., Frankliniella occidentalis and Bemisia argentifolii) and because of the very low aesthetic thresholds inherent in many crops (particularly floriculture). Multiple tactics must be used in the floriculture greenhouse if IPM and biological control are to become an integral part of grower practices. Toward that end, my laboratory has been examining the use of two or more natural enemies together for control of key pests and this has cut across different guilds of natural enemies. For example studies have been completed or are ongoing in the following areas; the use of a fungus (Beauveria bassiana) and an aphid parasitoid (Lysiphlebus) for control of melon aphids on Asiatic lilies; the utility of a predatory coccinelid (Delphastus) in conjunction with a whitefly parasitoid (Eretmocerus) for control of whiteflies in poinsettia; and a nematode (Neoaplectana) in conjunction with a leafminer parasitoid (Diglyphus) for control of leafminers on chrysanthemums and gerbera. These studies involve detailed laboratory investigations to examine potential compatibility which focuses on ecological interactions and intraguild predation. If promising, the next step involves small greenhouse trials on campus, and then larger trials with commercial growers.

Key Words: Biological Control, Intraquild Predation, predators, parasitoids, pathogens

[1458] DIFFERENTIAL HOST EXPLOITATION STRATEGIES BY MORPHOTYPES OF *MELITTOBIA DIGITATA* (HYMENOPTERA, EULOPHIDAE)

F. L. Cônsoli & S. B. Vinson, Dept. of Entomology, Texas A&M University, College Station, TX 77843-2475, USA, E-mail f-consoli@tamu.edu.

Melittobia digitata is an ectoparasitic wasp of mud-tauber wasps and many other species of bees. This parasitoid can develop in three different wing-types depending on how long they are able to feed on the hemolymph before they start digesting the host's tissues. Morphotypes differentiation will also dictate their ability to disperse and lay eggs. Shortwing wasps do not disperse, using the same host they developed to lay their eggs. They are provigenic, laying their eggs as soon as the host is found. On the contrary, the long-wing wasps are synovigenic and they must disperse, find and feed on a new host before they start laying their eggs. These morphotypes seems to use different cues to elicit host recognition. Long-wing wasps use physical cues to recognize the host and they also need an oviposition stimulant to lay their eggs. However, chemical cues are used for host recognition by the short-wing wasps.

Index terms: host location, host recognition, reproduction

[1460] INTRINSIC & EXTRINSIC FACTORS INFLUENCING BIOLOGICAL CONTROL OF BEMISIA ARGENTIFOLII IN GREENHOUSES

M. S. Hoddle, Department of Entomology, Univ. of California, Riverside CA 92521, USA. E-mail: mark.hoddle@ucr.edu.

Bemisia argentifolii is a serious foliar pest of greenhouse grown poinsettias. Evaluations of parasitoids in small experimental greenhouses and commercial greenhouses using paired life tables and concurrent functional response assays have revealed important intrinsic factors that affect successful biological control in the Greenhouse-Bemisia-Poinsettia-Parasitoid system. The most important intrinsic factors that affect successful biological control that we have identified are related to the speed at which parasitoids find whitefly patches, levels of parasitoid induced mortality of Bemisia argentifolii, in particular non-parasitism types of mortality (e.g., host feeding), and plant growth. An important extrinsic factor that can enhance the cost competitiveness of biological control of Bemisia argentifolii with conventional insecticide programs is the incorporation of a parasitoid compatible insect growth regulator (IGR) into an integrated Bemisia argentifolii control on poinsettias can produce colored poinsettia at a cost compatible to imidacloprid applications and similar low levels of whitefly infestation.

Index terms: Eretmocerus eremicus, Encarsia formosa, poinsettias, buprofezin

[1461] AUGMENTATION OF PARASITOIDS FOR CONTROL OF CITRUS PESTS IN SOUTHERN AFRICA

<u>S. D. Moore¹</u>, V. Hattingh², B. A. Tate² & A. B. Ware², ¹Capespan, P.O. Box 12531, Centrahil 6006, South Africa, E-mail: sean_moore@capespan.co.za; ²Outspan Citrus Centre, P.O. Box 28, Nelspruit 1200, South Africa, E-mail: vaughan_hattingh@capespan.co.za

The southern African citrus industry is committed to an approach of bio-intensive integrated pest management (IPM). In an effort to reduce the use of chemical insecticides, augmentation of natural enemies of certain key pests has been investigated over several years. This involves the mass production and inundative release of large numbers of parasitoids, resulting in an earlier peak in parasitism levels, an earlier decline in pest levels, and hopefully a lower pest presence at harvest. Intensive trials have indicated the value of this approach, particularly with Coccidoxenoides peregrinus, a parasitoid of citrus mealybug, Planococcus citri. In cases of low to moderate P. citri infestation, releases of 100 000 C. peregrinus per hectare per season over a five month period, have proved adequate. Greater release intensities were necessary against high levels of mealybug. Higher levels of parasitism of mealybug were recorded in release orchards than in adjacent control orchards, up to nine weeks after release. This showed that C. peregrinus disperses at a rate of approximately 100m per month. Mealybug came under commercial control biologically in well over 90% of 250ha in which semi-commercial releases were conducted. Lack of control could be blamed on injudicious use of pesticides and ant activity. A similar programme has been adopted with California red scale, Aonidiella aurantii, using Aphytis lingnanensis. The aim is to release 120 000 A. lingnanensis per hectare per season. This is however more difficult to implement than the mealybug biocontrol programme, due to problems with mass production, disruption by thripicides and ants, a low export tolerance for red scale, and uncertainty whether A. lingnanensis is the best species for certain areas. Currently, augmentation of the egg parasitoid, Trichogrammatoidea cryptophlebiae, is also being investigated, for control of lepidopteran pests. Initially a total of only 20 000 parasitoids were released per hectare per season. In one case, level of parasitism was increased by 40% and consequently fruit loss was reduced by 41%, compared to an adjoining non-release orchard. During a second season, 150 000 parasitoids were released per hectare. Early season evaluations indicate a higher level of parasitism and a lower level of fruit damage since parasitoids have been released, than in adjoining non-release orchards. As a consequence of the positive results achieved with these augmentation initiatives, a total of nine insectaries have been established in citrus producing regions throughout South Africa.

Index terms: Coccidoxenoides peregrinus, Aphytis lingnanensis, Trichogrammatoidea cryptophlebiae, Planococcus citri, Aonidiella aurantii.

[1462] THE INFLUENCES OF SPATIAL AND TEMPORAL DYNAMICS OF HOST-PARASITOID INTERACTIONS ON APHID BIOLOGICAL CONTROL

K.M. Heinz, Department of Entomology; Biological Control Laboratory; Texas A&M University; College Station, Texas 77843-2475. USA. E-mail KMHeinz@tamu.edu

During the early stages of an outbreak, aphids form small clumps on individual plants within chrysanthemum greenhouses. These initial outbreaks quickly become serious problems because aphid populations quadruple in size daily when occurring on healthy plants. Aphid population growth on a newly infested pot is greatest aphid densities are low and decreased when aphid infestations became more dense. In addition, Myzus persicae and Aphis gossypii can spread over an area of 13.5 m² per day after infesting an single potted chrysanthemum. Hence, aphids may be present for a long time within a greenhouse and have the opportunity to reproduce and spread throughout the crop before being noticed. For predators and parasitoids to provide successful aphid biological, these natural enemies must locate and consume aphid patches when they are relatively scarce and before the aphids infest the entire greenhouse. After completing a set of intensive studies, results demonstrated the limitations to obtaining biological aphid control by releasing predators and parasitoids. Chrysoperla rufilabris larvae, used as a model predator, were found to be incapable of navigating between potted chrysanthemums placed Although lacewing larvae voraciously consume aphids once atop solid benches. discovered, successful biological control requires placement of lacewing larvae onto each individual plant infested with aphids. By comparison, studies with the parasitoid wasp A. colemani demonstrated that it could spread over an area of 16 m² per day after being released from a single potted chrysanthemum. From these results, it was determined that the most effective biological aphid control could be obtained by releasing A. colemani from points no greater than 4-m apart within a potted chrysanthemum greenhouse. Results from these predictions were verified in field studies. Use of the optimal release distances (every 4-m) resulted in significantly better aphid biological control than the 16-m treatment and in comparison to plots not receiving any wasps.

Key Words: Biological Control, Dispersal; Aphid, Chrysoperla, Aphidius

[1463] AUGMENTATION BIOLOGICAL CONTROL AS APPLIED IN LATIN AMERICA

<u>V.II.P. Bueno¹</u> & J.C. van Lenteren², ¹Detp. de Entomologia, Univ. Fed. de Lavras, Caixa Postal 37, Lavras, MG, 37200-000, Brasil, E-mail vhpbueno@ufla.br, ² Laboratory of Entomology, Wageningen University, P.O. Box 8031, 6700EH, Wageningen, The Netherlands.

Inundative and seasonal inoculative biological control, where natural enemies are periodically introduced, is commercially applied over large areas in various cropping systems worldwide. Internationally, more than 125 species of natural enemies are commercially available for augmentative biological control. Up to date, reliable figures on current use of inundative and seasonal inoculative biological control are very hard to obtain and the estimates about application in Latin America are incomplete. The best known examples of inundative and seasonal inoculative biological control in Latin America are use of the egg parasitoid Trichogramma for management of Lepidoptera in various crops. More than 100 species of Trichogramma occur in agroecosystems throughout the world. However, only 10 species are used in biological control programmes and most trials have envolved only five species against two pests. Most of the commercially used species have a low host specificity, which makes it possible to mass rear them relatively easily on different host species, and to release then against various pest species. This low host specificity may, however, involve the risk of parasitisation of non-target species, a much-debated issue in biological control today. The former USSR ranked first in application of Trichogramma (10 milion hectares), followed by China (2.1 milion hectares) and Mexico (2 milion hectares). Application in South America is limited for economic reasons (high labour costs involved in mass production of Trichogramma) and more intensive use of pesticides that have a negative effect on natural enemies. In Brazil, in an area of 2590 hectares of tomato crop, was released T. pretiosum against Tuta absoluta (Meyrick). Estimations of applications with Trichogramma in all countries with the exception of former USSR, China and Mexico, are in the order of 300,000 to 400,000 hectares. Of egg parasitoids other than Trichogramma used in commercial releases, the main species is Trissolcus basalis (Wollaston) against the heteropteran Nezara viridula (L.) in soybean in Brazil, and Telenomus remus Nixon against Spodoptera frugiperda Smith in corn in Venezuela. Natural enemies attacking larval and pupal stages are not use to a large extent in augmentative biological control in field crops. An example is the use of Cotesia parasitoids against sugarcane borers in China and Brazil. Data from 1996, in Brazil, showed the release in the field (area of 200,000 hectares of sugar cane) of 23,6 milion cocoon masses of C. flavipes and 1.5 milion of tachinid fly Paratheresia claripalpis Wulf. adults. A recent development is the use of biological control in protected cutivation in Latin America, for example, Colombia, Brazil and Peru. Index terms: inundative biological control, seasonal inoculative biological control.

[1464] USING GREENHOUSE ENVIRONMENT TO AUGMENT BIOLOGICAL CONTROL

J. L. Shipp, Y. Zhang and K. Wang, Agriculture and Agri-Food Canada, Greenhouse and Processing Crops Research Centre, Harrow, ON NOR 1G0, CAN.

Greenhouse environment or more specifically greenhouse climate has a dominant impact on greenhouse production yield and fruit quality. Greenhouse climate also has an important influence on insect and mite population dynamics, ecology, damage caused by these pests and the effectiveness of different control strategies against greenhouse pests. In greenhouse production, the climate in the greenhouse is monitored with highly accurate sensors and computer system that can maintain the temperature and humidity within narrow limits. At the GPCRC, a model (PSCLIMATE) has been developed to predict the microclimate (temperature and humidity) within the plant canopy and at the leaf surface. Greenhouse climate can influence the dispersal of pests and their biological control agents. Studies have also found that temperature and humidity will influence the predation rate of mites on western flower thrips and the survival of predatory mite life stages. The effectiveness of control agents, such as entomopathogens, can be substantially affected by humidity conditions in the greenhouse. Manipulation of greenhouse climate can be used as a control measure itself during greenhouse clean-up depending on the time of the year. More accurate prediction of pest outbreaks and the interactions between predators/parasitoids and their prey/hosts would result in improved effectiveness of biological control. A decision-support system (DSS) for pest management of greenhouse vegetable pests has been developed at the GPCRC and software communication protocol is currently being developed so that climate control systems can transfer the climate information that they are monitoring to the DSS. Access to this information will result in the development of models that can accurately predict pest population dynamics and assist in determining the induction rates of biological control agents for more effective and costefficient biological control of greenhouse pests.

Index terms: greenhouse pests, biological control, greenhouse climate

[1465] DO ECONOMICS AND BIOLOGY POSSESS SIMILAR GOALS?

J. van Schelt, Koppert B.V., P.O. Box 155, 2650 AD Berkel en Rodenrijs, The Netherlands

Biology and economics in biological pest control can be viewed from many sides. There is the grower who decides to start with an IPM program, but the grower-organisation, auction, supermarket, consumer and legislation will influence him. Because large growers are dependent on the export of their products, these factors can differ depending on the country. Economics and biology are also playing a daily role in the rearing of the beneficials at the producer site. For already more than 30 years the main market for Koppert, a producer of beneficial insects, mites and microbials, has been mainly in protected crops. This seems obvious, because the turnover per square meter is considerable higher compared to outdoor crops. But there are also less clear reasons. Beneficials have a very short shelf life so it is very expensive to raise a natural enemy for a release period of only a few weeks per year. For most parasites the rearing costs are still relatively high because they are generally propagated on their natural hosts on a plant. For many predators however, the development of artificial diets and alternative food sources, as lepidopteran eggs, will economise the cost in the future. For Koppert around 70% of the turn over comes from products used in tomatoes. Bumblebees for pollination; Encarsia formosa, Phytoseiulus persimilis, Diglyphus isaea are used to control whiteflies, spidermites and leafminers. More recently Aphidius ervi against aphids and the mirid Macrolophus caliginosus has been added. M. caliginosus has proven to be a very efficient "stabiliser" during the season. Because the mirids can survive periods of food scarcity by feeding on plant juices the population can stay at a high level and immediately suppress whitefly outbreaks. An interesting side effect is its potential to prey on lepidopteran eggs and even on leaf miner larvae. E. formosa is recently "upgraded" by developing a new release card and scaling up a new strain which does better under cold as well as warm circumstances. Also the introduction of Eretmocerus eremicus helped to optimise the whitefly control. This parasite is more resistant to chemicals and contributes to the whitefly control by a very high level of host feeding. Many growers use both species. For the Mediterranean area the control of Bemisia at high temperatures is very important. At the moment the specific parasite Eretmocerus mundus is scaled up. For the US an indigenous mirid: Dicyphus hesperus is commercialised. In general polyphagous predators are very interesting because it is not very economic to develop a specific biocontrol agent for every new pest in every country. For pests like whitefly, aphids and caterpillars a biological solution with only one natural enemy is impossible. A shield with different parasites and predators will be the solution for the coming years.

Index terms: Macrolophus caliginosus, Dicyphus hesperus, Eretmocerus eremicus, Encarsia formosa, Phytoseiulus persimilis, Diglyphus isaea biological control, tomatoes

[1466] THE BIOLOGY OF RAPHIDIOPTERA: A REVIEW OF PRESENT KNOWLEDGE WITH A CRITICAL VALUATION OF THE POSSIBLE USE OF SNAKE-FLIES IN INTEGRATED PEST CONTROL

H. Aspöck, Dept. of Med. Parasitology, Clinical Institute of Hygiene of the University, Kinderspitalg. 15, A-1095 Vienna, Austria, E-mail horst.aspoeck@univie.ac.at.

Up to 1960 Raphidioptera were among the most poorly investigated insects and there was only little knowledge on the biology of snake-flies. During the past 40 years, however, both families of the order - Raphidiidae and Inocelliidae - have been the subjects of intensive research in all major parts of the world where snake-flies occur. Nowadays about 185 (valid species of) Raphidiidae and 21 Inocelliidae are known (the total of extant species may be around 250). The distribution of the order is restricted to certain arboreal parts of the Holarctic where there are sufficiently low temperatures during winter. Temperatures around or below 0°C are apparently an indispensable prerequisite for the development. The larvae of all species of both families (so far described or at least known of about 130 species) are predacious feeding on a great variety of preferably soft-bodied arthropods including many pests (aphids, coccids, larvae of Lepidoptera, Coleoptera, Hymenoptera). They live under the bark of trees or in the soil. Also the adults of Raphidiidae are predators mainly feeding on aphids and other Sternorrhyncha, while the food of Inocelliidae is unknown (possibly pollen). There are large regions in all continents, particularly in the Southern hemisphere, but also in North America, which offer excellent ecological conditions for snake-flies but which lack them for historical-biogeographical reasons. Thus, an introduction of certain species with a high potential as predators seems very promising. We have reared about 120 species (many of them from the egg stage) from all four continents where snake-flies occur so that a lot of information on various biological parameters (preferred habitats, associations with certain plants, developmental periods and life-spans, mating behaviour, optimal breeding conditions, food and parasites) has accumulated which represents a reasonable basis for a realistic estimation of the possible use of snake-flies in integrated pest control.

Index terms: Neuropterida, ecology, predators, intercontinental transfer.

[1467] LIFE HISTORY OF *PARASITUS CONSANGUINEUS* FED ON THREE SPECIES OF PESTS OCCURRING IN MUSHROOM HOUSES

<u>E. Szlendak</u> & M. Lewandowski, Dept. of Applied Entomology, Warsaw Agricultural Univ., ul. Nowoursynowska 166, 02-787 Warsaw, Poland. E-mail szlendak@alpha.sggw.waw.pl

Parasitus consanguineus is a non-parasitic mite, new for Polish fauna, which occurs in various habitats including mushroom houses. P. consanguineus feeds on small arthropods, nematodes, and eggs of both these groups. The objective of our study was to clarify whether P. consanguineus can complete its life cycle feeding on common pests occurring in Polish mushroom houses: the nematode Rhabditis cucumeris, or first- and second-instar larvae of the phorid Megaselia halterata and the sciarid Lycoriella solani. Life tables were constructed for P. consanguineus fed on these three species. The developmental time of immature stages of P. consanguineus was longest (8.33 days) on sciarid larvae and shortest (7.06 days) on nematodes. Young P. consanguineus fed on phorid larvae emerged into adults after 7.91 days. Survival of P. consanguineus up to the adult stage was low on all offered diets, reaching 53, 49, and 63% on R. cucumeris, M. halterata and L. solani, respectively. The total fecundity of P. consanguineus females reared on the various diets was also very low, averaging 11.2, 12.4 and 17.7 eggs/female on the above-mentioned diets, respectively. Population parameters computed for *P. consanguineus* indicated that sciarid larvae were the best of the three species of pests tested as food for the predator. On this diet all parameters reached higher values than for other species and were as follows: (rm) 0.16; (Ro) 5.61; (T) 10.96; (lambda) 1.17. The lowest population parameter values were obtained when nematodes were provided as food: (rm) 0.10; (Ro) 2.84; (T) 9.34; (lambda) 1.10. P. consanguineus fed on phorid larvae had the following population parameters: (r_m) 0.10; (Ro) 3.02; (T) 10.49; (lambda) 1.11. Low values for the net reproductive rate of increase (Ro) in all tests suggested that *P. consanguineus* populations can increase only 3- to 6-fold during one generation when fed on the selected species of pests. This result is significantly different from data recorded for other soil-associated predators of Gamasida, and indicates that our selected test species of mushroom pests are unfavourable as food for P. consanguineus.

Index terms: Parasitus consanguineus, population parameters

[1468] CRITICAL ISSUES IN EGG PARASITOIDS

F. Bin & E. Conti, Department of Arboriculture and Plant Protection – Entomology, University of Perugia, Borgo XX Giugno, Perugia 06121, Italy, E-mail: fbin@unipg.it

Three families of egg parasitoids (Scelionidae, Mymaridae and Trichogrammatidae) and species belonging to nine other families of Hymenoptera are associated worldwide with hosts belonging to eight orders of insects, including many pest species. However, the research on egg parasitoids and their utilization in biological control has been focused mainly on *Trichogramma* species while, in spite of their recognized ecological and economic importance, the other groups have been poorly studied. The host-parasitoid associations described in the literature (CAB Database, Current Contents and several other papers) and from unpublished observations are analyzed and the effort applied for each group is discussed in relation to the results obtained in biological control. Efficacy and limits of *Trichogramma* spp., that represent more than half of all the efforts on egg parasitoids, are evaluated and compared to the efficacy and limits of the other species. Indications are given with the aim of increasing the utilization of species other than *Trichogramma* spp. for the control of crop and forest pests. Some aspects that should be considered in order to predict egg parasitoid efficacy and prevent the risks of biological control are discussed.

Index terms: Scelionidae, Mymaridae, Trichogrammatidae

[1469] THE RELATIONSHIP BETWEEN EGG LOAD AND FECUNDITY AMONG TRICHOGRAMMA PARASITOIDS

N. J. Mills¹ & U. Kuhlmann², ¹Insect Biology, Wellman Hall, Univ. of California, Berkeley, CA 94720-3112, USA, E-mail nmills@nature.berekeley.edu; ²CABI Bioscience Centre, Rue des Grillons 1, CH-2800 Delémont, Switzerland.

The relationships between parasitoid egg load, size, and age (3-72h) for Trichogramma minutum, T. platneri, and T. pretiosum, reared from two factitious hosts, Ephestia kuchniella and Sitotroga cerealella, were evaluated to test the hypothesis that 24h egg load can be used to estimate the fecundity of Trichogramma parasitoids. Egg load increased in relation to female age over the first 3 days of adult life for all three Trichogramma species to a mean egg storage capacity of 46.7 eggs for T. minutum, 41.1 for T. pretiosum, and 35.7 for T. platneri. At 24 h of age, T. minutum had matured enough eggs to fill 67% of its storage capacity, in comparison to 74% for T. pretiosum and 91% for T. platneri. There was a positive relationship between egg load and parasitoid size for all ages of the three Trichogramma species reared from both hosts, accounting for 14-69% of the variance in egg load. The potential fecundity, estimated realized (3 day cumulative) fecundity, and oviposition rate (potential fecundity/longevity) of T. platneri were all related linearly to size-dependent variation in 24h egg load. However, only the realized fecundity of T. pretiosum, and none of the reproductive characteristics of T. minutum, were related to 24h egg load. It is suggested that 24h egg load may not be an accurate measure of egg storage capacity in parasitoids and should be used cautiously to represent fecundity. The potential fecundity of seven Trichogramma species reared from E. kuehniella varied from 55 to 150, but neither potential fecundity nor oviposition rate was related significantly to egg load. Selection to avoid egg depletion in the attack of gregarious hosts appears most likely to account for the variation in potential fecundity among Trichogramma species.

Index terms: Trichogramma minutum, Trichogramma platneri, Trichogramma pretiosum, age, oviposition rate, size

[1471] EFFECT OF ALTERNATING TEMPERATURES ON THE DEVELOPMENT, LONGEVITY AND REPRODUCTION OF *TRISSOLCUS BASALIS* (HYMENOPTERA: SCELIONIDAE)

L. A. Foerster¹ & P. A. Nakama¹, ¹Dept. of Zoology, Universidade Federal do Paraná, P. O. Box 19.020 (81531-990) Curitiba, PR, Brazil. E-mail: foerster@bio.ufpr.br

Scelionid egg parasitoids are effective in reducing populations of stink bugs in soybeans. In warmer areas of Northern Paraná State, these parasitoids remain active throughout the year due to the availability of host eggs laid on alternative plants during autumn and winter. Under colder conditions, these parasitoids must have other strategies to survive in the absence of hosts during adverse climatic conditions. In colder areas of Southern Brazil, the green stink bug Nezara viridula overwinters in the adult stage and it is not known if its egg parasitoid Trissolcus basalis is able to survive winter temperatures using alternative host eggs. To assess the development, longevity and reproduction of T. basalis at temperatures similar those prevailing during winter in Southern Paraná State, the immature stages of the parasitoid were submitted to 15°C for different periods. Parasitized eggs of N. viridula were transferred from 25°C either in the egg, first instar or pupal stage of T. basalis and remained at 15°C from 7 to 90 days. Part of the parasitized eggs was dissected after each interval at 15°C to determine the developmental stage of the parasitoids, and part returned to 25°C to assess their development and emergence. Parasitoids transferred to 15°C either in the egg or in the first instar completed larval development and pupated after 35 and 30 days respectively, but the adults failed to emerge at this temperature. Storage of T. basalis in the pupal stage at 15°C after egg and larval development at 25°C during seven days, did not affect adult emergence, but delayed the pupal stage by 10 days in comparison to the time required at 25°C. Adults emerged at 15°C obtained from parasitoids reared at 25°C until one day before emergence survived for five months at the lower temperature. However, female fertility was sharply reduced, and only 3.1% of the eggs exposed to the females at 15°C were parasitized. It is concluded that the immature stages of T. basalis do not complete their development at winter temperatures in Southern Paraná and that the adults are able to survive throughout the winter in a state of hibernation. During this period, reproduction of the parasitoids is significantly reduced. Index terms: Biological control, egg parasitoid, Nezara viridula, stink bug, soybean.

[1470] EFFECT OF DENSITY OF DIATRAEA SACCHARALIS EGGS IN THE PARASITISM OF TRICHOGRAMMA GALLOI IN SUGARCANE

A. de S. Pinto¹, J. R. P. Parra², H. N. de Oliveira² & E. de B. Arrigoni³, ¹C. U. Moura Lacerda, Ribeirão Preto-SP, Brazil, E-mail aspinn@uol.com.br; ²Dep. Entomol., Fitop. e Zool. Agrícola, ESALQ-USP, 13418-900, Piracicaba-SP, Brasil; Copersucar, Piracicaba-SP.

The performance of *Trichogramma galloi* Zucchi, 1988 in different egg densities per point of artificial infestation of *Diatraea saccharalis* (Fabr., 1794) in sugarcane was studied. The trials were conducted in commercial sugarcane fields in Piracicaba, SP, Brazil in 1998. An inverse proportional relationship between the number of eggs per infestation point and the percentage of parasitism starting with 50 eggs per infestation site was observed. The results indicated that the egg density is fundamental for studies on *T. galloi* parasitism under field conditions. The studies on parasitism by *T. galloi* must use areas with infestation points with low egg density, which can be achieved by using older females in the cages attached to the plants in which they lay fewer egg masses. Index terms: biological control, egg parasitoid, sugarcane borer

[1472] THE ROLE OF INDUCED PLANT VOLATILES FOR EGG PARASITOIDS AND THEIR POTENTIAL FOR SEMIOCHEMICAL CONTROL

T. Meiners & M. Hilker, Institut für Biologie, Freie Universität Berlin, Haderslebener Str. 9, D-12169 Berlin, Germany, e-mail meito@zedat.fu-berlin.de

Parasitoids of herbivorous hosts face the problem that they have to utilize reliable and detectable cues during host location. It has been shown that larval parasitoids can solve this problem by orientating towards plant odors that are released after herbivore feeding damage. The role of induced plant volatiles for egg parasitoids is almost unknown. Its elucidation, however, may contribute to the enhancement of performance of egg parasitoids utilized as biological control agents. The egg parasitoid Oomyzus gallerucae (Hymenoptera, Eulophidae) attacks eggs of the elm leaf beetle Xanthogaleruca luteola (Coleoptera, Chrysomelidae), which is a serious defoliator of different elm species in Southern Europe, North America and Australia. O. gallerucae has been repeatedly introduced into the United States for biological control of the elm leaf beetle. In Southern France 30 -70 % of elm leaf beetle egg masses sampled on different locations and during different years were parasitized by O, gallerucae. These high discovery efficiencies of female egg parasitoids might be mediated by volatile synomones. Our olfactory studies on host location of O. gallerucae proved that these egg parasitoids are attracted to the odor of field elm (Ulmus minor) leaves that are carrying eggs of the elm leaf beetle. Oviposition of X. luteola induces a change of the volatile pattern emitted by the field elm leaves resulting in the attraction of the egg parasitoids. The plant's reaction to oviposition is systemic; the leaves without eggs adjacent to those with eggs also emit attractants. Females O. gallerucae also react to odor of elm leaves treated with jasmonic acid. Jasmonic acid is known as mediator of plant responses induced by feeding of herbivorous arthropods. Plants that are able to respond to oviposition of herbivores may defend themselves by emission of volatiles which "call" for egg parasitoids. This potential might be used to enhance the performance of egg parasitoids for semiochemical control of herbivores. Index terms: Oomyzus gallerucae, elm leaf beetle, egg parasitoid, synomone induction, biological control

[1473] EFFECT OF DIATRAEA SACCHARALIS SCALES ON MASS PRODUCTION OF TRICHOGRAMMA GALLOI ZUCCHI REARED ON ANAGASTA KUEHNIELLA EGGS

M. Lima Filho¹ & J. O. G. de Lima², ¹Campus Dr. Leonel Miranda-UFRRJ, Estr. do Açúcar, Km5, Penha, CEP 28020-560, Campos dos Goytacazes, RJ, E-mail: clmufrj@rol.com.br; ²LPP/CCTA/UENF, Av. Alberto Lamego, 2000, CEP 28015-620, Campos dos Goytacazes, RJ, E-mail: joscar@uenf.br.

The parasitoid Trichogramma galloi is a potential agent for biological control of the sugar cane borer, Diatraea saccharalis. However, eggs of Anagasta kuehniella are the most appropriate substitute hosts for mass production of this parasitoid. Virgin female lepidopterans release pheromones through their scales which may function as kairomones. In order to test the effect of virgen females D. saccharalis scales on parastism of A. kuehniella eggs by T. galloi, the following experiments were carried out. Eggs were exposed to female parasitoids for 24 and 48 h, at 25 ± 1 °C, 70 ± 10 % RH and 13 h photoperiod. The presence of the scales was found not to increase parasitism. Independently of treatment with scales, an average of 30 and 45 eggs were parasitised by each female parasitoid during 24 and 48 h exposure, respectively. One adult parasitoid was generated per parasitized egg. Although reared for approximatelly 60 generations in eggs of A. kueniella, T. galloi was able to parasitise an average of 19 and 26 eggs of D. saccharalis during 24 and 48 h, respectively, from which emerged an average of 1.6 adult per parasitised egg. The number of adult offspring and adult sex ratio (r = 0.9) produced by each female T. galloi on eggs of both hosts was not significantly different (P< 0.05) (41 adults on eggs of D. saccharalis, 51 and 46 on eggs of A. kuehniella, treated and not treated with scales, respectively).

Index terms: Insecta, biological control, parasitoid, kairomone, sugar cane borer

[1475] BIOLOGICAL DATA ON *MEGAPHRAGMA AMALPHITANUM* VIGGIANI AND *MEGAPHRAGMA MYMARIPENNE* TIMBERLAKE (HYMENOPTERA: TRICHOGRAMMATIDAE), EGG-PARASITOIDS OF *HELIOTHRIPS HAEMORRHOIDALIS* (THYSANOPTERA: THRIPIDAE) IN SOUTHERN ITALY

U. Bernardo¹, <u>G. Viggiani²</u>, Centro di Studio CNR sulle Tecniche di Lotta Biologica, Via Università 133, 80055 Portici, Italia. E-mail: G.Viggiani@iabbam.na.cnr.it; Univ. di Napoli "Federico II", Dept. Entomologia e Zoologia Agraria, Via Università, 100, 80055 Portici, Italia. E-mail: genviggi@unina.it.

Megaphragma amalphitanum Viggiani, an anfigonic species, and Megaphragma mymaripenne Timberlake, a normally thelitokous species, (Hymenoptera: Trichogrammatidae) are egg-parasitoids of the greenhouse thrips, Heliothrips haemorrhoidalis (Bouché) (Thysanoptera: Thripidae) in Campania (southern Italy) (Viggiani and Bernardo, 1997). Several biological parameters of the two species (longevity, mating, egg and preimaginal stage development, duration of the egg-adult cycle, fecundity, progeny, sex-ratio) have been comparatively studied in laboratory at different temperatures. M. amalphitanum showed higher fecundity and longevity, shorter egg - adult cycle than M. mymaripenne, but the preimaginal stages of latter species were more resistant to low temperature.

Index terms: longevity, fecundity, progeny, egg-adult cycle

[1474] PARASITISM RATE AND VIABILITY OF *TRICHOGRAMMA MAXACALII* (HYM.: TRICHOGRAMMATIDAE) ON EGGS OF THE *EUCALYPTUS* DEFOLIATOR *EUSELASIA APISAON* (LEP.: RIODINIDAE)

H. N. de Oliveira¹, J. C. Zanuncio¹, D. Pratissoli² & L Cruz³, ¹Dep. de Biologia Animal, Univ. Federal de Viçosa, 36.571-000 Viçosa, MG, BRAZIL. E.mail: zanuncio@mail.ufv.br; ² Dep. de Filossanidade, Univ. Federal do Espírito Santo, 29.500-000 Alegre, ES, BRAZIL; ³ CNPMS/EMBRAPA, C. Postal 151, 35.701-970, Sete Lagoas, MG, BRAZIL.

Parasitism rates and viability of individuals of two populations of Trichogramma maxacalii (Voegelé and Pointel, 1980) (Hymenoptera: Trichogrammatidae) were evaluated in two Eucalyptus plantations in the Counts of Ribeirão Preto, State of São Paulo and Nova Era, State of Minas Gerais, Brazil. These parasitoids were reared on eggs of the host Anagasta kuehniella (Zeller 1879) (Lepidoptera: Pyralidae) with or without honey and were exposed to eggs of the host after 0, 6, 12, 24, 36, 48 and 60 hours after emergence. Each recently emerged parasitoid female was placed in a 4.0 x 0.7 cm glass tube with a blue 3.5 x 0.5 cm cartoon with 40 glued non viable eggs of A. kuehniella and parasitism was permitted during 24 hours. Viability of T. maxacalii (above 96.0%) was not affected by the presence of food, by the origin of the parasitoid population, or by the period in which it was kept without eggs of the host. However, parasitism rate was higher than 75.0% and lower than 65.0%, for parasitoids with or without honey, respectively. Individuals of the population from São Paulo showed higher parasitism rates when they received eggs of the host at longer periods after its emergence. Parasitism was higher for the population from Minas Gerais when eggs of the host were provided soon after emergence. Parasitism behaviour in these two populations shows that they can be combined to obtain a better efficiency of T. maxacalli in programs of mass release against Euselasia apisaon (Dalman) (Lepidoptera: Riodinidae) in Eucalyptus plantations. Intex terms: Trichogrammatidae; parasitoids; Eucalyptus

[1476] HOST ACCESSIBILITY IMPACTS ON BIOLOGICAL CONTROL OF LYGUS HESPERUS WITH ANAPHES IOLE: THE STRAWBERRY EXPERIENCE

S. Udavagiri¹ & S. C. Welter², ¹Univ. of California Cooperative Extension, 1432 Freedom Blvd., Watsonville CA 95076, USA, E-mail sujaya@ucdavis.edu; ²Div. of Insect Biology, Univ. of California, 201 Wellman Hall, Berkeley, CA 94720, USA.

Lygus hesperus Knight (Heteroptera: Miridae) is native to western parts of the US and is a major pest in strawberries on the central coast in California. Adults migrate from overwintering weed sites in spring when the rains cease, and two generations develop in strawberries. Nymphs and adults feed on the fruits, and as a result, the fruits are distorted or 'cat-faced', and are not acceptable in the fresh market. We evaluated the potential for inundative biological control of L. hesperus with the native Anaphes iole Girault (Hymenoptera: Mymaridae). Being a high cash value crop, inputs into strawberry production are high, and an expensive control strategy such as inundative biological control has a high likelihood of being adopted if the program is effective. We released 15,000 A. iole in acre (0.4 ha) sized plots every week at three sites, and observed a 64 % suppression of L. hesperus. We doubled the release frequency the following year but obtained only a marginal increase in Lygus hesperus suppression. On several weed species, high levels of parasitism of L. hesperus by A. iole have been observed. To determine whether plant-related factors affect parasitoid performance in strawberries, we examined L. hesperus egg distribution in individual strawberry plants, and parasitism by A. iole of eggs in different strawberry plant structures. We observed that L. hesperus laid more eggs (46.5% of all eggs laid) in the fruit (between the achenes [seeds] in the fleshy receptacle), compared to the petiole (23.3%), leaflet (20.3%), peduncle (6.2%) or calyx (3.7%). In a no-choice test, parasitism by A. iole was higher in the petiole (96.7%), calyx (91.9%) and leaflet (85.2%) compared to the fruit (51.8%), where the achenes appeared to hinder parasitoid access to host eggs. In young fruits where the inter-achene distance was minimum, parasitism was considerably lower (25.4%) than in fruits where receptacle swelling had resulted in inter-achene distances that were medium (65.7% parasitism) or large (77.1% parasitism). Our results suggest that strawberry fruits can provide refugia from parasitism by A. iole, and that maximum protection occurs when the achenes are contiguous. The relevance of these findings to inundative biological control of L. hesperus with A. iole, and options for integration with other strategies will be discussed. Index terms: Lygus hesperus, Anaphes iole, refugia, inundative biological control.

[1477] MULTIPLICATION OF TELENOMUS PODISI AND TRISSOLCUS BASALIS (HYMENOPTERA: SCELIONIDAE) ON EUSCHISTUS HEROS (HEMIPTERA: PENTATOMIDAE) EGGS FOR SOYBEAN STINK BUGS CONTROL

W.A.A. Peres¹ & B. S. Corrêa-Ferreira², ¹Universidade Federal do Paraná, Departamento de Zoologia, Caixa Postal 19020, Curitiba, Paraná 81531-990, Brasil. Email: wilsimar@cnpso.embrapa.br., ²Embrapa-Soja, Caixa Postal 231, Londrina, PR, 86001-970, Brasil, E-mail: beatriz@cnpso.embrapa.br.

The biological control of soybean stink bugs in Brazil is based on mass rearing in the laboratory and field release of the egg parasitoid *Trissolcus basalis*. Today the brown stink bug *Euschistus heros* is the most abundant pentatomid onsoybean crop, besides, Telenomus podisi has been considered as an important egg parasitoid of soybean stink bug. Laboratory studies were conducted to test the suitability of E. heros eggs to mass rearing T. podisi and T. basalis, compared to the standard methodology (T. basalis multiplied in N. viridula eggs). The eggs of E. heros were exposed to parasitoids by different ways. When individualized eggs were exposed, the parasitism was high (> 96%) but adult emergence rates were low (51.2 and 26.1%, respectively), showing that this egg distribution was inadequate to parasitoid multiplication. When egg masses were exposed to parasitism with eggs on the normal position, obtained emergence rates of 83.1% for T. podisi and 50.6% for T. basalis compared to values of 79.9% and 63.1% with eggs exposed on other positions, did not differed significantly, and showing that the egg mass pulverization methodology was adequate. On cardboard tickets, 162 egg masses or 1193 eggs of E, heros were laid, being 38%, 36.6% and 25.4% of the eggs on lateral, normal and inverted positions, respectively. Parasitism rates of T. podisi and T. basalis (ca. 99%) were similar to that observed with the standard methodology (99.7%). Nevertheless, the emergence rates (50.5% for T. podisi and 60.4% for T. basalis) were significantly lower, probably due a high number of eggs with lateral shrinking, in which there was no development of the parasitoid.

Index terms: biological control, egg parasitoid, mass rearing.

[1478] DIAPAUSE INDUCTION AND COLD STORAGE IN TRICHOGRAMMA NERUDAI

A. A. Tezze & E. N. Botto, Insectario de Investigaciones para Lucha Biológica. IMYZA-CNIA-INTA Castelar. C. C. 25 (1712), Buenos Aires, Argentina. E-mail: atezze@cnia.inta.gov.ar

Diapause induction in egg parasitoids can be used as a storage technique. In this study it was evaluated the effect of different cold storage periods (treatments) on previously diapause induced Trichogramma nerudai pupae. Developmental time from pupa to adult emergence (emergence time), birth proportion (born adults / parasitized eggs) and survival at 72 h. and sexual proportion (females / females + males) of emerged adults, were used to evaluate the effect of treatments. Diapause induction and breaking were obtained following the methodology developed in the Soviet Union for T. evanescens and T. pintoi. The experimental sequence followed in the treatments was: diapause induction - cold storage - diapause breaking - standard conditions. Cold storage times were 60, 120 and 150 days. Non diapause induced pupae (control group) and emerged adults after breaking the diapause were maintained at rearing standard conditions (temperature: $25 \pm 1^{\circ}$ C; humidity: 80 ± 5 %; and photoperiod of L14:D10). Time to adult emergence increased with increasing cold storage times whereas pupa survival (birth proportion) decreased in the 120 and 150 cold storage days. Adult survival and sexual proportion were no significantly different between treatments. Up to 60 days cold storage did not affect the emergence of adults but longer times reduced it by nearly 25%. The obtained results support the idea that diapause induction and cold storage techniques could be successfully applied to this novel species and used in its mass production.

[1479] HOST SPECIES AND AGE SELECTION BY TRICHOGRAMMA PRETIOSUM IN GREEN LACEWING SPECIES

N. M. M. S. de Albergaria¹, H. O. S. Dória², G. Bissolli³, R. J. Ferreira⁴ & S. A. De Bortoli¹, ^{1,2,3}Dept. de Fitossanidade, Fac. Ciências Agrárias e Veterinárias, UNESP, Via de Accesso Prof. Paulo Donato Castellane, s/n, 14884-900, Jaboticabal, SP, Brasil, (¹FAPESP Fellowship), (²CNPq Fellowship), ⁴Dept. de Biologia, Fac. Filosofia, Ciências e Letras de Ribeirão Preto, Univ. de São Paulo, Av. dos Bandeirantes, 3900, 14040-901, Ribeirão Preto, SP, Brasil (FAPESP – Fellowship). E-mail: nntendes@zaz.com.br.

The green lacewings are frequently parasited by *Trichogramma pretiosum* Riley, 1879, in several crop fields systems. This work was carried out to investigate *T. pretiosum* preference to the eggs of five different green lacewing species that belongs to 5 genders. Among the species was investigated the preference eggs age too. The trials was conducted using eggs of *Chrysoperla externa*, *Ceraeochrysa cincta*, *Chrysopa paraquaya*, *Nodita* sp and *Ceraeochrysa cubana* in four classes of age (0-24, 24-48, 48-72 and 72-96 hours). The eggs were submitted to the *T. pretiosum* females up to 24 hours of age. According to the results was observed difference among the parasitism to the five species of crisopids and there was preference to the eggs 0-24 hours age.

Index Terms: Crisopid, biological control, preference, Neuroptera

[1480] TETRASTICHUS PHYTOMYZAE (HYMENOPTERA: EULOPHIDAE), AN INTERNAL PARASITOID ON THE BROOMRAPE FLY, PHYTOMYZA OROBANCHIA (DIPTERA : AGROMYZIDAE)

Al-Eryan , M. A. S., Gadelhak, G. G. & Rezk, H. A, Dept. of Economic Entomology, fac. Agric. (Elshatby), Alexandria Univ., Egypt. Email: m_a_aleryan@yahoo.com

The broomrape, Orobanche crenata is one of the most important parasitic weeds on the legume plants causing considerable damage in yield. One of the most important biological control agents used against this weed is the monophagous dipteran fly, Phytomyza orobanchia. The use of this fly has been promising in many countries. The larvae of this fly feed only upon the immature seeds of Orobanche spp. destroying most seeds in the fruit capsule. The natural capacity of Phytomyza in reducing the Orobanche population is limited by many factors, such as low temperature, cultural practices, insecticide applications and natural enemies. Tetrastichus phytomyza is one of the encountered parasitoid of P. orobanchia in Egypt. This parasitoid lays its eggs in Phytomyza pupae where larvae live as gregarious endoparasites causing death of their hosts. This study aims to develop an understanding of its parasitization rats on P. orobanchia in three districts in northern Egypt. Infested Orobanche spikes with Phytomyza were collected in April of 1996, 1997 and 1998 seasons. At that time, larvae migrate into the underground parts of Orobanche to undergo pupation and start diapause for the next seasons. Stems were dissected to collect the fly pupae. Pupa was placed in glass veils covered with muslin till the next season. Percentage of Phytomyza adult emergence was calculated in each year, separately. Based on the above study, the season of 1998 was chosen for the investigation of the parasitoid on the pupae of *Phytomyza* at three districts in the west Nile Delta. Percentages of *Phytomyza* adult emergence were 87.32%, 32.13% and 18.72% in 1996, 1997 and 1998, respectively. Meanwhile, percentages of parasitized pupae with Tetrastichus were 0.0%, 27.87 and 64.25% in the three consecutive years at respect. The remains pupae enter prolonged diapause and represented 12.68%, 40.0% and 17.04% in the abovmentioned three years, respectively. Percentages of parasitism in 1998 season in Kafr El-Dawar, Housh Issa and Alexandria districts were 16.0%, 63.16% and 67.77%, respectively. According to high parasitism in over-summering generation of Phytomyza, the expected Phytomyza population synchronized with new emerged Orobanche will be decreased. As a matter of fact, this factor should be considered during the planning of Phytomyza release programs.

Key words: Biological control, Orobanche crenata, Egypt

[1481] PHYSIOLOGICAL FACTORS DETERMINING SUITABILITY OF BRACONID ENDOPARASITOIDS (COTESIA FLAVIPES COMPLEX) FOR DEVELOPMENT IN NOVEL-ASSOCIATION LEPIDOPTERAN STEMBORERS (DIATRAEA SPECIES AND OSTRINIA NUBILALIS)

<u>M. Allevne</u>¹ & R. N. Wiedenmann², ¹Univ. of Illinois at Urbana-Champaign, Department of Entomology, 320 Morrill Hall, Urbana, IL 61801, USA, E-mail: vanlaarh@uiuc.edu; ²Illinois Natural History Survey, Center for Enconomic Entomology, 607 Peabody Drive, Champaign, IL 61820, USA.

Extensive study of insect immune systems has yielded a better understanding of the interplay between behavioral, cellular, molecular and genetic mechanisms used by insects to defend against invaders. This knowledge should be used to predict how parasitoids (novel and coevolved) utilize potential hosts, which will help us plan the safe deployment of these natural enemies for biological control. Our experimental system consists of two New World pyralid stemborers, Diatraea saccharalis and D. grandiosella: one Old World pyralid, Ostrinia nubilalis; and three Old World braconid parasitoids, Cotesia chilonis, C. sesamiae, and C. flavipes. Experiments on host suitability, chronology of encapsulation, host hemocytes, etc., indicate that parasitoids that are taxonomically, behaviorally, and ecologically very similar may differ in utilization of a host of the same species. For instance, O. nubilalis is unsuitable for parasitoid development whereas D. saccharalis supports development of all three parasitoid species. D. grandiosella shows a mixed response. Those host species that encapsulate parasitoid progeny are only capable of doing so three to four days post-parasitization. These patterns of encapsulation do not correspond with differences in total hemocyte numbers. Parasitoids may use different methods at different times after parasitization to counter the immune response (i.e. egg and larval surface features, polydnavirus, parasitism specific proteins, teratocytes, etc.). The short-term immunosuppressive methods used by the parasitoids studied here are ineffective in O. nubilalis. In Diatraea hosts this short-term method does work, however, for some host-parasitoid combinations this effectiveness is lost or longer-term factors are not capable to evade the host's immune response. Patterns suggest that the host range of the parasitoids studied here will be narrow -- due to physiological factors -- thus limiting effects on non-targets. However, the lack of consistent patterns indicates that explicit testing will be needed to determine host ranges.

Index Items: biological control, encapsulation, host range, immune response.

[1482] INFLUENCE OF HOST DENSITY ON ATTACK RATES OF TACHINAEPHAGUS ZEALANDICUS ASHMEAD (IIYMENOPTERA: ENCYRTIDAE) ON MUSCA DOMESTICA (DIPTERA: MUSCIDAE) AND CHRYSOMYA PUTORIA (DIPTERA: CALLIPHORIDAE)

M.A.F. de Almeida¹, A.P. do Prado¹ & C.J. Geden², ¹Dep. de Parasitologia, IB, Universidade Estadual de Campinas, CP 6109, Campinas, São Paulo, Brasil, CEP 13083-970, E-mail: cmfa@lancernet.com.br, ² USDA, ARS, CMAVE, PO Box 14565, Gainesville, FL 32604, USA, E-mail: cgeden@nervm.nerdc.ufl.edu. This study was supported by FAPESP and CAPES.

Tachinaephagus zealandicus is a gregarious parasitoid that attacks muscoid flies in the larval stage; at 25°C adult parasitoids emerge from fly pupae ca. 25 days after oviposition. Certain evidences indicate that this species is endemic to the Southern Hemisphere and has been collected in carcasses and from poultry farms in Brazil. A colony of T. zealandicus was established in the Laboratory of Entomology, UNICAMP, Brazil from a sample collected in a poultry house in Santa Cruz da Conceição, São Paulo, Brazil. We evaluated the potential of females for killing pupae of M. domestica and C. putoria in different densities of hosts considering that these species of flies, mainly M. domestica are very noxious in these kinds of environments. We used five different densities (2, 4, 8, 16, 32) of larvae for each species of flies, and for each density we used 20 females of T. zealandicus (N = 100) that were isolated in 30ml clear plastic cups covered by snap-on plastic lids with screened openings, and the period of exposure to oviposition was 24 hours. The females used were 2d old and were removed from the colony where they were only fed with honey and water and had no contact with any kind of host. The results showed that the mean no. of M. domestica larvae killed by T. zealandicus was 1.9, 3.8, 7.0, 11.9 and 21.7 for the densities of 2, 4, 8, 16, 32; respectively. For C. putoria was 1.4, 1.8, 3.4, 5.3, 9.5 and 13.5 for the densities of 2, 4, 8, 16, 32, respectively. The number of killed pupae, either for C. putoria or M. domestica was affected by the host density and species (overall ANOVA F=52.00 **). Rates of host attacks were significantly affected by host species (F=14.41**), density (F=104.41**) and by the interaction of density*species (F=7.10**). This shows that T. zealandicus was able to kill large number of immatures of these two species of flies. Considering that these flies are the primary dipteran pest species found in poultry houses in Brazil, these results indicate that T. zealandicus may be an important biological control agent for use in poultry facilities.

Index terms: parasitoids, flies, biological control, density, gregarious

[1483] ECONOMICALLY IMPORTANT PESTS OF THE COSAVE REGION AND THE AVAILABLE TECHNOLOGIES FOR THEIR BIOLOGICAL CONTROL

¹<u>M.I. Ares</u>, Dirección del Servicio deProtección Agrícola Ministerio de Agricultura, Ganadería y Pesca Montevideo,Uruguay. Email: miares@netscape.net; ²E. De Nardo, CNPMA -Embrapa- JaguariunaCEP 1382000 , Sao Paulo Brazil sardo@cnpma.embrapa.br, ³S. A. Passalacqua Dir.Nacional de Protección Vegetal SENASA Buenos Aires dguillen@inea.com.ar;⁴J. M. C. De Sousa Dias CENARGEN-Embrapa, Brasilia, Brazil cabral@cernargen.embrapa.br;⁵P.Mondaca Ministerio de Agricultura Servicio Agrícola y Ganadero, Santiago, Chile pmondaca@sag.minagri.gob.cl, ⁶R. A.Bustamante Ministerio de Agricultura Servicio Agrícola y Ganadero ,Chile, rarce@sag.minagri.gob.cl;⁷R.B.Stelatto Dirección de Defensa Vegetal Ministerio de Agricultura y Ganadería, Paraguay ddv@conexion.com.py. ⁸R. Caceres, Paraguay.

In the Southern South America countries biological control activities have increased rapidly. The South Cone Plant Protection Committee (Comité de Sanidad Vegetal del Cono Sur - COSAVE) is a Regional Plant Protection Organization (RPPO) established in1989, through an agreement among the governments of Argentina , Brazil , Chile , Paraguay and Uruguay. COSAVE is in charge of developing Regional Standards to harmonize the phytosanitary regulations and procedures to facilitate the regional and international trade of agriculture products. Cosave has different Permanent Work Group (PWG) each one addresses specific issues related to Plant Protection. The Biological Control Permanent Work Group (BC-PWG) has established a list of biological control agents used within the countries of the region to determine which pests should be commonly targeted in order to speed the development of the biological control technologies. In this way, research was done in order to establish the main pest of each Cosave country and the biological control technologies available for each of these pests, including the stage in which these technologies have been developed. It was considered 4 stages of development: 0=no technology or research available.1= technology in the beginning stages of research.2=technology in advanced stages of development.3=technology available commercially.4=This technology was used in the past, but not in the present because the pest is no longer a problem in the country or because other technologies have replaced it. As a result of this work, a technical report was made and can be accessed at <htpp://www.cosave.org.py>.It was organized in a series of tables, each one addressing one crop that is important in at least three countries in the region. As of now, only insects, mites, and fungi are considered. Other pests, such as bacterias, nematodes, viruses, and insect vectors. will be included in further revisions of the report. This list is not static, and will be updated periodically as new pests or technologies are available in the region.

Index terms :Southern South America; South Cone Plant Protection Committee ;phytosanitary regulations; harmonization

[1484] BIOLOGICAL ASPECTS OF CHRYSOPERLA EXTERNA AND CERAEOCHRYSA CINCTA IMMATURE STAGES FED EGGS AND NYMPHS OF BIOTYPE "B" BEMISIA TABACI

A. M. Auad¹, L. C. Toscano¹, A. L. B. Junior¹ & S. Freitas¹, ¹Universidade Estadual Paulista (UNESP), Faculdade de Ciências Agrárias e Veterinárias (FCAV), Departamento de Fitossanidade, Via de Acesso Paulo Donato Castellani, s/n°, 14870-000, Jaboticabal, SP, E-mail: amauad@fcav.unesp.br.

It was evaluated the biological aspects of *Chrysoperla externa* (Hagen) and *Ceraeochrysa* cincta (Schneider) immature stages, fed eggs and nymphs of biotype "B" *Bemisia tabaci* (Genn.). After the larval eclosion, they were fed 2 cm diameter leaves discs, containing eggs and nymphs of whiteflies native of tomato and cabbage plants, respectively. The evaluated parameters were: duration (days) and viability (%) of each instar and pupal phase, for each specie of predator fed different prey stages. It was verified that for *C. externa* 1" instar larval there was influence of offered prey stage on development period, the same did not occur for *C. cincta*. The 1st instar larval development of both species of predators did not differ when they were fed eggs, however *C. cincta* showed a longer period (5.4 days) in relation to *C. externa* (4.0 days) when fed nymphs. For 2^{sd} instar larval and larval phase there was no influence of offered prey stage (egg or nymph) on development period, however the 2^{sd} instar duration was longer for *C. cincta* than *C. externa* (4.75 and 4.00 days, respectively). For 3^{sd} instar larval and larval phase there was a longer development period for *C. externa* (4.75 and 16.30 days, respectively) compared to *C. cincta* (4.0 and 15.3 days, respectively). The larval instars viability was up to 90% for both species, nevertheless, lower viability of pupal phase were recorded for *C. cincta* when fed eggs (30%) or nymphs (55.6%).

Index terms: Insecta, whitefly, green lacewing, predator.

[1485] FIELD SCALE RESPONSES OF APHIDS AND THEIR NATURAL ENEMIES TO ELEVATED CO_2 AND O_3

C.S.Awmack & R.L.Lindroth, Dept. of Entomology, University of Wisconsin-Madison, 1630 Linden Drive, Madison, WI 53706 U.S.A. E-mail: awmack@entomology.wisc.edu.

A key question in climate change research is the effects of environmental change on the population dynamics of insect pests and their natural enemies. Data collected so far suggest that chewing insects may be adversely affected by changes in plant quality caused by atmospheric pollutants while populations of sap-feeding insects may increase and cause more damage to their host plants. These studies have, however, been carried out using plants grown in pots in controlled environments, making it difficult to predict the probable effects of changes in atmospheric composition on populations of herbivores and their natural enemies. This talk will present data collected at the USDA FACTS II project in Rhinelander Wisconsin showing that there are effects of both CO2 and O3 on the performance of individual aphids, aphid populations and the natural enemy complexes associated with these aphids. Some aspects of individual aphid performance (development time, fecundity and intrinsic rate of increase) were not affected by elevated CO2 or O3 while adult weight and embryo number differed significantly between treatment. This uncoupling of fitness parameters has implications both for the effects of environmental change on aphid population dynamics and the ability of natural enemies such as ladybeetles and lacewings to control these populations. When populations of natural enemies were surveyed there were significant differences between the treatments., with more natural enemies at elevated CO2 and fewer at elevated O3. Index terms: Chaitophorus stevensis, Populus tremuloides, climate change, CO2, O3.

[1487] STATUS OF BIOLOGICAL CONTROL OF THE CITRUS LEAFMINER (PHYLLOCNISTIS CITRELLA) IN ITALY

<u>S. Barbagallo</u>, S. Longo, G. Siscaro, P. Reina, L. Zappalà, Dip. di Scienze e Tecnologie Fitosanitarie, Sez. Entomologia agraria, Univ. of Catania – Via Valdisavoia, 5 – 95123 Catania, Italy, E-mail sebarbag@mbox.unict.it.

In Italy, as well as in other Mediterranean citrus areas, several species of indigenous eulophid wasps (mainly belonging to the genera Cirrospilus and Pnigalio) have been detected on Phyllocnistis citrella Stainton (Lep. Gracillariidae) since its first appearance in 1994. Because of the low efficiency of these indigenous entomophagous, a classical biological control program of the leafminer has been started in Southern Italy by means of the introduction of exotic parasitoids. Ageniaspis citricola Logvinovskaya (Hym. Encyrtidae), Quadrastichus sp. and Citrostichus phyllocnistoides (Narayanan) (Hym. Eulophidae) have been introduced and reared. Among these entomophagous, only A. citricola and Quadrastichus sp. have been also released in field during spring 1996 and fall 1997. Up to the end of August 1996 about 3,000 Quadrastichus sp. specimens have been distributed in more than 30 sites in Sicily. A. citricola was released, in the same island, in the provinces of Messina, Catania, Enna, Siracusa, Caltanissetta and Ragusa during May-July 1997; nearly 6,000 specimens of the encyrtid have been distributed in 44 sites from May to July 1997. Periodical observations have been carried out to verify the establishment of the parasitoids and detect some bio-ecological aspects of the introduced species. The eulophid Quadrastichus sp. reached parasitization levels near to 40% but it has not overwintered in any release site. A. citricola was recovered in some lemon orchards of the provinces of Catania and Messina, lying in more temperate climatic areas. During summer-fall 1997, in these biotopes the parasitization rates varied from 60% to 90%. A. citricola has overwintered in these sites and the strain recovered in 1998 is presently maintained in rearing. Further studies are still in progress to evaluate its permanent establishment in the area. In addition, during the same year (1998) the Australasian specific parasitoid Semielacher petiolatus (Girault) (Hym. Eulophidae) has been recovered for the first time in many biotopes in Sicily and Calabria. This ecesis case has a particular ecological relevance, since the natural spreading of such an ectophagous wasp in the Mediterranean basin may efficiently improve the biological control of citrus leafminer. Index terms: indigenous eulophids, Ageniaspis citricola, Quadrastichus sp., Semielacher petiolatus, parasitoids.

[1486] PREDATION OF *DOCIOSTAURUS MAROCCANUS* BY ZOOPHAGOUS DIPTERA AND COLEOPTERA (SOUTHERN ITALY)

F. Baldacchino & T. Moleas, Dip. di Biologia e Chimica Agro-Forestale ed Ambientale, Università di Bari, v. Amendola 165/a, 70126 Bari, Italia.

The recent acrididae infestations reported from Apulia (Southern Italy), in some protected areas of 'Parco Nazionale del Gargano', have revived studies on the natural enemies of Dociostaurus maroccanus (Orthoptera, Caelifera). For carefully monitoring the infestations by this orthopteran, an environment-friendly control programme has been initiated, also including observations on ootheca predator insects. This preliminary work is aimed at reporting results obtained in the four-year period 1996-1999. In the first year of observations (1996), the presence of predators has not been reported. Conversely, since 1997, a few adults of the coleopteran Mylabris variabilis (Coleoptera, Meloidae) have been observed in some areas in May-July. In 1998, the presence and spread of this coleopteran increased. At the same time, the Diptera Systoechus ctenopterus and Cytherea obscura (Diptera, Bombyliidae) have been reported since June. Observations carried out the same year have highlighted the progressive spread, even in new areas, of Meloidae and to a larger extent of the above Bombyliidae. The soil samples have revealed the presence of Meloidae larvae and in particular, those of Bombyliidae until May, in the empty oothecas of D. maroccanus. In 1999, it was observed that the Bombyliidae flight is longer although it starts later compared to Meloidae; indeed, Diptera adults were reported until late September. The effectiveness of these predators has proved to be very high also for the year 1999, in that they considerably destroy oothcas. In general, Bombylidae larvae prevail (60% to 100%). This leads to assume a harmful effect of the chemical control, carried out to combat D. maroccanus from April to May, on the first adults of M. variabilis, which emerge since mid-May. In contrast, Bombyliidae would escape this effect because they emerge later.

Index terms: Dociostaurus maroccanus, predators, Mylabris variabilis, Bombyliidae.

[1488] DATA ON THE NATURAL CONTROL OF THE OLIVE MOTH, *PRAYS OLEAE*, BY PARASITOIDS IN TRÁS-OS-MONTES REGION (NORTHEASTERN PORTUGAL)

A. A. Bento¹; L. M. Torres² & J. A Pereira¹, ¹ Escola Superior Agrária de Bragança. Quinta de Sta Apolónia. Apartado 172. 5 301 - 855 Bragança. bento@ipb.pt. ² Universidade de Trás-os-Montes e Alto Douro. Apartado 202. 5 000 - 911 Vila Real. Itorres@utad.pt. This work was supported by the Project PAMAF IE&D 6117

A study was carried out over the period of 1996 to 1999 in unsprayed olive groves at Trásos-Montes region (northeastern Portugal) in order to identify the parasitoid complex of the olive moth, Prays oleae (Bern.) and to evaluate its role to control the pest. The study fell upon the last imature stage of development, of each of the three generations of P.oleae, that is phyllophagous, antophagous and carpophagous. Eight species of hymenoptera parasitoids were identified, namely: Ageniaspis fuscicollis Dalm. var. praysincola Silv. (Encyrtidae), Chelonus eleaphilus Silv. (Braconidae), Apanteles xanthostigmus Hal. (Braconidae), Habrocon crassicornis Thoms (Braconidae), Elasmus flabelatus Fonse. (Elasmidae), Angitia armilata Grav. (Icneumonidae), Pnigalio mediterraneus Ferr. & Del. (Eulophidae) and Dicladocerus westwoodi West. (Eulophidae). The level of parasitism recorded varied from 7.4% to 46.7% in the phyllophagous generation, from 25.4% to 56.5% in the anthophagous generation, and from 21.3% to 61.9% in the carpophagous generation. A. fuscicollis var. praysincola, C. eleaphilus and A xanthostigmus were the most frequent species observed, being present in all the samples. These species were also, in general, the ones which presented the highest levels of parasitism, with numbers between 5.5% and 55.2% for A. fuscicollis var. praysincola, between 0.2% and 14.2% for C. eleaphilus, and between 1.4% and 11.6% for A xanthostigmus.

Key-words: olive; integrated pest management; Prays oleae (Bern.); natural control; Ageniaspis fuscicollis Dalm.

[1489] BEHAVIOR OF TRICHOGRAMMA PRETIOSUM (HYMENOPTERA: TRICHOGRAMMATIDAE) IN SPODOPTERA FRUGIPERDA (LEPIDOPTERA: NOCTUIDAE) EGG-MASSES

E.B. Beserra^{1,2}, T.S. Dias³, J.R.P. Parra⁴, ¹Dept. Farmácia e Biologia, Univ. Estadual da Paraíba, cx 781/791, 58100-000, Campina Grande PB. ²Doutorando em entomologia ESALQ/USP, E-mail ebbeserr@carpa.ciagri.usp.br, ³Dept. de Ciências Exatas, ESALQ/USP, cx 09, 13418-900, E-mail etsdias@carpa.ciagr.usp.br, ⁴Dept. de Entomologia, Fitopatologia e Zoologia Agrícola, ESALQ/USP, cx 09, 13418-900, E-mail jrpparra.@carpa.ciagri.usp.br.

The fall armyworm, Spodoptera frugiperda, is potentially controlled by the egg parasitoids of the genus Trichogramma. The fall armyworm egg-masses is characterized by layered egg distribution covered by the female scales that may affect the action of the egg parasitoid. The paper deals with the impact of such physical barriers on the behavior of T. pretiosum. Daily egg-masses of S. frugiperda with different physical characteristics was used as follows: one layer with no scales, two layers with no scales, and one layer with scales. In the latter the scale density was discriminated as high and low density. For each egg-mass of 20-30 type *T. preliosum* females were set in glass tubes (7.0x1.2cm) with up to 24-hour emergence and filmed for 20min by means of a stereoscopic microscope coupled to a video camera system. The duration of drumming, drilling, oviposition, time over egg- mass and gap elapsed between parasitized eggs was timed, and the number of parasitized eggs recorded. The presence of scales in the egg-masses was observed to significantly increase the time spent by the parasitoid in every behavior stage, also increasing the gap elapsed between the parasitized eggs, decreasing the permanence time over egg- mass and the number of parasitized eggs. The growth in the number of layers decreased significantly the number of eggs parasitized in relation with the egg- masses with one layer and with no scales. A positive correlation was observed to occur between the time spent on the egg- mass and the number of eggs parasitized (r=0.85523) and an inverse correlation between the gap elapsed between parasitized eggs and the number of parasitized eggs (r=-0.75441). It was observed that the physical barriers in S. frugiperda egg-masses did change the behavior of T. pretiosum, affecting the parasitization capacity.

Index terms: egg parasitoid, fall armyworm, parasitization, mechanical defense

[1490] LONGEVITY AND REPRODUCTION OF *DIACHASMIMORPHA* LONGICAUDATA (HYMENOPTERA: BRACONIDAE) BRED IN LARVAE OF CERATITIS CAPITATA (DIPTERA: TEPHRITIDAE)

S. W. P. Bispo¹ & <u>A. S. Nascimento², ¹</u> UFBA-EMBRAPA, Rua Raul Leite, 921, apt. 304, Vila Laura, 40270-180, Salvador, BA,BR.²EMBRAPA Mandioca e Fruticultura, Caixa Postal 007, 44380-000, Cruz das Almas, BA, E-mail antnasc@cnpmf.embrapa.br

In order to understand the reproductive behavior of the Diachasmimorpha longicaudata (Ashmead, 1905) (Hymenoptera: Braconidae) fruit flies parasitoid, aiming at optimizing its laboratory breeding, studies were carried out about the longevity of its virgin and fertilized females, its periods of oviposition, and number and sexual rate of its descendants. These data were collected from insects specially bred with an artificial diet, under controlled conditions of temperature (25° C), humidity (60 – 80%) and hours of exposure to light (12 hours). As the oviposition substratum, 3^{rd} stadium larvae of *Ceratitis capitata* (Wiedemann, 1824) (Diptera: Tephritidae), also bred in laboratory, were used. The findings of these studies lead to the conclusion that virgin females of *D. longicaudata* live, on the average, 22,25% more than the fertilized ones, although they produce only male descendants. The fertilized females generate both male and female descendants, at a sexual rate of around 1:1. It was found that the females of that braconid, whether fertilized or not, are able to produce, on the average, approximately 170 parasitoids throughout their entire adult phase, concentrating around 90% of that offspring on the first 20 days of the cycle.

Index terms: behavior, fruit fly, parasitoid, biolgy

[1491] DEVELOPMENT OF IMMATURE STAGES OF PALMISTICHUS ELAEISIS (HYM.: EULOPHIDAE) ON LEPIDOPTERA PUPAE

M.A.L. Bittencourt¹ & E. Berti Filho², ¹Depto. de Ciências Agrárias e Ambientais (UESC), Rod. Ilhéus-Itabuna, Km 16, 45.650-000, Ilhéus, BA. E-mail¹: malbitte@ jacaranda.uescba.com.br. ²Depto. de Entomologia (ESALQ/USP) C. Postal, 9, 13.418-900, Piracicaba, SP. E-mail: eberti@carpa.ciagri.usp.br.

Palmistichus elaeisis Delvare & LaSalle, 1993 is an endoparasitoid collected from pupae of Sabulodes sp. (Lep.: Geometridae). The immature stages of this parasitoid were studied in laboratory ($25 \pm 1^{\circ}$ C; $70 \pm 10 \%$ RH; 14-hour photoperiod) on the following Lepidoptera pupae: Diatraea saccharalis (Fabricius, 1794) (Crambidae), Anticarsia gemmatalis Hübner, 1818, Heliothis virescens (Fabricius, 1781), Spodoptera frugiperda (J.E. Smith, 1797) (Noctuidae) and Thyrinteina arnobia (Stoll, 1782) (Geometridae). It was observed that the eggs and the 1st instar larvae are hyaline and hymenopteriform; 2nd, 3rd and 4th instars larvae are whitish and 12-segmented; the pupa is of the exarate type. The host species did not influence the number of instars.

Key words: biological control, forest entomology, parasitoids.

[1492] BIOLOGICAL CYCLE, REPRODUCTION AND LONGEVITY OF PALMISTICHUS ELAEISIS (HYM.: EULOPHIDAE) IN LABORATORY

M.A.L. Bittencourt¹ & E. Berti Filho², ¹Depto de Ciências Agrárias e Ambientais (UESC), Rod. Ilhéus-Itabuna, Km 16, 45.650-000, Ilhéus, BA. E-mail1: malbitte@ jacaranda.uescba.com.br. ²Depto. de Entomologia (ESALQ/USP) C. Postal, 9, 13.418-900, Piracicaba, SP. E-mail: eberti@carpa.ciagri.usp.br.

Biological aspects of *Palmistichus elaeisis* Delvare & LaSalle, 1993 were studied in laboratory by using Lepidoptera host pupae of *Diatraea saccharalis* (Fabricius, 1794) (Crambidae), *Anticarsia gemunatalis* Hübner, 1818, *Heliothis virescens* (Fabricius, 1781), *Spodoptera frugiperda* (J.E. Smith, 1797) (Noctuidae) and *Thyrinteina arnobia* (Geometridae). The results were as follows: the life cycle of the parasitoid was 23.4 ± 0.24 days (n=120); the mean longevity was 31.5 and 5.2 days for the females and 20.0 and 3.5 days for the males with and without food respectively; the oviposition period was 11.4 days, with a mean of 1.1 days of preoviposition and 90.9 parasitoids per couple; the sex ratio was 0.95 and the virgin females produced only males. Key words: biological control, forest entomology, parasitoids.

[1493] APPARENT COMPETITION MEDIATED VIA INSECT PARASITOIDS IN HETEROGENEOUS ENVIRONMENTS

M.B. Bonsall¹ & M.P. Hassell¹, ¹Department of Biology and NERC Centre for Population Biology, Imperial College at Silwood Park, Ascot Berkshire, SL5 7PY, U.K.

Prey that exists exclusively on different resources can compete in an indirect manner if they share common natural enemics. This is colloquially known as apparent competition. The role of apparent competition in homogenous (uniform) environments is well known and often leads to the exclusion or dramatic reduction in abundance of one of the prey species. Here, we explore the effects of apparent competition in heterogeneous environments. We present novel experimental evidence of the impact of a shared parasitoid in a heterogeneous environment and demonstrate the effects of dynamic monophagy on the population dynamics of a host-parasitoid assemblage. By considering a styliked interaction between two hosts and a polyphagous parasitoid, we demonstrate, theoretically, how environmental heterogeneity can influence coexistence. In particular, we highlight (1) how the underlying spatial distribution of hosts is paramount in influencing coexistence, (2) the role of temporal switching effects on coexistence and (3) the effects of spatial aggregative behaviours. We emphasis the different sources of variation that are prevalent in promoting coexistence in host-parasitoid assemblages where indirect interactions occur.

Index terms: Venturia canescens; coexistence; modelling; multitrophic interactions.

[1495] CLIMATIC CONSTRAINTS ON BIOCONTROL AGENTS: TRICHILOGASTER ACAIAELONGIFOLIAE IN SOUTH AFRICA

M.J. Byrne and S. Langa, Univ. of the Witwatersrand, Animal, Plant and Environmental Sciences Dept., Ecophysiological Studies Research Programme, Johannesburg, Wits, 2050. South Africa. E-mail: marcus@gecko.biol.wits.ac.za.

Acacia longifolia was introduced from Australia, into the South African Cape Province in the early 19th century for dune binding and is still used as a shade species, and for charcoal. It is highly invasive, choking waterways and catchments and threatens the Cape Fynbos. The wasp, *Trichilogaster acaiaelongifoliae* was introduced in 1982 as a biocontrol agent that attacks only the reproductive structures of the tree, leaving other useful components intact. The wasps originated from three areas in Australia around Sydney, Melbourne and Hobart, where the climate is predominantly Meditteranean, winter rainfall and the mean maximum temperature is less than 22°C. 'This temperature was considered to be the upper thermal limit of the wasp and used to explain poor establishment outside of the Cape region. The lifecycle of the wasp was examined in a summer rainfall region where the mean maximum temperature to December, and development is virtually the same as that in a Meditteranean climate. Infested trees produce fewer flowers, loose more flowers and eventually produce significantly fewer seed-pods than uninfested trees. There is a direct relationship between the number of galls on a branch and the amount of the branch tip death. No parasitoids of the wasp were found from emergence or dissection of galls. The upper fethal temperature limit for the pupal and adult wasps was measured to be well above the mean maximum of $22^{\circ}C$. Tacacaelongifolia has been shown to survive and flourish in hot, summer rainfall areas outside of its predicted climatic range.

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[1494] EFFECT OF ARTIFICIAL DEFOLIATION ON LANTANA GROWTH AND REPRODUCTION

<u>S. Broughton</u>, Entomology Division, Agriculture Western Australia, 3 Baron-Hay Crt, South Perth, Western Australia. E-mail smbroughton@agric.wa.gov.au.

Lantana camara L. (Verbenaceae), is a woody perennial weed that was introduced to Australia as an ornamental plant in the 1800's. Biological control of lantana commenced in 1914 and to date 26 insect species have been released for its control in Australia. Worldwide 38 species of insect have been released in 29 countries with varying levels of success. Only in parts of Hawaii, USA, is lantana considered to be under partial control. Since 71% of the released insect species mine, chew or suck the leaves resulting in defoliation, artificial defoliation techniques were used to examine the impact of frequency, timing and level of defoliation on lantana. Every three months (spring, summer, autumn), 0%, 50% or 100% of leaves were removed from plants. Changes in plant height, stem width and the number of stems were recorded one month after each episode of defoliation. At the end of the experiment all plants were harvested and the amount of biomass (dry weight) was calculated for the stens, roots, leaves and reproductive structures (buds, flowers and fruit). There were no significant decreases in vertical height or the number of stems produced, but plants defoliated in spring produced more stems than those defoliated in spring and autumn. Similarly, there were no differences in root, stem, leaf or reproductive structure biomass. However, differences in the proportion of biomass allocated to reproduction were recorded. Plants that had been defoliated three times allocated a higher proportion of their biomass to reproduction than those defoliated once or twice. Overall, these results suggest that lantana compensates for defoliation. Index terms: Lantana camara, artificial defoliation

[1496] PREDATION OF *PHYLLOPHAGA* (COLEOPTERA: SCARABAEIDAE) EGGS IN NO-TILL AND CONVENTIONAL-TILL MAIZE

C. K. Gerber¹, M. J. Stanyard¹, & T. J. Gibb¹, ¹Dept. of Entomology, Purdue Univ., West Lafayette, IN 47907-1158, USA.

Questions exist in Central and South America concerning the long term costs and benefits of no-tillage (NT) cultivation in maize fields compared with conventional-tillage (CT). White grubs of the genus *Phyllophaga* can cause significant economic danage in maize. To assess the costs and benefits of NT and CT, a survey of white grubs in both tillage practices was conducted. One aspect of the NT versus CT debate is the question of the relative impact of beneficial insects in the two systems. Anis are known to be a major predator on white grub eggs. Therefore, pitfall traps were used to assess ant activity in the soil profile. Correlations between tillage practices and ant populations were then used to explain any differences in grub densities. Results indicated that significantly more predation occurred in NT maize fields.

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Index terms: Biological control, corn carworm. Trichogramma, Televonus reamophylax.

[1497] CURRENT STATUS OF CITRUS LEAFMINER AND ITS PARASITOIDS IN CORRIENTES (ARGENTINA)

S. Cáceres, EEA INTA Bella Vista, Ctes. (Argentina) E-mail: intaexp@bvista.com.ar

Citrus leafminer (CLM), Phyllocnistis citrella, was detected in Corrientes in November 1996. Besides feeding injury, extensive lesions of citrus canker (a Northeast endemic disease) develop on leaves damaged by leafminer. Seasonal abundance and parasitism of the leafminer were investigated from 1997 through 1999 on lemon and orange groves with minimal insecticide spreads. The density of P. citrella was determined by randomly picking one flush per tree in 40 trees per grove, twice a month. Parasitoids were identified by J. LaSalle. Given the apparent low levels of control by native parasitoids, the importation and release of Ageniaspis citricola was considered; large number of pupae of *A. citricola* were brought to Corrientes from EEAOC (Tucumán, Argentina) where it had just established; 1052 adults emerged were released in five insecticide-free groves between April 30 and May 6, 1998. P. citrella population was higher (twice) in lemon flushes than in orange flushes. The number of larva + pupa per flush (orange and lemon) was high in 1997 fall and in 1998 summer-fall (more than 15 immature stages per flush in lemon). The presence of leafminer was considerably lower in 1999. Three species of native parasitoids attacked P. citrella immature stages: Cirrospilus sp. C, Cirrospilus sp. and Elasmus sp. Cirrospilus sp. C that parasites CLM larva 3, prepupa or pupa and Elasmus sp. that parasites only prepupa or pupa comprised 98% of the native parasitoids. Recoveries of A. citricola were made at the five released groves. A. citricola mass rearing was not successful and we found efficient to collect citrus leaves from insecticide-free groves and greenhouse pruned plants and rear out the parasitoid. 7233 A. citricola adults were released between March 15 (1999) and June 25 (1999) in 62 sites. In most releases (43%) 50-100 adults were used per site. A.. citricola has high reproductive rate (2.9 ± 0.4 pupae per CLM, Dec 98-Mar 99). Parasitism from A. citricola at monitored groves increased to almost 90% of total parasitism three moths after the release. Both natives Cirrospilus sp. C and Elasmus sp. were observed as primary parasitoids and as hyperparasitoids of A. citricola (facultative hyperparasitoids). Hyperparasitism has not negatively affected the dispersal and establishment of A. citricola; the presence of natives as primary parasitoid was higher than their presence as hyperparasites; the complete chain of A. citricola pupae was not consumed (usually one or two). Chemical control (avermectin and imidacloprid) is used in nurseries and for fresh market.

[1498] EGG PARASITOIDS OF *HELICOVERPA ZEA* IN SOUTHERN PARANÁ, BRAZIL AND REARING OF *TRICHOGRAMMA ATOPOVIRILIA* ON AN ALTERNATIVE HOST

C. L. Cañete¹, & L. A. Foerster¹, ¹ Dept. of Zoology, Univ. Federal do Paraná. P. O. Box 19.020 (81531-990) Curitiba, PR, Brazil. E-mail: caca@bio.ufpr.br

There are few studies related to natural parasitism in eggs of Helicoverpa zea in Brazil, despite the importance of this noctuid as a pest of corn ears. Previous surveys indicated the occurrence of Trichogramma pretiosum and T. atopovirilia parasitizing eggs of H. zea in Brazil. In order to evaluate the incidence of natural parasitism in eggs of H. zea, field surveys were carried out in corn during 1998 and 1999 in Southern Paraná State. The rate of parasitism in both years was estimated to assess the importance of egg parasitoids in the control of the corn earworm. Eggs were randomly collected in corn ears and transferred to the laboratory to determine the presence of parasitoids. In 1998, a total of 393 eggs of H. zea were collected and 4.9% were parasitized. In 1999, 734 eggs were sampled and 5.5% yielded parasitoids. Trichogramma pretiosum was the predominant species, accounting for 61.1% and 70.7% of the parasitoids emerged in laboratory. In the remaining of the parasitized eggs two species were collected: T. atopovirilia and Telenomus cyamophylax, the latter found for the first time in eggs of H. zea. T. cyamophylax was previously described in Southern Paraná parasitizing eggs of Anticarsia gemmatalis in soybeans. Corn is usually grown in association with soybeans and T. atopovirilia has also been found in soybeans parasitizing eggs of A. gemmatalis. The possibility of rearing T. atopovirilia using eggs of A. gemmatalis as hosts was investigated in laboratory. Its development, fecundity and longevity were evaluated at 25°C and compared to T. pretiosum which is the main egg parasitoid of A. gemmatalis. The developmental time of the immature stages of T. atopovirilia in eggs of A. gemmatalis did not differ from that of T. pretiosum and lasted ca. 10 days at 25°C. Females of T. atopovirilia laid an average of 104.5 eggs during their lifetime and survived for 11.4 days in the presence of host eggs. Their longevity was significantly reduced (6.7 days) in the absence of hosts, indicating that females feed on nutrients extruding from the eggs and thus increase their longevity when host eggs are available. The mean number of parasitoids emerged from each egg was 1.3. It is concluded that natural parasitism of H. zea eggs is low in Southern Paraná, and T. pretiosum is the predominant parasitoid species. T. atopovirilia can also be reared in eggs of A. gemmatalis and its reproductive potential is similar to that of T. pretiosum.

Index terms: Biological control, corn earworm, Trichogramma, Telenomus cyamophylax.

[1499] A FIRST APPROACH ON THE POTENTIAL ROLE OF *DICYPHUS CERASTII* WAGNER (HEMIPTERA: MIRIDAE), AS NATURAL CONTROL AGENT IN PORTUGUESE GREENHOUSES

"P. Carvalho¹", "F. Luz¹" & "<u>A.Mexia</u>², ¹ Instituto Superior de Agronomia, DPPF, Secção de Protecção Integrada, Tapada da Ajuda, 13449-017, Lisboa, Portugal, ppassos@isa.utl.pt ;² Instituto Nacional de Investigação Agrária, Estação Agronómica Nacional, Quinta do Marquês, 2780 Oeiras ean@mail.telepac.pt

The most common mirid bug found in the Portuguese greenhouses of the Oeste region, the Dicyphinae *Dicyphus cerastii*, (Hemiptera: Miridae) was studied and the seasonal evolution of its population on protected tomato crops was elucidated as well as the role played by weeds. Its potential to predate the leafminer *Liriomyza huidobrensis* was shown in a laboratorial trial. In the laboratory it was also possible to demonstrate that necrophagy, occasionally observed in the field, is an adaptive advantage for this facultative phytophagous and predator insect, since feeding on entomological cadavers, increases the fertility.

Index terms: Miridae, biological control, greenhouse crops, Oeste region of Portugal.

[1500] THE ROLE OF CHRYSOPIDS AS NATURAL CONTROL AGENTS IN PORTUGUESE GREENHOUSES

P. Carvalho¹, C. Couto¹ & <u>A. Mexia²</u>, ¹ Instituto Superior de Agronomia, DPPF, Secção de Protecção Integrada, Tapada da Ajuda, 13449-017, Lisboa, Portugal ppassos@isa.utl.pt ;Instituto Nacional de Investigação Agrária, Estação Agronómica Nacional, Quinta do Marquês, 2780 Oeiras ean@mail.telepac.pt

Among the native polyphagous predators of the entomofauna in Portugal. 28 species of chrysopids have been observed. However there is a great lack of information related to their potential use as pest control agents. In Portugal, the most relevant data concerning chrysopids is mostly, if not all, based on *Chrysoperla carnea* ignoring the real significance of all other species, although some of them are very common (*Mallada* sp). Long term global climatic changes may be a reason for the current relative importance of *C. carnea* given that new adjustments of the different ecosystems might be taking place. In this work the most common species are listed and their relative importance is discussed; specifically with regard to protected crops in the Oeste region, using either ammonium dihydrogen phosphate + protein traps or yellow sticky traps. These traps were either used isolated in some experimental plots or combined, in other plots.

Index terms: Neuroptera: Chrysopidae, Chrysoperla camea, Mallada sp., natural control, greenhouse crops

[1501] HOST SPECIFICITY TESTING OF RODOLIA CARDINALIS, A CENTURY

C.E. Causton¹ & T. Poulsom¹, ¹Invertebrate Program, Charles Darwin Research Station, A.P. 17-01-3891, Quito, Ecuador, causton@fcdarwin.org.ec

Serious damage to indigenous plant species of the Galápagos Islands by the cottony cushion scale, *Icerya purchasi* Maskell, has led the Galápagos National Park Service and the Charles Darwin Research Station to consider the use of biological control in the archipelago for the first time. *Icerya purchasi* was discovered in the Galápagos in 1982 and has since spread to 12 islands. To date, 56 plant species are known to be affected by the scale insect. An advisory committee set up in 1996 approved the evaluation of *Rodolia cardinalis* to control this species. Concern that the feeding range of *R. cardinalis* has not been experimentally studied and that the agent might negatively impact endemic scale insects, most notably, an endemic margarodid, prompted studies on its host feeding range. Endemic and native representatives of Margarodidae, Orthezidae, Pseudococcidae, Eriococcidae, Diaspidae and Aphididae were tested on adults and larvae of *R. cardinalis* and the results of these studies are presented.

Index words: Vedalia beetle, Icerya purchasi, host range, Galápagos Islands.

[1502] AGENIASPIS CITRICOLA: INTRODUCTION, LABORATORY REARING AND ADAPTATION IN BRAZIL

M. C. M. Chagas¹, P. T. Yamamoto², P. Milano³, A. L. G. C. Parra³, A. M. Nascimento³ & J. R. P. Parra³, ¹Embrapa/Emparn, Caixa Postal 188, Natal-RN, Brazil, E-nail marcone@dmrh.emparn.br; ²Fundecitrus, Araraguara-SP, 14807-040; ³Dep. Entomol., Fitop. e Zool. Agrícola, ESALQ-USP, 13418-900, Piracicaba-SP, Brasil. Financial support: Fundecitrus.

A. citricola was introduced in Brazil in July, 1998, imported from Florida-U.S.A. In the quarantine facilities, emerged 450 wasps; after this period, in the laboratory of Insect Biology from the Department of Entomology, Plant Pathology and Agricultural Zoology, ESALQ/USP, a new system for the citrus leafminer rearing was developed, in order to improve the parasitoid production. The host is reared in Citrus limonia, cultivated in small black rigid plastic tubes, 20 cm height per 1.5 cm diameter containing vermiculite and vegetal compound (1:1) as substrate. In order to get flushing (leaves age preferred by citrus leaf miner oviposition), the plants are pruned approximately 1/3 below top, later properly fertilized and kept in metal grids (capacity for 40 small tubes). They are maintained in rearing rooms (temperature of 25 ± 1 °C; $60 \pm 10\%$ RH and 14 hour photophase) during 15-17 days until early flushings, that are exposed to P. citrella adults in the ratio of one newly-emerged insect to each three plants (1:3). The P. citrella eggs and/or first instar larvae are exposed for A. citricola parasitization during 3 to 5 days. The rearing system developed require little space, less time for hand labor. As a consequence it is possible to use incubators to maintain the plants and get the synchronization between host and parasitoid development by using thermal requirements for both. Thus, it is possible to keep an average of 400 plants/m² with a mean population potential of 6,300 parasitoids in an average period of 17 days under previously mentioned conditions. So, according to laboratory observations, one considered mean values of 4 leaves liable to egg lay/plant; 2 (two) eggs/leaf; production of 3.3 wasps/parasitized host, and 60% of parasitism viability. The first parasitoid releasing in Brazil, occurred in October, 1998, in Descalvado and Nova Granada counties, in the State of São Paulo. The goal of this program is the parasitoid inoculative releasing in this state, where the citrus grove area reaches 800.000 ha; and we are also releasing in other states of Brazil, as Paraná, Minas Gerais, Santa Catarina and Rio Grande do Sul, too. After a year of parasitoid rearing, we have released around 150,000 parasitoids in 53 localities and 57 citrus groves, corresponding to 15,000 ha. The parasitoid recovering was observed in different weather conditions.

Index terms: citrus leaf miner, biological control, rearing techniques, citrus pest.

Symposium and Poster Session

[1503] LABORATORY OBSERVATIONS ON THE LIFE HISTORY AND PREDATORY EFFICIENCY OF SEVEN SPECIES OF *PHILONTHUS* (COLEOPTERA: STAPHYLINIDAE) ON THE HOUSE FLY (DIPTERA: MUSCIDAE)

<u>M. R. Chani Posse</u>, Fundacion Miguel Lillo, Instituto Superior de Entomologia (INSUE), Miguel Lillo 205, (4000) Tucuman, Argentina. E-mail: march@impsat1.com.ar.

The Southamerican dung-beetle fauna includes many predatory and parasitic species belonging to the families Staphylinidae, Hydrophilidae and Histeridae (Fletchmann 1995; Cabrera Walsh et al. 1997; Guimaraes et al. 1998). Beetles from these three families have been shown to reduce populations of dung-breeding flies in both southern Africa (Fay 1980; Doube et al. 1987; Doube 1987) and North America (Roth 1982; Summunerlin et al. 1982; Fincher 1994; Hu et al. 1996; Hu et al. 1997). Staphylinids of the genus *Philonthus* have long been important predators of dung-breeding Diptera. However, the bionomics of local Philonthus species are virtually unknown. The present study constitutes a preliminary investigation about biological aspects of local Philonthus species and their ability to prey on dung-breeding flies under laboratory conditions. Seven species of Philonthus which are frequent inhabitants of cattle dung in Tucuman, Argentina, are considered for study. Potential predators were collected from naturally deposited dung by collecting the excrement in the field, returning the manure to the lab and removing the insects by flotation. Rearing techniques was developed by following the method of Hunter et al. (1986) for Philonthus. For observation, individual beetles from egg to adult were confined and house fly eggs and 1st instar larvae were provided for food. Data on egg hatch, larval molt, pupation and adult emergence, as well as counts of house fly eggs and larvae offered and consumed were recorded daily. Variables considered in data analysis were feeding rates of Philonthus larvae and adults as well as duration and size of each stage from egg to adult. Results derived from a cluster analysis showed that Philonthus rectangulus, P. bruchi and P. sp7 comprised a cluster associated primarily with the highest feeding rates and sizes. The other cluster comprised P. flavolimbatus, P.sp5 and P.sp6. These species were smaller and had lower feeding rates. P. pauxillus appeared as a separate taxa with the lowest feeding rates. Duration of life cycle from egg to adults are reported for all species. Based on these preliminary results, we conclude that Philonthus rectangulus, P. bruchi and P. sp7 appear to be prospective biological control agents of dung-breeding flies although additional field and laboratory investigations are required to accurately access their effectiveness.

Index terms: *Philonthus rectangulus*, *P. bruchi*, feeding rates, potential predators, house fly

[1504] THE EFFECT OF PREY DENSITY ON THE PREDATORY ABILITY OF THREE SPECIES OF *PHILONTHUS* (COLEOPTERA: STAPHYLINIDAE) ASSOCIATED WITH CATTLE DUNG

M. R. Chani Posse, Fundacion Miguel Lillo, Instituto Superior de Entomologia (INSUE), Miguel Lillo 205, (4000) Tucuman, Argentina. E-mail: march@impsat1.com.ar.

Insect predators inhabiting bovine dung pats may influence populations of dung breeding flies. Several species of predators have been reported attacking dung breeding Diptera in North America (Roth 1982; Summmerlin et al. 1982; Fincher 1994; Hu et al. 1996; Hu et al. 1997) and southern Africa (Fay 1980; Doube et al. 1987; Doube 1987) and they have long been viewed as potential biological control agents. The introduction of the horn fly Haematobia irritans irritans (Diptera: Muscidae), in southern Brazil, Paraguay, Uruguay and Argentina stimulated interest in research on the identification, biology, and utility of such species (Fletchmann 1995; Cabrera Walsh et al. 1997; Guimaraes et al. 1998; Lizarralde de Gosso et al. 1999). Predation by staphylinid beetles of the genus Philonthus has been implicated as a mortality factor of dung-breeding flies. Although the predation potential of Philonthus species appears well documented, there is only limited information published on the capacity of the southamerican fauna to prey upon the pre-adult stages of flies. Objectives of this study were to evaluate the functional responses of three *Philonthus* species frequently associated with cattle droppings in Tucuman, Argentina. Adult Philonthus spp. were collected from naturally deposited dung by collecting the excrement in the field, returning the manure to the lab and removing the insects by flotation. Rearing techniques was developed by following the method of Hunter et al. (1986) for Philonthus. For observation, individual beetles from egg to adult were confined under laboratory conditions and house fly (Diptera: Muscidae) eggs and 1st instar larvae were provided for food. The feeding rates of adults and larvae of Philonthus bruchi, P. flavolimbatus and P. pauxillus were compared at different densities of prey in the laboratory by measuring their patxinus were compared a unterent densities of prevail on habitatory of inclusion and the second sec (Neotropical species, collected in Tucuman) on the immature stages of house flies are reported. When confined with abundant prey, adults and larvae of P. bruchi had a higher predation rate than did those of P. flavolimbatus, which in turn had a higher rate than did those of P. pauxillus. The relationship derived from functional responses in both larvae and adults of these species was similar to the type II functional response.

Index terms: Philonthus bruchi, Philonthus flavolimbatus, Philonthus pauxillus, house fly, functional response

Symposium and Poster Session

[1505] THE OCCURRENCE OF LEAFMINERS AND THEIR PARASITOIDS ON VEGETABLE CROPS AND WEEDS IN SOUTHEAST CHINA

X.X. Chen, Z.H. Xu, J.H. He, Y. Ma & R.Q. Rong, Department of Plant Protection, College of Agriculture and Biotechnology, Zhejiang University, No.286 Kaixuan Road, Huajiachi Campus, Hangzhou 310029 CHINA, E-mail xxchen@zju.edu.cn

A survey was carried out in Southeast China in 1998-1999 to determine the distribution of leafminers and their parasitoids on vegetable crops and weeds in the field. Leaves were collected weekly at random and taken to the laboratory and the number of galleries were counted and maintained in insectaries until the emergence of the parasitoids. The leafminer species found comprised Liriomyza bryoniae, L. chineneis, L. sativae, and Chromatomyia horticola, with Ch. horticola and L. sativae the most abundant in Spring and Autumn, respectively. In total 23 hymenopterous species of four families (16 eulophids, four pteromalids, one ceraphronid, and two braconids) were found. They are as follows: Hemiptarsenus dropion, Hemiptarsenus variconis, Diglyphus isaea, Diglyphus albiscapus, Closterocerus trifasciatus, Chrysocharis phryne, Chrysocharis peniheus, Pnigalio katonis, Neochrysocharis formosa, Neochrysocharis punctiventris, Pediobius mitsukurii, Teleopterus erxias, Diaulinopsis arenaria, Cirrospilus lyncus, Tetrastichus chara, Tetrastichus mandanis; Callitura sp., Sphegigaster humugurivora, Thinodytes cyzicus, Halticoptera circulus, Ceraphron sp., Opius pallipes, and Opius sp.. Among them 20 parasitoid species were reared from Ch. horticola, two species from L. chinensis, four species from L. bryoniae, and nine species from L. sativae. Six parasitoid species were reared from leafminers on four selected weeds: Diglyphus isaea, Diglyphus albiscapus, Pnigalio katonis, Neochrysocharis formosa, Halticoptera circulus, and Opius sp.. These parasitoids could possibly enhance the biological control of the leafminers on vegetable

crops. Index terms: leafminers, parasitoids, vegetable crops, weeds

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[1506] BIOLOGYCAL CONTROL OF SOME PHYTOPHAGUE INSECTS WITH TRICHOGRAMMA SPP. (INSECT., HYM.)

<u>CIOCHIA</u>, Florentina MARCU*, Felicia MURESAN**"Lucian Blaga" University – SIBIU: *SCCCPN – D ăbuleni (Dolj Depart.); ** SCA Tuzda (Cluj Depart.), ROMANIA, Str. Pavilioanelor CFR, Nr. 30, 2200 - Brașov, România, Europa

The excessive environmet pollution forces agriculture, the great producer of survival elements, to find and use, by means of scientific research, new methods in limitation of vegetal and animal pest, competing us for food. In this respect, the agricultural research and the universitz one have approached themes concernig the entomophagus or some biotechnology means (pheromenes), in order to limit the Economic Damage Threshold for some population of pthytophague insect pest for sugar beet (Autographa gamma, Scotia ipsilon, S. exclamations, Agrotis segetum, Mamestra brassicae, Discestra trifolii as.o., bytreatnets with Trichogramma spp., obtaining a very good control, 85,7-93,3% unattacked plants), corn (Ostrinia nubilalis by T. maldis, obtaining 70 – 81% unattacked plants), corn (Ostrinia nubilation by T. evanescens, obtaining 60-76% unattacked plants), vine (Lobesia botrana by T. evanescens, obtaining 90-93% unattacked fruits) and appele (Cydia pomonella by T. embryophagum, obtaining 90-93% unattacked fruits) and appele (Cydia pomonella by T. embryophagum, obtaining 90-93% unattacked fruits) and appele (Cydia pomonella by T. embryophagum, obtaining 90-93% unattacked fruits) and appele (Cydia pomonella by T. embryophagum, obtaining 90-93% unattacked fruits) and appele (Cydia pomonella by T. embryophagum, obtaining 90-93% unattacked fruits) and comparing it with a bioproduct based on Bacillus thyringiensis and chemical insecticides, the results were similar, but the treatment period is different. The use of the Trichogramma spp. is possible on production scale, trying to abtain indigenous populations, taxonomically well known, with important economic and social advantages.

tool. The feeding rates of adults and harvae of *Philonthus brachi*. *P. favolishumr and P. panallae were compared at different demarks of prey in the laboratory by measuring fitter, assumption of available pray. The results of predation by three spectra. <i>Philonthus transmitter* (from Argentina, collected in Tocuman). *P. favolithington and P. panallae view fitter and the presses, collected in Tocuman)*, *P. favolithington and P. panallae view fitter and the presses of the pression of the panallae view fitter and the pression of the pression of the immuter stages of house fitter are required. When confreed with atumatati press, adults and farwas of <i>P. panallae view fitter and the pression of the farmality on the immuter stages of the pression of the pression of the farmation of the stages and adults of these species was atumate to the type II (unctional response).*

Index terms: Philosoftus bracht, Philosothux flavolimbulus, Philosothes parcillar, bounc fly, Interfault response. [1507] MOLECULAR KEY TO SOME BRAZILIAN SPECIES OF TRICHOGRAMMA USING ITS2 SEQUENCES AND RESTRICTION ANALYSIS

A. I.Ciociola In¹, R.A. Zucchi¹ & R. Stouthamer², ¹Departmento de Entomologia, Fitopatologia e Zoologia Agrícola. Caixa Postal 9, CEP:13.418-900, ESALQ/USP, Piracicaba-SP, Brazil. E-mail: ciociola@carpa. ciagri.usp.br; ²Department of Plant Sciences, Laboratory of Entomology, Wageningen-UR Centre, P.O Box 8031, 6700EH Wageningen, The Netherlands.

Since the beginning of the 1970's, the *Trichogramma* identification is based on the morphological analysis of the male genitalia. Sometimes, identification of closely related species is difficult. A new technique is used in this paper to solve this problems. Using the ITS2 sequences of the ribosomal DNA together with some restriction enzymes, we are able to construct a simple and precise molecular key to some Brazilian species of *Trichogramma*. This key is easy to build and we can obtain quick results for the identification of this minute wasp (about 0.25 mm). Using this methodology we can also check for possible contaminations under laboratory rearings, and its easy to apply. To choose the best restriction enzyme to build the molecular key, we used a free program available in the internet, Webcutter 2.0 (http://www.ccsi.com/firstmarket/firsmarket/cutter/cut2.html). Enzymes that were able to distinguish between ITS2 products of similar size were tested to verify that they indeed cut the product at the predicted location. The key presented in this study is restricted to the collecting sites and the species analysed. It is important to know that for the success of this method, we must work together with a taxonomist.

Index terms: rDNA, Molecular technique, enzymes, biological control.

[1508] CURRENT STATUS OF THE BIOLOGICAL CONTROL PROGRAM FOR THE MEALYBUG, ORACELLA ACUTA, IN THE PEOPLE'S REPUBLIC OF CHINA

S. R. Clarke¹, J. H. Sun², G. L. DeBarr³, H. B. Yu⁴ & M. R. Chen⁴, ¹Forest Health Protection. USDA Forest Service, 701 N 1st St., Lufkin, TX 75901, USA, E-mail sclarke/r8_tx@fc.fcd.us; ²Dept. of Forestry, Northeast Forestry University, Heilongjiang, Harbin 515004, China; ³Southern Research Station, USDA Forest Service, Athens, GA 30602, USA; ⁴Forest Disease and Pest Control Station, Guangdong Province, Guangzhou 510173, China.

A mealybug, Oracella acuta, was introduced into the Guangdong Province in the People's Republic of China in 1988. Insecticides and native natural enemies were unable to control the mealybug, and populations were spreading through slash pine plantations at a rate of up to 63 km/year. A cooperative project was initiated between the PRC and the United States to import natural enemies from the USA into the PRC to control the mealybug. Natural enemies keep mealybug populations at low levels in the southeastern USA, and appear to be the best method for control in the PRC. Efforts began in 1994 to both create Oracella populations in the USA and locate infested seed orchards to provide rearing material for parasitoids. Thirty-two shipments of three species of parasitoids, Alloitropa sp., Zarhopalus debarri, and Acerophagus coccois, have been sent to Guangdong since 1995. Though a mass-rearing program of these species in China has not yet proved successful, the parasitoids have been reared through at least one generation in a lab. Field releases, usually within cages around branches or whole trees, were made at several sites. A systematic monitoring program around the release sites was established in 1997, but no establishment of the released parasitoids has been recorded to date. The parasitoids do not appear to have significantly impacted the mealybug populations at this time. Continued parasitoid shipments and releases are planned for 2000. Another parasitoid, Anagyrus daciylopii, was discovered parasiting Oracella at some of the release sites. This parasitoid sin to host-specific, and competition trials between this species and the introduced parasitoids are scheduled. In 1999, the mealybug infestation spread into Guangxi Province, and is now very close to plantations of lobioly pine, its main host in the United States. Results from the current year's sampling will be reported. Index terms: Allotropa sp., Zarhopalus debarri, Anagyrus dactylopii, parasitoids

have released around 150,000 gamminude to \$3 locatilies and 57 cutum growns, corresponding to 15,000 ha. The paramoid recovering was observed in different weather conditions.

Index terms ritres leaf miner, bislogical control, rearing techniques, circus gest

[1509] INFLUENCE OF PREY SIZE ON PREDATION SUCCESS BY ZELUS LONGIPES (HETEROPTERA: REDUVIDAE)

<u>R. Cogni</u>¹, A. V. L. Freitas¹ & B. F. Amaral Filho², ¹Museu de História Natural, Inst. de Biologia, Univ. Estadual de Campinas, CP 6109, 13083-970, Campinas-SP, Brazil, E-mail cogni@unicamp.br; ²Dept. de Zoologia, Inst. de Biologia, Univ. Estadual de Campinas, CP 6109, 13083-970, Campinas-SP, Brazil, Financial support: SAE-Univ. Estadual de Campinas.

We investigated the influence of prey size on attack rate, predator success, and feeding time, relating this to the behavior of a predator and the consequences to the predatory responses in an arthropod with extra-oral digestion. We made tests in laboratory using adults of the reduviid Zelus longipes as predator and the larva of the notuid moth Spadoptera frugiperda as prey. In tests with one caterpillar, we offered larvae of three different weight classes individually to the predator. The prey weight was positively correlated with relative weight gain by the predator (Spearman r, = 0.694), mean feeding time (r, = 0.0706) and discarded biomass (r, = 0.915), but not with the relative extraction rate (defined as the relative weight gain by the predator per feeding time) (r, = 0.097). The different sizes of caterpillars were attacked with the same frequency ($\chi^2 = 1.75$; d.f. = 2; p > 0.20), but the successful attacks were more frequent in small larvae ($\chi^2 = 32.2$; d.f. = 2; p < 0.001). The median mass of successfully attacked larvae (84.2 mg; n = 20) was also smaller than that of unsuccessfully attacked (279.0 mg; n = 30) (Mann-Whitney U = 26.0; p < 0.001). In tests with three caterpillars, we offered larvae of three weight classes at the same time; small caterpillars were more attacked and killed than the medium and large ones ($\chi^2 = 8.48$; d.f. = 2; p < 0.05). The results showed that even if larger prey resulted in more energy intake, when the choice is possible, smaller caterpillars were more attacked than medium and large. This is probably related with the fact that successful attacks were more frequent mediates attacks avere more energy intake, probably related with the fact that successful attacks were more frequent on small larvae (see the mediate mate in the same time; Spodoptera frugiperda. Noctuidae, feeding time, attack rate, extra-oral digestion.

The different ages of females are 0-2 day-old females, unit of 1 - 4.3, 2×6 arguing females, 1 - 3.6, 7 - 10 day-old females, 1 - 4.0, females inter than 10 days, 1 - 6.5. These results thit not show a significant difference through the qui-nume tast $(\mu = 0.62)$, 1_0 centrated 0 transfer in papers found in the interaction, the data obtained indicate data, in the contrast of gamma of data experiment, it was not provide in observe (aftering of the (provation and regarding the experiment, it was not provide in observe (aftering of the (provation data regarding the experiment, it was not provide in observe (aftering of the (provation data regarding the experiment, it interpret for the provided.

[1510] USING BIOCHEMICAL APPROACHES FOR QUALITY CONTROL OF INSECTS REARED ON ARTIFICIAL DIETS

A. C. Cohen, BCMRRU P.O. Box 5367 Mississippi State University, MS 39762-5367, USA, e-mail acohen@bcmrru.msstate.edu

Polyclonal antibodies were used in ELISAs, dot blots, and Western blots to assess the vitellin quantity in *Lygus hesperus* and *Chrysoperla rufilabris* to detormine the correlation between biochemical characteristics and biological fitness as indicated by body weight, ovarian development, egg production, and survival time. The correlation between vitellin content and biological fitness was significant, and it was demonstrated that vitellin content, and possibly other biochemical characteristics, can be used as a measure of fitness and an early warning sign of colony deterioration or other problems in the quality of mass produced insects. Further analyses of yolk proteins in neonates also indicated that there is a high likelihood that biochemical characteristics can predict fitness and quality of early development stages of mass reared insects. Index terms: vitellin, predators, chrysopids.

previous exposure of fert mesons to fungacions and publica features for an significant effect an upder mite distribution. We filen observed the response of *T*, arrivar to cales from two species of produkin that had been neared as a diet of either splater mixes or politon to apider mixe features showed stronger avoidance of load these liple were previously exposed to apider-mixe features, than of discret respond to polices for produken before terms. Then we discret respond to polices for produken fields terms of produces, articles, Phytosetalas, Areforeaux eleminat ecology, before previously. [1511] USING KNOWLEDGE OF FEEDING BIOLOGY AND BIOCHEMISTRY TO DEVELOP ARTIFICIAL DIETS FOR PREDACEOUS AND PHYTOPHAGOUS INSECTS

A. C. Cohen, BCMRRU P.O. Box 5367 Mississippi State University, MS 39762-5367, USA, e-mail acohen@bcmrru.msstate.edu

Several artificial diets have been developed using a combination of methods that includes detailed studies of the biochemistry of the micro feeding behavior, digestive enzymes, and fanalysis of the composition of the natural foods of targeted arthropods. Success in development of diets for predators (such as *Chrysoperla rufflabris*, *Geocoris punctipes*, and *Orius insidiosus*) and for zoophytophages (such as *Lygus hesperus* and *L. lineolaris*) has been greatly enhanced by the recognition that these insects use extra-oral digestion to process nutritious portions of their prey or plant hosts: Such understanding, along with knowledge of specialized digestive enzymes, provides a clear profile of what macromolecular structures these insects are prepared to encounter. Furthermore, an exact: knowledge of food profiles (amounts of protein, lipids; carbohydrates, for example) gives greater resolution of ideal diet profiles to be targeted. A matrix that models the interplay between behavioral choices, enzyme types, and food profiles is presented as a means of optimizing diets for *L. hesperus* and *L. lineolaris*.

was anyore [2.8 to 3.0) in the 'untreased' experiment. The yields were literary and investely correlated to the increase in full armyworm erg must infentation and the yield reduction was 42.4% to the highers infention.

Index terms: Intente, fail acceptions, artificial infestation, biological control, Basalovenes, Sea wairi

[1512] HOST SELECTION BEHAVIOR OF IN VIVO- AND IN VITRO-REARED ; TRICHOGRAMMA GALLOI AND T. PRETIOSUM (HYMENOPTERA: TRICHOGRAMMATIDAE)

F.L. Cônsoli¹ & J.R.P. Parra², ¹Department of Entomology, Texas A&M University, College Station, TX 77843-2475, USA; ²Departameneto de Entomologia, Fitopatologia e Zoologia Agrícola, Escola Superior de Agricultura "Luiz de Queirco"/USP, Caixa Postal 9, Piracicaba, SP 13418-900, Brasil, E-mail: f-consoli@tamu.edu.

Trichogramma is the only parasitoid that has been successfully mass-produced on artificial eggs and used in mass releasing programs to control agricultural pests. Chinese researchers are the only ones capable to use this technology in large scale, although researchers in Australia, Brazil, France and USA have improved their *in vitro* rearing techniques. Despite the possibility of mass producing these parasitoids on artificial diets, few have been the reports comparing the quality of the *in vitro*-reared wasps to those *in vivo*-reared. Most of *Trichogramma* species reared on artificial diets had their parasitization capacity and survivorship reduced if compared to those insects developing on their natural or factitious hosts. Although some biological traits were used to assess the quality of parasitoids produced on artificial diets, very little is known about their host selection behavior. We have reared *Trichogramma galloi* and *T. pretiosum* in artificial eggs by using different artificial diets, and we have compared the host selection behavior of *in vitro*-reared wasps was similar to those reared *in vivo*. However, females eclosed from low-quality dist showed reduced agressiveness, increased searching time and time for host exploitation (host evaluation, drilling and oviposition). The use of behavioral studies for the evaluation of the quality of *in vitro*-reared *Trichogramma* is also discussed, and the use of *in vitro*-rearing techniques as a tool for studying the host selection behavior of parasitoids is going to be addressed as well. Index terms: artificial diet, biological control, quality control
Symposium and Poster Session

[1513] EFFECT OF A NUCLEAR POLYHEDROSIS VIRUS ON SPODOPTERA FRUGIPERDA LARVAE, ITS DAMAGE AND YIELD OF MAIZE CROP AT DIFFERENT EGG MASS INFESTATION LEVELS

Ivan Cruz¹, M. L. C. Figueiredo¹, A. C. Oliveira¹ & P. A. Viana¹, Embrapa Milho e Sorgo, Caixa Postal 151, 35700-970 Sete Lagoas, MG, Brasil. E-mail: ivancruz@cnpms.embrapa.br.

The efficiency of Baculovirus in a wettable powder formulation to control the fall armyworm Spodoptera frugiperda (Smith) was evaluated. The treatments were arranged in a randomized complete block with six replications. Plants at the 8-10-leaf growth stage were artificially infested with different densities of fall armyworm egg masses (0, 20, 40, 60, 80 and 100% of infested plants). The virus was applied using a dose of 50 grams per hectare (2.5 x 10¹¹ polyhedron inclusion bodies - PIB/ha) applied once as an aqueous suspension (300 l/ha) 72 days hours after egg hatching using a back-pack-manual sprayer at 40 PSI (2.8 kg/cm²) and a regular flat fan nozzle. Evaluation was based on larva mortality, leaf damage and yield. A comparison, a similar experiment was conducted without virus application ("untreated"). Larva mortality rate obtained on plots protected by the virus varied from 82.6% (100% infestation) to 93.2 (20% infestation level). The leaf damage (1 to 5 scale) was 3.5 and 2.3. The yield obtained from plots with infestation levels of up to 60% was similar to the yield obtained from non-infested plots. Leaf damage was severe (2.8 to 5.0) in the "untreated" experiment. The yields were linearly and inversely correlated to the increase in fall armyworm egg mass infestation and the yield reduction was 42.3% in the highest infestation.

Index terms: Insecta, fall armyworm, artificial infestation, biological control, Baculovirus, Zea maiz)

[1515] REMARKS ON THE SEXUAL RATIO OF THE CAMPOLETIS FLAVICINCTA IN LABORATORIAL REARING

S. T. Dequech¹, <u>R. F. da Silva²</u> & L. M. Fiuza³, ¹ Fitosanity Defense Dept. CCR – Univ. Fed. of Santa Maria. 97119-900 Santa Maria, RS, Br, E-mail soniabd@zaz.com.br; ^{1, 2} Health Plant Department, School of Agr., Univ. Fed. of Rio Grande do Sul, P. O. Box 776, 90001-970, Porto Alegre, RS, Br, E-mail rogeriop@vortex.ufrgs.br; ³ Microbiology Department / UNISINOS, Av. Unisinos, 950, 93022, São Leopoldo, RS, Br, E-mail fiuza@cirrus.unisinos.br.

Amongst the more important natural enemies of Spodoptera frugiperda is Campoletis flavicincta (Hym., Ichneumonidae). The rearing of this parasitoid in laboratory many times faces relative problems concerning the sexual ratio which is obtained, with much bigger predominance of males. The objective of the present work was to evaluate some factors which can possibly modify the ratio mentioned, such as: (1) formation of pairs at the moment of receiving hosts or before, (2) age of host organisms and (3) age of females when parasitism occurs. Pairs of C. flavicincta, with known age, were individualizated, fed with honey solution at 10% and kept in a B.O.D incubator regulated for 25°C, humidity of 65% and photoperiod of 12 h. In order to test objective 1, the sexual ratio of pairs formed before being exposed to the larvae was compared with the sexual ratio of the pairs formed at the moment of the larvae exposition. For objective 2, the sexual ratios of the parasitoids which emerged from larvae that, at the moment of the exposition, were on the 2nd or on the 3rd instar were compared. And for objective 3, different ages of females at the moment of exposition to the 2nd instar larvae were analysed. The values obtained for 374 parasitoids stemming from pairs formed prior to larvae exposition, compared with 530 ones which did not undergo such previous exposition, have resulted in the ratios of 1 female : 5.4 males and 1: 4.0, respectively, which was not statistically significant at the qui-square test (p=0.05). Considering the age of the exposed larvae, when at the 2^{nd} instar, the ratio was of 1: 4.3 for 680 analysed insects, and of 1: 4.2 for 149 parasitoids when the exposed harvae were at the 3rd instar, which also showed no significant difference. The results concerning the different ages of females are: 0-2 day-old females, ratio of 1 : 4.5; 3-6 day-old females, 1: 3.6; 7-10 day-old females, 1: 4.0; females older than 10 days, 1: 6.5. These results did not show a significant difference through the qui-square test (p=0.05). In contrast to results in papers found in the literature, the data obtained indicate that, in the conditions of this experiment, it was not possible to observe influence of the factors studied regarding the sexual ratio of the parasitoid.

Index terms: Spodoptera frugiperda, biological control, parasitoid.

[1514] BIOLOGY OF THE IMMATURE STAGES OF NORTH AMERICAN PLANT MINING GRACILLARIDAE (LEPIDOPTERA)

D. R. Davis¹ & D. L. Wagner², Dept. of Entomology, Smithsonian Institution, Washington, D.C., USA, 20560-0127; ² Dept. of Ecology & Evolutionary Biology, Univ. of Connecticut, Storrs, CT, USA. 06269-3043.

The complex hypermetamorphic development of gracillariid plant mining larvae involves numerous morphological and behavioral adaptations that reflect evolutionary history within the family. Gracillariid larvae begin as specialized sapfeders possessing a prognathous, flattened, apodal body form adapted for tunneling through restricted space immediately beneath the epidermis of the plant host. Their diet (and frass) is mostly liquid, with the larva filtering fluids from damaged subepidermal cells. Later instars typically assume a more generalized, hypognathous, caterpillar form that normally ingests solid food, feeds deeper into the parenchyma, and excretes granular frass. Numerous modifications of this basic developmental scenario have appeared throughout the family, which, when considered with corresponding morphological adaptations, help to resolve phylogenetic relationships at the generic level and above. The life stages of over 120 species of North American Gracillariidae, representing all 26 previously described and 6 new Nearctic genera, have been studied in detail. All instars were tabulated and their general biology noted. Morphological details of each major larval phase and pupa were documented with more than 3000 SEM photographs and drawings. An overview of the phylogeny of the North American genera and subfamilies based principally on the biology and morphology of their immature stages will be presented.

Index terms: Hypermetamorphism, larval adaptation, life history, phylogeny

[1516] DIET OF GENERALIST PREDATOR AFFECTS AVOIDANCE BEHAVIOUR OF PREY

Marcel Dicke & Paul Grostal, Lab. of Entomology, Wageningen Univ., P.O. Box 8031, NL-6700 EH Wageningen, The Netherlands. E-mail: marcel.dicke@users.ento.wag-ur.nl.

Accurate perception of the environment is crucial for animal survival. Thus, most behavioral decisions made by animals are shaped by the information about abiotic conditions, food, mates, competitors and natural enemies. Recognition of natural enemies is one of the most important forms of information gathering by animals, as mistakes are often fatal. We used predator-naive spider mites (Tetranychus urticae, Tetranychidae) to: 1) compare the responses of prey to chemical cues from enemy and non-enemy species, and 2) investigate the source of these cues. We observed the distribution of T. urticae in response to cues from nine mite species, including: a) predators of spider mites, b) predators / parasites of other animals, and c) fungivores / pollen-feeders. When given a choice over 24 h, spider mites foraged and oviposited in fewer numbers on leaf discs that were previously exposed to predatory or parasitic mites (including species incapable of attacking spider mites), than on clean leaf discs (unexposed to mites). Interestingly, previous exposure of leaf arenas to fungivores and pollen feeders had no significant effect provide the provided of the theory of the provided the provided of T unlike the theory of the provided the theory of T unlike the theory of the provided the theory of the theory o Tetranychus urticae showed stronger avoidance of leaf discs that were previously exposed to spider-mite-fed predators, than of discs exposed to pollen-fed predators.

Index terms: Tetranychus urticae, Phytoseiulus, Amblyseius, chemical ecology, behavioural ecology

[1517] PRELIMINARY EVALUATION OF AGENIASPIS CITRICOLA (HYM: ENCYRTIDAE) ATTACKING PHYLLOCNISTIS CITRELLA (CITRUS LEAFMINER) IN ARGENTINA

P. A. Diez¹, E. A. Frias², N. E. Ovruski³ & <u>A. A. P. Fidalgo²</u>, ¹Fac de Agronomía y Zootécnia, UNT, Av. Roca N° 1900, 4000, Tucumán, Argentina; ²Fund. Miguel Lillo, Miguel Lillo N° 251, 4000, Tucumán, Argentina; ³Fac. de Ciencias Naturales, UNT, Miguel Lillo N° 251, 4000, Tucumán, Argentina.

Between 1995 and 1996 Phyllocnistis citrella (Citrus leafminer, CLM), was registered in Northwestern Argentina. Very rapidly it was widespread in all the citrus areas of the country. In 1998 Ageniaspis citricola Logvinovskaya, a specific parasitoid of CLM, was introduced and released in Argentina. Probably due to a fortuitous introduccion, it had been recorded the previous year. A. citricola disperses slowly than the pest; therefore it has not been found in several areas yet. The aim of the present paper is to know the presence of A. citricola and the level of total parasitism. Samples in citrus orchards north to 32° parallel were taken periodically. In each of the areas affected by the pest, 300 to 1,500 leaf were taken and observed at the laboratory afterwards. When A. citricola was lacking, the percentages of the indigenous parasitoids varied beetween 0% and 18%. When A. citricola was present, total parasitism varied between 31% and 66.2%. These results suggest that the total level of parasitsm increased with presence of A. citricola into the monitoired areas. The indigenous parasitoids were Cirrospilus sp., Elasmus sp. and Galeopsomyia fausta, their individual numbers changing in diferent sampling region. These results have been explained by the diversity of abiotic and biotic factors, characteristc of each area. Index terms: Ageniaspis citricola, Phyllocnistis citrella, percentage of parasitism

[1519] COLD STORAGE OF IMMATURE STAGES OF TRISSOLCUS BASALIS AND TELENOMUS PODISI (HYMENOPTERA: SCELIONIDAE): EFFECT ON DEVELOPMENT, ADULT LONGEVITY AND REPRODUCTION

A K. Doetzer¹ & L. A Foerster¹, ¹Dept. of Zoology, Univ. Federal do Paraná, P.O. Box 19020 ZIP 81531-990, Curitiba - PR, Brazil. E-mail: doetzer@garoupa.bio.ufpr.br.

The development, survival and reproduction of the egg parasitoids Trissolcus basalis and Telenomus podisi stored in the stages of egg, larvae and pupae at 12° and 15°C were evaluated in laboratory, using respectively Nezara viridula and Euschistus heros eggs as hosts. To store eggs and larvae, three parasitized egg masses at 18°C were transferred to 12° and 15°C after 2 and 5 days of parasitism date and returned to 18°C after 20, 30 and 40 days, to emerge. Pupae were stored at low temperatures after rearing the parasitoids at 18°C for 15, 20, 25, 26, 28, 30 and 35 days. Adults were maintained in tubes and honey was provided as food. Reproductive capacity of stored females for a period of 3 and 5 months at 15°C was evaluated at 21°C, using emerged females obtained from the storage in the pupal stage after 30 days of parasitism date. After 10 days at 21°C, 10 E. heros eggs were daily supplied during 5 days. There was no emergence from storage of immatures at 12°C. Emergence of adults at 18°C after transference to 15°C in the egg and larval stages was low for both parasitoids, ranging from 0.0 to 35% and it was inversaly proporcional to storage time. The developmental time was similar for the parasitoids and increasead progressively with increasing storage time, ranging from 49 to 61 days. The maximum adult longevity deriving from the storage in the egg and larval stages at 15°C was 132 days, but the low percentage of emergence shows that the method is not suitable for the parasitoids production. Storage in the pupal stage at 15° C resulted in adult emergence in all treatments for *T. basalis*, ranging from 1.5 and 86.4%, when the egg masses were stored after 15 and 30 days of parasitism date, respectively. Emergence of T. podisi at 15°C ranged from 26.3 to 59.9%, at storage after 20 and 35 days of parasitism date, respectively. There was no emergence when the parasitoids were transferred to 15°C after 15 days at 18°C. Longevity of emerged females from the storage in the pupal stage at 15°C was 249,6 and 209,2 days for T. basalis and T. podisi respectively and decreased progressively with decreasing time at 18°C before the storage. Females of T. basalis stored for 3 and 5 months parasitized respectively 16.1 and 24.5 eggs during 5 days. Females of T. podisi stored for 3 months parasitized 3.0 eggs and failed to oviposit after storage for 5 months.

Index-terms: Nezara viridula, Euschistus heros, egg parasitoids, biological control

[1518] DEVELOPMENT, SURVIVAL AND REPRODUCTION OF TRISSOLCUS BASALIS AND TELENOMUS PODISI (HYMENOPTERA: SCELIONIDAE) REARED IN GREENHOUSE IN SOUTHERN PARANÁ STATE, BRAZIL

A.K. Doetzer¹ & L. A Foerster¹, ¹Dept. of Zoology, Univ. Federal do Paraná, P.O. Box 19020 ZIP 81531-990, Curitiba - PR, Brazil. E-mail: doetzer@garoupa.bio.ufpr.br.

Experiments were conducted in Curitiba, Paraná, Brazil to evaluate the development, survival and reproduction of the egg parasitoids Trissolcus basalis and Telenomus podisi reared in greenhouse, during autumn and winter, 1999. In laboratory, at 18°C, Nezara viridula and Euschistus heros egg masses were exposed respectively to T. basalis and T. podisi females for a period of 72 hours to allow oviposition. The parasitism occurred in autumn, using 10 egg masses in April, 10 in May and 10 in June, and after the eggs had been parasitized, the egg masses were transferred to the greenhouse. The duration of development and the number of emerged parasitoids were recorded. The emerged adults were maintained in tubes and honey was provided as food. After 2, 4 and 6 months in greenhouse, 30 females were transferred to the laboratory to evaluate their reproductive capacity at 21°C. After 2, 7 and 14 days at this temperature, 10 E. heros eggs were daily supplied for a period of 5 days. When the parasitism occurred in April, the developmental time was 29.1 days for *T. basalis* and 34.7 days for *T. podis*; the number of parasitoids that successfully emerged as adults was respectively 89.0 and 76.5%. Parasitized egg masses in May and June resulted in longer duration of development and lower emergence. Adults survival in winter was higher than 75% for both species, indicating that the parasitoids are capable of overwintering as adults. The mortality was higher in October and November; in December, 20% of the parasitoids were still alive. T, basalis and T, podisi females maintained in greenhouse for 2, 4 and 6 months parasitized E. heros eggs after their transference to 21° C. There was no significant difference between the three periods of pre-oviposition (2, 7 and 14 days) and the results were pooled. *T. basalis* females maintained in greenhouse for 2 and 4 months parasitized respectively 20.0 and 24.7 host eggs and the fecundity decreased after 6 months of maintenance in greenhouse (13.0 eggs/female). The fecundity of T. podisi was lower in relation to T. basalis and there was no significant difference between the treatments. After 2, 4 and 6 months in greenhouse, T. podisi females parasitized respectively 6.3, 8.8 and 5.2 host eggs for a period of 5 days.

Index-terms: Nezara viridula, Euschistus heros, egg parasitoids, overwintering, biological control

[1520] RESPONSE OF THE PREDACIOUS MITE, AMBLYSEIUS CYDNODACTYLON TO INCREASING PREY DENSITY OF THE TWO SPOTTED SPIDER MITE, TETRANYCHUS URTICAE IN ABSENCE OR PRESENCE OF NYMPHS OF TOBACCO WHITE FLY, BEMESIA TABACI (ACARI: PHYTOSEIIDAE)

E.M. El-Banhawy¹, S.M. Hafez² & S.A. Saber¹, ¹- National Research Centre, Dokki, Cairo, Egypt; ²- Faculty of Agriculture, Ain-Shams Univ., Cairo, Egypt.

The predacious mite, Amblyseius cydnodactylon Shehata&Zaher is a common natural enemy inhabiting low growing plants like cucumber. It has been recorded associated with infestations of the two-spotted spider mite, Tetranychus urticae Koch and the white fly, Bemesia tahaci (Genn.). Under laboratory conditions of 28-30°C and 70-80% R.H., the predator adult female consumed nymphs of T.urticae at the defferent experimented densities. However, the consumption rate increased by increasing prey densities up to 32 nymphs/female/day and decreased significantly at 64 and 128 nymphs/female/day. Addition of fixed number of the 1" instar nymph of B.tabaci (10 individuals) to every TSSM prey density significantly reduced consumption, although the predator female respond in similar fashion to increasing prey densities. Reproduction increased by increasing prey densities and reached a maximum at 32 nymphs/female/day. The addition of nymphs of B.tabaci substantially increased reproduction at every density. This increase in reproduction would have compensated the reduction in nymph prey consumption due to the presence of B.tabaci.

Index terms: Cucumber pests, consumption, reproduction

[1521] STUDIES ON WALNUT APHIDS AND THEIR NATURAL ENEMIES IN KARAJ

<u>P. A. Fard</u>³, Entomology Dept. College of Agriculture Univ. of Tehran, Karaj Iran 31584 E-mail:pafard@chamran.ut.ac.ir.

Two species of aphids, Green walnut aphid Chromaphis Juglandicola and Dusky-veined aphid Panaphis Juglandis are common in Karaj and vicinities. For studying factors affecting their population fluctuations, several unsprayed walnut trees in different parts of Karaj were kept under consideration. Aphids and their natural enemies were regularly collected and evaluated. Their investigations revealed that green walnut aphids are much smaller than dusky-veined aphids and are typically found scattered on the lower side of leaves while dusky-veined aphids feed in rows along the mid-vein on the upper surface. During the spring and summer, adult females commonly have wings. Dasky-veined aphids have wings with distinctive dusky marking along the veins. The nymphs of the dusky-veined aphid have dark-banded spots on the back, these spots are much less pronounced or absent on the nymphs of the walnut aphid. Both aphids are in the egg stage on the twigs during winter. Aphids are most damaging in spring and early summer. Temperatures of 38°C or more, maintained over several days in the orchard, suppress dusky-veined aphid populations, whereas the walnut is less susceptible to heat. Several parasites control their population density. Four species of ladybird beetles, three species of syrphid flies and lacewings are more common under Karaj conditions. Index terms: Veinedaphids-Parasites-Ladybird days, but the low percentage of consegure shows that the method is not soltable for the paraminide production. Storage in the pupil store at LPC resulted in adult emergence in all meanweath for T. Joanlie, ranging from 1.5 and 86.4%, when the east masses were moved after 15 and 20 days of parasitivity date, respectively, little rgence of T podist at 15°C ranged from 26.3 to 59.9%, at storage after 20 and 35 days of patasitions date. trapectively. There was no energence when the parametrize were transferred to 15° C after (5)Isys at ISC. Longevity of entargod females from the monge in the popul stage at 15% was 249.0 and 270.2 days for T branch and T product maps to be an observed pairs document progressively with decreasing time at 18°C before the diverge. Females of T branchis more or 3 and 5 months paramozed respectively 16.1 and 26.5 eggs dowing 5 days. Female: wi E positi stored for 3 months parasitized 3.0 eggs and failed to oviposit after notate for S

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[1523] ECOLOGICAL ASPECTS AND DAMAGE EVALUATION OF FUIT FLIES IN CAGAITA IN THE SAVANNAS OF GOIAS STATE, BRAZIL

G.A. Ferreira¹, V.R.S. Veloso¹, J.H.S. Lima¹, J.R. Braga Filho¹ & K.C.C. Rabelo¹, ¹Escola de Agronomia/Universidade Federal de Goiás. Campus II, Rod. Goiânia/Nova Veneza, km 0, Caixa Postal 131, CEP. 74001-970 Goiânia, Goiás E-mail: yveloso@agro.ufg.br.

The savanna ecosystem has greets environmental gradients. This fact conferring urge floral biodiversity and audible fruits in addition. Local people like fruitful, medicinal, and ornamental specie know the cagaita (Eugenia dysenterica D.C.) tree. The cagaita put is hosting of fruit flies attacks the pulp of fruits in oviposition phase. Oviposition points aid fitopatogenic agent's infection becoming impracticable the twit's utilization. This study was carried out in 19 counties of Goiás State from September to November 1998. It was studied occurrence of fruit flies and natural economics species and damaging level. Fruit samples were collected, counted, weight and disposed in plastic boxes containing sterilized and wet sand, and cowered with "voil" stuff. Afterwards, pupary were collected and transferred to appropriated adults emergence containers. Fruit flies were counted and fixed with 70% alcohol to posterior identification. The determination of number of species per fruit was carried out in nine couties with 50 fruits per plant disposed in plastic glasses. To damaging evaluation fruits were sliced reporting presence or absence of larvae. Identified species were Anastrepha fraterculus, A. abliqua and Ceratitis capitata. Other occurrence insects were Neosilba spp. (Lonchaeidae), Atherigona orientalis (Muscidae) and specimens of Family Oititidae, Natural enemies identified were Doryctobracon areolatus (Braconidae), Lopheucoila anastrephae, Aganaspis pelleranoi, A. nordlanderi (Eucoilidae), Spalangia endius, Pachycrepoideus vindemiae (Pteromalidae) and non-identified Pteromalidae specie. All identified species occurred concomitantly in fruits with pulp destruction by larvae and fruit depreciation by galleries and excrements. The damaging level got 44 at 100 per cent. Then cagaita plant way is considered natural source of fruit flics in Goiás State. This is the first reporting of parasitoids L. anastrephae, A. nordlanderi (Eucoilidae), P. vindemiae (Pteromalidae) of Tephritoidea in cagaita fruits. Index terms: Fruit fly, Savannas, Eugenia dysenterica, damaging evaluation, Parasitoids

[1524] ACARICIDES SELETIVITY EVALUATION ON CHRYSOPERLA EXTERNA (NEUROPTERA: CHRYSOPIDAE)

R. J. Ferreira¹, K. C. A. Senő², N. M. M. S. Albergarin², H. O. S. Dória² & S. de Freitas², ¹Depto, de Biologia, Univ. de São Paulo, CEP 14040-901, Ribeirão Preto, SP, Brasil, E-mail, raimundo@usp.br (Fapesp Fellowship); ²Depto, de Fitossanidade, Univ. Estadual Paulista, CEP 14870-000, Jaboticabal, SP, Brasil,

This work was carried out to evaluated the effect of two acaricides, frequently used in citros orchards, on larvae of Chrysoperla externa. The trial was accomplished in the Chrysopids Biosystematic Lab located at the Univ. of São Paulo State, Jaboticabal, SP, BR. The experimental desing used was completely randomized with 3 treatments and 5 replications. Each replication was composed by tem 1" instar larvae, previously fed and fastened by dorsal side on a slide microscope plate, came from 3rd lab generation and with 24 hour age. The treatment use were: 1-) oxide[enbutatin (Torque) - 0,8ml/l; cyhexatin (Cyhexatin PM) - 0.5g/l; 3-) checking (destiled water). The effect of treatments was evaluated 24, 48 and 72 hours after the larvae immersion and the results showed: 1-) cyhexatin presented higher level of larvae mortality after 72 hours; oxifenbutatin and checking did not differ to each other in all evaluations and presented low larvae mortality index. was 29.1 days for T. Joundie and 34 Index terms: bioassay, chrysopid, generalist predator. masses to May and June resulted in trager mention of development and lower emergence Adults survival in winter was higher than 75% for both species, industing that the paramonits are capable of overwisiering as adults. The mortality was higher in October and November, in December, 20% of the parasitolith were still slive, T feasible and T

perfect females maintained in prevaluance for 2, 4 and 6 months providered 4. here eggs after their transference to 21%. There was no againficial difference between the these periods of me-responsion (2, 2 and 14 days) and the results were peopled. T. bandli females maintained in prevaluance for 2 and 4 months paramitized respectively 20,0 and 24.7 here eggs and the ferendity decrement after 6 months of maintenance in greenhouse (13.0 eggs/female). The ferendity decrement after 6 months of maintenance in greenhouse (13.0 eggs/female). The ferendity of *T*, polarit was lower in relation to *T*, fearfit and there was no significant difference between the transmust. After 2, 4 and 6 months in greenhouse. To possible females paramitized respectively 6.3, 8.8 and 3.2 heat oggs for a period of 5 days.

Index-tearm: Negara virilatia, Euselianas heros, egg parastocido, overventering, biological control

[1522] TUTA ABSOLUTA PARASITISM BY TRICHOGRAMMA PRETIOSUM WITH NOTES ON HOST SITE C.A. Faria¹, J.B. Torres², A.M.I. Farias³ & A.M.V. Fernandes³, ¹DBA/Entomologia, UFV, Viçosa, MG, 36570-000, Brazil, E-mail: cristina@insecta.ufv.br; ²DEPA-Fitossanidade, UFRPE, Ave. Dom Manoel de Medeiros s/n, Dois Irmãos, Recife, PE, 52171-900, Brazil; ³CCB-Zoologia, UFPE, Ave. Prof. Moraes Rego s/n, Recife, PE, 51123-900, Brazil.

This study aimed to evaluate the response of *Trichogramma pretiosum* females to *Tuta absoluta* oviposition site on tomato (var. IPA - 5) plant capoy. The tests were conducted in individually caged plants. In each cage 5-15 *T. absoluta* moths were released, followed by the release of 15 *T. pretiosum* females 12 h later. After 24 h, the oviposition was quantified and its site determined, and the total levels of parasitism were assessed after 4 days. The parasitism tanged from 1,5 to 28%. Both *T. absoluta* oviposition and its parasitism by *T. pretiosum* were higher in the plant apex, decreasing along canopy. The results show that *T. pretiosum* can locate and parasite *T. absoluta* eggs at different densities. Moreover, the parasitism was related to the host spatial distribution on the host plant. The data obtained in this study suggest that the response of *T. pretiosum* to *T. absoluta* eggs is spatially density-dependent.

Index terms: Chemister petts, committen reproduction.

[1525] DISPERSAL OF THE FILTH FLY PARASITOID MUSCIDIFURAX RAPTORELLUS (HYMENOPTERA: PTEROMALIDAE) FOLLOWING MASS-RELEASES IN CATTLE CONFINEMENTS

K. D. Floate¹, P. Coghlin¹ & G. A. P. Gibson², ¹Agriculture and Agri-Food Canada, Lethbridge Research Centre, P.O. Box 3000, Lethbridge, AB, Canada, T1J 4B1, E-mail: floatek@em.agr.ca; ²AAFC, Eastern Cereal and Oilseed Research Centre,K. W. Neatby, Bldg., 960 Carling Avenue, Ottawa, ON, Canada, K1A 0C6.

Pupae of house fly, Musca domestica L. (Diptera: Muscidae), reared in the laboratory were used to assess the movement of *Muscidifurax raptorellus* Kogan & Legner (Hymenoptera: Pteromalidae) following mass-releases of this filth fly parasitoid in cattle confinements. Parasitism of sentinel pupae was 34%, averaged for three mass-releases (ca. 220,000 individuals/release) at each of two sites. Parasitism declined only slightly with the distance (1 to 100 m) of pupe from the point of parasitoid release (for data combined from all releases, P < 0.001, $r^2 = 0.032$). Wind direction had no consistent effect on parasitism for six releases (P > 0.05). Twenty-nine specimens of *M. raptorellus* were recovered in 1998, following release of more than 1.3 million individuals in previous years. Because the winter of 1997-98 was unusually warm, further studies are required to determine whether the parasitoid can survive winters more typical of southern Alberta. These results suggest that: 1) mass-releases of M. raptorellus can be used to help manage populations of stable fly and house fly in cattle confinements, 2) mass-releases at intervals of 200 m should achieve fairly uniform coverage of the confinement facility with parasitoids, and 3) mass-releases will be required each year. Eight additional species of parasitoids (Hymenoptera) were recovered from pupae during the study. Each of these species previously has been reported from southern Alberta, with the exception of Eupelmus (Macroneura) vesicularis (Retzius) (Eupelmidae).

Index terms: Musca domestica; Stomoxys calcitrans; biological control

[1527] EGG PARASITOIDS OF ANTICARSIA GEMMATALIS (LEPIDOPTERA: NOCTUIDAE) ON SOYBEANS IN BRAZIL

L. A. Foerster¹ <u>M.R. F. Avanci</u>¹, J.M.R. Martins¹ & C.L. Cañete¹, ¹Depto. de Zoologia, Univ. Federal do Paraná, P.O. Box 19.020 (81531-990) Curitiba, PR, Brazil. e-mail: foerster@bio.ufpr.br

Until 1995 only Trichogramma pretiosum was described parasitizing eggs of the velvetbean caterpillar Anticarsia gemmatalis in Brazil. Since then, the Laboratory of Integrated Insect Control of Universidade Federal do Paraná has set up field surveys on soybean fields in Southern Paraná State to investigate the incidence of parasitism in eggs of A. gemmatalis. Eggs laid on soybean leaves were collected and transferred to the laboratory to check for the presence of parasitoids. Colonies of the collected species were maintained in laboratory for bio-ecological studies. Between 1995 and 1998 five species of parasitoids belonging to three families were reared from eggs of A. gemmatalis: Trichogramma pretiosum, T. rojasi and T. atopovirilia (Trichogrammatidae), Telenomus cyamophylax (Scelionidae) and Encarsia porteri (Aphelinidae). In 1999, another two species of Trichogramma were found, namely T. acacioi and T. lassalei. This is the first record of both species in eggs of A. gemmatalis. In 1998, weekly samplings were taken during the vegetative and reproductive stages of the crop. Parasitized eggs were collected still during the vegetative stage of soybeans, however the highest levels of incidence occurred during the pod-filling stage of the crop. Overall percentage of parasitized eggs reached 23.3% in 1998. T. pretiosum was the predominant species, representing 94% of the parasitoids sampled in the field. Eggs of the noctuids Pseudaletia sequax, Spodoptera eridania and Pseudoplusia includens were tested in laboratory as alternative hosts for T. cyamophylax and some of the Trichogramma species reared in laboratory. T. cyamophylax, T. pretiosum and T. rojasi developed successfully in eggs of P. sequat. However, neither T. pretiosum, nor T. cyamophylax developed satisfactorily in eggs of S. eridania. Eggs of P. includens were suitable for rearing T. pretiosum, T. atopovirilia and T. acacioi. Only males of E. porteri have been obtained from eggs of A. gemmatalis, and this is probably an heterotrophic parasitoid, like other species of *Encarsia*, in which the female progeny develops on whiteflies and the male progeny is produced on eggs of lepidopterous hosts. The diversity of parasitoid species found on eggs of A. gemmatalis shows the potential of this egg parasitoids for the control of the velvetbean caterpillar. Index terms: Biological control, velvetbean caterpillar, Trichogramma, Telenomus, Encarsia.

[1526] SUBLETHAL EFFECTS OF BACILLUS THURINGIENSIS VAR. ISRAELENSIS (VECTOBAC G & AS) ON LIFE PARAMETERS OF AEDES AEGYPTI

A.E. Flores, G. Ponce, M.H. Badii & M.L. Rodríguez, ¹Autonomus University of Nuevo Leon, AP. 391. San Nicolas de los Garza, Nuevo Leon, 66450, México, e- mail adflores@ccr.dsi.uanl.mx

Beginning in the 1960's, Abate (temephos) has been used in control of mosquito larvae in Mexico and has generated several ecological as well as environmental problems. This has created a need for environmentally sound alternatives such as the utilization in US, Central and South America of highly toxic and specific *Bacillus thuringiensis* var. *israelensis* against *Aedes aegypti*. Some studies indicate there is an alteration of the life cycle as well as the reproductive parameters in 1⁴⁴ generation (FI) progeny of this vector. The purpose of this investigation is to determine the toxicity of *B.t.i* (Vectobac G and AS) on the 2nd and 3nd larval instars of *Aedes aegypti* under laboratory conditions as well as the sublethal effects (LC30, LC50 and LC70) of the same microbial agent on survival, fecundity and life cycle of *Aedes aegypti*. Based on bioassays, LC30, LC50 and LC70 of the commercial product Vectobac G and AS at 24h exposure on 2nd and 3nd larval instars of *Ae. aegypti* 26,000 and 2,6098 ppm).

[1528] PHENOLOGICAL PATTERNS FOR PARASITOIDS SPECIALIZED IN ATTACKING SOLENOPSIS FIRE ANTS, AT THE RESERVA ECOLÓGICA COSTANERA SUR, ARGENTINA

P. J. Folgarait¹, O. A. Bruzzone¹, & L. E. Gilbert², ⁴Centro de Estudios e Investigaciones, Universidad Nacional de Quilmes, Roque Saenz Peña 180, 1876 Bernal, Bs As, Argentina, E-mail pfolgarait@unq.edu.ar; ²Department of Zoology, University of Texas, Austin, TX 78712, USA.

We have been sampling every month phorid populations attacking Solenopsis richteri ants at the Reserva Ecológica Costanera Sur, Argentina, for the past four years. We estimated the abundance of phorids as the number of phorids collected per hour of sampling effort; data presented here show phorid abundance per month joining data for all the years. Phenological data showed strong seasonal patterns related to temperature and precipitation, and allowed the discrimination between season and trail/mound generalist versus specialist species and abundant versus rare species. The most abundant and constant species was the mound-specialist P. borgmeieri, being the single species present during the winter; its abundance was negatively correlated with temperatures and precipitation and was classified as a winter specialist. P. obtusus was a trail specialist and the most rare one, found only during the fall and spring; its abundance was positively correlated with temperature and precipitation. The other 4 species were present in 8 of the 12 months. The most abundant P. curvatus showed its peak during the summer when temperatures were greatest and precipitation intermediate, and was considered a hot specialist. The second most abundant was the fall specialist *P. nudicornis* which attained greatest abundance during the fall, and less during spring, when temperatures were intermediate but precipitation highest; we classified it as a fall specialist. P. comatus, the other mound-specialist, had intermediate to low but constant abundances that were correlated positively with temperature and precipitation. P. tricuspis with the least abundance seemed to be a summer species which activity was positively correlated to temperature but not to precipitation. Phorid abundance showed a negative relationship with wind speed at ground level. Phorids seemed to track ant activity throughout the year with a peak of activity for both groups during the summer. The abundance of moundphorids resembled the total abundance of phorids, with a peak in March mainly due to the generalists P. curvatus and P. nudicornis. The abundance of trail-phorids peaked in January. From a biological control perspective, it will be profitable to consider for introduction more than one species, selecting those with greater abundance and complementary phenology and searching behavior. Selected species should have complementary phenology and searching behavior. similarities in climatic conditions between sites of origin and of introduction of these phorid species.

Index terms: Argentina, biological control, climate, fire ants, phorids

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[1529] FUNCTIONAL RESPONSE OF CHRYSOPERLA EXTERNA FED ON SCHIZAPHIS GRAMINUM

<u>A.R. Fonseca¹</u>, C.F. Carvallo¹, B. Souza¹ & C.C. Ecole¹, ¹Dept. of Entomology, Federal Univ. of Lavras, Caixa Postal 37, CEP. 37200-000, MG, Brazil, E-mail rsjorge@ufla.br

The functional response of Chrysoperla externa fed on Schizaphis graminum under five densities of prey was studied. The experimental design was completely randomized with five treatments and ten replications. The tests were conducted in growth chambers at 25 ± 1 °C, RH of 70 ± 10 % and photophase of 12 hours. An increase in consumption, in function of increased prey density offered, was observed for three instars. There was, however, a consumption stabilization tendency starting from a pre established average density of prey, except for the first instar, which showed a constant increase in aphid consumption. The duration of the first and third instars and of the larval phase, as a whole, increased in function of the increased prey availability. The duration of the second instar, however, decreased in function of increased prey availability. The results for the 1st, 2nd and 3rd instars and the larval phase as a whole showed a Type II functional response. Handling and searching time was verified for second instar larvae while the first instar showed the highest searching and handling time. Handling time diminished progressively with larvae development, the third instar having the lowest handling time.

Index terms: green lacewing, predation, consumption, searching time, handling time.

[1531] PARASITISM OF EGGS OF APPLE LEAF ROLLER BONAGOTA CRANAODES (LEPIDOPTERA: TORTRICIDAE) BY TRICHOGRAMMA SP. IN FIELD CONDITIONS

M. S. Garcia¹, <u>A. Kovaleski²</u>, A. D. Grützmacher¹, A. E. Loeck¹, J. Foresti¹, F. L. Fonseca¹, ¹Dept. de Fitossanidade, FAEM/UFPel, P. O. Box 354, 96.010-900, Pelotas, RS, Brazil, E-mail: msgarcia@ufpel.tche.br; ²Embrapa – Centro Nacional de Pesquisa de Uva e Vinho, P. O. Box 30, 95.700-000, Bento Gonçalves, RS, Brazil.

The apple leaf roller Bonagota cranaodes has been characterized in the last years as one of the main pest of the Brazilian apple production. Now the control is done with insecticides of wide action spectrum, presenting a variable efficiency from 40 to 80%. New control alternatives are being studied, mainly biological control, through parasitoids of eggs of the genus Trichogramma. With the objective of to identify species with control potential for the pest surveys in localities of Pelotas, Bento Gonçalves and Vacaria in the State of Rio Grande do Sul (Brazil). Egg depositions of B. cranaodes, are liberated in soy, corn, tomato, peach and apple. The eggs of the apple leaf roller are obtained in the laboratory in ribbons of transparent plastic. The plastic contend the postures it is cut and stapled in rectangles of celestial blue cardboard of $6,0 \times 2,0$ cm. The eggs are placed in the medium part of the plants during 48 hours, and then brought to the laboratory. In each cardboard it is stapled one egg deposition. In Vacaria important area of apple production, parasitism of eggs was not yet verified in commercial orchards. In this locality the parasitism was registered in eggs of B. cranaodes liberated in tomato plants. Observations made in 120 egg depositions, distributed randomly in tomato plants, in Bento Gonçalves, showed an index of natural parasitism for *Trichogramma* sp. of 51% of the egg depositions and 13% of parasitism for the total of distributed eggs. These results demonstrated that there is a potential for use of species of the genus *Trichogramma* in massive liberations for biological control of *B. cranaodes* in apple orchards, being an important component (or the system of integrated production of apple.

Index terms: Benagota cranaodes, Trichogramma, biological control.

[1530] BIOLOGICAL CONTROL OF FLORIDA RED SCALE IN TEXAS CITRUS

J. V. French¹, J. C. Legaspi², J. Anciso³ & D. Flores⁴, ¹Texas A&M-Kingsville Citrus Center, P.O. Box 1150, Weslaco, TX 78599, USA; ²Texas Ag. Expt. Sta., 2415 E. Hwy 83, Weslaco, TX 78596, USA; ³Texas Ag. Ext. Service, P. O. Box 6700, Edinburg, TX 78540, USA; ⁴USDA-APHIS-PPQ Mission Plant Protection Center, Mission, TX 78573, USA.

Infestations of Florida red scale (FRS), Chrysomphalus aonidum, have increased significantly in the Lower Rio Grande Valley (LRGV) citrus orchards during the 1998 scason. Beginning in December 1998, we surveyed the population densities of FRS (and other armored scale species) in LRGV commercial citrus orchards. FRS infested fruit and foliage were collected and processed in the laboratory for parasite emergence, identification and collection. Citrus and non-citrus plant hosts were evaluated for culturing of FRS to mass rear Aphytis holoxanthus parasites. Release and redistribution of newly emerged A. holoxanthus into FRS-infested orchards, and monitoring of parasitism levels is currently underway. The twice-stabbed ladybeetle predator, *Chilocorus stigma*, was evaluated in laboratory feeding studies for its efficacy as a biological control agent of FRS. In surveys of over 50 LRGV orchard sites during 1998-99, the identified armored scale species in order of decreasing abundance were: California red scale, Florida red scale and chaff scale. California red scale infestations were prevalent in orchards throughout the 3 county (Hidalgo, Cameron and Willacy) LRGV citrus growing area, while FRS was more localized in orchards in Western Hidalgo County. In December 1998, FRS orchard infestations were high, but declined rapidly in January 1999, with populations remaining low throughout the spring and early summer. FRS infestations then increased dramatically during late summer and fall (Aug.-Nov.) of 1999. Surveys confirmed that the dominant parasite of FRS in LRGV orchards was *Aphytis holoxanthus*. Parasite numbers were very low, except in a few survey orchards and these sites were then more intensively monitored. Sustained peak parasite populations occurred during September--November 1999, and were generally much higher on FRS infested fruit versus leaves. Preliminary laboratory feeding studies showed that individual adult C. stigma can consume up to 50 FRS crawlers (1" stage larvae) per day. Based on these predation studies several hundred adult ladybeetles were collected from citrus trees at the Texas Agricultural Experiment Station in Weslaco, Texas and released in two nearby FRS infested commercial orchards. Early observations indicated predator establishment and feeding, with the two orchard sites still being monitored to better evaluate efficacy of C. stigma as a biological control agent of FRS under field conditions

[1532] EFFECTS OF WASP DENSITY ON THE BIOLOGY OF TRICHOGRAMMA CORDUBENSIS

P. V. Garcia¹, L. M. Oliveira¹ & J. C. Tavares¹, ¹Univ. dos Açores, Dept⁰. de Biologia, Rua da Mãe de Deus 58, P-9500 Ponta Delgada, Açores, Portugal. e-mail: patriciag@notes.uac.pt.

In mass rearing and inundative releases, which involve a large number of parasitoids, the relations between wasps are very important with consequences on the species biology. The effects of such relations depend on the number of suitable hosts available for oviposition, influencing the fecundity, longevity, sex ratio of the parasitoids populations (Waage, 1986). The effect of the density of *Trichogramma cordubensis* (Hymenoptera: Trichogrammatidae) on female fecundity, superparasitism and offspring emergence rates were analysed in this work. Groups with 1, 2, 3, 4, 8, 16 and 32 females with less than 24h old were isolated in glass tubes (7x1 cm) containing and a drop of honey and a card with 200 Ephestia kuehniella (Lepidoptera: Pyralidae) eggs aged less than 24 h and ultra-violet irradiated for 20 minutes. The wasps were left to parasitize the hosts for 24h and then removed. The experiments were run in an environmental chamber at 20 ± 0.5 °C, 75 ± 5 % r.h. and L16:D8. Cards with parasitized eggs were maintained under the same conditions for offspring development. The fecundity was determined by counting the host eggs that turned black. Analyses of variance (ANOVA) were conducted on all data. Where statistical differences existed between data sets (P<0.05), Fisher's Protected Least Significant Difference tests (PLSD) were used to separate differing means (Zar, 1996). As the number of wasps increased, the mean fecundity per female decreased. However, this decrease was only found to be significant (p<0.05, PLSD Tests) for the groups with more than 8 females per egg card. Up to 8 females per egg card the superparasitism was very low. Offspring emergence rates decreased with the increasing female density. According to Smith (1996) ratios of females to small host eggs of 1:10 are often used to maintain parasitism of 70-80% in rearing facilities. Our results show that for T. cordubensis this ratio should be lower (1:50) in order to simultaneously keep superparasitism low and maximise the wasp fecundity. Smith, S. M. 1996. Biological control with Trichogramma: Advances, successes and potential of their use. Annual Review of Entomology, 41: 375-406. Waage, J. K. 1986. Family planning in parasitoids: adaptive patterns of progeny and sex allocation. In: Waage J. & D. Grathead (eds.), Insect Parasitoids. Academic Press, UK, pp. 63-95. Zar, J. H., 1996. Biostatistical analysis, 3rd ed Prentice-Hall, Upper Saddle River, NJ.

Index terms: Trichogramma cordubensis, within strain competition, mass rearing

Index terms: Chrysomphalus aonidum, Aphytis holoxanthus, damage, parasitism, predation

[1533] SURVEY OF PARASITOIDS OF THE FALL ARMYWORM, SPODOPTERA FRUGIPERDA (LEPIDOPTERA: NOCTUIDAE), IN FERNANDÓPOLIS REGION, SÃO PAULO STATE, BRAZIL

F. S. Gielfi¹, A. G. Koga¹, J. L. B. Andrade¹ & L. E. B. Silveira¹, ¹Faculdade de Ciências Agrarias, Univ. Camilo Castelo Branco, Estrada Projetada F-1, Fazenda Santa Rita. ZIP: 15600-000, Fernandópolis, São Paulo State, Brazil. E-mail gielfi@fcav.unesp.br.

The fall armyworm is the major corn pest in Fernandópolis region. The control of this insect have been mainly with chemical insecticides, in detriment of the biological control, a of the main tatics of the IPM programs. The objective of this work was evaluate the parasitoids species in the population regulation these insect and the parasitism percentage. Larvae of age differents were collect at three counties of the Fernandópolis region (Mira Estrela, Dolcinópolis and Turmalina), whole seven distinct farms, during the 1998/99 growing season. The larvae were individualize at glasses box (Gerbox model), with moistened paper, fed with natural diet (corn leaf) and maintened in a environmental chamber at 27°C±0,5°C and photophase of 12 h. Daily evaluations were realized to determine the larvae and pupae parasitism and the parasitism percentage. Of the total of the collected larvae (509), ascertained the parasitism in 24.0% (124), but only 43.5% (54) could be identified. The parasitoids recorded were Chelonus insularis (Hymenoptera: Braconidae), wich reached 37.3% of parasitism; Archytas marmoratus (Diptera: Tachinidae), which reached 37.3%; and Campoletis sp. (Hymenoptera: Ichneumonidae), which reached 25.4%. The parasitoid A. marmoratus emerges only of pupae. The results indicate that the larvae parasitism is elevate and thus, the farmers might utize the selective insecticides to conserve the population parasitoids in the corn agroecossystem. Index terms: Chelonus insularis, Campoletis sp., Archytas marmoratus, biological control.

[1535] EFFECTS OF MOLASSES GRASS (*MELINIS MINUTIFLORA*) VOLATILES ON THE FORAGING BEHAVIOUR OF THE STEMBORER PARASITOID COTESIA SESAMIAE

I. S. Gohole^{1,2}, L. E. M. Vet¹, W. A. Overholt² & Z.R. Khan², ¹ Department of Entomology, Wageningen Agricultural University, P.O. Box 8031, 6700 EH Wageningen, The Netherlands. ² The International Centre for Insect Physiology and Ecology, P.O. Box 30772, Nairobi, Kenya. E-mail: Igohole@icipe.org

Information about multitrophic-level interactions may provide an essential foundation for designing effective biological control. The role of a non-host plant, molasses grass (Melinis minutiflora), in enhancing attraction of the cereal stemborer parasitoid, Cotesia sesamiae, to its hosts was investigated. Previous work had shown that this grass was highly attractive to C. sesamiae, and suggested that it could be used to attract stemborer natural enemies to a maize-molasses grass intercrop. However, no studies have examined the relative attractiveness of molasses grass and sorghum. Thus, observations were made on the response of the parasitoid to volatile cues from molasses grass, uninfested sorghum and infested sorghum, in a Y- tube olfactometer. In comparison to a control of a pot of soil, C. sesamiae was more attracted to odours from the molasses grass, uninfested sorghum and infested sorghum. When exposed to two odour sources, C. sesamiae was more attracted to volatiles from infested sorghum than those from molasses grass, or uninfested sorghum. No preference was exhibited between volatiles from molasses grass and uninfested sorghum. When offered a combination of odour sources, infested sorghum alone proved to be more attractive than the molasses grass combined with infested sorghun. A molasses grass + infested sorghum combination was significantly more attractive than molasses grass alone. The wasps did not discriminate between a combination of molasses grass + uninfested sorghum over either uninfested sorghum alone or molasses grass alone. The investigations also revealed a difference in response to molasses grass populations collected from two different locations, Thika and Mbita. The Thika population was significantly attractive than the population from Mbita. Key words: Multitrophic interactions, sorghum, Melinis minutiflora, Cotesia sesamiae, Y-

Key words: Multitrophic interactions, sorghum, Melinis minutiflora, Cotesia sesamiae, Ytube olfactometer.

[1534] THE BIOLOGICAL CONTROL OF HOUSEFLIES ASSOCIATED WITH POULTRY PRODUCTION

J. II. Giliomee & J. P. T. Kapongo, Dept. of Entomology & Nematology, Univ. of Stellenbosch, Private Bag X1, Matieland 7602, South Africa, E-mail jhg@maties.sun.ac.za.

Several species of flies breed in the manure which accumulates when poultry are kept in units for egg or meat production. The most common species are *Musca domestica* and *Fannia* spp. The flies are not only a nuisance in surrounding households, but can also act as vectors of serious diseases. They are difficult to control chemically, although the IGR cyromazine, added to poultry food, is effective albeit expensive. In an attempt to find alternative control measures we have searched for natural enemies and found several species of parasitoids (Hymenoptera: Pteromalidae) which attack the mature larva or young pupa. The natural levels of parasitism appear to be too low for effective control, although correct manure management and additives with which we are experimenting can increase these. One of the parasitoid species *Muscidifurax raptor* could easily be reared in large numbers, lives long (20 days), parasitizes both *Musca* and *Fannia* and can affect more than 90% of exposed pupae. Field trials were carried out to evaluate the effectivences of these experiments indicate that the parasitoids are as effective as cyromazine.

Index terms: Muscidifurax raptor, Musca domestica, Fannia sp

[1536] DEVELOPMENT OF TRICHOGRAMMA PRETIOSUM (HYMENOPTERA: TRICHOGRAMMATIDAE) IN ARTIFICIAL DIET, FOCUSING ON PROTEIN UTILIZATION

<u>S. Gomes^{1, 2}</u>, S. Grenier¹, G. Febvay¹, J. Guillaud¹ & J.R.P. Parra², ¹Laboratoire de Biologie Appliquée, INRA-INSA, Bât. 406, 20 av. Einstein, 69621 Villeurbanne France, E-mail gomes@jouy.inra.fr; ²Laboratory of Insect Biology, ESALQ / USP, Piracicaba, Brazil.

The oophagous Trichogramma can be produced on Ephestia kuchniella eggs as substitution host, Development is also possible in artificial conditions with diets mainly composed of insect-originated elements (hemolymph, body or egg juices). To try to define new artificial diets, and improve the performances of the existing diets, we studied some nutritional and metabolism traits of Trichogramma pretiosum. The artificial dict tested contains hemolymph of Mamestra brassicae, chicken egg yolk, semi-skimmed cow milk, Neisenheimer salt solution and distilled water as basic components. Proteins are key components for the nutrition of parasitoid insects. Biochemical analyses were conducted on total and free amino acid contents of T, pretiosum pupae reared in diets with or without addition of casein. The addition of casein (1.6 %) allows an increase of the protein content of pupae from 7.2 to 7.9 %. To better understand the nutritional value of proteins, a new method was developed for studying the assimilation of these nutrients by pre-imaginal stages of Trichogramma. The method consists in addition of a mixture of free 14C-labeled amino acids to the diet, containing more or less protein. The comparison of the specific activity of total aminoacids in pupae with the specific activity of free and protein aminoacids in diet allow to determine the degree and the way of the utilization of the protein. This work was supported by a CAPES/COFECUB project (261/98). Index terms: Trichogramma, entomophagous insect, nutrition, in vitro rearing

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[1537] EFFECT OF THE AGE OF APHIDIUS COLEMANI FEMALES (HYMENOPTERA: APHIDIDAE) ON THE GREEN APHID SCHIZAPHIS GRAMINUM (HOMOPTERA: APHIDIDAE) PARASITISM

R.C.R. Gonçalves-Gervásio¹, <u>LaV.C. Santa-Cecília¹</u>, V.L. de Carvalho¹, L.V. Foureaux², C.M. Kato² & M.G. Campelo², ¹EPAMIG-CTSM P.O.Box 176, 37200-000 Lavras, MG, Brazil. e-mail: scecilia@ufla.br; ²IMA, Br 040, Km 527, 32.145-900, Contagem, MG, Brazil. e-mail: foureaux@acesso.com.br

The effects of the age of Aphidius colemani Viereck females on the parasitism of the green aphid Schizaphis graminum (Rond.) were studied. After mating, an A. colemani female was placed into a cage containing 50 nymphs of 3^{cd} and 4^{th} instars of the green aphid. Daily, this female was transferred into a new cage until the eight-day period completed. By taking into account a daily population of 50 nymphs of S. graminum, it was found that an A. colemani female parasited, on average, 90 aphids for the eight days of lifetime, with the greatest concentration of the parasitism in the former, decreasing linearly up to the eight day. A percentage of emergence of the adults of the order of 75,5% and a period of mummy formation until the emergence of 0,51 was noticed which went through influence of the age of females of A. colemani.

Index terms: Insecta, parasitoid, biological control, green aphid, sorghum.

[1539] AN EXOTIC APHID SPECIES IS FAVOURED BY ADJACENT TROPHIC LEVELS: HOST PLANT AND NATURAL ENEMY IMPACT ON CEREAL APHID COMPETITION

W. L. Gonzáles¹, E. Fuentes-Contreras² & Hermann M. Niemeyer¹, ¹Departamento de Ciencias Ecológicas, Facultad de Ciencias, Univ. de Chile, Casilla 653, Santiago, Chile, willy@abulafia.ciencias.uchile.cl. ²Departamento de Producción Agrícola, Facultad de Ciencias Agrarias, Univ de Talca, Casilla 747, Talca, Chile

Successful establishment of an introduced species depend of its biological traits and interactions with other species in the new environment. Phloem sucking, colonial or aggregative, exotic, phytophagous insects frequently establish competitive interactions which are mediated by the natural enemies or host plant quality. Sipha flava, a newlyintroduced aphid in Chile, shows some biological traits that could enhance its competitive abilities: 1) low level of parasitism by braconids (an important group of aphid natural enemies), and 2) it produces change on the host plant quality. The relationship between S. flava and Rhopalosiphum maidis on a common host plant, Sorghum halepense was evaluated during two seasons, fall and spring, in environments with and without natural enemics (garden experiment). Additionally, the effects of Lysiphlebus testaceipes (the major natural enemy associated to this system), and the changes on S. halepense by aphid attack, on the aphid - aphid relationship, were evaluated under laboratory conditions. Finally, the effects of temperature and photoperiod on time to first reproduction, number of nymphs and longevity of aphids were studied. Both aphids were negatively affected by interspecific competition during fall (with or without natural enemies), when S. flava was practically excluded by R. maidis. During spring, without natural enemies, R. maidis was negatively affected by S. flava, but this aphid was not affected by R. maidis; with natural enemies, R. maidis diluted the negative impact of natural enemies on S. flava. Both changes in host plant quality induced by S. flava attack, and presence of L. testaceipes negatively affected *R. maidis*. Finally, changes in temperature and photoperiod strongly affected *S. flava* and showed its susceptibility to these abiotic changes typical of each season; however, *R. maidis* was much less strongly affected. The consequences of the adjacent trophic levels on the S. flava - R. maidis interactions are discussed. Index terms: Sipha flava, aphid competition, host plant quality, natural enemies

[1538] FOOD CONSUMPTION OF CHRYSOPERLA EXTERNA (NEUROPTERA: CHRYSOPIDAE) IN THE DIFFERENT DEVELOPMENTAL PHASES OF DYSMICOCCUS BREVIPES (HEMIPTERA: PSEUDOCOCCIDAE), UNDER LABORATORY CONDITIONS

R. de C.R. Gonçalves-Gervásio¹, <u>L.V.C. Santa-Cecília¹</u> & M.V. Sousa¹, ¹EPAMIG-CTSM P.O.Box 176, 37200-000 Lavras, MG, Brazil. e-mail: scecilia@ufla.br

The damages provoked by the mealybug Dysmicoccus brevipes (Hemiptera: Pseudococcidae) have been one of the chief causes of the unsuccess of pineapple culture in the main producing regions being able to cause looses in the yield of the order of 70 %. That mealybug undergoes the action of predators which can contribute to the redution of the pest's population. With a view to evaluating both the consumption and feeding preference of larvae of *Crysoperla externa*, by utilizing as a prey the pineapple mealybug at its different developmental phases, an experiment with randomized block design in split plot sheme with five replicates at temperature of 25 ± 2 °C and relative humidity of 70 ± 10 % was set up at the Biological Control Laboratory of EPAMIG/CTSM. The results showed that during the predator's larval phase were consumed on average, 70, 50 and 15,8 mealybugs of the 1st, 2nd and 3nd instar, respectively and 10 adult females amounting to 145,8 individuals. It was noticed that 51,0% of the total number of mealybugs consumed shows that *C. externa* presents a potential to be utilized in biological control of the mealybug *D. brevipes*.

Index terms: Biological Control, pineapple, green lacewing, mealybug.

[1540] STABILITY OF THE WOLBACHIA TRANSFER FROM TRICHOGRAMMA PRETIOSUM TO T. DENDROLIMI

S. Grenier¹, B. Pintureau¹, A. Heddi¹ & F. Lassablière^{1,2}, ¹INSA, UA INRA 203, Lab. Biologie appliquée, Bât. 406, 20 Ave. A. Einstein, 69621-Villeurbanne-cedex, France, Enail: pinture@jouy.inra.fr; ³Present address: Univ. J. Monnet, Fac. Médecine, Lab. Biochimie, 42023-Saint Etienne-cedex 2, France

Wolbachia symbionts (Bacteria: Rickettsiaceae) induce the thelytokous reproduction in several egg parasitoid species of the Trichogramma genus (Hym.: Trichogrammatidae). Purified Wolbachia from an infected species, T. preliosum, were transferred by microinjection into in vitro developed pupae of a naturally uninfected species, T. dendrolimi. The presence or absence of Wolbachia was checked using DAPI staining, PCR (ftsZ primers), Fluorescence In Situ Hybridization (F.I.S.H.) using the 16S ribosomal DNA probes, and ftsZ gene sequencing. An ftsZ gene fragment from microinjected T. dendrolimi was shown to be identical to that of T. pretiosum, confirming that transfer was successful. Wolbachia were still present 48 and 60 generations after the transfer in two recipient strains of T. dendrolimi, although no obvious induction of thelytoky was observed. F.I.S.H. allows a semi-quantitative estimation of symbiont abundance and a control of their dynamics in the course of generations. It was showed that Wolbachia have a low metabolic activity and abundance in microinjected lines and that eggs of these lines are polymorphic for the infection. Comparison of the intraline and interline variances of the symbiont abundance did not allow to suspect a genetic variability for this character. Moreover, unlike naturally infected lines, *Wolbachia* are not concentrated at the posterior pole of eggs in microinjected lines. The lack of induction of thelytoky in microinjected lines of *Trichogramma* revealed the existence of interactions between hosts and symbionts, and probably a relative specificity of Wolbachia for their hosts. The lower metabolic activity and abundance of Wolbachia in microinjected lines could indicate the progressive elimination of a symbiont possibly insufficiently adapted to its host. Index terms: Bacteria, co-adaptation, egg parasitoid, interaction, symbiosis.

[1541] REARING IN ARTIFICIAL CONDITIONS AS A TOOL FOR PHYSIOLOGICAL OR BEHAVIOURAL STUDIES OF EGG PARASITOID INSECTS

S. Grenier, Labo. Biologie Appliquée, UA INRA 203, INSA Bât. 406, 20 av. A. Einstein, 69621 Villeurbanne Cedex France, E-mail: sgrenier@jouy.inra.fr

The production of parasitoids for their use in biological control programs is the first and more evident aim for the investigations on the development in artificial diets of these entomophagous insects. There is a second aim also very important, especially with endoparasitoids: the utilization of this technique of rearing as a powerful tool for different kinds of physiological and behavioral studies. Trichogramma sp., an egg parasitoid worldwide used as biological control agent against many lepidopterous pest insects, can develop on artificial diet proposed as artificial host eggs. i) Different factors, such as the components present on the surface of the eggshell, the eggshell itself, and the components of the egg content, govern the stimulation of the egg laying by Trichogramma females. To show the role of these factors, we tested artificial host eggs made of different kinds of membrane (polyethylene, polypropylene of various thickness), smeared with different chemicals (hydrocarbons, scale insect extracts), containing artificial media, more or less rich in free amino-acids, ii) The nutritional needs could be evaluated thanks to the development of Trichogramma in artificial host eggs using various diets. iii) The sensibility to bacterial and antifungal agents was tested by adding increasing percentages of different preservative agents inside the media and checking efficiency against contaminants and induced mortality in pre-imaginal stages of Trichogramma. iv) Trichogramma nymphs developed in artificial conditions were used as recipient species for studying the artificial transfer of Wolbachia, a Rickettsial symbiont that induces thelytokous parthenogenesis in some Trichogramma species. A special technique was developed to inject some nanolitres of a solution containing the symbionts extracted from donor species naturally harboring the symbiont into recipient species devoid of this symbiont. The artificial culture allows to choose the most favorable time for the injection. Successful transfer of Wolbachia was performed from T. pretiosum to T. dendrolimi. Index terms: Trichogramma, Wolbachia, symbiont, egg laying, nutrition

[1542] CONSEQUENCES OF INBREEDING AND HYBRIDIZATION IN THE GREGARIOUS PARASITOID COTESIA GLOMERATA

H. Gu & S. Dorn, Institute of Plant Sciences/Applied Entomology, Swiss Federal Institute of Technology, Zurich, CH-8092, Switzerland, E-mail hainan.gu@ipw.agrl.ethz.ch.

Inbreeding and outbreeding in parasitoids are important issues of relevance to all aspects of biological control. A consequence of inbreeding is the increase of homozygotes; as a result, the expression of recessive deleterious alleles increases in inbred populations, which can lead to the loss of fitness, i.e. inbreeding depression. The gregarious parasitoid Hymenoptera are thought to inbreed chronically due to sib-mating, and one would predict that such parasitoid species suffer very little from inbreeding. However, experiment evidence does not always support this prediction. In Cotesia glomerata (L.), a well-known gregarious parasitoid, mating between brothers and sisters not only causes a male-biased sex ratio but also leads to significant inbreeding depression in some fitness traits, including larval development and adult body size. The opposite of inbreeding depression is heterosis. Heterosis is referred to as the performance of F1 hybrids that exceeds the average parental performance, due to over-dominance of genes in heterozygous individuals. The haplodiploidy of parasitoid Hymenoptera is presumed to facilitate population divergence. Hybridisation between the genetically differentiated populations of such species may cause outbreeding depression due to incompatibility rather than heterosis. Our experiments with Cotesia glomerata, on the other hand, demonstrate significant heterosis in a number of female-related traits, such as sex ratio, larval developmental rate and adult body size. The F1 hybrids of crosses between a Swiss strain and a Holland strain produce a lower ratio of males to females, faster larval development and larger female wasps. The implication of these findings to breeding and mass production of parasitoids will be discussed.

Index terms: Cotesia glomerata, inbreeding depression, heterosis

[1543] UPDATING THE KNOWLEDGE OF INDIAN PHYTOSEIID MITES (ACARI) AND HIGHLIGHTING THE POTENTIALLY IMPORTANT INDIGENOUS PREDATORY SPECIES FOR BIOCONTROL PROGRAMME

S.K.Gupta, 1C/10 Anandam Housing Complex, 7 K.B Sarani, Calcutta- 700080, India.

Phytoseiid mites received importance in India from the middle of the last century and due to its growing importance as efficient biocontrol agents, reasonably good work has been done in this country not only towards explorations of fauna but also to generate data on bio-ecological aspects, food preference, predator-prey interaction, mass culture, etc. The available results indicate that uptil now 173 species under 11 generand 3 subfamilies are high degree of endemism. Six species have been identified as most efficient predators while another six are there which are of occasional importance and for many of those species studies have been conducted on biology seasonal occurrence, food preference, feeding potentiality, predator- prey interaction, effect of pesticides on predatory phytoseiids, mass culture, etc. This paper reviews all the available informations on Indian Phytoseiidae, discusses the future lines of work and concludes that there is a good scope in commercial exploitation, mass multiplication and release of promising predatory phytoseiids which will keep the pest mite population under check and lessen our heavy dependence on pesticides to fulfill the two main objectives of the modern pest management concept.

Index terms: Indian Phytoseiidae, biocontrol, indigenous predators.

[1544] SURVEY FOR NATIVE TRICHOGRAMMATID SPECIES IN KENYA

A. T. Haile¹, <u>S. Sithanantham¹</u>, C.K.P.O. Ogol², J.C. Monje³ & C.P.W. Zebitz³. ¹International Centre of Insect Physiology & Ecology, P.O. Box 30772, Nairobi, Kenya sithanantam@icipe.org; ²Kenyatta University, P.O. Box 43844, Nairobi, Kenya; ³University of Hohenheim, D-70593 Stuttgart, Germany.

In Kenya, past records of trichogrammatid egg parasitoid species have been limited to two species of Trichogramma and four species of Trichogrammatoidea. These included Trichogramma sp. nr. exiguum and Trichogramma sp. nr. mwanzai on Chilo spp., and Trichogrammatoidea armigera, Trichogrammatoidea eldanae, Trichogrammatoidea lutea and Trichogrammatoidea simmondsi on Helicoverpa armigera. As part of an initiative to promote utilization of native egg parasitoids in augmentative biocontrol of Helicoverpa armigera and Plutella xylostella, surveys were undertaken in 1998-99 in different parts of the country. Naturally occurring egg parasitoid collections were made from Plutella xylostella (48), Helicoverpa armigera (5) and Chilo spp.(43) and are being maintained as live cultures. Interestingly, eggs of Chilo laid on maize and occasionally also on kale (Brassica oleracea variety Collards) both harbored trichogrammatid parasitoids. The collections include Trichogramma bournieri, recovered from Chilo partellus on maize at Mbita (near Lake Victoria), which is a new record for Kenya. This species has been so far reported only from Comoros Islands off Eastern Africa. The natural occurrence of trichogrammati species on Plutella xylostella is a new record for Kenya, and also for Eastern Africa. Further studies on the species status of the collections are in progress. Index terms: Trichogramma, native species, survey, Kenya

Symposium and Poster Session

[1545] AN EDIBLE ALGINATE FORMULATION OF STEINERNEMA CARPOCAPSAE – ITS INSECTICIDAL EFFECT AND MOISTURE-HOLDING PROPERTIES

S. Han, S. Lee & Y. Kim, School of Bioresource Sciences, College of Natural Sciences, Andong National University, Andong, Korea 760-749

Field application of the entomopathogenic nematode, Steinernema carpocapsae Weiser, is limited by its susceptibility to UV irradiation and desiccation especially in leaf spray This study was conducted to develop the control technique using alginate control. biocapsulation of the nematodes against the beet armyworm, Spodoptera exigua (Hübner) and the tobacco cutworm, Sp. litura. The alginate capsules including the infective juveniles resulted in the oral toxicities to the larvae of two lepidopteran species. The mortality increased with the nematode densities embedded in the capsules and showed the typical sigmoid responses. Water content in the capsule was critical to the survival of the infective juvenile nematodes. More than 80% nematodes could survive above 10% moisture content remained in the capsules. The degree of moisture loss within the capsules was not affected by the citric acid reaction time during capsulation, but by the capsule size, ambient temperature, and relative humidity. More than 80% of infective juveniles in the alginate capsules could survive in distilled water at 15°C for 60 days. These results indicate that the alginate capsulation can be used to be an edible nematode carrier to control the larvae of two lepidopteran species, and that its moisture content was critical to the survival of the nematodes.

Index words - Steinernema carpocapsae, alginate, biocapsulation

[1547] POSSIBILITIES FOR THE USE OF ENCARSIA HISPIDA DE SANTIS (HYMENOPTERA: APHELINIDAE) IN THE BIOLOGICAL CONTROL OF THE SPIRALLING WHITEFLIES ALEURODICUS DISPERSUS RUSSELL AND LECANOIDEUS FLOCCISSIMUS MARTIN ET AL. (HEMIPTERA: ALEYRODIDAE)

E. Hernández-Suárez, <u>A. Carnero</u>, P. Brito, J.C. Febles & M. Hernández-García, Inst. Canario de Investigaciones Agrarias, P.B. 60 - E38200 La Laguna, Tenerife, Canary Islands, Spain

The spiralling whiteflies Aleurodicus dispersus and Lecanoideus floccissimus, a relative new arrival, are important pests of economic crops in the Canary Islands. A study conducted over the last two years recorded them on more than 40 plant species. Heavy populations were found on economic crops such as banana (Musa acuminata), papaya (Carica papaya), guava (Psidium guajava), and mango (Mangifera indica). As chemical control of spiralling whiteflies has not proved successful, a project has been initiated to develop control strategies, largely based on biological control. A survey was conducted to determine natural enemies' species, primarily parasitoids, present in our islands to be evaluated for potential as biological control agents. Thus, whitefly-infested leaves were collected from the field and the whiteflies reared through in the laboratory. Parasitized A. dispersus individuals were found developing in more than 15 host plants in six of the seven Canary Islands. Identification of emerged parasitoids indicated that 100% of the parasitism was due to Encarsia hispida. On the other hand, none parasitism has been found on L. floccissimus. E. hispida is in the process of being evaluated as candidate for improvement of natural control of A. dispersus and as biological control agent of L. floccissimus. Studies included biological attributes, interspecific interactions, host species, and stage preferences. In this poster authors present the first results of these studies. Data on distribution, hosts, host plants and interaction with other whitefly parasitoid species in the Canaries are provided. In particular, data are reported here on adult longevity, fertility and preimaginal developmental time of E. hispida on A. dispersus at different temperatures. Initial results of laboratory trials on the parasitism of L. floccissimus by E. hispida are also provided. Possibilities for the use of this parasitoid as biological control agent of the spiralling whiteflies in the archipelago are discussed.

Index terms: Encarsia hispida, Aleurodicus dispersus, Lecanoideus floccissimus, biological control

[1546] IMPLEMENTING AN ECOLOGICAL PERSPECTIVE OF HOST-NATURAL ENEMY INTERACTIONS TO AUGMENTATION BIOLOGICAL CONTROL

K. M. Heinz, Department of Entomology; Texas A&M University; College Station, Texas; 77843-2475; U.S.A.

It has frequently been proclaimed that ecology has contributed less to pest management than pest management has contributed to ecology. If this proclamation is true, it may be a result of ecological entomologists focusing on questions that address "how" systems operate rather than "why" they operate the way they do. This pattern is easily explained by the positive correlation between pest status and research effort. However, the proximate "how" approach provides little predictive power relative to the ultimate "why" approach as to how systems will respond to environmental perturbations. To achieve this predictive power in the case of augmentation biological control, research entomologists must construct and evaluate a body of theory that is implementable by biological control practitioners. In the first part of my presentation I will give a brief overview of the utility of ecological theory to pest management research. While most cringe at the thought of theory, it provides binomial, testable hypotheses that may be most easily studied experimentally in agricultural systems. In the second part of my presentation, I will develop the theory and tests of parasitoid sex allocation, parasitoid dispersal biology, and predator prey switching behavior as examples whereby ecological thought has contributed to predictable pest management strategies applicable to biological control within greenhouses. I will conclude by constructing a framework whereby ecological thought may be applied to pest management research. This framework will address the roles of fundamental and applied research in developing robust solutions to augmentation biological control problems.

[1548] DEVELOPMENTAL BIOLOGY OF *GYMNOSOMA ROTUNDATA* (DIPTERA: TACHINIDAE) PARASITIZING BROWN-WINGED GREEN BUG (HETEROPTERA: PENTATOMIDAE) AND ITS EFFECTS ON REPRODUCTION OF THE HOST

M. Higaki, Laboratory of Entomology, Department of Plant Protection, National Institute of Fruit Tree Science, Tsukuba 305-8605, Japan, E-mail scarabee@fruit.offrc.go.jp

Three species of stink bugs, Plautia crossota stali, Glaucias subpunctatus and Halyomorpha halys are well-known as serious fruit pests in Japan. Among them, P. c. stali is the most dreadful. Because P. c. stali reproduces mainly in the coniferous forests and occasionally migrates into fruit orchards, this pest is difficult to be controlled by appropriate spraying of insecticides. Therefore, the control of P. c. stali by natural enemies is desired. The tachinid fly, Gymnosoma rotundata is a parasitoid of P. c. stali. I studied the developmental biology of G. rotundata on P. c. stali and the reproductive ability of parasitized hosts in the laboratory (LD 16:8 h at 21-22°C). G. rotundata females laid 100 eggs on the average during their oviposition period of about two weeks on the abdominal tergum of P. c. stali adults. The newly-hatched maggot bored into the host body and a mature maggot emerged from the host to purate. Even if the fly deposited more than one egg onto a single host, only one maggot could survive to maturity. Parasitized hosts had shorter longevity than unparasitized ones, and without exception, died within a day after the maggot emerged. The mean periods of the larval and pupal stage of G. rotundata were 18 and 15 days, respectively. The mean adults body size of G. rotundata was 2.8 mm in head width. There were no significant differences in such the developmental periods and the body size between the two sexes of the fly. However, there was a tendency that larger G. rotundata adults emerged from larger hosts. Parasitized P. c. stali could retain the reproductive abilities for a while, but lost them as tachinid maggots matured. In females, both the number of laid eggs and the percentage of viable eggs decreased rapidly after the 8th day of parasitization. In males, the number of individuals that could fertilize eggs and/or copulate with female decreased rapidly after the 7th day of parasitization.

Îndex terms: Tachinidae, Gymnosoma rotundata, parasitoid, parasitic effects, Plautia crossota stali

[1549] HOST-PARASITE RELATIONSHIP BETWEEN THE MIGRANT BUTTERFLY, PARANTICA SITA (LEPIDOPTERA: DANAIDAE), AND ITS TACHINID PARASITOID, STURMIA BELLA (DIPTERA: TACHINIDAE), AT THREE HABITATS IN THE KII PENINSULA, CENTRAL JAPAN

N. Hirai & M. Ishii, Entomological Laboratory, Graduate School of Agriculture and Biological Sciences, Osaka Prefecture University, Sakai, Osaka 599-8531, Japan, E-mail n_hirai@plant.osakafu-u.ac.jp

It has become known that the migrant butterfly, Parantica sita, migrates sometimes over 1,000 km toward northeast or highland in spring, and vice versa in autumn in Japan. We made field researches in 3 habitats of *P. sita*, Sites A. B and C, in the Kii Peninsula from February 1998 to February 2000. The results revealed that Site A (alt.: about 20 m), located on the south coast facing the Pacific Ocean, was used mainly by the larvae of overwintering generation and few individuals were seen between spring and autumn. At Site B (alt.: about 360 m), located at the southern foot of the Izumi Range, individuals of immature stages were seen almost through the year, although the density was low. Most of the individuals were found on the evergreen milkvine, Marsdenia tomentosa (Asclepiadaceae), in both Sites A and B. At Site C (att.: 1,100 m), located on the eastern slope of the mountain, lots of adults were seen from July to August, and eggs and larvae were also seen on the deciduous milkvine, Cynanchum caudatum (Asclepiadaceae). The tachinid fly, Sturmia bella, is the most major parasitoid of larval P. sita in Japan. Female adults of this tachinid deposit nucrotype eggs on foliage of nost's food plants and the prasitization starts by ingestion of eggs with leaf tissue. We found eggs of this tachinid on the food plant of P. sita, and more than 80 % of individuals were parasitized by this tachinid in both Sites A and B, while we had not found both tachinid eggs and prasitized P. sita at Site C. We discuss the relationship between host's migration and parasitization of S. bella from the field observations.

Index terms: Parantica sita, Sturmia bella, host-parasite relationship, migration, Japan

[1551] *HYDROTAEA AENESCENS*, A LARVAL PREDATOR OF THE HOUSE FLY: A SUMMARY OF RECENT RESERCH

J. A. Hogsette¹, R. Farkas², R. Ripa³ & C. Arancibia³, ¹USDA-ARS, P.O. Box 14565, Gainesville, FL 32604, USA, E-mail: jbogsette@gainesville.usda.ufl.edu; ²Szent István University, Faculty of Veterinary Science, Pf. 2., H-1400 Budapest, Hungary; ³Instituto de Investigaciones Agropecuarias, Subestacion Experimental La Cruz, Chorrillos 86 - Casilla 3, La Cruz, Chile.

Hydrotaea aenescens, the black dump fly, is native to the Western Hemisphere except for parts of western Canada. It was transported by commerce to Europe, with the exception of the U.K., and has moved across Europe into western parts of the former Soviet Union and south into the Levant. Naturally occurring dominant populations of H. aenescens have been observed in open-sided caged layer poultry houses in the U.S. and Chile. In these situations house flies all but disappear because of predation by Hydrotaea. In Florida, H. aenescens larvae and pupae were released in very wet pullet houses in an attempt to establish black dump fly populations. H. aenescens did not become established, but instead dispersed 0.3 km to adjacent layer houses where they not only became established in large numbers, but controlled house flies for more than 1 year. During this period, Hydrotaea adults did not become a nuisance on the layer farm or at nearby houses or at a nearby dairy farm. Release and establishment of colonized Hydrotaea on farms is still not easy because manure habitats may differ greatly from artificial laboratory diets in which colonized Hydrotaea populations have been reared, particularly in moisture content. Thus the laboratory populations have become acclimated to a narrow moisture range while field populations become adapted to a much wider moisture range. Hydrotaea can compete well with house flies in swine and poultry manure. Although Hydrotaea has not been associated with manures from ruminant animals, this fly can develop successfully in the manure of unweaned calves. Hydrotaea has been established on dairies by releasing larvae in calf-rearing areas. Field populations of H. aenescens are subjected to attack by many natural enemies of the house fly, like coleopteran predators and hymenopteran parasitoids. So after H. aenescens destroys the house fly populations, it in turn becomes the prey. In most of its range, *H. aenescens* is viewed as a beneficial biological control organism. However in many parts of South America, *H. aenescens* is viewed as a potential vector of disease and carrier of the eggs of Dematobia hominis. Tests are underway to better define the role of H. aenescens in these activities and possibly to change the image of H. aenescens from bad to good.

Index terms: black dump fly, biological control, poultry, swine, dairy

[1550] INOCULATIVE RELEASES OF TRICHOGRAMMA OSTRINIAE FOR EUROPEAN CORN BORER CONTROL

M.P. Hoffmann, M. G. Wright, S. Chenus, J. Gardner, Dept. of Entomology, Cornell University, Ithaca, NY 14853, USA, E-Mail mph3@cornell.edu.

European corn borer (Ostrinia nubilalis) is an important pest of sweet corn in the USA. Chemical control is the principal means of control of this pest, but because of regulatory changes, insecticides currently available for its control are likely to be withdrawn. Alternative management techniques for O. nubilalis are therefore clearly needed. Inundative biological control has not been effective for O. nubilalis in the USA, as the egg parasitoids evaluated were unable to parasitize adequate proportions of eggs and adequately reduce damage. We report on inoculative release of Trichogramma ostriniae, made early in the season at low densities (75 000 females ha⁻¹) in New York, USA. Results of research conducted over three years have been very promising. High proportions of egg masses were parasitized throughout the growing season, even where initial O. nubilalis activity was low. The wasps showed no density dependant functional response to egg or egg mass density under field conditions. They also showed a propensity for rapid dispersal, yet demonstrated considerable fidelity for their release field, with parasitism continuing to occur far and near from release points, throughout the season. A method for accounting for mortality to T. ostriniae and inclusion in threshold and scouting protocols is presented. It is suggested that T. ostriniae has potential to become an important biological control agent of O. nubilalis in the USA.

Index terms: Inoculative release, Ostrinia nubilalis, sweet corn, Trichogramma ostriniae.

[1552] EFFECT OF TEMPORARY HOST DEPRIVATION ON THE REPRODUCTION AND SURVIVAL OF WOLBACHIA-INFECTED AND UNINFECTED TRICHOGRAMMA KAYKAI PINTO AND STOUTHAMER (HYMENOPTERA: TRICHOGRAMMATIDAE)

C. L. Hohmann¹ & R. F. Luck², ¹Inst. Agronômico do Paraná/IAPAR, C. Postal, 481, 86001-970 Londrina, PR, Brazil, E-mail celuiz@pr.gov.br; ²Dept. of Entomology, Univ. of California. Riverside, CA 92521, USA.

The effect of temporary host deprivation on the reproduction and survival of Trichogramma kaykai Pinto and Stouthamer (Hymenoptera: Trichogrammatidae) was determined by comparing a Wolbachia-infected (= thelytokous) and a field-collected arrhenotokous line of T. kaykai when reared on Trichoplusia ni Hübner (Lepidoptera: Noctuidae) eggs. The progeny of both arrhenotokous and thelytokous females decreased with increasing periods of host deprivation but, arrhenotokous females produced significantly more progeny than thelytokous females regardless of the period of host deprivation (0 to 10 days). They also produced more daughters. Host deprivation did not affect brood size within arrhenotokous or thelytokous lines. However, fewer wasps emerged from hosts parasitized by Welbachia-infected than those parasitized by uninfected T. kaykai. A direct relationship existed between longevity and the length of time an arthenotokous or a thelytokous wasp was deprived of hosts. The longer the deprivation period, the longer they lived. However, arrhenotokous females lived longer than their thelytokous counterparts. The results suggest that a cost exists in infected wasps when they are compared with uniafected wasps and that this cost has potential consequences on the dynamics of these two co-existing, conspecific populations. Index terms: arthenotokous, parthenogenesis, reproductive success, thelytokous, Wolbachia.

[1553] SUPERPARASITISM IN ARRHENOTOKOUS AND THELYTOKOUS TRICHOGRAMMA KAYKAI PINTO AND STOUTHAMER (HYMENOPTERA: TRICHOGRAMMATIDAE)

C. L Hohmann¹ & R. F. Luck², ¹Inst. Agronômico do Paraná/IAPAR, C. Postal 481, 86001-970 Londrina, PR, Brazil, E-mail celso@pr.gov.br; ²Dept. of Entomology, Univ. of California. Riverside, CA 92521, USA.

The ovipositional behavior of field-collected arrhenotokous and Wolbachia-infected (thelytokous) female Trichogramma kaykai Pinto and Stouthamer (Hymenoptera: Trichogrammatidae) was evaluated, using Trichoplusia ni Hübner (Lepidoptera: Noctuidae) eggs as hosts. Both arrhenotokous and thelytokous females rejected significantly more parasitized than unparasitized hosts, but arrhenotokous females rejected fewer such hosts. The rejection rate for both reproductive forms increased as the elapsed time increased between the initial oviposition and subsequent host encounter. When an arrhenotokous female oviposited in a host that had been parasitized by a thelytokous female 2 h earlier, she usually laid a single female egg. She usually laid a male egg when she superparasitized a host 5 h after its initial parasitization. A thelytokous female usually laid a clutch of a single female egg when she was exposed to a host previously parasitized by her arrhenotokous counterpart. Ten to eighteen percent of the eggs laid by arrhenotokous females and 66 to 78% of those laid by a thelytokous female in previously parasitized hosts died during development. In contrast, only 2 % of the eggs laid by an arrhenotokous female and 28% of the eggs laid by a thelytokous female in previously unparasitized hosts died during development. The degree of mortality suffered by the eggs of a thelytokous female in a superparasitized host depended on the clutch size laid by the arrhenotokous female. When the arrhenotokous female added a single egg in a previously parasitized host, 54% of the thelytokous eggs died during development. When she added two eggs to the host, 90% of the thelytokous eggs died during development. Thus, the offspring of Wolbachia-infected females suffered higher mortality than arrhenotokous females when they were the sole offspring in a host. They suffered disproportionately greater mortality when they competed with arrhenotokous offspring in a host. The greater mortality of eggs laid by the thelytokous wasp likely explains the smaller broods that emerged from the hosts they parasitized when compared with those parasitized by arrhenotokous wasps.

Index terms: egg parasitoid, conspecific superparasitism, Wolhachia infection.

[1554] DEVELOPMENT OF AN ARTIFICIAL DIET FOR REARING EDOVUM PUTTLERI, AN EGG PARASITOID OF THE COLORADO POTATO BEETLE, LEPTINOTARSA DECEMLINEATA

J. S. Hu, <u>D. B. Gelman</u>, M. G. Rojas¹, M. J. Loeb, D. E. Lynn and R. A. Bell, Insect Biocontrol Lab, U.S. Dept. of Agric., Bldg. 306, Rm. 322, BARC East, Beltsville, MD 20705 USA and ¹USDA, ARS, Southern Region Research Center, New Orleans LA 70179 USA.

Edovum puttleri has been shown to effectively control Colorado potato beetle (CPB) populations on eggplant crops so that plant damage is kept below economic threshold Since E. puttleri is unable to overwinter in temperate climates, yearly augmentative releases are necessary to prevent CPB damage. However, the current method for rearing E. puttleri using eggs produced by CPB reared on potato plants is not cost effective. A variety of semi-defined artificial diets have been developed and tested for their ability to support the in vitro development of E. puttleri. A diet containing high levels of hen egg yolk and egg homogenate and/or hemolymph prepared from Manduca sexta was able to support parasitoid development to the pupal stage. An extract of M. sexta pupal fat body tissue was able to replace the hemolymph component of the diet as was conditioned medium prepared from cell lines of CPB embryos. The effects of 13 amino acids and 20 carbohydrates (in the absence of all insect components) on the growth and development of the parasitoid were also tested. Glutamine in combination with lactose or sorbitol, and threonine in combination with fructose, gentiobiose, glucose, lactose, sorbitol or trehalose (lactose or sorbitol were most effective) promoted pupation. Both glutamine and threonine were present in relatively high concentrations in 0-48-h-old (preferred time for parasitization) CPB eggs, with glutamine being present at 2-6 times higher levels than threonine. Proline, asparagine, serine, glutamic acid, lysine and tyrosine were also present in significant quantities, but were not effective in promoting pupation. In 0-48-h-old CPB eggs, physiologically active ecdysteroid (20-hydroxyecdysone and perhaps, ecdysone) was present at concentrations of between 50 and 200 pg/egg. Index terms: cell line-conditioned medium, fat body factor, amino acids, sugars,

Index terms: cell line-conditioned medium, lat body lactor, amino actus, sugars, ecdysteroids

[1555] A DISCUSSION ON THE PRELIMINARY OBSERVATIONS OF THE RELATIONSHIP BETWEEN XENOS VESPARUM ROSSI AND IT'S HOST POLISTES DOMINULUS CHRIST (HYMENOPTERA)

David Hughes1, Jeyaraney Kathirithamby1 & Stefano Turillazzi2, 1 Department of Zoology, South Parks Rd., Oxford OX1 3PS, UK; 2 Dipartimento di Biologia Animale e Genetica, Universita di Firenza, Via Romana 17, 50125, Firenze, Italy.

Strepsiptera are unusual and interesting in terms of life history and morphological adaptations. Previous work has focused mainly on the morphology and phylogenetic position of the order. Here we present our initial findings into the relationship between the parasite and the host. In particular, alteration and possible manipulation of host behaviour due to the presence of the parasite, behaviour of the parasite (during copulation and host infestation) and the change in behaviour of colony members towards parasitized (stylopised) individuals. The future direction of this study will also be discussed. Key words: host-parasite, behaviour, host manipulation

[1556] THE EFFECT OF ALTERNATIVE FOOD ON ORIUS LAEVIGATUS, ITS PREY FRANKLINIELLA OCCIDENTALIS AND THEIR INTERACTION

J. Hulshof & I. Vänninen, Agricultural Research Centre, Plant Production Research, Plant Protection, FIN-31600 Jokioinen, Finland, E-mail: jan.hulshof@mtt.fi.

In the absence of prey, alternative food sources (e.g. pollen or nectar), appear to play a role in the establishment and persistence of oligophagous predators. Such predators remain in pollenbearing crops in the absence of prey, whereas their numbers decline in crops lacking pollen. We studied the potential of introducing the predatory bug Orius laevigatus on non-pollenbearing cucumber with the help of alternative food sources. First, the suitability of different food sources for both O. laevigatus and its prey Frankliniella occidentalis was studied. The aim was to select food sources that would facilitate the development and reproduction of the bugs, but that the thrips could utilize to a lesser extent. The bugs were unable to develop into adults on 6 studied food sources: pollen of Salix spp., the common cattail, broad bean and firewced (bee and hand collected), or a mix of milk powder and yeast. Feeding the bugs with six other food sources: Ephestia kuehnielln eggs, an entomophage diet and the pollen of pine, hazel, birch and sweet pepper supported the development of nymphs into adults. Except hazel pollen, five of these food sources resulted in a positive intrinsic rate of increase (rm), with a maximum of 0.092 for bugs fed with Ephestia eggs, followed by 0.084 and 0.049, resp., for those fed with pine and sweet pepper pollen. All food sources, except the mix of milk powder and yeast, enhanced the population development of the thrips, mainly their fecundity. The thrips benefited most from pine pollen: the r_m of thrips fed with encumber leaf was 0.175 and it rose to 0.256 when pine pollen were added to the leaf. We conclude that for the tested types of food, O. laevigatus has a smaller food range than the thrips. Next, the effect of the presence of an alternative food source on the predator-prey interaction, and specifically the searching behavior of the bugs, was studied in two-choice situations. Sweet pepper pollen (the pollen species that was found most quickly by the bugs in preceding experiments) placed on one half of a cucumber leaf was offered simultaneously with either thrips larvae and their damage, or mere thrips damage on the other half of the leaf. The bugs searched longer on the leaf half showing thrips damage, both in presence or absence of thrips larvae, than on the half containing sweet pepper pollen. Further experiments will concentrate on the predation behavior of the bugs in the presence of alternative food. The importance of alternative food for the bugs in times of prey scarceness, and the potential of the use of alternative food for O. laevigatus on non-pollen bearing crops will be discussed. Index terms: pollen, thrips biocontrol, cucumber, intrinsic rate of increase

[1557] SUBLETHAL EFFECTS OF INSECTICIDES ON THE BEHAVIOUR OF TWO PARASITOIDS : INFLUENCE OF INDIVIDUAL EXPERIENCE AND GENETIC VARIABILITY

L. Kaiser¹, N. Desneux¹, H. Rafalimanana², J.M. Delpuech³ & M.II. Pham-Delègue¹, ¹INRA, BP23, 91440 Bures-sur-Yvette, France, E-mail kaiser@jouy.inra.fr; ²ESSA, BP 175, Antananarivo, Madagascar; ³Lab. Biométrie, Génétique & Biologie des Populations, Univ. Lyon1, 69622 Villeurbanne Cedex, France.

Most insecticides are neurotoxic. Non target Arthropods are exposed to residues so their behaviour can be impaired. Among them, parasitoids represent an important group by limiting pest insect populations and for their abundance and diversity. Reproduction success lies on finding suitable hosts. Few studies examined how insecticide exposure could affect this skill. In addition, responses involved in host location can vary depending on individual experience, and genetic variability was also reported. We examined the influence of geographical populations and individual oviposition experience on the susceptibility of orientation and probing responses to odors. We report the results from two studies, one on a parasitoid of Drosophila larvae, Leptopilina heterotoma, exposed to an organophosphorus insecticide ; the second on an aphid parasitoid, Aphidius ervi, exposed to a pyrethroid. Laboratory experiments were conducted. Wasps were exposed for 24h to dry residues of the active ingredients, chlorpyrifos-ethyl and lambda-cyhalothrine respectively. In L. heterotoma, females probe fruits with their ovipositor to find larvae. This can be triggered by fruit odors. We compared two strains with high and low probing activity. High activity is viewed as a response to competition. These contrasted levels caracterize naive females, i.e. searching for their first host ; activities are equalized once the fruit odour has been learned when perceived during oviposition. Females were exposed to a LD 20. Probing responses of the less active strain were more numerous after this exposure, and further more after learning. These effects were not visible in the more active strain, of which responses were too high to be significantly augmented. The situation was very different with A. ervi exposed to the pyrethroid. In this species, females are attracted by the odour from host-infested plant (here, Myzus persicae on oilseed rape). This attraction is prolonged by previous oviposition on a host-infested leaf. Only one strain was studied. Exposure to LD 0.1 but not to LD 20 weakened responses of naive females, whereas experienced responses were robust to the insecticide exposure. In both studied systems, the insecticide effects disappeared within 24h following the end of exposure. Then this work shows that in addition to insecticide nature and doses, biotic factors like individual experience and genetic variability should be considered to understand consequences of exposure on parasitoids behaviours.

Index terms: Leptopilina heterotoma, Aphidius ervi, olfaction, ecotoxicity

[1558] THE INFLUENCE OF CITRUS SPECIES ON THE PARASITIZATION OF APHIS GOSSYPHI BY VARIOUS PARASITOIDS

N. G. Kavallieratos & D. P. Lykouressis, Lab. of Agr. Zoology and Entomology, Agricultural University of Athens, 75 Iera Odos, 118 55, Athens, GREECE, E-mail esimou@auadec.aua.gr

Aphids are very important pests of citrus in several citrus growing areas of the world. Amongst them Aphis gossypii is one of the most abundant species on citrus trees in Greece. The aim of this work was to investigate the possible role of three citrus species on the parasitization of A. gossypii by various aphidiids. For that purpose, leaf samples, bearing mummified aphids, were taken from Citrus aurantium, Citrus deliciosa and Citrus sinensis from different areas of the country in 1996 and 1997. The species of aphidiids which were found to have a significantly different preference on A. gossypii were Aphidius colemani, Aphidius matricariae, Lysiphlebus testaceipes and Trioxys (Binodoxys) angelicae. Parasitization rates by various parasitoids of A. gossypii were affected by citrus species in a different way amongst the investigated regions. A special case was the area of Southern - Western Greece, a unique region amongst the others, in which L. testaceipes is very well established dominating other aphidiids. In the remainder of the regions this parasitoid was recorded in low levels from A. gossypii. However, parasitization rate by A. matricariae on C. deliciosa was significantly different to that on C. aurantium in Northern Western Greece and Southern - Eastern Greece. Similarly, in Southern - Western and Eastern Greece parasitization rate by A. colemani on C. deliciosa was Southern significantly different than that on C. sinensis. Irrespective of study area, A. colemani on C. aurantium did not express a considerable variation. On the contrary, T. (B.) angelicae, on the same citrus species and study areas as before, appeared to be area depended. Index terms: Aphis gossypii, parasitoids, citrus species

[1559] BIOLOGICAL CONTROL OF VECTOR INSECTS IN CITRUS: A CASE STUDY IN TURKEY

U. Kersting, Faculty of Agricultural Sciences & Technologies, European University of Lefke, Gemikonagi, Mersin 10, Turkey, E-mail kersting@vuni.lefke.edu.tr

Many virus and virus-like diseases seriously damage citrus plants all over the world. The causal agents of some of the most devastating diseases, such as citrus tristeza virus, African greening and huanglungbin, witches' broom disease of lime, and citrus variegated chlorosis are transmitted by insects, making the control of these diseases even more difficult. Successful reports on biological control of insect vectors in citrus are limited. A major reason is that the primary objective of biological control is reducing insect populations to economically insignificant low levels, rather than eradication. This approach may fail for insect vectors, as even a single individual is capable of virus transmission, and thus the disease may continue to spread even at low population densities. The aleyrodid Parabemisia myricae (Kuwana) was first noticed in the citrusgrowing areas of the east Mediterranean region of Turkey in 1982 and later spread to many other countries in the Mediterranean basin. It soon became the major citrus pest and as chemical control was unsuccessful, a biological control program was launched in 1987. After mass releases of the specific aphelinid Eretmocerus debachi Rose & Rosen, the whitefly populations on citrus dropped sharply from more than 60 to far less than 0.1 individuals per leaf within five years. By the end of the 1980's a new citrus disease of possible viral etiology (citrus chlorotic dwarf, CCD) was observed in the Mersin district, which quickly spread throughout the western parts of the east Mediterranean region. About 50% of all citrus trees were affected with more severe symptoms on lemon and grapefruit than on orange. Laboratory experiments revealed that the causal agent of CCD is highly transmissible by P. myricae, but not by other citrus whiteflies or by pruning. The spread of the disease slowed down considerably from 1992 onwards and never reached the eastern parts of the citrus-growing area. Moreover, several thousand virus-tested trees planted in the most affected areas after 1990 have not been found infected with CCD when surveyed in 1994/95. The use of E. debachi to control P. myricae is one of the very few examples of a highly successful biological control program for insect vectors worldwide. The high success of this program was apparently due to several factors: i.) early launch of a successful parasitoid release program, ii) high efficiency and high searching activity of E. debachi even at very low host population densities, iii) the lack of hyperparasitoids, and iv) the high number of alternative host plants of P. myricae serving as important refuges for the vector and the parasitoid.

Index terms: Parabemisia myrica, Eretmocerus debachi, citrus chlorotic dwarf

[1560] DEVELOPMENT AND REPRODUCTION OF PREDATORY INSECTS STETHORUS JAPONICUS (COLEOPTERA: COCCINELLIDAE), OLIGOTA KASHMIRICA BENEFICA (COLEOPTERA: STAPHYLINIDAE) AND SCOLOTHRIPS TAKHASHII (THYSANOPTERA: THRIPIDAE) REARED ON DIFFERENT SPECIES OF SPIDER MITES (ACARI: TETRANYCHIDAE)

II. Kishimoto, Lab. of Entomology, Dep. of plant protection, National Institute of Fruit Tree Science, Fujimoto 2-1, Tsukuba, Ibaraki 305-8605, Japan, E-mail kisimoto@fruit.affrc.go.jp.

The development and reproduction of three predatory insects Stethorus japonicus H. Kamiya, Oligota kashmirica benefica Naomi, and Scolothrips takahashii Priesner were studied when they were reared on different species of spider mites at 27°C;16L8D. Eggs and deutonymphs of three species of spider mites, Panonychus mori Yokoyama, Tetranychus urticae Koch and Amphitetranychus viennensis (Zacher), which are serious pests on pear, were provided as the prey. DEVELOPMENT: Most of S. japonicus larvae died during the first instar and only about 10% of larvae developed to pupae when they were reared on eggs of P. mori. The shells of P. mori eggs were too hard for the first instar of S. japonicus to feed on. More than 80% of larvae, however, developed to pupae, when they were reared on P. mori deutonymphs, and the eggs and deutonymphs of both T. urticae and A. viennensis. Most of O. kashmirica benefica larvae reared on P. mori eggs also died during the first instar for the same reason as S. japonicus larvae. On the other hand, S. takahashii larvae could successfully develop to pupae regardless of the prey species and stages. REPRODUCTION: The oviposition rates of S. japonicus differed significantly among the prey species: females reared on A. viennensis laid more eggs than those reared on P. mori, and females reared on T. urticae showed an intermediate number of eggs. On the other hand, the oviposition rates of O. kashmirica benefica were not significantly different among all the prey species or stages provided. The oviposition rates of S. takahashii will be examined in the future. These differences in the suitability of prey species for each predatory species enabled to illustrate the different patterns of species composition between spider mites and their predators in Japanese pear orchards.

Index terms: Stethorus japonicus, Oligota kashmirica henefica, Scolothrips takahashii, development and reproduction, prey species

[1561] EFFECTS OF SOME PLANTS ON PARASITIZATION OF EURYGASTER INTEGRICEPS EGGS BY TRISSOLCUS SEMISTRIATUS

M. Kivan¹ & N. Kilie¹, ¹Dept. of Plant Protection, Agric. Faculty, Univ. of Trakya, 59030, Tekirdag, TURKEY, E-mail tzfbitkikoruma@superonline.com.

The egg parasitoid Trissolcus semistriatus (Hymenoptera, Scelionidae) is the natural nemy of sunn pest, Eurygaster integriceps (Heteroptera, Scutelleridae), which is one of sost destructive pests of wheat. An examination was conducted to determinate whether ome plant species have an effect on the parasitism of T.semistriatus at 26±2 °C, 60±10 % slative humidity and 16:8 hr photoperiod. The parasitism rate of T. semistriatus on E. ntegriceps eggs was investigated in the absence and presence of plants. The plants used vere wheat (Triticum vulgare), cow cockle (Vaccaria pyramidata var. grandiflora), bifora Bifora radians), common vetch (Vicia sativa) and turnipweed (Rapistrum rugosum). hese plants were chosen because they were common in or near the cereal fields in lekirdag and also hosts of pentatomids which are secondary host of egg parasitoids. The plants significantly affected the parasitism rate, adult emergence and sexual ratio (p<0.05) of T.semistriatus. The presence of turnipweed and cow cockle leaves resulted in lower parasitism ratio than the others or alone eggs. However, developmental period of male and emale were not influenced by plants. It was concluded that some plants or absence of plant did not change the parasitism, while some plants, as cow cockle and turnipweed, reduced the parasitism. As a result, it could be suggested that the responses of egg parasitoid to plant semiochemicals involved probably in host recognition should be determined.

Index terms: Trissolcus semistriatus, Eurygaster integriceps, plants, parasitism

[1563] LARVAE OF CHRYSOPID AND FALL WEBWORM HAVE PREFERENCE FOR PARTIALLY DRIED FOOD TO FRESH ONE

T. Kubota¹, ¹Kitakarasuyama 6-31-2, Setagaya, Tokyo 157-0061, Japan, E-mail: tkubota@mtd.biglobe.ne.jp

It is commonly believed that insects whose known food is living animal/plant have preference for fresh food to desiccated one. Although explicit verification for this has not been given, it is quite difficult to demonstrate food preference in a reliable and quantitative manner, especially when partially dried food is compared to its fresh counterpart. In this study, the author developed a method, based upon two-choice test, in which larvae are individually given desiccated food with controlled degree of dryness and fresh food to choose between them so that the food preference can be measured accurately for each individual animal. The author used larvae of Chrysoperla carnea, Pseudomallada alcestes (Neuroptera, Chrysopidae; food, eggs of Tribolium castaneum) and Hyphantria cunea (Lepidoptera, Arctiidae; food, leaves of mulberry, Morus alba). Four drying methods were employed to prepare food with various extent of dryness as measured by reduction of total food weight from untreated one: first, cutting leaf, which resulted in weight reduction by 5 %. Second, brief desiccation in drying-oven at 35 °C temperature for 35 min for Morus leaves and 38 °C for 60 min for Tribolium eggs, with weight reduction by 14% and by 8%, respectively. And third, 7-h desiccation of leaves at room temperature with 30 % reduction in weight and forth is 6-weeks of refrigeration (at 5 °C temperature) of Tribolium eggs with weight reduction by 8 %. The author observed statistically significant (5% level) preference for partially dried food prepared by the first two methods described above in both animal species. More specifically, a prominent shift of food preference toward partially dried one was observed in the following 3 cases: 4th instar *II. cunea* larvae preferred the cut edge of Morus leaf to the intact edge and did oven-dried Morus leaf to the intact leaf and 1st instar larvae of Pm. alcestes did for oven-dried Tribolium eggs to fresh ones. Furthermore, the frequency of larvae which preferred partially dried food declined linearly with larval development in Pseudomallada alcestes (significant at 5% analyzed by logistic regression model) and the same frequency in Hyphantria cunea showed also a decline during 4th to 5th larval instar (significant at 5% by logistic regression model). In conclusion, the author developed a statistical behavioral analysis, which confirmed significant food preference for partially dried in animals previously believed to favor fresh food to dried one.

Index terms: food preference, partial desiccation, Hyphantria cunea, Pseudomallada alcestes, Chrysoperla carnea.

[1562] SAMPLING PREDATORY INSECTS AND SPIDERS IN COTTON

A. E. Knutson¹, L. T. Wilson², S. E. Naranjo³ & M. A. Muegge⁴, ¹Texas A&M Research and Extension Center, 17360 Coit Road, Dallas, TX 75252-6599, USA, E-mail a-knutson@tamu.edu; ²Texas A&M Research & Extension Center, Rt 7, Box 999, Beaumont, TX 77713 USA; ³ USDA-ARS 4135 E. Broadway Rd, Phoenix AZ 85040, ⁴Texas A&M Research and Extension Center, Box 1298, Ft. Stockton, TX, 79735-1298, USA.

Predatory insects and spiders have been demonstrated to suppress populations of cotton pests including Helicoverpa zea, H. armigera, Heliothis virescens, Spodoptera exigua, and Aphis gossypii. However, there are few guidelines on how to use field information on predatory arthropods to aid pest management decisions in cotton IPM programs. A major constraint to the development and adoption of these guidelines has been the lack of a reliable and efficient sampling method for estimating predator densities in commercial monitoring programs. Adult and immature Orius spp. and Geocoris puncitpes, adult Hippodiamia convergens and Pseudatomoscelis seriatus, immature Chrysoperla spp. and spiders, primarily Misumenops spp. and Oxyopes salticus, were sampled in cotton with a sweep net, drop cloth, beat bucket, shake bucket and by visual search of the plant. The density-dependent sample size (n) was estimated for each predator species/group using the relationship $n = ax^{(b-2)}/D^2$ where a and b = Taylor's coefficients, and D = desired level of precision. The cost (product of sampling time and sample size) was calculated for each method and predator. The relative cost-efficiency was estimated as the ratio of the products of the estimated sample size (n) and the cost (c) per sample unit $(n_x c_y/n_y c_y)$ for each method (x) relative to the visual search method (v). The beat bucket method was one of the most cost efficient methods for sampling Orius adults and nymphs, Chrysoperla larvae and spiders which together accounted for 82% of the total predators recovered in an "absolute" sampling method. The beat bucket was constructed from a common 18 liter, white plastic pail (37 cm X 27 cm). The bottom was removed and fitted with a large plastic funnel to direct predators into a plastic jar. The bucket was held at a 45° angle to the ground and the top 20-24 cm of a single cotton plant was quickly grasped by the lower stem and bent into the bucket. The plant was beaten against the sides of the bucket for 3-4 seconds to dislodge predators. The plant was removed, the bucket was held upright and the sides sharply taped with the hand until all arthropods had fallen through the funnel. Sample units of 1, 3, 5 and 10 plants per beat bucket sample were collected in Texas and Arizona. Three or 5 plants/beat bucket sample provided the most cost-efficient estimate for most predator groups. Sample size for a mean density of 0.5/plant ranged from as few 8 for H. convergens to 48 for immature Orius spp.

Index Terms: Orius, Geocoris, Hippodiamia, Chrysoperla, Misumenops,

[1564] JALISCO FLY (DIPTERA: TACHINIDAE) AS A BIOLOGICAL CONTROL AGAINST MEXICAN RICE BORER (LEPIDOPTERA: PYRALIDAE) IN TEXAS SUGARCANE

J. C. Legaspi¹, B. C. Legaspi, Jr.¹, I. Lauzière¹, J. W. Smith, Jr.², L. A. Rodríguezdel-Bosque², & W. A. Jones⁴, ¹Texas Ag. Expt. Sta., 2415 East Hwy 83, Weslaco, TX 78596, USA; ²Dept. Entomol., Texas A&M Univ., College Station TX 77843, USA; ³INIFAP, PO Box 79, Progress TX 78579, USA; ⁴USDA ARS 2413 East Hwy 83, Weslaco, TX 78596, USA.

The Mexican rice borer, Eoreuma loftini (Dyar) (Lepidoptera: Pyralidae), injures -20% of sugarcane (Saccharum spp.) internodes in Texas, causing estimated annual losses of \$10 to 20 million. Interest has focused on the Jalisco fly, Lydella jalisco Woodley (Diptera: Tachinidae), which causes field parasitism levels of about 33% in its native Mexico. In 1998, a collaborative research effort was made to import and evaluate L. jalisco as a biological control agent. Borer larvae were collected in Mexico from August 1998 to March 1999 to measure parasitism and to initiate a parasite colony. Sugarcane injury from E. loftini was relatively low, ranging from 3-4.4% bored internodes. Injury caused by Diatraea considerata Heinrich (Pyralidae) ranged from 1.3-6.3% bored internodes. The extant stalkborer population was almost equally divided between the 2 species. A total of 3,040 E. loftini larvae were collected of which 209 were parasitized (6.9%). Lydella jalisco was collected most consistently from the Los Lirios, Ejido Caimanero locality, which yielded 16.1% parasitism (193 fly larvae / 1197 borer larvae). Parasitism by L. jalisco was highest from mid-August (1998) to mid-October at ~30%. After mid-October, L. jalisco declined and parasitism was predominantly due to the egg-larval parasite Chelonus sonorensis Cameron (Hymenoptera: Braconidae). Surveys and field collections were performed in the subsequent sugarcane season, and data are currently being analyzed. We are also interested in assessing the efficacy of L jalisco on different graminaceous host plants should E. loftini become a significant pest of those crops. In a greenhouse experiment, L. jalisco was evaluated on: a) sugarcane; b) corn, Zea mays; c) sorghum, Sorghum bicolor, d) rice, Oryza sativa; and, e) johnsongrass, Sorghum halepense (weed alternative host). Parasitism was significantly different among the host plants, being highest on sugarcane (81.4%), lowest on johnsongrass (10.0%), and intermediate in the other plants (corn = 54.6%, sorghum = 22.0%, rice = 14.9%). Therefore, the Jalisco fly can successfully parasitize Mexican rice borer larvae on alternative graminaceous host plants such as corn, sorghum or rice despite its documented geographical and biological specificity. Currently, studies are underway to assess efficacy in the field. Index terms: Eoreuma loftini, Lydella jalisco, damage, parasitism, preference

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[1565] OBSERVATIONS ON CULTURING *DIADEGMA INSULARE*, AN IMPORTANT PARASITOID OF THE DIAMONDBACK MOTH

G. L. Leibee & K. E. Savage, Mid-FL Res. & Ed. Ctr, IFAS, Univ. of FL 2725 Binion Rd, Apopka, FL 32703-8504, USA, E-mail glle@gnv.ifas.ufl.edu.

One of the most important parasitoids of the diamondback moth, *Plutella xylostella*, is *Diadegma insulare*. Augmentative releases of this species could be an important component of a management program for the diamondback moth. However, unlike several other species of diamondback moth parasitoids, *D. insulare* is not readily available from commercial insectaries. One apparent reason for this is that *D. insulare* is difficult to keep in continuous culture. One obvious and characteristic "symptom" often associated with a problem culture is a gradual increase in the number of males relative to number of females, often referred to as "going to male." We have cultured *D. insulare* for months at a time without experiencing difficulties, and have produced numbers in the thousands for experimentation and release. We describe our method of culturing the diamondback moth and *D. insulare* to contribute knowledge that might facilitate the use of this parasitoid in the management of the diamondback moth.

Index terms: Diadegma insulare, Plutella xylostella, diamondback moth, culturing

[1567] PREDATOR-PREY INTERACTIONS AT VARIOUS SPATIAL SCALES: BIOLOGICAL CONTROL OF THE BULB MITE, *RHIZOGLYPHUS ROBINI*, BY THE PREDATORY MITE, *HYPOASPIS ACULEIFER*, ON LILIES

I. Lesun¹, M. W. Sabelis¹ & C.G.M. Conijn², ¹ Section Population Biology, University of Amsterdam, Kruislaan 320, 1098 SM Amsterdam, The Netherlands, E-mail: lesna@bio.uva.nl; ² Bulb Research Centre, Vennestraat 22, Lisse, The Netherlands.

(1) Experiments in closed jars with lily bulbs showed that the predator, Hypoaspis aculeifer, can suppress populations of its prey, the bulb mite Rhizoglyphus robini, to very low levels. When the bulbs were decomposed into scales, the prey was suppressed earlier, supposedly because of increased accessibility to the sites where bulb mites reside. (2) Repeating the experiment in open jars also led to strong suppression of the prey population: the predators did not leave the jars until almost all prey was eaten. (3) To assess possibilities for biocontrol of bulb mites in lilies at a larger spatial scale, experiments were carried out in closed plastic bags filled with lily bulb scales and vermiculite, as is common practice in lily bulb propagation. The results showed that H. aculeifer was able to suppress its prey to very low densities, but probably due to a more complex spatial structure (i.e. vermiculite), prey suppression took longer. (4) Experiments in the greenhouse and in the field showed that in absence of predatory mites populations of the bulb mite, Rhizoglyphus robini, on lily bulbs increased, whereas the release of predatory mites either slowed down the increase – as observed in the field – or caused the bulb mite populations to decrease - as observed in the greenhouse. In all cases the population of predatory mites increased as long as bulb mite densities were not too low. (5) The initial predator-to-prey ratios required to achieve suppression (c. 1 : 2) or elimination (3:1) in the soil environment are much higher than those required for bulb mite elimination when lily bulb scales were embedded in a medium of vermiculite (c. 1 : 20). Possible causes will be discussed. (6) Since 1996 the predatory mite Hypoaspis aculeifer is commercially available under the trade name ENTOMITE.

Index terms: biological control, predator-prey interactions, spatial complexity, bulb mites, predatory mites, lily bulbs, soil

[1566] PARASITOIDS OF THE CITRUS LEAFMINER *PHYLLOCNISTIS CITRELLA* (LEP: GRACILLARIDAE) IN THE PIEDMONT OF THE DEPARTMENT OF META

G. A. León M. & J. C. Campos P., Centro de Investigación La Lebertad, CORPOICA, A.A. 3129 Villavicencio, Colombia. E-mail: gleon@corpoica.org.co

Studies about presence and abundance of native parasitoids of citrus leafminer *Phyllocnistis* citrella, was done during March 1997 to August 1998 in Acacias, Restrepo, Lejanias and Villavicencio, four citrus productive zones of eastern plains piedmont, located in the Department of Meta, Colombia. It was determinate the presence of nine different species parasitoids of larvae and pupae of citrus leafminer. Results show that most frequent parasitoids are *Cirrospilus* spp., *Closterocerus* sp. and *Galeopsomyia fausta*. (Hymenoptera: Pteromalidae), Each of them were found in all citrus areas in the Meta Department, specially in the localities of Acacías, Restrepo and Lejanias. There are tree new country records among the reported species: *Closterocerus* sp., *Horismenus* sp., and *Cirrospilus* spp. In addition to this fact, *Galeopsomyia fausta* is a pupae parasitoid and *Closterocerus* sp. a larval superparasitoid. The presence of this beneficial insects represent a high possibility of natural pest regulation and a great biological control potential to citrus leafminer in the region. Parasitoids were identified by Dr. Jhon LaSalle from International Institute of Entomology IIE Key words: Populational dynamics; citrus pest; pest-natural Institute – USA.

Key words: Phyllocnistis citrella. Natural control. Cítrus.

[1568] STRUCTURE OF A TROPICAL LEAFMINER-PARASITOID COMMUNITY

O.T. Lewis, Department of Entomology, The Natural History Museum, UK & NERC Centre for Population Biology, Imperial College at Silwood Park, Ascot, Berkshire SL5 7PY, UK. Email: o.lewis@ic.ac.uk.

Understanding the enormous diversity of tropical insects is one of the major challenges facing ecologists today. Quantitative food webs may provide insights into some of the dynamic processes underlying tropical diversity. In a quantitative host-parasitoid food web the abundance of hosts and parasitoids, and the magnitude of the trophic interactions among them, are all quantified in the same units. I describe a quantitative food web for generated by sampling systematically in a 0.85 ha plot over a 1-year period, and rearing over 5000 hosts and parasitoid for subsequent identification. The web contains 93 host species and 71 parasitoid species. Overall, 50% of leafminers were killed by parasitoids. There is little tendency for one or a few hosts or parasitoids to dominate the web, and most of the parasitoid species are generalists. Seasonal food webs indicate considerable variation in the composition of the community during the year, particularly among the hosts. Some of the factors influencing the parasitism fractions and parasitoid species load experienced by different host species about community interactions is highlighted.

Index terms: rainforest, food webs, biodiversity

Session 08 - ENTOMOPHAGOUS INSECTS AND BIOLOGICAL CONTROL

[1569] EFFECT OF THE FILARIAL PARASITE WUCHERERIA BANCROFTI (NEMATODA: FILARIDAE) ON THE REPRODUCTION OF CULEX QUINQUEFASCIATUS (DIPTERA:CULICIDAE)

C. A. Lima¹, <u>C. M. R. Alburguerque¹</u> & H. Hurd², ¹Mest.em Biologia Animal, Dept. de Zoologia, Univ. Federal de Pernambuco-Av. Moraes Rego s/n, Recife PE, CEP-50670 420, Brazil, E-mail cleide@npd.ufpe.br. ²Centre for Applied Entomology and Parasitology, School of Life Sciences, Huxley Building, Keele Univ., Staffordshire, STS 5BG, UK. Financial support:FACEPE, CNPq

Lymphatic filariasis is one of the most important human diseases transmitted by mosquitoes. Understanding of vector/parasite interactions is essential for rational development of filariasis control. A recent survey in Recife, a Brazilian coastal city has shown a prevalence rates of Wuchereria bancrofti ranging from 0.64 to 14.95% in several areas. This study was undertaken in order to determine whether the filarial parasite would interfere with the reproductive fitness of the mosquito Culex quinquefasciatus, vector of W. bancrofti in Recife. Mosquito, emerged from pupa collected in the field, were infected via a membrane feeding procedure, using blood from donors who participated in a survey carried out by Centro de Pesquisas Aggeu Magalhães, after written informed consent. Number of parasites in the blood ranged between 600-2900 mf/ml¹. Approximately 83% of engorged females (n=64) assessed after an infective blood meal were infected. A reduction of 32.4% in the number of positive insects was observed four days later. In three experiments, infected mosquitoes produced significantly fewer eggs (81.9 ± 21.5, n=127) than uninfected mosquitoes (96.11 ± 23.9, n=165) (Student's t test P<0.05). However, in 2 others experiments infected females produced significantly more eggs (96.8 ± 21.8, n= 52) than uninfected ones (84.1 ± 22.4) (Student's t test P<0.05). The mean size of females (measure by wing length) showed significant difference amongst different experiments ANOVA (F=29.3 P<0.05) but not when infected and uninfected females were compared via pairwise comparisons using Student t test. There was no significant difference (ANOVA) in the amount of haematin excreted by uninfected (14.9 \pm 1.9 mg, n=285) and infected mosquitoes (15.2 \pm 1.9, n=199). These results suggest that the effect of W. bancrofti infection on C. quinquefasciatus reproduction is variable.

Index terms: Culex quinquefasciatus, Wuchereria bancrofti, reproduction.

[1571] THE TYPES OF ENCYRTIDAE (HYMENOPTERA, CHALCIDOIDEA) HOUSED IN THE MUSEO DE LA PLATA

M. S. Loiácono¹, N. B. Dias¹, F. E. Gallardo¹ and C. B. Margaría¹, ¹Dept. Cient. de Entomologia, Univ. Nac. de La Plata, Passeo del Bosque s/n, 1900, La Plata, Argentina, Email: loiacono@museo.fcnym.unlp.edu.ar

According to De Santis (1998) the knowledge of this family has a singular importance for the number of species that it includes and because many of them have been used in the biological or integrated control against other insects and acari of economic or sanitary importance. The data of Grissell and Schauff (1990) indicate 3277 known species, 390 species of these are neartics and 236 neotropicals, distributed in 135 and 153 genera, respectively. For the Argentina there are 157 species, about 100 are studied in the revision of De Santis (1964) which would represent 4,7% of the known species. The study of types is fundamental to subsequent revisions and reliable identifications, mostly in this group of "Parasitica" in which so often new species of economic importance are described. This contribution gives information on the types of species described by De Santis principally, besides other authors. The 371 types (63 holotypes, 27 sintypes, 18 allotypes, 262 paratypes and one paralectotype) of Encyrtidae housed in Museo de La Plata (Departamento Científico de Entomologia) were examined and listed. These types belonging to 101 species and 2 subspecies of Encyrtinae. They were contributed by the following authors: De Santis (70), Erdoes (8), Annecke (6), Annecke & Mynhardt (5), Blanchard (3), Noyes (3), Brèthes (2), Bennet (1), Compere (1), Fidalgo (1), Gahan (1), Ghesquiere (1), Hoffer (1) Kerrich (1), Mercet (1). The genera and the species are in alphabetical order. For each taxon complete information about original and valid names, publication, subsequens combination, collection data and condition are given. Index terms: catalogue, entomological types, encyrtines, Museo de La Plata collection

[1570] NEOTROPICAL MYRMECOPHILIC DIAPRIID WASPS ASSOCIATED WITH MYRMICINAE AND FORMICINAE ANTS (HYMENOPTERA, PROCTOTRUPOIDEA, DIAPRIIDAE)

<u>M.S. Loiácono¹</u>, C.B. Margaría¹, E. Quirán² & B. Corró Molas², ¹Dept. Cient. de Entomología, Univ. Nac. de La Plata, Paseo del Bosque s/n, 1900, La Plata, Argentina, Email loiacono@museo.fcnym.unlp.edu.ar; ² Univ. Nac. de La Pampa, Uruguay 151, 6300, Santa Rosa, Argentina.

Representatives of three subfamilies of ants (Myrmicinae, Formicinae and Dorylinae) are the main hosts of myrmecophilic diapriine wasps (Diapriidae: Diapriinae). Within Myrmecinae, the genera known to be associated with diapriines are Solenopsis, Tetramorium, Acromyrmex and possibily Myrmica. Formicinae hosts include the genera Formica, Camponotus, Lasius and Plagiolepis. The main objectives of the present contribution are to study some diapriids associated with ants of the genera Acromyrmex. Solenopsis (Myrmicinae) and Camponotus (Formicinae) from Argentina, Brazil and Uruguay. The material studied belongs to the Canadian National Collection, Ottawa, Canada; Museo de La Plata, Buenos Aires, Argentina, and Fundación e Instituto Miguel Lillo de San Miguel de Tucumán, Argentina. The samples come from ant mounds of A. lobicornis and A. ambiguus. They are composed for more than 300 formicid mature larvae parasited by the diapriids. The larvae and pupae of the microhimenoptera were extracted and clarified for microscopic preparations; the adults of diapriids were studied following the usual techniques. Sixteen species of diapriids associated with the ants mentioned herein are treated. Two new species of Gymnopria and Trichopria are shown to be parasitoids of larvae of the ant Acromyrmex lobicornis in Argentina. Seven new species of Gymnopria from Brazil are described and illustrated; a redescription of the genus considering the new taxa is presented, and cladistic analyisis of the nine known species of Gymnopria are included. The diapriids of the genus Bruchopria associated with ants of the genus Solenopsis in Argentina and Brazil are also considered; an extended redescription of Bruchopria and its species are given; B. hexatoma distribution is amplified. Species of Bruchopria show a number a features correlated with myrmecophilous habits in diapriids, such as reduced eye size, integument similar to ants', and dealation. So, we consider that these species might behave as true mirmecophilous. The presence of tegula with normal development and wing stump demonstrate that the apterism has a secondary origin, caused by autotomy or by the host ants. Diapriids associated with the ant Camponotus rufipes are considered: Coecopria plaumanni, C. pygmaea, Doliopria flavipes and Paramesius sp. The two last species are mentioned for the first time associated with this ant. Ant's data and available host records are included.

Index terms: diapriids, myrmechophilous, Myrmicinae, Formicinae, ants

[1572] HOW THE EFFICIENCY OF A PREDATOR VARIES WITH RICE VARIETY: FORAGING BEHAVIOR, POPULATION INCREASE AND FUNCTIONAL RESPONSE + B201

Y. Lou, J. Cheng, M. Du & II. Guo, Dept. of Plant Protection, Zhejiang Univ., Hangzhou 310029, P. R. China

Many studies have revealed large differences among rice varieties in suitability for population increase of the brown planthopper (BPH), Nilaparvata lugens (Stal), one of main insect pests on rice. This paper addresses the question whether rice varieties that differ in suitability for BPH are equally suitable for *Cyrtorhimus lividipennis* Reuter, a main predator of BPH. We chose five varieties with different level resistance to BPH and investigated: 1) whether rice volatiles emitted from various varieties differ in attractiveness to the predator, 2) whether the population increase rate of the predator is affected by rice varieties, and 3) whether predators feeding BPH on different varieties differ in functional responses to BPH. The results showed that rice varieties could influence not only the searching behavior and population growth rate of the predator, but also functional responses of the predator to BPH. And in general, the stronger the attractiveness of volatiles emitted from one variety to the predator, the higher or stronger the population increase rate and functional response of the predator on this variety. However, these were not corresponding to the resistance of rice varieties to BPH. In conclusion, Our data demonstrate that the number and quality of the predator could be influenced by rice varieties. Applying rice varieties with characteristics enhancing the effectiveness of natural enemies may improve the control of insect pests.

Key words: rice varieties, Cyrtorhinus lividipennis, Nilaparvata lugens, tritrophic interactions

[1573] INTERACTIONS BETWEEN THE APHID PARASITOID PRAON VOLUCRE AND THE PREDATOR COCCINELLA SEPTEMPUCTATA

G. L. Lövei, D. Lola-Luz, Danish Institute of Agricultural Sciences, Department of Crop Protection, Research Centre Flakkebjerg, DK-4200 Slagelse, Denmark.

We studied the interactions between the aphid parasitoid, *Praon volucre* and the predator, *Coccinella septempuctata* in laboratory cages, enclosing wheat plants infested with the aphid *Sitobion avenae*. Behavioural observations showed that the two natural enemies did not interfere with each other: coccinellids consumed similar number of aphids in the presence or absence of parasitoids while parasitoids parasitised more aphids when a coccinellid larva was present. The effect natural enemies on aphid density was compared in three treatments: predators (coccinellid larvae) only, aphid parasitoids only and both natural enemies present. Aphid population growth was-11.3 % in the presence of *Praon volucre* and -0.3% with *Coccinella septempuctata*. In the combination treatment the growth rate of the aphids was -45.0%. These results suggested that coccinellid larvae did not impair the oviposition behaviour of the parasitoid. With 2 parasitoids, while ladybird larvae caused a decrease (-51.4%). The former was still significantly below the growth rate of the aphids wintout natural enemies (control). The data suggested that there was no intra-guild predation effect, direct or indirect, in this experimental system but a synergistic interaction seemed to operate.

Keywords: Biological control, intra-guild predation, parasitoids, predators, aphids

[1575] COMPARISON AND DEVELOPMENT OF ARTIFICIAL DIETS FOR BRACON HEBETOR (HYMENOPTERA: BRACONIDAE) REARING

<u>S.R. Magro</u>¹ & J.R.P. Parra¹, ¹Dep. Entomologia, Fitopatologia e Zoologia Agrícola, ESALQ-USP, 13418-900, Piracicaba-SP, Brasil, E-mail srmagro@carpa.ciagri.usp.br

Bracon hebetor Say is a larval ectoparasitoid of several lepidopteran pests attacking stored grains and is considered an efficient biological control agent. The biological aspects of *B. hebetor* were evaluated in the natural host rearing, *Anagasta kuehniella* (Zeller) (selected as the most suitable for the species among six other lepidopterans) and compared to those found in seven artificial media prepared for *Trichogramma* spp. One of the artificial diets (60% pupal holotissues of *Diatraea saccharalis* (Fabricius); 12% fetal bovine serum, 12% lactalbumin hydrolysate, 16% egg yolk) was considerably similar to the natural host, for the lenght of the cycle (egg-adult) was the same and the adults promptly paralyzed and parasitized the larvae, although at a lower rate than that presented by for those reared on *A. kuehniella*. The longevity of females reared *in vitro* was statistically similar to that found when reared was on *A. kuehniella*; however, approximately 60% of the larvae developed on the diets failed to spin the protective cocoons during the pupal stage. No morphological differences was verified in the salivary glands of the insects producing or not silk, and this deficiency is probably due to the chemical differences of the glands.

Index terms: Biological control, in vitro rearing, ectoparasitoid, cocoon spinning,

[1574] STUDIES ON THE KAIROMONE INFLUENCING PARASITE OF TRICHOGRAMMA OSTRINIAE ON ARTIFICIAL EGGS

C. Luo & Zhili Zhang, Inst. of Plant and Environmental Protection Beijing Acad. of Agric. and Forestry Sciences Beijing 100089, China

The materials located in the anal tuft of the female moth Ostrinia furnacalis can be nhexane extracted. The extracts greatly influenced the host-searching and oviposition behavior of *Trichogramma ostriniae*. If they were applied to artificial eggs, the time of the detaining will be lengthened, and the parasite efficiency will be improved. Index words: Ostrinia furnacalis, Extracts, Host-searching, Oviposition [1576] INFLUENCE OF TEMPERATURE ON THE WEIGHT OF LARVAE AND ADULTS OF CIIRYSOPERLA EXTERNA (NEUROPTERA: CHRYSOPIDAE) FED ON SCHIZAPHIS GRAMINUM (HEMIPTERA: APHIDIDAE)

W. J. M. S. Maia¹, C. F. Carvalho¹, B. Souza¹, L. P. M. Macedo¹, M. M. Goussain Jr¹, ¹Dept⁰ de Entomologia, Univ. Federal de Lavras, Caixa Postal 37, Lavras-MG, 37.200-000, Brasil, E-mail: wjmsmaia@ufla

Chrysopids are insects naturally occurring in several agroecosystems contributing for the biological control of pest insects. Nevertheless, the knowledge of the biology of those insects and their interactions with the abiotic factors to reach success in the mass production arming to support applied biological control programs, has become necessary. Among those factors, temperature which influences both directly affecting its development and its comportment and indirectly affecting its feeding. This work was designed to study the indirect influence of temperature on the weight of *Chrysoperla externa* larvae and adults fed on aphid *Schizaphis graminum*. The works were developed in the Insect Biology Laboratory of the UFLA Entomology Department in climat chambers at 15, 21, 24, 27 and 30 °C, RH of 70 \pm 10 % and 12-hour photophase. Average weights in all larval instars, stages of prepupa and pupa 48 hours later and of adults freshly-emerged before the meconium release, were evaluated. Considering the existence of a direct relationship between temperature and insects' developmental velocity, the weight of 1st, 2^{md} and 3rd instars larvae of *C. externa* with the temperature of 21 to 30 °C, differed from the larvae's weight kept at 15 °C, but there were no differences among the weights when compared with the total larval stage and weight of freshly-emerged adults.

Index terms: green lacewing, predator, development, abiotic factors, aphid.

[1577] COMPOSITION AND EFFICIENCY OF A YEAST FREE LARVAL DIET FOR THE MEDITERRANEAN FRUIT FLY

A. G. Manoukas & E. N. Zografou, Institute of Biology, NCSR "Demokritoos", Aghia Pareaskevi 15310 Attiki, GREECE

The larval diets, used today, for research, production and release of the mediterranean fruit fly Ceratitis capitata Wied. contain yeast. Yeast is expensive, variable in composition, has a short shelf life and it is not produced in many countries. This presentation reports the nutritional composition and the biological efficiency of a practical yeast free larval diet (YF) for rearing the mediterranean fruit fly. The results were compared with those of a yeast containing diet, which is widely used for rearing this fly. The YF diet was made up of low cost ingredients supplemented with amino acids, salts and vitamins and the control of brewers yeast, sugar and wheat bran. The control and YF diet contained, based on proximate analysis 57.4 and 65.3 moisture, 8 and 6.7 protein, 0.8 and 0.9 lipids, 1.7 and 3.5 ash, 4.5 and 4.3 fiber and 27.5 and 23.7 nitrogen free extract (by difference from 100), respectively. The YF diet was tested with eggs obtained from flies of white pupa strain (IAEA, Austria) for three generations and from wild flies (Attiki, Greece) for seven generations. 25 eggs/g.diet were placed in all treatments. Records were kept on hatched eggs, number of pupae, pupal weight and adult emergence. YF diet gave 18, 16 and 17.1 pupae per gram diet compared to 10.3, 7.3 and 13.2 of the control for the first, second and third generation, respectively. All other biological parameters were satisfactory and did not differ significantly between the two diets. Similar were the results with eggs from wild flies. It was calculated that overall dietary efficiency of YF diet was at least 50% higher than the control. The results will be discussed with reference to nutritional ecology of this fly.

Index terms: Ceratitis capitata, insect nutrition, rearing.

[1579] PARASITISM AND PERSISTENCE IN THE FIELD OF ENTOMOPATIIOGENIC NEMATODES AND OTHER NATURAL ENEMIES OF THE LARVAE *DIAPREPES ABBREVIATUS* (COLEOPTERA: CURCULIONIDAE)

C. W. McCor¹, D. L. Shapiro² & L. W. Duncan¹, ¹ Dept. of Entomology, Univ. of Fla., Citrus Res. and Ed. Ctr., 700 Experiment Sta. Rd., Lk. Alfred, FL 33850, USA, E-mail cwmy@lal.ufl.edu; ²USDA-ARS SE Fruit and Tree Nut Res. Lab., Byron, GA 31008.

Parasitism and persistence of three species of entomopathogenic nematodes, Steinernema riobrave Cabanillas, Poinar and Raulston, Heterorhabditis bacteriophora Poinar, and Heterorhabditis indica Poinar, Karunakar and David were evaluated as biopesticides against larvae of Diaprepes abbreviatus L. in a mature citrus grove using different soil In three separate tests, commercial formulations of different sampling methods. nematodes were applied with herbicide delivery equipment at rates from 11 to 216 IJ's/cm2 to the soil beneath the tree. The prevalence of parasitism and/or predation by either commercially-applied nematodes or indigenous natural enemies associated with weevil larvae in the soil was also measured using larvae-baited screened cages placed in the soil before and after nematode application. Ant predation and nematode parasitism were the dominant mortality factors of caged, 6th instar D. abbreviatus during 7 days exposure to field soil. Entomopathogenic fungi and bacteria were incidental. Inoculative applications of different rates of entomopathogenic nematodes showed a positive quadratic relationship between number of nematodes applied per given area (log scale) and parasitism of caged larvae. Higher rates (>54 IJ's/cm²) were required to achieve levels of parasitism significantly greater than that in the controls. Nematode parasitism of D. abbreviatus larvae was similar in caged versus no cage comparisons conducted in the greenhouse. Nematode numbers in the soil declined over time, reaching pretreatment levels at 14 days post-treatment based on a modified Baermann sampling procedure. The use of larvae-baited soil cages as indicators of nematode efficacy in the field is discussed. The feasibility of inoculative applications of nematodes at a time when natural control by indigenous nematodes is high is also addressed.

Keywords: ant predation; biological control; Heterorhabditis; Steinernema

[1578] PERSPECTIVES IN THE BIOLOGICAL CONTROL OF *NEMATUS* OLIGOSPILUS FOERSTER (HYMENOPTERA; TENTHREDINIDAE) PEST OF WILLOWS IN ARGENTINA AND CHILE

Alderete Mariela & <u>Fidalzo Patricio</u>, INSUE, CONICET, prOIMI, Miguel Lillo N° 205. C.P. 4000. Tucumán. Argentina, e- mail: amariela@infovia.com.ar.

Nematus oligospilus Foerster (=N. desantisi Smith) is a sawfly of holartic origin where has wide distribution. It was accidentaly introduced in Argentina and Chile in the 80's, in South Africa in 1993 and more recently in New Zeland in 1997. The larva eats the leaves of Salix spp. In the holartic region the single known host of N. oligospilus is S. lasiolepis which distribution is limited to the west of North America and Mexico. In the introduced areas presents periodical outbreaks causing up to 100% of defolations in willows trees. At the Delta of Paraná in Argentina, where 50.000 has of willows are cultivated, this sawfly produces lost of 60% in wood commercial production. In Arizona, where its populations were observed during more than 10 years, it has been uncommon and never visibly damaged its host plant, suggesting that it maintains stable in low density populations. The character of nonoutbreaking species in its home range could be the result of control agents that regulate its populations. Little information is available about the natural enemies of N. oligospilus in holartic region: Ctenochira frigida (Ichneumonidae: Tryphoninae), larval parasitoid, and an unidentified parasitoid of eggs. Both are the single parasitoids registered in the litterature. In Argentina, Chile and South Africa several parasitoids were recorded attacking the sawfly but the level of parasitism ranged from 0,1 to 0.8 % during high and low density populations. The typical parasitoid complex of nematine is composed mainly by monophagous and oligophagous Ichneumonids of the subfamilies Tryphoninae, Ctenopelmatinae and Campopleginae. While in the introduced areas the parasitoid complex is composed of poliphagous chalcidoids. Because of the wide distribution of this sawfly in the northern hemisphere and there is no information about the place of origin of the introduced strain in this region, we recommend to look for parasitoids in the range of distribution of S. lasiolepis and to introduce species of the Tryphoninae subfamily that are oligophagous. These control agents will act in Argentina and Chile as "monophagous" because N. oligospilus is the single present nematine in these countries.

Index terms: Nematus oligospilus, oligophagous, Triphoninae, Salix lasiolepis.

[1580] CLASSICAL BIOLOGICAL CONTROL OF SOLANUM VIARUM (SOLANACEAE) IN THE USA

J.C. Medal¹, D.Gandolfo², R.A. Pitelli³, A. Santana³, D.Ohashi⁴, J.P. Cuda¹, ¹University of Florida-Department of Entomology & Nematology, Gainesville, FL.32605 USA;² USDA-South-American Biological Control laboratory, Hurlingham, Buenos Aires Province, Argentina; ³Universidade Estadual Paulista, Jaboticabal campus, Sao Paulo state, Brasil; ⁴Inta-Agricultural Experiment Station, Cerro Azul, Misiones, Argentina.

Solanum viarum (Solanaceae) is a perennial weed, native to southern Brazil, north-east Argentina, Paraguay and Uruguay that has been spreading in the United States at an alarming rate during the 1990s. *S. viarum* was first reported in the middle 1980s in Florida, and is currently present in Alabama, Georgia, Louisiana, Mississippi, North Carolina, Pennsylvania, South Carolina, Tennessee, and Puerto Rico. The rapid spread in the USA can be partially attributed to the great reproductive potential (40,000 to 50,000 seeds per plant), highly effective seed dispersal by cattle and wild life, such as deer, feral hogs, raccoons and birds that feed on the fruits. Control of S. viarum in pasture lands are based on herbicide applications and mechanical (mowing) practices. These control methods only provide a temporary weed suppression that in addition of being expensive, are not always practical in rough terrain or inaccessible areas. Initial explorations in Brazil and Paraguay searching for potential biocontrol agents were started in June 1994 by Medal (Univ. of Fl.) in collaboration with Pitelli and Santana (Universidade Estadual Brazil). Initial surveys revealed several potential candidates Pualista, Jaboticabal, including two chrysomelid beetles (Metriona elatior and Gratiana boliviana). Screening tests have been conducted since December 1996. Further plant surveys in South America in collaboration with Gandolfo (USDA-South-American Biocontrol Laboratory, Argentina) have revealed a weevil that feeds on S. viarum bud-flowers (Authononus terebrosus) whose screening tests will be initiated soon. Host-range specificity tests, field surveys in South-America (Argentina, Brazil, Paraguay, Uruguay), and the lack of unfavorable host records in the scientific literature provide strong evidence that M. elatior and G. boliviana are safe for biocontrol of S. viarum Approval of the petition to release M. elatior in Florida is pending, and the request to release G. boliviana will be submitted to the Technical Advisory Group for Biological Control of Weeds (TAG) in April 2000. Weed Biocontrol, Metriona elatior, Gratiana boliviana, Anthonomus Index terms: tenebrosus

[1581] CONTROL OF THE SOUTH AMERICAN TOMATO PINWORM IN GLASSHOUSE WITH T. PRETIOSUM: BIOLOGICAL AND ECONOMICAL EFFICIENCY

M. A. Medeiros, F. H. França & N. J. Vilela, Embrapa Hortaliças, Caixa Postal 218, 70.359-970. Brasília, D.F. Brazil, E-mail: malice@cnph.embrapa.br.

The economic and biological efficiency of controlling the South American Tomato Pinworm through inundative releases of *Trichogramma pretiosum* on tomato plants cultivated in glasshouse was evaluated at farm level. The experiment was conducted in Luziania County, Goiás, Brazil during the summer of 1999/2000 in two glasshouses, each submitted to the following pest control regimes: (1) commom farmer practice: pesticides sprayed weekly on a rotation basis (OP; PY; Bt; abamectin; imidacloprid) (2) inundative release of T. pretiosum associated with weekly sprays of Bacillus thuringiensis. Insecticide sprays and parasitoid mass release were initiated soon after the first catch of moths. Mass release consisted of 2 cards/week (20x30 cm) that were gradually increased until reaching 6 cards/week at the end of the harvest of tomato crop. Pest control efficiency was determined through the number of eggs, mines and larvae from 50 leaflets colected from 50 plants chosen at random. Collected eggs were stored in gelatin capsules and kept in BOD chambers at a 25 ± 2° C, 70% RH and 14 hours photophase until the emergence of either larvae or parasitoid. Tomato productivity and percent fruit damage was determined for both systems tested. The cost of production for both systems were the same except for the fact that in the biological control system was included the mass rearing production costs of T. pretiosum. The results show that pest control efficiency in both systems were similar. Egg parasitism level was as high as 33%. Tomato production in the glasshouse submitted to chemical control was lower than that in the biological control system. Tomato fruit damage averaged about 4% and 8%, respectively. The economic analysis revealed that tomato produced in the biological system provided a better income to the farmer.

Index terms: Trichogramma pretiosum, Tuta absoluta, biological control, economic analysis.

[1582] BIOLOGICAL ASPECTS OF *PODISUS NIGRISPINUS* (HETEROPTERA: PENTATOMIDAE) BEING AS PREY SPODOPTERA FRUGIPERDA (LEPIDOPTERA: NOCTUIDAE)

S.S.A. Medeiros¹, <u>M.G.A. Lima²</u> & J.A. Mezzomo¹, ¹Laboratory of Biological Control, Dept. of Pharmacy and Biology, Paraíba State Univ., Félix Araújo Square, 13B, 58101-450, Campina Grande, PB, Brazil, E-mail jamezzo@zaz.com.br; ²Dept. of Biology, Ceará State Univ., P.O. Box 1531, 60740-020, Fortaleza, CE, Brazil, E-mail goretti@uece.br

The fall armyworm, Spodoptera frugiperda, is the principal pest of corn culture in Brazil, causing great economic losses when not controled. For its control are used principally chemical products, which are hazardous to humans and the environment. So, alternative controls should be sought that don't offer risks to the environment, like the usage of predators. The objective of this research was to assess some biological aspects of the predator Podisus nigrispinus having as prey the fall armyworm. The study was done under a temperature of 25 ± 2° C, relative humidity of 60 ± 10% and photophase of 12 hours. Were used 30 nymphs of the 2nd instar, individualized in plastic cups, offering water and a larvae of the 2nd, 3rd, 4th and 5th instar every 24 hours, being these denominated, respectively, diets I, II, III and IV. The duration and viability of each instar were assessed, and in the adults the weight, sex ratio, number of eggs and layings. The results were submitted to analysis of variance and the averages compared to the test of Tukey at the level of 1% of probability. Only the duration of the 2nd instar didn't differ significantly with the increase in the size of the prey. The 3rd, 4th and 5th instars presented a significant increase in the duration, principally when they preyed on the 2nd instar. The duration of the nymph phase was inversely proportional to the size of the prey, while the survival of each instar was greater when larger prey were offered. The heaviest adults were those originated from nymphs fed on larger prey. In all the diets tested, except the diet I, a sex ratio near 0,50 was seen, or one female for each male. As to the reproductive characteristics, the females originated from nymphs fed on diet III presented the largest number of layings and largest number of eggs. It was concluded that the duration of the nymph phase, of each instar and the weight of the adult of P. nigrispinus depended on the size of the prey. The number of adults of the predator increased when the nymphs were fed with larger prey. Therefore, S. frugiperda showed itself to be an adequate prey for the development of P. nigrispinus.

Index terms: Insecta, predator, biology, fall armyworm.

Symposium and Poster Session

[1583] THE COCCINELLID BEETLE, OENOPIA CONGLOBATA, AN IMPORTANT PREDATOR OF THE COMMON PISTACHIO PSYLLA

M.R. Mehrneiad, Pistachio Research Institute, P. O. Box 77175.435, Rafsanjan, Iran.

The common pistachio psylla, Agonoscena pistaciae, is considered as the major pistachio pest in Iran. Several species of parasitoids and predators attack the common pistachio psylla in the pistachio growing areas of the country. The wide investigation are managed to organise an IPM programme to control of this pest. The predatory beetle, Oenopia conglobata is an important natural enemy of A. pistaciae, in the main pistachio plantation areas of the country (Kerman province). The adult beetles overwinter under the stem's bark of the hedge trees (e.g. Elaeagnus angustifolia) in the pistachio orchards. Although O. conglobata was known as the aphids predator, this beetle attacks A. pistaciae from early spring to late summer. The larvae and adults of this species feed upon psyllid eggs and nymphs as well as psyllid honeydew. Development and fecundity of O. conglobata was growing in the controlled condition $(27\pm0.5^{\circ}C, 55\pm5\%$ r.h. and 16L:8D) on fourth stage psyllids in the four larval instars, and the larval development completed in 9.44 days. Developmental period from egg to adult lasted 18.44 days and the male coccinellid emerged about one day early. The female ladybird laid 245 eggs during the first 15 days of her life span, moreover, she consumed 165 (on average) fourth stage psyllids per day.

[1584] A LABORATORY SELECTION EXPERIMENT: EVOLUTION OF DROSOPHILA MELANOGASTER UNDER THE ATTACK OF THE PUPAL PARASITOID PACHYCREPOIDEUS VINDEMIAE

M. de S. Mendonca Jr.¹, A. R. Kraaijeveld¹ & H.C.J. Godfray¹, ¹ Centre for Population Biology & Dept. of Biology, Imperial College at Silwood Park, Ascot, Berkshire, SL5 7PY, UK. E-mail: m.mendoncajr@ic.ac.uk

Laboratory selection experiments using natural enemies can reveal aspects of ecological interactions from an evolutionary perspective, providing insights into the evolution of these interactions in the field. Replicate D. melanogaster populations were exposed to P. vindemiae attack for 12 generations. We expected parasitoid selection to result in resistance: shorter pupal development times or thicker puparium. Flies were cultured in standard medium, with 3rd instar larvae taken to banana slices. These were placed in cages, where parasitoids were released for selected lines, but not for controls. Surviving flies were used to breed the next generation. After the end of selection, flies were assayed in optimal conditions for life history traits comparing control and selected lines. Parasitism was highly variable, but averaged at 40% for all lines. Time to emergence of the flies during aelection showed that selected lines had significantly shorter development times than controls. This reflects a parasitisation pattern: as the faster developing flics emerge and escape parasitism, the smaller number of remaining pupae face attack by the same number of female parasitoids, increasing parasitism rate. Despite being variable, parasitism decreased significantly towards the end of the selection procedure, indicating a possible adaptation to parasitoid attack. The assays revealed that development time did not change genotypically. The proposed explanation is that the emergence pattern under a light-dark cycle (most flies emerge in the morning) interferes with the phenotypic expression of development time (selection for shorter development time in D. melanogaster is only successful under constant light conditions). A selection syndrome of evolving traits was detected: selected flies had faster feeding rates, attaining larger sizes as adults, and higher pupal viability; they had lower larval viability and a lower early fecundity for the females. No difference in puparium thickness was found, but it seems that selection involved this trait somehow since it is correlated with puparium size: lárger puparia are also thicker in absolute terms. Fecundity and body size are usually correlated in life history studies but not in this case, fecundity representing the cost to resistance. This work highlights the importance of a) correlations between life history traits in the evolution of defense against natural enemies and b) environmental conditions acting as constraints on the evolution of these traits.

Index terms: life history, body size, development time.

[1585] EFFECTS OF LARVAL DENSITY AND PREDATION BY TOXORHYNCHITES AMBOINENSIS (DIPTERA; CULICIDAE) UPON AEDES POLYNESIENSIS PRODUCTION

D. R. Mercer^{1,2}, G. R. Wettach³ & J. L. Smith³, ¹Inst. Territorial de Recherches Médicales Louis Malardé, B. P. 30, Papeete, Tahiti, French Polynesia, ²Dept. of Biology, Univ. Northern Iowa, Cedar Falls, IA 50614-0421 USA (current address), ³Gump Biological Research Station, Univ. California, Berkeley, B. P. 244, Temae, French Polynesia.

Biological control agents of disease vectors should reduce numbers of host-seeking adults without providing fitness benefits to survivors developing among fewer competitors with increased per capita resources. Survival in nature and vector efficiency of Aedes polynesiensis for human Bancroftian filariasis may be greater for larger female adults. Therefore, biological control agents that produce fewer but larger vectors may actually increase rates of disease transmission. We investigated the effects of predation by Toxorhynchites amboinensis upon the production of Ae. polynesiensis adults at three larval density of Ae. polynesiensis in rat-chewed coconuts, a prominent larval developmental site thoughout French Polynesia. The presence of predators significantly reduced the survival rates of Ae. polynesiensis and the numbers of both males and females produced from coconuts compared with cohorts of comparable initial densities reared in coconuts without predators. Adults from larval cohorts exposed to predators emerged at the same time and were equal in size to adults emerging from predator-free cohorts. No differences were detected in the numbers or sizes Ae. polynesiensis reaching adulthood among the larval densities tested. Therefore, at least for this common natural habitat, Tx. amboinensis provided a good level of biological control of the vector Ae. polynesiensis.

[1586] FIRST APPROACH ON THE POTENTIAL ROLE OF SEVERAL SPECIES (NEUROPTERA: CHHRYSOPIDAE), AS NATURAL CONTROL AGENT IN PORTUGUESE GREENHOUSES

A. Mexia; C. Couto; <u>P. Passos</u>, Secção Autónoma de Protecção Integrada, DPPF, Instituto Superior de Agronomia, Tapada da Ajuda, 1349-017, Lisboa - Portugal.

Several species are among the native polyphagous predators of the entomofauna in Portugal. Although 28 species have been observed in Portugal, here is a big lack of information related with their potential use as pest control agents. In Portugal, the more relevant data concerning Chrysopids are, most of them, if not all, based on *Chrysopida carnea* (Stephens) ignoring the real significance of all other species, some of them very common. In this work the most common species are listed and its relative importance is discussed, specifically in protected crops in the Oeste region, based either in Ammonium dihydrogen phosphate and protein traps, or on yellow sticky traps, used isolated in some experimental plots or combined, in other plots.

Key words: (Neuroptera: Chrysopidae), Chrysoperla carnea, natural limitation, greenhouse crops

[1587] BIOLOGICAL CONTROL OF THE PINK HIBISCUS MEALYBUG, MACONELLICOCCUS HIRSUTUS (GREEN), IN THE CARIBBEAN

D. E. Meverdirk, US Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, National Biological Control Institute, 4700 River Rd. Unit 135, Riverdale, MD 20737, USA.

The pink hibiscus mealybug (PHM), Maconellicoccus hirsutus (Green), was first found in the Western Hemisphere in Grenada in 1994, and has now expanded its geographical distribution to over 25 Caribbean Islands, Guyana in South America and most recently to Southern California in August and in Belize, Central America in September of 1999. It was first found in St. Kitts and Trinidad and Tobago in 1996, US Virgin Islands by May of 1997, in Vieques and Culebra by June and December of 1997 respectively, and on the mainland of Puerto Rico by April of 1998. PHM attacks over 200 host plant species in more then 74 plant families, but most common on hibiscus and sour sop (Annona muricata) in the Caribbean. It has been observed to commonly kill hibiscus plants and closely related species and even some forest trees (Samanea saman). Estimated economic losses have been reported to be as high as \$3.5 million/year in Grenada, \$18 million/year in Trinidad and Tobago, and projected to be \$750 million/year in the United States if no control efforts are made once it spreads to all the southern States. Two species of exotic parasites, Anagyrus kamali originally from China and Gyranusoidea indica from Egypt were initially released in St. Kitts in August of 1996. By April of 1998, the parasites had reduced the PHM population density on hibiscus in St. Kitts by 94%. In the US Virgin Islands, PHM densities were reduced by 90% in St. Thomas and 94% in St. Croix within a period from July 1997 to February 1999. In Puerto Rico, PHM densities have been reduced by 93.8% on the mainland from May 1998 to May 1999; 84.3% in Vieques during this same period; and 96.4% in Culebra from January 1998 to May 1999. Parasitization has reached as high as 54.4%. Both parasites have a life cycle producing two generations for every one generation of the mealybug. The PHM has spread halfway across Puerto Rico from east to west much slower then anticipated, because of the impact of the parasites. A total of 80% of the new mealybug infested locations are also being found accompanied by the exotic parasite species, which appear to be moving with this mealybug. Anagyrus kamali, which is the dominate parasite, has been reported moving up to three miles from initial release points. PHM is under complete biological control in St. Kitts, and it is believed that the US Virgin Islands and Puerto Rico will have equal success.

Index terms: Anagyrus kamali, Gyranusoidea indica, parasites

[1588] ARTIFICIAL DIET FOR *DIABROTICA SPECIOSA* (COLEOPTERA; CHRYSOMELIDAE) REARING

J. M. Milanez¹, C. J. Ávila² & J. R. P. Parra³, ¹Centro de Pesquisas para Pequenas Propriedades - Epagri, 89801-970, Chapecó-SC, Brasil, E-mail milanez@epagri.rct-sc.br; Embrapa/CPAO, Caixa Postal 661, 79804-970, Dourados-MS, Brasil; ³Dep. Entomol., Fitop. e Zool. Agrícola, ESALQ-USP, 13418-900, Piracicaba-SP, Brasil.

The aim of the research was to develop an artificial diet for D. speciosa rearing, since no records on artificial media are available for the species. The development of the insect was evaluated through four diets containing the following protein sources: 1) beans and yeast; 2) corn flour, wheat germ and yeast; 3) wheat germ and casein; and 4) identical to 3 plus cellulose. The insect was also reared in a natural diet (corn seedlings), which was the standard treatment. Each treatment consisted of 150 insects maintained in glass or plastic containers, respectively, for the artificial and the natural diets, and the rearing was kept at 25°C, RH 60 ± 10% and 14-hour photophase. The only artificial diet in which the development of D. speciosa occurred was that based on wheat germ and casein containing cellulose, which provided a 34-day larva-adult period, approximately 14% higher in comparison with the standard treatment (natural diet). Since the number of instars was constant and equal to three in both environments, there is an indication of nutritional diets adequacy of the artificial diet, although the viability at the larva-adult period was lower in that medium. The rhythm of egg-laying and longevity were similar in both diets, although the number of egg-laying and eggs/female was higher in the natural dict. Morphologically, the insects were similar in both diets, however, the adults achieved under artificial diet showed paler coloration. Diet adjustments regarding cellulose amount and change of pupation site allowed the viability increase of the larva-adult period (56%) and insect fecundity (1367 eggs/females), even though these figures were even lower regarding the natural diet. With small changes in the physical characteristics of diets and containers, besides the adaptation of the insect after a few generations in laboratory, one believes that this diet is quite promising for D. speciosa rearing. Index terms: corn rootworm, rearing technique, biology

[1589] MASSPRODUCTION OF THE EGG PARASITOID, TELENOMUS PODISI, ON THE PENTATOMID, EUSCHISTUS HEROS, FOR BIOLOGICAL CONTROL OF PENTATOMID PESTS ON SOYBEAN IN BOLIVIA

E. Miranda¹ & O. Mochida¹ ¹CETABOL, Casilla 555, Santa Cruz, Bolivia: cetabol@daitec.scz.com.

Piezodorus guildinii, Euschistus heros, Edessa meditabunda, & Dichelop furcatus (Het., Pentatomidae) are major pests on soybean. Some egg parasitoids were observed on such Pentatomids; Telenomus podisi (Scelionidae), Trissolcus spp. (ditto) & Ooencyrtus submetallicus (Encyrtidae). Massproduction of T. podisi has been attempted on E. heros eggs since 1998. Rearing of the host: For 45 days, about 600 adults (d: 2=about 1:1) were kept for oviposition in each 60x60x120cm (in WxLxH) screen cage with 8 soybean plants potted together with soybean & peanut seeds as feeds at room temperatures of 25-35 with 14L:10D illumination. Six pieces of cloths, 3cm wide x 120cm long, were kept in the cage for oviposition. Eggs were removed from the pieces of cloths every 2 days & separated into 2 groups, one for repeating host generations & the other for parasitoid massproduction. Eggs were kept in Petri-dishes (10x2cm) for 3 days, transferred to larger ones (12X10cm) with soybean pods & kept for 4 days to hatch out. About 20 1st-instars were kept in each 300ml plastic cup containing soybean & peanut seeds together with a wet cotton pillar for 3 wks to grow to adults. Rearing of the parasitoid: Host eggs were kept at -1960 for 7 mins & stored at -120 for 3 mos. About 500 Pentatomid eggs were fixed on a piece of paper with glue & kept in a 500ml plastic bottle with 300-400 parasitoid adults (d:9=about 1:4) for 7 days. About 60-70% host eggs were parasitized. Parasitoid adults emerged from host eggs at 25-35 after 12-14 days; one wasp/host egg. Cost for breeding 10,000 wasps to suppress Pentatomids on soybean /ha: Two labourers were hired with US\$140 & 100/ mo, respectively. A total of 52,293 Pentatomid eggs was produced for about 45 days, whereas that of 35,438 (=52,293 eggs x 67.8% parasitism) parasitized eggs was obtained for 19-21 days. The Pentatomid took about 30 days to grow from egg to adult. These 3 processes were operated simultaneously. Production cost for 10,000 wasps to be released /ha/once was estimated at US\$41.67 without consid- eration of investments in facilities, when US\$1.00 was equivalent to 6.04B\$.

[1590] BIOLOGICAL CONTROL OF THE NANTUCKET PINE TIP MOTH (RHYACIONIA FRUSTRANA), A PEST OF THE GENUS PINUS

<u>P. A. Mojena</u>¹ & Ing. A. F. Vera², Pinar del Río University, Cuba. ² Research. Forest Experimental, Station Viñales. Pinar del Río, Cuba.

This paper describes the results obtained by employing the biopreparado Metarrhyzium anisopliae Metch (Sorokin), sublethal doses of Dipterex 80 % PH and

the predator Trichogramma pintoi as an important technique for controlling Rhyacionia frustrana (Comstock) in young plantations of Pinus caribaea Morelet Pinardel Río, Cuba. The results were obtained by comparing field applications of the biological product, the insecticidal chemical and the mixture of the predator with sublethal doses of the insecticide. The results of this first trial show that populations of Rhyacionia frustrana were reduced in the areas discussed down to minimal levels of infestation using a mixture of T. pintoi and sublethal doses of the insecticide , while the control plots using the biopreparado or the insecticide alone expressed a higher incidence of the pest. Statistic analysis (ANOVA) of the levels of infestation by the pest in treated areas, compared with controls (technical efficiency) proved that both the percentage of outbreaks and buds damaged by the pest were reduced to levels close to zero percent in the areas discussed when using the predator Trichogramma pintoi . Observing the stage of development of the pest enables us to plan the timing of the releases of the biological control agent with greater efficiency and economy.

Index terms: Pine Tip Moth, Rhyacionoa, control, Biological

[1591] DIVERSITY AND COMMUNITY STRUCTURE OF PARASITOIDS ASSOCIATED WITH ENTOMOGENOUS GALLS IN BRAZIL

F. Monteiro & M.A.P. Azevedo, Lab. Ecologia de Insetos: Depto Ecologia/IB/UFRJ CP68020 - CEP21941-590 Rio de Janeiro, Brazil / E-mail: monteiro@biologia.ufri.br

Parasitoids are one of the most important groups of insects. Due to the scarcity of studies, especially in the neotropical region, litlle is known about their diversity and importance. In this work we described some aspects of the parasitoid community associated with entomogenous galls. This study was carried out at two small areas, one at restinga (coastal scrub vegetation) and the other at Atlantic Forest, both near Rio de Janeiro city. A total of 15 plant species harbouring 55 galls were sampled. The overall parasitoid species richness obtained was about 120 species. The average number of parasitoid species per gall was 3, but there was a high variance as at least three gall types had over 20 species associated to each of them. Most gall types had a very high parasitism rate, sometimes making it difficult to find out the real gall inducer. Differently from other biogeographical regions, Eulophidae was by far the most common and diverse group of parasitoid wasps. In both ecosystems the percentage of Eulophidae species was about 46%, the second most important group being Eurytomidae, with 17% of the species. Although most parasitoid species were found in a single host gall type, one should be careful about concluding that they are specialist parasitoids, as there should be unsampled host galls in both areas. Finally, this study shows how complex the guilds studied are in the neotropical region; both parasitoids and gall makers presented a high richness of species, about 80% of which unknown in the literature.

Index terms: Insect galls, community structure, species richness.

[1592] OCCURRENCE OF BACULOVIRUS AND HEXAMERMIS SP. (NEMATODA, MERMITHIDAE) IN LONOMIA OBLIQUA (LEPIDOPTERA, SATURNIIDAE)

R.II.P.Moraes¹, <u>E. Berti-Filho</u>² & J.L.Wolff³, ¹Laboratório de Parasitologia - Instituto Butantan São Paulo, Brasil, rhenrique@uol.com.br;2Depto de Entomologia, Fitopatologia e Zoologia Agrícola - ESALQ/USP. Caixa postal 9, 13418.900, Piracicaba, SP.; ebert@carpa.ciagri.usp.br; 3Núcleo Integrado de Biotecnologia. Universidade de Mogi das Cruzes, SP. Brasil, jwolff@uol.com.br. Financial support: CNPq

The contact of setae of Lonomia obliqua caterpillars with the human skin may result in severe acquired haemorrhagic disorders. Accidents with this saturniid, have been quite frequent in the South and Southeast Brazil since 1989. The only effective treatment to revert the haemorrhagic process, is the application of the specific serum "Antilonomico", produced by the Institute Butantan of São Paulo, Brazil. This serum is obtained by cutting the setae of caterpillars, where the producing toxin glands are located. Caterpillars collected in Cotia, São Paulo-Brazil, were observed to contain a nematode (Hexamermis sp.) inside the alimentary canal. From another lot of caterpillars collected in São Miguel do Oeste, State of Santa Catarina, Brazil some specimens were killed by a virus identified as Lonomia obliqua Multiple Nucleopolyhedrovirus (LoobMNPV). These two natural enemies will certainly be useful in a program of biological control.

Index terms: hairy caterpillars, venomous setae, pathogens, biological control.

[1593] A SURVEY OF LACEWINGS (NEUROPTERA: CHRYSOPIDAE), IN COFFEE AGROECOSSYSTEM, IN LAVRAS, MG, BRAZIL

<u>A. A. Morais</u>¹ & B. Souza¹, ¹ Dept. of Entomology, Federal University of Lavras, 37200-000 Lavras, MG, Brazil, E-mail: a_morais@hotmail.com; brgsouza@ufla.br

The Chrysopidae are important polyphagous predators found in several crops of economic importance with a great influence in the biological control of phytophagous arthropods. Lacewings like other beneficial insects stand out by being voracious, having high search ability and a broad number of prey species. In coffee crop, they are important in controlling secondary pests such as scales and aphids. Larvae of lacewings were observed preying eggs and adults of *Oligonychus ilicis* and larvae of *Perileucoptera coffeella*. Sampling was carried out at 15-day intervals in a coffee field at the Federal University of Lavras. Egg, larva, pupa and adult lacewings collected were placed in plastic bags and entomological net. Immature forms were reared to the adult stage, wich were mounted, labeled and sent to specialists for identification. A total of 64 adults, 4 larvae and 41 eggs were collected from September 1998 to August 1999. The species found were: *Chrysoperla externa*, *Ceraeochrysa cincta* and *C. claveri*.

index terms: chrysoperla externa, ceraeochrysa cincta, ceraeochrysa claveri, predator, chrysopid.

[1595] EVALUATION OF THE PARASITISM OF TELENOMUS PODISI ON PIEZODORUS GUILDINII (HETEROPTERA: PENTATOMIDAE) EGGS, IN SOYBEAN CROP IN RORAIMA, BRAZIL

M. A. B. Moreira¹, B. S. Correa-Ferreira², L. C. Corso², ¹Embrapa Roraima, Brazil, 174, Km 08, Distrito Industrial, Boa Vista-RR, Caixa Postal, 133, CEP 69.301.970, Email: marcos@cpafrr.embrapa.br; ²Embrapa Soja, Cx. Postal 231, CEP 86001-970, Londrina-PR.

The mortality of at the egg stage *Piezodorus guildinii*, main soybean crop pest, was studied under field condition in Roraima, during the years of 1997, 1998 and 1999. The experiments were carried out in Boa Vista, Roraima, Brazil, during the soybean crop season. Egg masses found in the field were observed dayly in laboratory to check the total number of viable eggs and those parasitized. Two species of egg parasitoids were recovered: *Telenomus podisi* Ashmead and *Trissolcus urich* Crawford. The incidence of parasitism in eggs of *P.guildinii* was 53% in 1997, 66% in 1998 and 70% in 1999. In Roraima conditions, *T. podisi*, was considered the most important and frequent species of *P. guildinii* parasitoid eggs due to its high occurrence and parasitism level.

[1594] BIOLOGY, THERMAL REQUIREMENTS AND PARASITIZATION OF TRICHOGRAMMA PRETIOSUM STRAINS ON HELICOVERPA ZEA EGGS

J. O.T. Moreira¹ & J.R.P. Parra², ¹ Depto. de Tecnologia e C. Sociais, Univ. do Est. da Bahia, C. Postal 171, 48900-000 Juazeiro-BA-Brasil, E-mail: osmateles@bol.com.br; ² Esc. Sup. de Agricultura "Luiz de Queiroz"/USP, C. Postal 9, 13418-900 Piracicaba – SP-Brasil, E-mail: jrpparra@carpa.ciagri.usp.br.

The research is part of a program of Integrated Pest Management of tomato crop in the Northeast region of Brazil using *Trichogramma pretiosum* to control the corn earworm (tomato fruitworm), *Helicoverpa zea* and the moth *Tuta absoluta*. The research was developed in laboratory at the Insect Biology Laboratory, at the Department of Entomology, Plant Pathology and Agricultural Zoology, Escola Superior de Agricultura "Luiz de Queiroz" (ESALQ), University of São Paulo (USP), in Piracicaba, State of São Paulo - Brazil, in order to study biological aspects and thermal requirements of *T. pretiosum* strains the factitious hosts *Anagasta kuelniella* and *Sitotroga cerealella* and the eggs parasitization on *H. zea* under 18, 20, 22, 25, 30 and 32° C. The *T. pretiosum* strains were from Petrolina-Pernambuco-Brazil (lat.S 9° 24' 42" and long.W Greenwich: 40° 29' 55") and from Piracicaba-São Paulo-Brazil'(lat.S 22° 43' 31" and long.W Greenwich: 47° 38'55"). The origin of the *T. pretiosum* strain affected the biological development of the parasitization and its parasitization capacity. The thermal requirements were also dependent on the origin of the strain, ranguing from 152 to 163 degree days for Petrolina and Piracicaba strain, respectively.

Index terms: biological control, temperature, corn earworm

[1596] CLASSICAL BIOLOGICAL CONTROL OF IMPORTED FIRE ANTS BY PARASITOID FLIES

L. W. Morrison¹, S. D. Porter¹ & L. A. Nogueira de Sá², ¹ Center for Medical, Agricultural and Veterinary Entomology, USDA-ARS, P.O. Box 14565, Gainesville, FL 32604, USA; ² Lab. de Quarentena "Costa Lima", Embrapa Meio Ambiente, Cx.P. 69, 13820-000, Jaguariúna, SP, Brasil.

Phorid flies in the genus Pseudacteon are solitary parasitoids of ants. Development occurs inside the head capsule of the host worker, killing the ant in the process. Pseudacteon flies may also have relatively large indirect effects on colony-level foraging and interspecific competition, as the presence of a single phorid can modify the behavior of hundreds of workers. Two Solenopsis fire ant species, S. invicta and S. richteri, have been introduced into the United States from South America and are serious pests in their introduced range. The high population densities of these two exotic ants may be due in part to an escape from natural enemies. Pseudacteon phorid flies from South America have the potential to be used as classical biological control agents of imported fire ants in North America. Laboratory studies of one Pseudacteon species, P. tricuspis, and its interactions with S. invicta, revealed that the presence of this phorid decreased food retrieval by as much as 50%. The primary mechanism of this effect was a significant decrease in worker activity when phorids were present. The presence of phorids did not significantly affect interspecific interactions between S. invicta and its close congener, S. geminata. The overall effect of introduced Pseudacteon phorids on imported Solenopsis fire ants in the United States will be evaluated from field releases of the flies and monitoring of target ant and associated arthropod communities. We have exported select *Pseudacteon* species from the Brazilian Quarantine Laboratory at Embrapa Environment, Jaguariúna, São Paulo State, Brazil to the United States for laboratory evaluation and field release, as part of a cooperative program between Embrapa and the USDA-ARS. In northern Florida, we had established 5 field populations of *Pseudacteon tricuspis* by the end of 1999. One population has been in existence since October 1997. The introduced populations are increasing in abundance and expanding in size, with the largest population covering an area of almost 100 square kilometers. Adult P. tricuspis were found to be active in the release areas in every month of the year. Long term monitoring of release and control sites should elucidate the magnitude of the effect of these parasitoids on target fire ant and associated arthropod populations. Pseudacteon flies and other natural enemies will not eradicate imported fire ants in North America, but could reduce fire ant populations to lower densities.

Index terms: Pseudacteon tricuspis, Solenopsis invicta, parasite, Phoridae

[1597] HOST SELECTION CUES OF A POTENTIAL BIOLOGICAL CONTROL AGENT FOR THE LILY LEAF BEETLE, *LILIOCERIS LILII*

<u>C. Müller^{1,2}</u>, F. Vencl³, T. Morton⁴ & U. Schaffner², ¹ Boyce Thompson Inst., Tower Road, Ithaca, NY 14850, USA, e-mail cm227@cornell.edu; ² CABI Bioscience Centre, Delémont, Switzerland; ³ Dep. of State Univ. of New York at Stony Brook, USA; ⁴ Dep. of Entomology, Pennsylvania State Univ., USA.

The use of natural enemies to control invasive species has become an important tool in biological control. to reduce the risk of non-target effects, the host range of the control candidate should be extremely narrow. the lily leaf beetle, lilioceris lilii (coleoptera, chrysomelidae), has become an important ornamental pest both in part of its native european as well as in its naturalized north american range, one of its antagonists in europe is the larval parasitoid lemophagus pulcher (hymenoptera: ichneumonidae), which is supposed to be highly specific, in order to elucidate the chemical basis of the specificity, host selection cues of this parasitoid were investigated in olfactometer and contact bioassays, volatiles of both the l. lilii larvae itself and their faeces which they carry as a shield were attractive to naive and experienced I. pulcher females. also, plant volatiles of the larvaes host plant, *lilium martagon* (liliaceae), but not of other tested green plants, attracted *l. pulcher* females. in contact bioassays, *l. lilii* larvae with faecal shield, larvae without shield, and shields alone were regularly contacted and induced oviposition behaviour, the combination of larva and faecal shield being more attractive than either one alone. nevertheless, the faecal shield seems to be a major cue in the host acceptance, since larvae of a non-host species covered with the faecal shield of *l. lilii* were as attractive to the parasitoids as I. lilii. dummies treated with a methanol extract of the shields evoke oviposition behaviour in l. pulcher females. since also leaf sap of l. martagon on dummies was attractive for the females, it is suggested that some of the kairomones inducing oviposition behaviour in *l. pulcher* originate from the host plant. index terms: lemophagus pulcher, faecal shield, kairomone.

[1598] DEVELOPING A COMMERCIALLY VIABLE SYSTEM USING TRICHOGRAMMA CHILONIS FOR CONTROL OF COTTON BOLLWORM HELIOTHIS ARMIGERA IN INDIA

N. Muthukrishnan, R.K.M. Baskaran, P.J.S. Roy, T.R. Manjula, M.S. Venugopal & R. Janarthanan, Department of Agricultural Entomology, Tamil Nadu Agricultural University, Agricultural College and Research Institute, Madurai 625 104, Tamil Nadu, India. E-mail: nmuthu64@hotmail.com

We established a pilot plant for large-scale production and distribution of Trichogramma chilonis to mitigate cotton bollworm, Heliothis armigera in Tamil Nadu, India. Nucleus insect cultures obtained from Biocontrol laboratory, Tamil Nadu Agricultural University, Coimbatore, and Project Directorate of Biological Control, Bangalore were used for propagation. Experiments on host acceptance revealed that T. chilonis preferred eggs of Corcyra cephalonica and contributed better biological attributes as that of natural host H. armigera. Therefore, we used C. cephalonica eggs for continuous mass culturing. However, rearing the parasitoids on H. armigera once in 5-6 generations minimized quality deterioration. Development of T. chilonis from sting to adult emergence was 7d on C. cephalonica eggs. Longevity of male and female was 5.3d and 6.5d with fecundity of 16 progenies/day. Techniques were developed to produce 15 x 10⁶ parasitoids/week. UV irradiation of C. cephalonica eggs to 20m, and exposure of parasitoids and host eggs at 1:8 ratio resulted in greater parasitization and emergence, and lower super parasitization. T. chilonis highly preferred C. cephalonica eggs that derived from diet incorporated with multivitamin, protein hydrolysate or honey, and in combination with either clomiphene citrate or tocopheryl acetate for development. T. chilonis also contributed increased fecundity and longevity when its adult honey food was mixed with clomiphene citrate or tocopheryl acetate. Field evaluation was conducted in winter and summer seasons using laboratory-reared parasitized eggs cards attached to top leaves of plants. Six releases of T. chilonis at 15x10⁴/ha/release at 10-12d interval, with as few as 50 release sites, gave moderate control of H. armigera. However, release of T. chilonis in alternation with NPV of II. armigera, endosulfan, Chrysoperla carnea and neem oil resulted in minimum larval population and boll damage, and maximum yield. Release of T. chilonis either before or after the release of C. carnea was deleterious as T. chilonis parasitized the eggs of C. carnea in the field. Testing effects of pesticides on T. chilonis in laboratory, semi-field and field conditions will be presented.

Index terms: Trichogramma chilonis, Corcyra cephalonica, mass production, field release, field evaluation

[1599] DEVELOPING A COMMERCIALLY VIABLE SYSTEM USING CHRYSOPERLA CARNEA FOR CONTROL OF COTTON PESTS IN INDIA

N. Muthukrishnan, T.R. Manjula, P.J.S. Roy, L. Geethalakshmi, M.S. Venugopal & R. Janarthanan, Department of Agricultural Entomology, Tamil Nadu Agricultural University, Agricultural College and Research Institute, Madurai 625 104, Tamil Nadu, India. E-mail: nmuthu64@hotmail.com

A native species of Chrysopids, Chrysoperla carnea was collected from cotton fields and assessed for its suitability for commercial use against cotton pests. Effect on acceptance of host eggs indicated that C. carnea preferred eggs of Corcyra cephalonica. Development from egg to adult emergence was completed in 22d. Egg period was 3.5d. Larval period averaged for 11d, Pupal period lasted for 7.5d, Progeny had sex ratio of 1.05: 0.95, Preoviposition period was 4d. Average fecundity was 640 eggs in lifetime. Males lived for 26d and females for 39d. Feeding experiments revealed that a single larvae fed on an average, 33.4 eggs of Heliothis armigera and 0.54 egg mass of Spodoptera litura; 5.9, 3.5 and 6.9 first to second instar larvae of H. armigera, Earias vittella and S. litura; 33.3, 24.6 and 19.5 aphids, mealy bugs and white flies respectively in a single day. A feasible smallscale mass production system using easily available and inexpensive materials was developed. About 25 x 10^5 C. carnea eggs were produced/week and distributed for field release. An efficient storage condition for C. camea eggs at low temperature was established which delayed hatchability, but yielded better survivorship and reproductive performance. We studied and categorized effects of pesticides in laboratory. Insecticides, methyl-o-demeton, dimethoate, phosalone, quinalphos, ethion, chloropyriphos, endosulfan, fenvalerate, cypermethrin, decamethrin and carboryl; plant products, need oil, need seed kernel extract (NSKE) and nochi leaf extract; biocides, nuclear polyhedrosis virus (NPV) of H. armigera and S. litura; fungicides, sulphur, dicofol, copper oxy chloride, mancozeb, ziram, captofol, carbendazim, streptomycin + tetracycline mixture; and plant growth regulator, naphthalene acetic acid were harmless based on egg, larval and adult mortality, and reduction in reproductive capacity. Augmentation of four releases of laboratory-reared C. carnea eggs at 50, 000/ha/release on 30, 60, 90 and 120 days after sowing, with as few as 50 release sites; or integrating C. carnea release with the use of NPV of H. armigera, Trichogramma chilonis, endosulfan, and need oil were significantly effective in minimizing aphids, white flies, thrips, mealy bugs and small larvae of E. *vittella* and *H. armigera*, and also contributed higher yield. Field recovery was up to 60%. Field evaluation of pesticides revealed that most of them were harmless as evidenced by less than 10% mortality on adults and larvae, and no significant effects on the life cycle of C. carnen.

Index terms: Chrysoperla carnea, Mass production, Field release, Pesticide toxicity

[1600] THE ENCARSIA SPECIES - PARASITODS OF WHITEFLIES (HOMOPTERA: ALEYRODIDAE) IN MÉXICO

S. N. Myartseva^{1,2}, E. Ruíz-Cancino¹ and <u>J. M. Coronado-Blanco¹</u>, ¹UAM Agronomía y Ciencias, UAT. Cd. Victoria, Tam., 87149. México, ²National Institute of Deserts, Flora and Fauna. Ashgabat, Turkmenistan.

Recently, several whiteflies species in many countries are serious agricultural pests, attacking crops and causing millions of dollars of damage each year. among the most common damaging whiteflies throughout the subtropics and tropics are citrus pests aleurocanthus woglumi and aleurothrixus floccosus and bemisia (tabaci complex), pests of a wide variety of field crops, including vegetables. many years ago were introduced into méxico several parasitoids and predators for citrus whiteflies biological control from different countries, the most effective whiteflies parasitoids belong to the family aphelinidae, generally to the genus encarsia. eight species of this genus were introduced into méxico, six against citrus blackfly aleurocanthus woglumi and two for woolly whitefly aleurothrixus floccosus biocontrol: e. clypealis, e. divergens, e. merceti, e. pergandiella, e. perplexa, e. smithi, and e. brasiliensis and e. haitiensis, respectively. for bemisia (tabaci complex) biological control, e. formosa was introduced. the study of the history of biological control successes in different countries established than it is necessary a priori knowledge of the natural enemies attacking invasive pest species. during the last two years, we studied the mexican fauna of aphelinidae, general method of our study is parasitoids rearing from different homoptera hosts (coccoidea and aleyrodoidea), especially the more important pests. by our and literature data, 26 species of the genus encarsia are registered at present in méxico as parasitoids of whiteflies. from them, 17 species are parasitoids of serious whitefly pest species. in the state of tamaulipas, different aphelinids were reared from three of the above mentioned whitefly species, seven belong to the genus encarsia, only three of them are species introduced earlier. aleurocanthus woglumi is parasitized by e. perplexa. aleurothrixus floccossus is attacked by e. americana, e. formosa and e. perplexa. heuronnikus juccosans is actuated by e. citrella, e. meritoria, e. pergandiella and e. luteola. Index terms: hymenoptera, aphelinidae, tamaulipas

[1601] BASIC STUDIES ON TRISSOLCUS URICHI CRAWFORD HYMENOPTERA: SCELIONIDAE) RELATED TO EDESSA MEDITABUNDA FABRICIUS (HEMIPTERA: PENTATOMIDAE)

<u>N. C. La Porta¹</u>, ¹ Dep. of Vegetal Protection, Faculty of Agricultural Cs., Univ. Nac. of Córdoba, C.C. 509, 5000 Cba, Argentina, E-mail <u>nlaporta@agro.uncor.edu</u>.

Species of the genus Trissolcus are egg parasitoids of bugs of the family Pentatomidae. In Argenting many of these hosts are harmful pests on field crops such as soybean. Therefore, the species of Trissolcus are interesting as biological control agents. Egg masses of Edessa meditabunda and Dichelops furcatus parasited by T. urichi were collected on soybean crops, in Córdoba, Argentina. This study was carried out due to the fact that there were no references about its biology in the country. Aspects of life cycle, reproduction and fecundity of T. urichi reared on E. meditabunda eggs were studied under controlled conditions of 25 \pm 2 °C; 60 \pm 10 % RH and 16 h photophase. Survival and fecundity were analysed through life tables. The following results were obtained: life cycle length (egg to adult): 10,2 d (females) and 9,3 d (males); preimaginal mortality: 4 %; adult longevity: significantly longer (p < 0.05) for females (43,6 d) than for males (40,3 d); number of progeny (females and males): $127,3 \pm 23,1$ eggs; greatest specific fecundity (m_x): 30,3 female/female during the first 24- 48 h after adult emergence; sex ratio: 9: 1 (females: male); net reproductive rate (Ro): 116,4 females/ female; generation time (T): 13,5 d; intrinsic rate of natural increase (r): 0,353 females/ female/day; finite rate of increase (λ): 1.42 females/ female.

Index terms: Trissolcus urichi, Edessa meditabunda, life cycle, reproduction, fecundity

[1603] REQUIREMENT OF LIPOPHORIN AND ECDYSTEROID FOR *IN VITRO* DEVELOPMENT OF A LARVAL ENDOPARASITOID, *VENTURIA CANESCENS* (HYMENOPTERA: ICHNEUMONIDAE)

Y. Nakahara¹, J. Osaka², T. Iliraoka² & K. Iwabuchi², ¹National Inst. of Sericultural and Entomological Science, 1-2 Ohwashi, Tsukuba, Ibaraki 305-8634, Japan. ²Tokyo Univ. of Agri. and Tech., 3-5-8 Saiwai-cho, Fuchu, Tokyo 183-8509, Japan.

In the field of biological control using parasitoids, one of the greatest needs is to produce adult wasps and flies at a low production cost. So far, many species of parasitoids including hymenopterous and dipterous species have been reared in vitro successfully from embryo to adult, but successful in vitro rearing of hymenopterous larval endoparasitoids has not been reported. We studied in vitro rearing of Venturia canescens, a larval endoparasitoid of pyralid stored-products pests. In this wasp, embryos at the postgermband stage were successfully reared to the last (5th) larval instar in an insect cell culture medium, MGM-450, supplemented with lipophorin purified from the host pupae, 20-hydroxyecdysone (20-HE) and fetal bovine serum (FBS). If one of these factors was omitted, the larvae failed to reach the 2nd larval instar. Lipophorin is an insect specific lipoprotein. V. canescens grew and developed in the medium supplemented with chicken egg yolk lipoprotein instead of lipophorin, suggesting that its lipoprotein-requirement is not so specific. The amount of lipids supplied to the parasitoid may be critical. FBS may be a source of growth-promoting factor(s), although it is not of insect origin. The growthpromoting ability of FBS was not lost after heat-treatment (100 °C, 5 min), dialysis (cut off <6,000 M.W.), and incubation with dextran-coated charcoal. In addition to 20-IIE, the effects of ecdysone, 2-deoxy-20-hydroxyecdysone, polypodine B and cholesterol were examined. Any of these ecdysteroids promoted development of V. canescens, but cholesterol did not. 20-HE is likely to function as the molting hormone for the parasitoid rather than as a nutrient, because its effect on development was dose-dependent within a certain range and a dose above that range was deleterious. It is noted, however, that a few larvae developed to the 2nd larval instar in the hormone-free medium, suggesting that the first instar larvae could synthesize their own ecdysteroid. In fact, a small amount of ecdysteroid was detected from the hormone-free medium in which the first instar larva was cultured for 3 days. When juvenile hormone (JH) was added to the medium, the duration of the developmental period was slightly shortened, but this hormone turned out to be not essential as a component of the culture medium.

Index terms: Venturia canescens, endoparasitoid, in vitro rearing, lipophorin, ecdysteroids

[1602] ANALYSIS OF SURVIVAL AND FECUNDITY OF TRISSOLCUS URICIII CRAWFORD (IIYMENOPTERA: SCELIONIDAE) ON DICHELOPS FURCATUS FABRICIUS (HEMIPTERA: PENTATOMIDAE)

N. C. La Porta¹, ¹ Dep. of Vegetal Protection, Faculty of Agricultural Cs., Univ. of Córdoba, C.C. 509, 5000 Cba, Argentina, E-mail <u>nlaporta@agro.uncor.edu</u>.

Trissolcus urichi, a scelionid egg parasitoid of Pentatomidae, was captured in Córdoba, Argentina from *Edessa meditabunda* and *Dichelops furcatus* egg masses collected on soybean crops. Survival and fecundity of *T. urichi* reared on *D. furcatus* eggs were analysed under laboratory conditions of 25 ± 2 °C; 60 ± 10 % RH and 16 h photophase. Vital statistics such as the net reproductive rate (R_0), the generation time (T), the intrinsic rate of natural increase (r) and the finite rate of increase (λ) were computed. Time of development from egg to adult emergence was 10 ± 0.9 days. Adult longevity average 47.6 ± 22.2 and 41.2 ± 9.4 days for females and males, respectively; no significant differences (p> 0.05) were observed between sexes. Progeny production reached a peak during the first 24-48 hours after adult emergence. The number of progeny, males and females/ female, was 133.8 ± 14.6 eggs and the greatest specific fecundity (m_{χ}) was 29.2females/ female. Sex ratio was 13:1 (females/ male). Other results were: r= 0.274; R_0 = 113.1; T= 17.3 and $\lambda = 1.3$. No differences were observed when comparing these results with those obtained using *Edessa meditabunda* as host.

Index terms: Trissolcus urichi, Dichelops furcatus, biology, survival, vital statistics

[1604] HOST-AGE EFFECTS ON OVIPOSITION BEHAVIOR AND DEVELOPMENT OF AN EULOPHID LARVAL-PUPAL PARASITOID, OOMYZUS SOKOLOWSKII

Akiko Nakamura¹ and Takashi Noda², ¹Department of Bioscience and Technology, Faculty of Agriculture, Iwate University, Morioka 020-8550, Japan, E-mail akikon@tnaes.affrc.gojp; ²Tohoku National Agricultural Experiment Station, 4 Akahira, Shimo-kuriyagawa, Morioka 020-0198, Japan.

Many studies have shown that host stadium (or age) at parasitism affects parasitoid host acceptance behavior, development and survival rates, and clutch size. Talekar & Hu (1996) reported that Oomyzus sokolowskii (Kurdjumov) (Hymenoptera: Eulophidae) preferred third- and fourth-instar Plutella xylostella (L.) (Lepidoptera: Yponomeutidae) larvae over first- and second-instar hosts for parasitization. We reported here the results of a laboratory study on host age affects host selection of O. sokolowskii. Second-, third-, early and late fourth-instar larva, and pupa of P. xylostella were singly presented to female O. sokolowskii in the laboratory to investigate the effects of host age on oviposition behavior and development of the parasitoid. The sequence of oviposition behavior after contacting the host could be divided into three steps: (1) drumming by antennae, (2) ovipositor insert in and oviposition, and (3) host feeding. Host acceptance rates did not differ among the different host ages except for pupa. Time required for ovipositor insertion and oviposition tended to increase as the host became old. About one third to half of the wasps showed host-feeding behavior irrespective of the host age. Parasitism rates and clutch sizes for the fourth-instar host larvae were higher and larger than that for the second- and third-instars. For all host stages and clutch sizes, offspring sex ratios were extremely female biased. There were no significant differences among the mean development times of the wasp on the second-, third-, and fourth-instar larvae. In the fourth-instar hosts, however, those on the early fourth-instar hosts were significantly longer than on the late fourth-instar hosts (= prepupa). This suggested that the larval development of *O. sokolowskii* should be influenced by the host physiology.

Index terms: Oomyzus sokolowskii, parasitoid, oviposition behavior, host age, development time, clutch size, Plutella xylostella.

[1605] MULTIPLE OVIPOSITION BY THE PARASITOID FLY EXORISTA JAPONICA IS ADVANTAGEOUS IN INTERSPECIFIC COMPETITION WITH THE MICROTYPE-EGG STRATEGIST, PALES PAVIDA

<u>S. Nakamura</u>, International Centre of Insect Physiology and Ecology (ICIPE), P. O. Box 30772, Nairobi, Kenya. E-mail snakamura@icipe.org

The gregarious tachinids, *Exorista japonica* and *Pales pavida*, parasitize the same host species in common habitats, and thus could compete for hosts in the field. It takes a few days for macrotype eggs of *E. japonica* laid on a host cuticle to hatch, while microtype eggs of *P. pavida* hatch and parasitize a host soon after being ingested by the host. Laboratory experiments were conducted to elucidate the mechanisms of interspecific competition between the two species. Adults of the two species often emerge from hosts multiply parasitized by bth species. However, the relative success of emergence of both species depends on the timing of hatching. Progeny of species that happen to hatch earlier will develop to adults better than their competitors. The number of *E. japonica* adults that emerged per multiparasitized host also increased with increasing number of eggs laid per host. *E. japonica* females tend to oviposit on self-parasitized hosts, or multiply oviposited on the same hosts even when unparasitized hosts are present. Such multiple oviositions on the same hosts may be advantageous for *E. japonica* in situations where it is competing for hosts with *P. pavida*.

Index terms: Tachinidae, parasitoids, multiple oviposition, interspecific competition.

[1607] STUDY ON INTERSPECIFIC COMPETITON BETWEEN TWO LARVAL PARASITOIDS OF THE DIAMONDBACK MOTH

T. Noda¹ & A. Nakamura², ¹Lab. of Insect Pest Control, Tohoku National Agricultural Experiment Station, Morioka, Iwate 020-0198, JAPAN, E-mail nodat@tnaes.affrc.go.jp; ²Dept. of Bioscience and Technology, Iwate Univ., Morioka, Iwate 020-8550, JAPAN.

The eulophid parasitoid *Oomyzus sokolowskii* is a larval-pupal parasitoid of *Plutella xylostella*. This wasp is also known as a facultative secondary parasitoid of *Cotesia plutellae*, because there are some reports that *O. sokolowskii* emerged from field collected *C. plutellae* coccons. However, there have been no reports on when and how *O. sokolowskii* parasitize *C. plutellae*. Because *C. plutellae* is an endoparasitoid, *O. sokolowskii* must oviposit *C. plutellae* larvae inside the host or emerging larvae for spinning the coccon. To examine hyperparasitism of *O. sokolowskii*, *P. xylostella* larvae of one through ten days after parasitism by *C. plutellae* were presented to *O. sokolowskii* females in the laboratory. Results showed that *P. xylostella* larvae ten days before parasitized by *C. plutellae* were successfully parasitized by *O. sokolowskii*, but only *C. plutellae* emerged from the other aged hosts. This suggests that the secondary parasitism by *O. sokolowskii* occurred in case that the female oviposit in the body of *C. plutellae* larvae inside the host. Therefore, the timing of secondary parasitism by *O. sokolowskii* both in the laboratory and field will be demonstrated and the ecological meaning will be discussed.

Index terms: Oomyzus sokolowskii, Cotesia plutellae, Plutella xylostella, hyperparasitism

[1606] DISTRIBUTION OF WOLBACHIA INFECTION AMONG COTESIA SESAMIAE (HYMENOPTERA: BRACONIDAE) POPULATIONS IN EASTERN AND SOUTHERN AFRICA

A. J. Nei-Song & W. A. Overholt, The International Centre of Insect Physiology and Ecology (ICIPE), P. O. Box 30772 Nairobi, Kenya, E-mail angisong@ICIPE.org.

Cotesia sesamiae is the most common larval parasitoid of a variety of noctuid and pyralid stem borers in gramineous crops in sub-saharan Africa. Its major hosts include Busseola fusca and Sesamia spp. A recent report indicated that two biotypes of C. sesamiae that are partially reproductively isolated exist in Kenya. One biotype is encapsulated in *B. fusca* and harbors the symbiotic bacteria *Wolbachia*. The aim of the current work was to determine how widely spread was the infection by Wolbachia among the different C. sesamiae populations found in Kenya and some eastern and southern African countries. The presence of Wolbachia infections in C. sesamiae populations collected from Zambia, Zimbabwe, Mozambique, Uganda, Zanzibar, and Kenya, was tested using a PCR technique. DNA was extracted from five individuals from each population. In Kenya, populations from Mombasa and Machakos, in the east, were positive for the infection with Wolbachia and served as a positive control for subsequent tests. In all PCR reactions using the FTSZ Holden primers. For the populations from Kuja and Kitale areas, in the western part of Kenya, none of the Wolbachia specific primers produced any product. The parasitoids from Mombasa were double infected with both the Wolbachia of group A and group B. Cotesia sesamiae samples obtained from field surveys conducted in Uganda were not infected with Wolbachia. Samples from Zambia, Zimbabwe and Mozambique showed the infection. Samples from other East African countries including Malawi, Ethiopia, Zanzibar, are being tested. The occurrence of Wolbachia in some population of C. sesamiae within same region, causing unidirectional mating incompatibility, may have negative impact on the biological control of cereal stem borers in East Africa. Index terms: Incompatibility, biotypes, Busseola fusca, biocontrol.

[1608] MORPHOLOGICAL AND QUANTITATIVE STUDIES OF THE HEMOCYTES IN *DIATRAEA SACCHARALIS* (LEPIDOPTERA: PYRALIDAE) LARVAE PARASITIZED BY *COTESIA FLAVIPES* (HYMENOPTERA: BRACONIDAE)

C.C.C. Nunes¹, M.T.S Bombonato² & <u>E.A. Gregório¹</u>, ¹Centro de Microscopia Eletrônica, Inst. Biociências, UNESP, Campus de Botucatu. 18618-000, Botucatu, SP, BR; E mail elisa@ibb.unesp.br ²Dept. Ciências Biológicas, Fac. Ciências, UNESP, Campus de Bauru. 17033-360, Bauru SP, BR.

The hemocytes are considered to participate in the cellular encapsulation making layers of extremely flattened cells around foreign material implanted in the insect hemocoel. Although encapsulation provides the insect defense against many invading microorganisms, this defense is ineffective against certain parasitoids that successfully live within insects. The suppression of cellular immune reactions by entomopathogens remain largely misunderstood. The Diatraea saccharalis is the major pest of the sugarcane crop. This insect may be controlled, in nature, by the parasitoid wasp Cotesia flavipes. There are few investigations correlating the immune response along the parasitoid development and the morphology of the host insect hemocytes. In this work we studied the participation of different hemocyte types in the reaction of the D. saccharalis larvae against the C. flavipes. by morphological and quantitative analysis. The total hemocyte counts (THC) were estimated, under phase contrast microscope, in hemolymph of D. saccharalis larvae parasitized up to 144 h. For the morphological study, hemolymph of parasitized D. saccharalis larvae (6, 72 and 144 h) was collected directly in 2.5% glutaraldehyde solution; the pellets obtained by contribution were conventionally prepared for transmission electron microscopic analyses. A significant decrease in the THC was detected in parasitized *D. saccharalis* larvae along the infection. The parasitoid was recovered with the hemocytes, but no blood cell was visualized attached to the wasp surface. Initially the granulocytes showed a decrease in the amount of structured granules and the plasmatocytes exhibited many vacuoles with flocullated content. Later on, both cell types showed an increase in the rough endoplasmic reticulum and Golgi complex. The oenocytoid was strongly affected by the parasitism, being represented only by the nucleus surrounded by cytoplasm fragments. Close relationship of hemocytes (plasmatocyte, granulocyte, oenocytoid and spherule cell) and teratocytes was observed. These findings suggest that the host insect, D. saccharalis, is mobilizing its hemocytes against the invader C. flavipes, although the insect host was not able to avoid the parasitoid development. (Partially supported by CAPES)

Index terms: Diatraea saccharalis, Cotesia flavipes, hemocyte, ultrastructure, parasitoid

[1609] PARASITISM OF *HEXACLADIA SMITHII* ON THE NEOTROPICAL BROWN STINK BUG *EUSCHISTUS HEROS* DURING AND AFTER THE SOYBEAN SEASON

<u>M. C. Nunes</u>¹ & B. S. Corrêa-Ferreira², ¹Universidade Federal do Paraná, Departamento de Zoologia, Caixa Postal 19020, Curitiba, Paraná 81531-990, Brasil E-mail: clarice@cnpso.embrapa.br; ² Embrapa-Soja, Caixa Postal 231, Londrina, Pr, 86001-970, Brasil, E-mail: beatriz@cnpso.embrapa.br.

Euschistus heros is considered a major pest of soybean in Brazil. In the 1996/97 growing season, the parasitoid Hexacladia smithii was reported for the first time afecting adult populations of the brown stink bug E. heros at the region of Londrina, Paraná. In the 1998/99 growing season, the natural incidence was evaluated by colecting 50 female samples at 15 days intervals at Embrapa Soja experimental fields in Londrina. In the laboratory, the reproductive capacity of females was studied during and after soybean season, comparing healthy and parasitized females. From a total of 900 E. heros females collected from December 1998 to August 1999, 40.3% were parasitized by H. smithii. The parasitism varied from 93.3% to 0% with higher occurrence in the months of January and February. At the end of the soybean season the parasitism decreased down to zero by the end of August. When the reproductive potencial of females was evaluated the total average number of eggs layed by healthy females (1133.8) was 5.2 higher than those deposited by parasitized females (216.8) reaching a maximum diference of 9.5 fold in January. The size of egg masses and egg fertility were not influenced by H. smithii parasitism. Results indicated that parasitism by H. smithii was important for the reduction of the E. heros population during the soybean growing season but its effects was insignificant on the population on diapause. Parasitism also affected the reproductive potential of E. heros females, its influence being drastic on offspring of the populations in December and January, when it acted as a natural control agent.

Index terms: biological control, fecundity, natural incidence, Pentatomidae, Encyrtidae.

[1610] EFFECT OF PARASITSM BY *IIEXACLADIA SMITHII* ON SURVIVAL AND REPRODUCTIVE CAPACITY OF *EUSCHISTUS HEROS* FEMALES

<u>M. C. Nunes</u>¹ & B. S. Corrêa-Ferreira², ¹Universidade Federal do Paraná, Departamento de Zoologia, Caixa Postal 19020, Curitiba, Paraná 81531-990, Brasil E-mail: clarice@cnpso.embrapa.br; ²Embrapa-Soja, Caixa Postal 231, Londrina, Pr, 86001-970, Brasil, E-mail: beatriz@cnpso.embrapa.br.

Considering the importance of Euschistus heros a soybean pest and the high incidence of the parasitoid Hexacladia smithii on this host, its influence on the survival and reproductive potential was evaluated. These two factors were compared under laboratory conditions (25°C ± 2°C, 65% ± 10% RH, 14L:10D) using healthy and parasitized females at different development stages (1, 7 and 14 days of adult life). A strong influence of *H. smithii* parasitism on the reproductive capacity of *E. heros* females at the different ages studied was detected. Fecundity was drasticaly reduced when the parasitism occurred at the first day of female adult life, when they are reproductively imature. During ca. 46 days, healthy *E. heros* females deposited an average of 66.92 eggs, (11.31 eggs masses/female), statistically higher than the values obtained for females parasitized by H. smithii at 1, 7 and 14 days of adult life, when average values of 1, 8.86 and 14.10 eggs per female, respectively. In relation to egg masses size there was significant differences among treatments. Althoug data had shown a tendency for bigger egg masses (5.71 eggs) for healthy females as compared to H. smithii parasitized females (1 to 4.24 eggs/egg mass). E. heros egg fertility was not affected by H. smithii parasitism when this occurred at seven (60.41%) and 14 days of adult life (71.40%) as compared to healthy females (94.22%). Parasitism supressed adult survival after 45 days, compared to 32% survival of unparasitized ones. These results indicate that parasitism by H. smithii affected the reproductive capacity of E. heros in all stages tested being its influence higher when the insect was immature (1 day) reducing the offsprings and causing high mortality to the host.

Index terms: biological control, fecundity, Pentatomidae, Encyrtidae, soybean

[1611] PARASITISM OF THREE ENCARSIA SPECIES ON TRIALEURODES VAPORARIORUM (HEMIPTERA, ALEYRODIDAE)

M.R.V. Oliveira, Embrapa Recursos Genéticos e Biotecnologia. P.O Box 02372, CEP 70.849-970, Brasilia, DF, Brazil. E-mail: vilarin@cenargen.embrapa.br

The greenhouse whitely, Trialeurodes vaporariorum, is a key pest of many greenhouses in the temperate world, attacking over 279 plant species belonging to 83 botanic families. Although this species, in Brazil, is considered a secondary pest, it can be found in greenhouses, of central, south and Southeast regions of the country. However, it is a major pest in greenhouses of "Embrapa Recursos Genéticos e Biotecnologia". Natural enemies, endemic to the "Distrito Federal" region, have been prospected and analysed among the greenhouse whitely populations. Three species of Encarsia have been found, this is, formosa, hispida and lycopersici. Studies were conducted to compare instar preference for parasitization by each of the species collected. Tomato, cotton and tobacco were used as host plants. The adults of the there species of parasitoids (n=100) were kept feeding on water + honey and their longevity, determined. Results showed that E. formosa adult parasitoids lived 10.3 ± 13.1 days. Females laid 9 eggs/day in tomato, 8 in cotton and 4.70 in tobacco. Parasitism found in first and second instars nymphs were of 37.1%, in tomato; 27.2%, in tobacco and 19.5%, in cotton. For third and fourth instars, the parasitism were of 90.7%, in tomato, 73.7%, in tobacco and 73.4%, in cotton. E. hispida adult parasitoids lived 5.7 ± 5.9 days. Females laid 4.6 eggs/day in tomato, 5.5 in cotton and 6.9 in tobacco. Parasitism found in first and second instars nymphs were of 37.0%, in tomato; 32.0%, in tobacco and 14,3%, in cotton. For third and fourth instars, the parasitism were of 53.0%, in tobacco, 43.8%, in tomato; and 11.4%, in cotton. E. lycopersici adult parasitoids lived 7.14 ± 13.7 days. Parasitism found in first and second instars nymphs were of 51.2%, in tobacco; 46.4%, in cotton and 41.9%, in tomato. For third and fourth instars, the parasitism were of 56.2%, in cotton, 51.6%, in tomato and 27.2%, in tobacco. In these studies, E. formosa revealed a better performance when compared to the parasitoids analysed.

Index terms: Encarsia formosa, E. híspida, E. lycopersici, Traileurodes vaporariorum, parasitoids.

[1612] BIOLOGICAL STUDIES OF NEPHASPIS GEMINII (COLEOPTERA: COCCINELIDAE) A PREDATOR OF BEMISIA TABACI BIOTYPE B (HEMIPTERA: ALEYRODIDADE), IN BRAZIL

M.R.V. Oliveira¹, P.R.G. Vieira¹ & R.A. Laumann¹, ¹Embrapa Recursos Genéticos e Biotecnologia, Cx. Postal 02372, CEP 70.849-970, Brasília, DF, Brazil. E.mail: vilarin@cenargen.embrapa.br.

In recent years the B-biotype of Bemisia tabaci has become one of the most important pest in greenhouses and open fields, worldwide. In Brazil, this biotype was first recorded ca. of 1992, in the state of São Paulo, although now it has spread to all regions of the country. Important agricultural and vegetable crops like cotton, beans, tomato and fruits (cantaloupe and watermelon) are being attacked by the insect. Control strategies are based exclusively on insecticides. In order to reduce reliance on chemicals a project on biological control (parasitoids and predators) are under way. Studies were conducted to evaluate the biology of Nephaspis geminii (Coleoptera, Coccinellidae), a species endemic to central Brazil. Development, fecundity and consumption rates of the insect was assessed when fed on a diet of immature individuals of B. tabaci biotype B. The development time (days) found for eggs was of 5.96 (± 1.03); L1, 1.87 (± 1.11); L2, 1.77 (± 0.82); L3, 2.56 (± 1.18); L4, 4.21 (± 1.96) and for pupa, 5.40 (± 0.87). Some of the immature (n=9) presented an additional L5 stage, with development time of 3.75 (±2.05) days. The overall mortality of immature stages was elevated (50%). Preoviposition period was of 7.90 (± 0.69) days and a mean of 1.64 (\pm 0.11) eggs per day was laid. Predation rates of adults and larvae of two ages (old: L4-L5) and (young: L2-L3) were evaluated in relation to two host plants, cabbage (Brassica oleraceae) and melon (Cucumis melo). Predations rates were higher in cabbage, demonstrating host plant preference. Adults coccinelid was able to increment the predation rates in response to higher densities of whiteflies eggs and nymphs. In laboratory condition, N. geminii showed good potential for the biological control of B. tabaci biotype B.

Index terms: Nephaspis geminii, Bemisia tabaci, Coleoptera, predator, whitefly.

[1613] IMPACT OF A SYMBIOTIC GRASS-ENDOPHYTE ASSOCIATION ON INSECT HERBIVORES AND THEIR NATURAL ENEMIES

M. Omacini¹, <u>E.J. Chaneton</u>¹, C.B. Müller² & C.M. Ghersa¹, ¹Department of Ecology, Faculty of Agronomy, University of Buenos Aires, Av. San Martín 4453, 1417 Buenos Aires, Argentina; ²Department of Biology, Imperial College at Silwood Park, Ascot, Berkshire, SL5 7PY, UK.

The mutualistic association of fungal endophytes with certain grass species can change the quality of the food resource for different guilds of herbivorous insects, and therefore, influence their local abundances. In addition, effects of endophyte infection on herbivore populations could be transmitted to higher trophic levels, altering the diversity, species composition, and behaviour of secondary consumers. Such endophyte induced "bottom-up cascades" may be common in insect food webs of natural and agricultural systems, but have not yet been investigated. We recorded naturally occurring densities of leaf miners and aphids on replicated patches (50×50 cm) of the annual grass Lolium multiflorum, grown from seed infected with the fungus Neotyphodium sp. (E+) and from seed free of endophytes (E-). We also collected parasitised aphids ("mummies") to assess the parasitois (c), we assume that the parasitois approximate the parasitois (community structure on E_+ and E_- grass patches. The frequency of L. multiflorum shots attacked by leaf miners was significantly lower in E_+ patches. Endophyte infection decreased aphid densities, especially that of the dominant aphid species Rhopalosiphum padi. This effect was transmitted to the aphid parasitoids, as the mean density of parasitised aphids on E+ patches was 85% lower than that on E- patches. Moreover, parasitoid attack rates (proportion of parasitised aphids) were enhanced on grass patches lacking the endophyte. From the sampled aphid mummies we reared 3 and 4 species of primary and secondary parasitoids, respectively. There was no consistent difference in parasitoid diversity or species composition between E+ and E- grass patches, although the secondary/primary parasitoid ratio was higher on E- patches. This study shows that fungal endophyte infection of a food plant can strongly affect insect herbivore populations, whereas bottom-up effects of grass endophytes on higher levels of the food chain are subtle.

Index terms: aphid parasitoids, fungal endophytes, indirect effects, leaf miners, trophic interactions

[1614] THE ROLE OF LANDSCAPE STRUCTURE AND FARMING PRACTICE ON PREDATION OF APHID

<u>Ö. Östman¹</u>, B. Ekbom² & J. Bengtsson¹, ¹Dept. of Ecology and Crop Production Science, P. O. Box 7043, 750 07 Uppsala Sweden, E-mail: orjan.ostman@evp.slu.se; ²Dept. of Entomology, P. O. Box 7044, 750 07 Uppsala, Sweden.

The goal of conservation biological control is to enhance the action of naturally occurring pest enemies. Landscape structure and farming practices (conventional or organic) have been suggested to play an important role in this enhancement. We have measured the impact of the natural enemy assemblage on the growth rate and abundance of the bird cherry-oat aphid (Rhopalosiphum padi) in cereal, at ten farms with different landscape structure and farming practice around Uppsala, Sweden. Aphid abundance was measured, using a D-vac, in spring barley every third day, from the onset of the aphid attack to their departure. The aphid growth rate was calculated as the regression between days and the logarithm of aphid abundance. In every field we put out exclusion barriers where ground living predators could not enter. The impact of the natural enemies on aphid growth rate was calculated as the difference between the growth rate in the exclusion barriers minus the growth rate in the field. Aphid growth rate was significantly higher within barriers than in the field. The impact of the natural enemies was greater in simpler landscapes than in more complex landscapes. There was no effect of farming system. The peak abundance of aphids was not correlated with the impact of natural enemies. Instead, the colonisation rate had a significant effect on the peak aphid abundance. Colonisation rate was significantly negatively correlated to mean perimeter-to-area ratio of cultivated fields and was lower on organic farms than conventional farms. Unfortunately, we cannot tell if the lower colonisation rate was due to higher predation of newly arrived aphids or due to a lower aphid influx into cereals. From the impact of the natural enemies on aphid growth rate we calculated the economic benefits of natural enemies in terms of increased yield. Since the difference in colonisation rate could not unambiguously be ascribed to natural enemies we did not include this effect in the economic calculations. The mean increase in yield due to the impact of natural enemies on aphid growth rate was 61 kg/ha, which was equivalent to 5% of the yield 1999. However, there was variation in how much natural enemies increased the yield, which partly can be attributed to landscape structure. We conclude that there is potential to manipulate the landscape to decrease the losses from aphids in cereals. Index terms: Rhopalosiphum padi, biocontrol, economic benefit

[1615] HYMENOPTERAN PARASITOIDS ON FRUIT – INFESTING TEPHRITIDAE (DIPTERA) IN LATIN AMERICA AND THE SOUTHERN UNITED STATES: DIVERSITY, DISTRIBUTION, TAXONOMIC STATUS AND THEIR USE IN FRUIT FLY BIOLOGICAL CONTROL

<u>S.M. Ovruski</u>¹, M. Aluja², J. Sivinski³ & R. Wharton⁴, ¹ INSUE, CIRPON-FML, CONICET. M. Lillo 205 (4000) S.M. de Tucumán, Argentina. E-mail: sovruski@infovia.com.ar; ² Instituto de Ecología A.C., Apdo. Postal 63, 91000 Xalapa, Veracruz, México. E-mail: alujam@ecologia.edu.mx;³ Center for Medical, Agricultural and Veterinary Entomology, USDA-ARS, Gainesville, FL 32604, USA. E-mail: jsivinski@gainesville.usda.ufi.edu; ⁴ Texas A&M University, Department of Entomology, College Station, TX 77843-2475, USA. E-mail: rawbaw@acs.tamu.edu

We first discuss the diversity of fruit fly (Diptera: Tephritidae) parasitoids Hymenoptera) of the Neotropics. Even though the emphasis is on Anastrepha parasitoids, we also review all the information available on parasitoids attacking files in the genera Ceratitis, Rhagoletis, Rhagoletis, Rhagoletis, Rhagoletis, and Zonosemata. We center our analysis in parasitoid guilds, parasitoid asemblage size and fly host profiles. We also discuss distribution patterns and the taxonomic status of all known Anastrepha parasitoids. We follow by providing a historical overview of biological control of pestiferous tephritids in Latin American and Florida (USA) and by analyzing the success or failure of classical and augmentative biological control programs implemented to date in these regions. We also discuss the lack of success of introductions of exotic fruit fly parasitoids in various Latin American countries. We finish by discussing the most pressing needs related to fruit fly biological control (classical, augmentative and conservation modalities) in areas of the Neotropics where fruit fly populations severely restrict the development of commercial fruit growing. We also address the need for much more intensive research on the bioecology of native fruit fly parasitoids.

Index terms: Anastrepha - Ceratitis - Braconidae - Figitidae - parasitoid guilds

[1616] INTRODUCTION OF THE PARASITOID AGENIASPIS CITRICOLA FOR THE BIOLOGICAL CONTROL OF CITRUS LEAFMINER PHYLLOCNISTIS CITRELLA IN BRAZIL

P.E.B. Paiva¹, <u>S. Gravena¹</u> & L.C.S. Amorim¹, ¹Gravena ManEcol Ltda, Rua Monteiro Lobato 856, 14870-000, Jaboticabal/SP, Brazil. E-mail gravena@asbyte.com.br

The citrus leafniner Phyllocnistis citrella was first detected in Brazil ocurring in citrus in march 1996. Since then this pest has rapidly spread throughout the major citrus area in state of São Paulo. Besides this pest has seriously damaged the young citrus leaves the main impact of the new intruder on citrus industry has been facilitated the citrus canker infection. Two native parasitoids were found attacking larvae and pupae of P. citrella. in the commercial groves in São Paulo, the eulophids Galeopsomyia fausta and Cirrospilus The parasitoid Ageniaspis citricola was collected from citrus groves in Florida SD.C. (USA) and imported into quarentine facilities of EMBRAPA- Meio Ambiente in Jaguariúna, São Paulo in July 1998 as part of a classical biological control program against *P. citrella* that has been supported by CNPq and Fundecitrus. After the quarentine procedures *A. citricola* has been reared at Gravena-Manecol in Jaboticabal/São Paulo and ESALO/USP in Piracicaba/São Paulo. The citrus leafminer and the parasitoid have been reared on controlled chambers with lime seedlings (Citrus limonia) as host and on greenhouses with sweet orange plants (Citrus sinensis). In 1999 approximately 25000 A. citricola were reared in Jaboticabal alone and 134 releases were made in São Paulo citrus groves. Some recoveries were made until february 2000 but the establishment has not yet been confirmed.

Index terms: classical biological control program ,citrus canker

[1617] PARASITISM EFFICIENCY OF THE BRACONIDAE WASPS, DIACHASMIMORPHA LONGICAUTA, ON LARVE OF MEDFLY IN GUAVAS

B. A. J. Paranhos^{1,2}, J. M. M. Walder^{1,3} & L. Blumer^{1,4}, ¹ Laboratory of Food Irradiation and Radioentomology, CENA/USP, P.O. Box 96, Piracicaba, SP 13400-970, Brazil, E-mail bajparan@cena.usp.br; ² Post-Doctor - FAPESP; ³ Associated Professor USP, CNPq-BP Fellowship; ⁴ CAPES graduated fellowship.

The efficiency of parasitism of the Braconidae wasps, *D. longicaudata*, were checked on four different varieties of guavas infested with larvae of medfly, *Ceratitis capitata*. The guavas were infested by introducing them inside of the cages of adult medflies for two hours. Data on fruit weight, dead larvae, pupae recovered, % emerged flies (males and females) and % parasitism (males and females) were collected. It was observed that medflies have preference on laying eggs in larger and greener fruits, resulting in larger offspring, but the parasitism rate was not affected. The parasitism rate did not present significant statistical difference annong varieties of guavas tested and ranged from 3.34% to 7.9%. Medfly and parasitoid females did not present oviposition preference for none of the varieties studied. There was significantly larger mortality of larva of flies in the c.v. Sassaoca in relation to c.v. Pedro Sato. The parasitoid *D. longicuudata* shown low efficiency, in lab conditions, to parasite guavas infested with medfly larvae.

Index terms: Parasitism rate, biological control, medfly, Diachasmimorpha longicaudata, guava.

[1619] FIRST APPROACH ON THE POTENTIAL ROLE OF DICYPHUS CERASTII (HEMIPTERA: MIRIDAE), AS NATURAL CONTROL AGENT IN PORTUGUESE GREENHOUSES

P. Passos, F. Luz, A. Mexia, Instituto Superior de Agronomia, DPPF, Secção de Protecção Integrada, Tapada da Ajuda, 13449-017, Lisboa, Portugal.

In this paper is given a first sample of data concerning the most common mirid bug of the Portuguese greenhouses of the Oeste region, the Dicyphinae *Dicyphus cerasii* Wagner 1951, (Hemiptera: Miridae). Along with seasonal evolution of the population on protected tomato, a laboratorial trial showed the potential to predate the leafniner *Liriomyza huidobrensis*. In the laboratory it was also posible to demonstrate that the necrophagy ocasionally observed in the field, is a adaptative advantage for this facultative phytophag and predator, since feeding cadavers from entomological nature increases the fertility. Keywords: Região Oeste of Portugal, biological control, greenhouse crops, (Hemiptera: Miridae) *Dicyphus cerastii* Wagner 1951

[1618] BIOLOGICAL CONTROL OF MEDFLY IN PEACH USING PARASITOID [DIACHASMIMORPHA LONGICAUDATA (HYMENOPTERA: BRACONIDAE)] INUNDATIVE RELEASINGS

B. A. J. Paranhos ^{1,2} & J. M. M. Walder ^{1,3}, ¹ Laboratory of Food Irradiation and Radioentomology, CENA/USP, P.O. Box 96, Piracicaba, SP 13400-970, Brazil, E-mail-bajparan@cena.usp.br; ² Post-Doctor - FAPESP; ³ Associated professor-USP, CNPq-BP fellowship.

The efficiency of parasitism of the wasp *D. longicaudata* in a peach orchard was evaluated, using 2 different peach varieties (c.v. Maravilha and c.v. Ouro Mel), located in tree different blocks (c.a. 1 ha each) in the field. The parasitoids were released weekly during 4 weeks period for c.v. Maravilha and 2 weeks for c.v. Ouro Mel. About of 24,800 adults were released every week in each block. Infested artificially peaches were used as baits. They were infested in laboratory, irradiated to avoid adult medfly emergence, and individually hang in a plastic net, among peach fruits in the trees during a 24 hours period. After that period, the bait peaches were taken to the laboratory to observation. The parasitism rate, in peach c.v. Maravilha, ranged from 18.28% to 47.89%, with an average of 31.31%. From emerged parasitoids, 59.60% were males and 40.40% were females. It was found for the peach c.v. Ouro Mel a parasitism rate of 11.52% after the first releasing and 53.83% after the second one. When increased the reason of parasitoids released/pupa recovered in the peaches "baits" (parasitoid: host), decreased the parasitism percentage in the field, perhaps doe to a factor of over parasitism

Index terms: Parasitism rate, fruit fly, peach, Diachasmimorpha longicaudata.

[1620] PREDICTABLE RISK TO NATIVE PLANTS IN WEED BIOLOGICAL CONTROL

R. W. Pemberton, US Dept. Agric. - Agric. Res. Service, Aquatic Plant Management Lab, 3205 College Ave. Ft. Lauderdale, FL USA 33314

Environmental safety is an important issue for biological control. Data on field host use of 112 insects, 3 fungi, 1 mite, and 1 nematode established for biological control of weeds in Hawaii, the continental U.S., and the Caribbean indicate that the risk to native flora can be judged reliably before introduction. Virtually all risk is bourne by native plant species that are closely related to target weeds. Fifteen species of insects introduced for biological control of wheels while 4 others belong to 2 closely allied genera. Only 1 of 117 established biological organisms uses a native plant unrelated to the target weed. Thus the elements of protection for the native flora is the selection of weed targets that have few or no native congeners and the introduction of biological control organisms with suitably narrow diets. biocontrol reform, biocontrol safety, natural enemies, non-target use

[1621] THERMAL REQUIREMENTS FOR DEVELOPMENT OF THE PREDATOR MACROLOPHUS PYGMAEUS (HEMIPTERA:MIRIDAE)

D. CH. Perdikis & <u>D. P. Lykouressis</u>, Lab. of Agr. Zoology and Entomology, Agricultural University of Athens, 75 Iera Odos, 118 55, Athens, GREECE, E-mail lykouressis@auadec.aua.gr.

Macrolophus pygmacus is a polyphagous predator preying on whiteflies and aphids on various vegetables like tomato, eggplant and pepper-plant and it can also complete its development feeding exclusively on plant sap. Egg and nymphal development as well as the length of preoviposition period of M. pygmaeus were studied on eggplant and tomato in the presence of insect prey, at 15, 20, 25, 27.5 and 30°C, with 65±5% RH and photoperiod of 16:8 (L:D) h. The aphid Myzus persicae was used as prey on eggplant whilst the whitefly Trialeurodes vaporariorum, on tomato. The temperature threshold and the thermal constant for egg, nymphal stages and oviposition of the predator were calculated. The above parameters for preimaginal and egg to egg development were also estimated. The temperature threshold for egg development was found 7.53 and 6.85°C, for nymphs 8.71 and 9.19°C, for oviposition 6.83 and 6.50°C, for preimaginal development 8.42 and 8.75°C and finally for egg to egg development 8.19 and 8.48°C on eggplant and tomato, respectively. The thermal constant of egg development was calculated as 180 and 185 day-degrees, of nymphs 270 and 261, of oviposition 108 and 103, of preimaginal development 447 and 435 and finally of egg to egg development 552 and 535 day-degrees, on eggplant and tomato, respectively. These results show that development of *M. pygmaeus* can begin at a temperature somewhat lower than other beneficial insects which feed on or parasitize at aphids and/or whiteflies on vegetables.

Index terms: developmental temperature threshold, thermal constant, nymphal development, egg development

[1623] REARING OF BROWN STINK BUG *EUSCHISTUS HEROS* AND GREEN STINK BUG *NEZARA VIRIDULA* AS HOSTS IN THE MULTIPLICATION OF EGG PARASITOIDS

W.A.A. Peres¹ & B. S. Corrêa-Ferreira², ¹Universidade Federal do Paraná, Departamento de Zoologia, Caixa Postal 19020, Curitiba, Paraná 81531-990, Brasil. Email: wilsimar@cnpso.embrapa.br., ²Embrapa-Soja, Caixa Postal 231, Londrina, PR, 86001-970, Brasil, E-mail: beatriz@cnpso.embrapa.br.

Experiments were conducted in Londrina, PR, Brazil, under rearing room conditions (25°C, 60% RH, 14hL:10hD), to evaluated the nymph development and the reproduction of brown stink bug Euschistus heros and green stink bug Nezara viridula (Hemiptera: Pentatomidae) as hosts in the eggs parasitoids multiplication. One hundred eggs of E. heros and N, viridula were put into the cage (50x50x70 cm) with soybean plant plus dry soybean and peanut seeds used as diet. Dialy observations were made until adult emergence, and the duration of nymph development time and the survival of adults were calculated. The nymph development time were 33 days for E. heros and 34 days for N. viridula, with survival average of 65% and 71.3%, respectively and there was no significant difference between the trataments. The reprodutive capacity of laboratory and field populations of E. heros and N. viridula were evaluated during February-April 1999. During 13 weeks the egg production per cage was studied with one hundred pairs of stink bugs/cage with the same diet. Dialy observations were made and egg masses were collected. Adults of E. heros reared under laboratory conditions produced 2.08 times more eggs than that collected in field, 5547 and 2262 eggs/ cage to laboratory and field rearing adults, respectively, being this population with high rate of parasitism by Hexacladia smithii, that reduced reproduction and longevity of adults. The N. viridula adults collected in field produced 1.75 times more eggs than adults reared in laboratory (6304 and 3609 eggs/ cage) and, in this period, it was observed low density of adults parasitized by tachinid flies in the field population.

[1622] BIOLOGICAL DATA OF SOME NATURAL ENEMIES OF THE SOURSOP BORER CERCONOTA ANONELLA (LEPIDOPTERA: OECOPHORIDAE) IN PLANALTINA, FEDERAL DISCTRICT, BRAZIL

M. J. B. Pereira¹, M.A.S. Oliveira², E. Berti-Filho¹, I. Icuma² & N.T.V. Junqueira², ¹Depto de Entomologia, Fitopatologia e Zoologia Agrícola-ESALQ/USP. Caixa postal 9, 13418.900, Piracicaba, SP. E-mail: mjbperei@carpa.ciagri.usp.br; ² EMBRAPA-CERRADOS, BR 020, Km 18, Rodovia Brasília - Fortaleza. 73301-970, Planaltina, DF. Financial support: CNPq

Soursop fruits (Annona muricata) infested by Cerconota anonella, were collected in Federal District orchards from May to November 1998 and taken to the Laboratory of Entomology of EMBRAPA-CERRADOS ($25.0 \pm 0.9^{\circ}$ C temperature; $64.5 \pm 7.3\%$ relative humidity). The fruits were opened and the C. anonella larvae were placed in Petri dishes (1 larva/dish) with pieces of fruits, while the pupae were placed in Petri dishes with humid towel paper. Upon emergence the adults were transferred to mating cages (15.0 cm x 25.0 cm)cm) covered with towel paper for the insect to lay the eggs, and a recipient with honey solution. The parasitoids collected and the percentages of parasitism were as follows: Apanteles sp. (25.3%) larval parasitoid, Xyphosomella sp.(2.0%) - larval parasitoid, Brachymeria annulata (2.0%) - pupal parasitoid, Trichospilus diatraeae (5.0%) - pupal parasitoid. C. anonella larvae of different ages were given to Apanteles females, however only the newly hatched larvae were parasitized, and the egg-adult period was approximately 15 days, but only males emerged. One to three day old *C. anonella* pupae were exposed for 24 hours to B. annulata females and the mean life span was 19 days, but again only males emerged. Newly formed C. anonella pupae were exposed to T. diatraeae females for 48 hours, and the egg-adult period was approximately 17 days, emerging 100 a 200 adults per pupa, with a sex ratio of 0.70. C. anonella larvae of different ages were exposed to Xyphosomella sp. females, but no parasitism was observed. T. diatraeae was the most promising species for laboratory rearing. However new methodologies should be developed for laboratory rearing of the other parasitoid species, namely Apanteles, the most frequent one in the collectings done during this research.

Index terms: larval parasitoid, pupal parasitoid, life span, biological control.

[1624] THE EFFECT OF THE ADDITION OF AMINO ACIDS TO THE TOXICITY OF BACILLUS THRUINGIENSIS AGAINST PLUTELLA XYLOSTELLA LARAVE

<u>A. D. Permana</u> and S. T. Rastrya, Department of Biology Institut Teknologi Bandung, Ganesa 10 Bandung 40132, Indonesia. E-mail : agus@bi.itb.ac.id

A study was conducted to observe the effect of alanine, arginine and leusine addition to the toxicity of the *Bacillus thuringiensis* var. Aizawai (Bt-A) and Bt var. Kurstaki (Bt-K) against early instar larvae of *Plutella xylostella* under laboratory condition. Bt-A and Bt-K were tested at 1 to 10,000 ppm by using the leaf dipping method. The results showed that the addition of alanine0.05% remarkably increased the toxicity of Bt-K at 1 to 100 ppm. The addition of arginine 0.05% was also increased the toxicity of Bt-A at 1 to 1,000 ppm. Comparative potency of the amino acids addition to increase the toxicity of Bt-K were alanine 0.05% > leusine 0.05% respectively. For Bt-A, the addition of arginine 0.05% pives the better toxicity compare with alanin 0.05% and leusine 0.05%. Index term: *Bacillus thuringiensis*, alanine, arginine, leusine, toxicity.

[1625] OCCURRENCE OF SCALES, WHITEFLIES AND NATURAL ENEMIES IN CITRIC PLANTS IN THE MUNICIPAL DISTRICT OF CÁCERES, MT, BRASIL

<u>J. M. Pinto¹</u>, F. A. A. Ferrara¹, V. A. Teixeira², S. R. S. Ventura³, A. G. Carvalho³ & P. C. R. Cassino⁴, ¹Dept. Fitotecnia, CPGF, UFRRJ, Seropédica, RJ, 23.890-000, Brasil. E-mail: jmiranda@ufrj.br; ²Dept. de Produção e Extensão, EAFC, C.P. 244, Cáceres, MT 78.200-000, Brasil; ³Dept. de Produtos Florestais, IF, UFRRJ, Seropédica, RJ 23.890-000, Brasil; ⁴Dept. de Entomologia e Fitopatologia, CIMP, UFRRJ, Seropédica, RJ 23.890-000, Brasil;

They are countless the scales registrations and Aleyrodidae damaging the citric plants, causing considerable damages due to the great amount of sap that they extract for its feeding. This provokes the decline and even death of the plant, besides other indirect damages. The study was accomplished in February of 2000, in an orchard with 18 years of age implanted in the limits of the Escola Agrotécnica Federal, municipal district of Cáceres, MT, Brasil, to an altitude of 118 m, which included the tangerines "poncā", "mexirica" and "murcote"; the oranges "pêra", "lima" and "valência" and the lemon "tahiti", totaling about 400 plants. The number of the sample was of 20 plants according to the precasualization extolled for the methodology of sampling binomial, "presence-absence", where 10 leaves per plant per quadrant was observed, therefore, 40 leaves per plant. The following insects associated with its respective occurrence degrees were observed: Scales: *Coccus viridis* (0,13%), *Pinnaspis aspidistrae* (0,13%), *Selenaspidus articulaus* (2,50%), *Orthezia praelonga* (8,13%) and *Chrysoperlas* pp. (30,00%).

Index terms: Citrus, Aleyrodidae

[1626] COEXISTENCE IN ONE FIELD OF DIFFERENT *TRICHOGRAMMA* SPECIES SHOWING DIFFERENT MODES OF REPRODUCTION AND DIFFERENT LEVELS OF *WOLBACHIA* INFECTION

B. Pintureau¹, E. Tabone⁴, P. Bolland¹ & F. Lassablière¹⁻³, ¹INSA-INRA (UA 203), Båt. 406, 20 Ave. A. Einstein, 69621-Villeurbanne, France; E-mail: pinture@jouy.inra.fr. ²INRA, Unité Santé vég. et environnement, 37 Bd. du Cap, 06606-Antibes, France. ³Present address: Univ. J. Monnet, Fac. Médecine, Lab. Biochimie, 42023-Saint Etienne-cedex 2, France

In summer 1998, eggs of *Plutella xylostella* (Lep.: Plutellidae) were collected in two fields of cabbage located in Pas-de-Calais, north France (coll. S. Sénéchal) and Valbonne, south France (coll. N. Sorbier-Lezcano). In another field of cabbage located in Hyères, south France, C. Vidal distributed and then collected patches of UV-irradiated *Ephestia kuehniella* (Lep. Pyralidae) eggs. Each *Trichogramma* from one patch of loss eggs was reared on *E. kuchniella* eggs. Collected *Trichogramma* were classified in four species (Table) and three groups of species (evanescens, pretiosum and pintof).

Region	Trichogramma Species and Wolbachia in- fected individuals	Number of parasitoids (fe- males or sets)	% of thely- tokous in- dividuals	% of thelytokous
Pas-de-Calais	T. evanescens	1	100	100
	T. semblidis	24	0	0
Valbonne	T. semblidis	5	20	20
	T. cacoeciae	14	100	0
Hyères	T. evanescens	31	3	3
	T. cacoeciae	2	100	0
	T. buesi	4	0	0

The most frequent species were T. semblidis in Pas-de-Calais (96%), T. cacoeciae in Valbonne (74%) and T. evanescens in Hyères (84%). All T. cacoeciae individuals and some T. evanescens and T. semblidis individuals showed a thelytokous reproduction. A high temperature (30° C) rearing produced males in thelytokous strains of T. evanescens and T. semblidis, but not of T. cacoeciae. This means that the thelytoky is induced by a heat-sensitive symbiont, Wolbachia, in the two first species but not in the third. The presence or absence of Wolbachia was confirmed by PCR (primers of FisZ gene). It is the first indication of such a rich Trichogramma biodiversity (in relation to the species composition, the mode of reproduction and the level of Wolbachia infection) in one field. It is also the first indication of a Wolbachia infection in T. semblidis.

Index terms: Bacteria, Biodiversity, egg parasitoid, symbiosis, thelytoky.

[1627] COLLECTS AND IDENTIFICATION OF RACES OF *TRICHOGRAMMA* IN COMMERCIAL FIELDS OF TOMATO, IN DIFFERENT ALTITUDE

<u>D. Pratissoli¹</u>, A. M. Holts¹, A. B. Chioramital¹, H. B. Zago¹ & R. T. Thuler¹, ¹CAUFES, P. O. Box 16, ZIP CODE: 29500-000, Alegre, Brazil, E-mail direcu@npd.ufes.br.

seven experimental fields were installed in altitude that varied of 200 to 1050 meters, located in the municipal districts of afonso cláudio and venda nova do imigrante in espírito santo state, brazil. in all the commercial fields of tomato it was just collected *trichogramma pretiosum*. in the first year of collection the medium number of sample, of egg-cards with parasitism, as well as the medium number of parasitized eggs, they presented an inverse relationship when compared with the areas of altitude among 200 to 850 meters. in the areas of smaller altitude (200, 380 and 450m) a constant presence of that parasitoid of eggs was observed in all the areas inspect. In the second year of collection the same behavior was not observed in relation to the first, tends the medium values of the inferior parameters, with the medium number of eggs parasitized by cards, reduced by the half. Its two years results showed that the aggressiveness of the races of *t. pretiosum* was differentiated in function of the areas.

index terms: biological control, trichogrammatidae, tomatoes, eggs parasitoids

[1628] THE USE OF SUCTION TRAP TO COLLECT TRICHOGRAMMA SPECIES

<u>R. B. Ouerino</u> & R. A. Zucchi, Dep. de Entomologia, Fitopatologia e Zoologia, Univ. de São Paulo, ESALQ, Av. Pádua Dias 11, C. Postal 09, 13418-900, Piracicaba, São Paulo, Brasil, E-mail rbqsilva@carpa.ciagri.usp.br

Several studies with Trichogramma have been conducted for biological control of insect pests in the world, and consequently most species in agroecosystems have already been studied. Therefore, relatively little is known about Trichogramma species in other habitats. Several hosts occur in habitats not explored commercially and certainly many Trichogramma species can be found in these habitats. A common way to collect Trichogramma is to sample host eggs on plants. However, because host eggs usually are not found in natural habitats, indirect methods have been used such as: screened sweep nets, yellow pan traps, fine meshed-malaise traps, and vacuum samplers. In this study an electrical suction trap stationary (model "Seção de Virologia do Instituto Agronômico de Campinas") was used to collect Trichogramma species. The trap was set in a forest reserve of the Tupi Experimental Station, in Piracicaba, São Paulo, Brazil. The collecting recipient with the solution of glycerine and alcohol (3:1) was replaced every week. The specimens collected were taken to the laboratory for separation of the Trichogramma species. Later on, Trichogramma species were slide-mounted using Hoyer's medium. The results are preliminary and represent six months of collecting, with a total of twenty-four samples. Two species were identified: *Trichogramma pretiosum* a common species) and Trichogramma lasallei (a species described recently), but identifications of other species are being carried out. The suction trap is a good method to collect Trichogramma species. The specimens are not damaged, and they can be used for preparation of microscopic slides. Therefore suction trap can be used to survey Trichogramma in natural habitats (research supported by FAPESP).

Index terms: Hymenoptera, Trichogrammatidae, collecting method, egg parasitoid.

[1629] CHARACTERIZATION OF THREE SPECIES OF THE GENUS TRICHOGRAMMA

R. B. Ouerino¹, **R. A. Zucchi¹**, **A. I. Ciociola Jr.¹**, **C. L. Canete²**, & **L. A Foerster²**, ¹ Dep. de Entomologia, Fitopatologia e Zoologia, Univ. de São Paulo, ESALQ, Av. Pádua Dias 11, C. Postal 09, 13418-900, Piracicaba, São Paulo, Brazil, E-mail rbqsilva@carpa.ciagri.usp.br. ² Dep. de Zoologia, Universidade Federal do Paraná, C. Postal 19.020, 81531-990, Curitiba, Paraná, Brazil.

The separation of the species Trichogramma rojasi, T. lasallei and T. bruni based on morphological characters are discussed. T. lasallei (first record in Brazil) and T. rojasi were obtained from Anticarsia gemmatalis eggs on soybean, T. bruni was collected from Heliconius phyllis eggs (first host record) on wild passion fruit (Passiflora sp.) A morphometric study based on principal component analysis (multivariate statistical method) was conducted to characterize these three species and find out the characters which more contributed to distinguish them. The result shows that species are grouped differently and characters related to fringe setae of the forewing, setae scutellum and mesoscutum and male genitalia are more reliable to separate these species. T. lasallei and T. rojasi are dark species with a sclerotized genital capsule. T. lasallei can be separated by more anterior position of the ventral processes, the short setae posterior track of the hind wing and the ventral ridge linear, moderately long (anterior limits difficult to discern in slide material). In T. rojasi the ventral processes are positioned near to intervolsellar processes base, setae posterior track of the hind wing reaches the wing apex. T. bruni is yellow and differs primarily by having scutellum with the shorter anterior pair of setae difficult to see, ventral ridge linear more elongate (anterior limits visible), the shorter length of the posterior extension of the dorsal lamina and flagellum of antenna with basiconic peg sensilla (BPS) formula 2-2-2-0-1-1. However, in some specimens the BPS at 4th position can be found. Crosses (heterogamic and homogamic) between T. lasallei and T. bruni were developed and the results show incompatibility between them (research supported by FAPESP).

Index terms: Hymenoptera, Trichogrammatidae, Systematic, Egg parasitoid.

[1630] PARASITOIDS OF CITRUS PESTS IN REUNION ISLAND (INDIAN OCEAN)

S. Quilici, CIRAD-FLHOR Réunion, Laboratoire d'Entomologie, BP180, 97455, Saint-Pierre Cedex, France. E-mail quilici@cirad.fr

Reunion Island is a French overseas department in the west of the Indian Ocean. Citrus crops, which have been developped there since the last thirty years, are attacked by a variety of pests. The Citrus Greening Disease (CGD) has long been a major limiting factor of citrus growing. Until the 1980's, it was transmitted by the african psylla Trioza erytreae and the asian psylla Diaphorina citri. Among major pests are aphids transmitting the CTV (Citrus Tristeza Virus), particularly Toxongra citricidus and Aphis gossypii, different species of fruit flies (Ceratitis rosa and C. capitata), the Citrus Rust Mite (Phyllocoptruta oleivora), the South African Citrus Thrips (Scirtothrips aurantii), the Citrus Flower Moth (Prays citri), and various species of scale insects. More recently, the Citrus Leafminer (Phyllocnistis citrella), has been recorded in the island. The Wooly Whitefly, Aleurothrixus floccosus, for a long time a major pest, has been successfully controlled biologically. During the last thirty years, parasitoids have been used in classical biological control programs conducted by CIRAD scientists against citrus pests. The programme against the vectors of CGD can be considered a case-study of successful biocontrol in an island. While the introduction of the eulophid Tamarixia dryi (1974) allowed the eradication of T. erytreae at the beginning of the 80's, the introduction of Tamarixia radiata (1978) led to a drastic reduction in the populations of the asian psylla. A very favorable biological equilibrium also followed the introduction of Cales noacki against the Wooly Whitefly in 1976. More recently, the successful introduction of Ageniaspis citricola in 1997 enabled us to improve the natural control of the Citrus Leafminer. Indigenous parasitoids may play a prominent role in the natural control of various citrus pests, as in the case of the large parasitoid complexes associated with lecanid or diaspid scales. The Margarodidae Icerya seychellarum is under very good control by the combined action of the ladybird Rodolia chermesina and the dipteran parasitoid Cryptochetum sp.. Five indigenous parasitoids play a major role in the control of the Citrus Leafminer. Aphids are also attacked by various species of Aphidiidae and Aphelinidae, with a variable degree of control. In other cases, the contribution of parasitoids to the natural control of the pest seems much less effective, like for fruit flies, for which parasitoids contribute as a minor mortality factor on wild host-plants. The possible side-effects of classical biocontrol must be thoroughly considered before any operation, particularly in the case of fragile island ecosystems. Current and future programmes will only consider the possibility of using parasitoids with the narrowest possible host-range. In the meantime, the knowledge of the local entomofauna has considerably progressed, allowing a better prevision of possible side-effects.

[1631] TEN YEARS OF STUDIES ON PARASITODS OF THE PEAR PSYLLA, CACOPSYLLA PYRI, IN SICILY (RHYNCHOTA PSYLLOIDEA)

<u>C. Rapisarda¹</u>, G. Siscaro¹, S. La Morella¹, S. Beninato², G. Campo², ¹Dip. di Scienze e Tecnologie Fitosanitarie, Sez. Entomologia agraria, Univ. of Catania, Via Valdisavoia, 5, I-95123 Catania, Italy, E-mail rapicar@mbox.unict.it; ²Osservatorio per le Malattie delle Piante, Corso Umberto, 114, I-95024 Acircale, Italy.

Studies on the parasitic complex of pear psylla, Cacopsylla pyri (L.), are carrying on from 1990 in Sicily, mainly in fruit orchards occurring in the area of Mount Etna. Springsummer observations have been based on periodical collections from foliage of parasitized nymphs of the psyllid and their isolation up to parasitoid emergence; similarly, winter studies have been carried on parasitized psyllid nymphs collected from branches and trunks of the plants, inside the bark cracks. For evaluating the total parasitization, adult emergence has been compared between C. pyri and its parasitoids, in stocks of 200 infested leaves collected during summer-autumn. Among primary parasitoids, the occurrence has been evidenced in the investigated area of three species of Hymenoptera Encyrtidae: Prionomitus mitratus (Dalman), P. tiliaris (Dalman) and Trechnites psyllae (Ruschka), all reported to develop on various pear- and hawthorn-feeding Cacopsylla species. Both the two species of Prionomitus are biparental, while T. psyllae is supposed to be parthenogenetic and no males have been ever collected in Sicily. Relative incidence of the three species showed to be variable in the investigated area. Compared to central European and North Italian environments, *P. mitratus* seems to have a lower diffusion and its occurrence never exceeded the 30% of the total parasitoid population; it has been mostly obtained from C, pyri nymphs during summer [June-July] and only in a few cases it overwintered on this host (rarely representing more than 10% of the overwintering parasitoid population). A higher frequence has been showed by P. tiliaris and T. psyllae, but with patterns of distribution and abundance differing even between close biotopes. P. tiliaris appeared to be the prevalent species (from 70 to 100% of total parasitoid population, both in summer and in winter) in orchards where IPM is applied, but showed lower levels, and very rarely exceeded 30% of the total parasitoid population, in orchards frequently sprayed with wide spectrum insecticides, where it seems to be replaced by T. psyllae. A different behaviour is shown by the two species also in their autumnal resurgence, after summer treatments: T. psyllae has a hasty start and may be abundantly recovered from mid September; on the contrary, P. tiliaris takes a longer time and its action significantly starts again from mid of October. Total parasitization, due to the whole complex of the three mentioned species, highly depends on peculiar ecological situations: in orchards where IPM is applied it may reaches values close to 46%.

Index terms: Prionomitus mitratus, P. tiliaris, Trechnites psyllae, parasitic activity.

[1632] PREDATORS IMPAIRING PARASITOIDS IN THE NATURAL BIOLOGICAL CONTROL

<u>R. Reis Jr.</u> O. DeSouza & E. F. Vilela, Depto Biologia. Animal Universidade Federal de Viçosa. 36571-000, Viçosa - MG. E-mail: crysopa@insecta.ufv.br .

There are many situations in which strategies of the natural biological control are not technically effective, failing to keep insect pest populations below damaging levels. We analyze a well known case of this insuccess: the puzzling coexistence of the coffee leaf miner (Leucoptera coffeella) and its natural enemies. Despite being a suitable prey to eight parasitoid species and three wasp species, all occurring simultaneously, the coffee leaf miner too often presents populations far above the damaging level for the coffee plantation. The experiment was carried out in three commercial coffee plantations in the region of Vicosa, state of Minas Gerais, Southeastern Brazil. The coffee leaf miner have not been subjected to any non-natural kind of control in these plantations, for the last 10 years. A total of thirteen 100m rows of continuous coffee plants were chosen within the selected plantations, so that three rows were located in the smaller plantation and the other two plantations held five rows each. Rows were chosen so as to cover the widest spatial range within each plantation, observing a minimum inter-row distance of 100m along lines of coffee plants, and 50m across lines. Statistical analyses inspected the relationship between presence of predators and presence of parasitoids, at the local scale; and the pattern of resource exploitation by predators and parasitoids. Regression lines were fitted to the data, along with control variables, as appropriate. It is demonstrated that wasps and parasitoids interact negatively ($F_{[1;11]} = 7.98$; P= 0.0165), possibly because wasps kill parasitized miner's larvae. In doing so, wasps indirectly kill parasitoids, thereby impairing the efficacy of the natural biological control. Patterns of resource exploitation by predators and parasitoids overlap partially, with predators exploiting mines which are slightly larger than the mines attacked by the parasitoids (Predators $F_{11:6j}$ = 43.99; P= 0.0006; t^2 = 0.88. Parasitoids: $F_{11:6j}$ = 1165.18; P< 0.0001; r^2 = 0.99.). It is warned that biological control programs should be based on knowledge of food web interactions, rather than simply on strategies involving introduction of exotic natural enemies.

Index terms: Leucoptera coffeella, interguild interactions, coffee.

Symposium and Poster Session

[1633] EFFECT OF THE PREY DENSITY ON THE FUNCTIONAL AND NUMERICAL RESPONSE OF TWO SPECIES OF PREDACEOUS MITES

P.R. Reis, E.O. Sousa, A.V. Teodoro & M. Pedro Neto¹, ¹EPAMIG-CTSM, P. O. Box 176, Lavras, MG, 37200-000, Brazil, E-mail: rebelles@utla.br.

The mites of the Phytoseiidae family are the most important and studied natural enemies of pest-mites. A question raised is that whether phytoseiid may reduce high densities of phytophagous mites and the studies which bring that answer are that of functional response (number of preys consumed per unit of time) and numeric response (offspring produced per unit of time or another change in the predator density). It was objective of this work to evaluate the predation potential of *Iphiseiodes zuluagai* and *Euseius alatus* (Acari: Phytoseiidae) as biological control agents of the phytophagous mite Brevipalpus phoenicis (Acari: Tenuipalpidae) vector of citrus leprosis and coffee ringspot. The bioassays were performed in laboratory at 25 ± 2 °C, 70 ± 10 % of RH and 14 hours' photophase. An adult female of each predator, in independent experiments, was confined in 3 cm diameter arena made with citrus leaves, floating on water inside a Petri dish. Immature phases of *B. phoenicis*, preferred by phytoseiid for predation were placed at the following amounts / arena: 1, 2, 5, 10, 20, 30, 35, 45, 55, 70, 100, 125, 200 and 300. The number of preys consumed and eggs laid by the predator were evaluated every 24 hours when the number of prey was replaced to the initial amount, for eight days. To both the predator mites, a positive and highly significant correlation was found between the number of mites consumed and the ones given. The number of eggs/day increased in terms of the number of preys consumed with a positive and highly significant correlation. The number of B. phoenicis consumed per day by the predator mite I. zuluagai increased in terms of the number of mites given, reaching a maximum percentage of predation around 55 mites / day. The number of mites *B.* phoenicis consumed per day by the predator mite *E. alatus* also increased in terms of the number of preys offered, reaching a maximum amount between 5 and 35 mites / day, less than, therefore, that presented by I, zuluagai. At the lowest densities, E. alatus proved more efficient in predation than I. zuluagai. It may follow also that E. alatus may prevent the increase of the population of B. phoenicis even at low densities of the phytophagous mite. The results showed that I. zuluagai was a predator more efficient than E. alatus at the highest prey densities. The fact for E. alatus to need less prey than I. zuluagai suggests that its survival may be better than that of I. zuluagai under low prey densities in the field.

Index terms: Iphiseiodes zuluagai, Euseius alatus, Brevipalpus phoenicis, citrus, coffee

[1635] EVALUATION OF BIOLOGICAL CONTROL – BACILLUS SPHAERICUS 2362, EFFECTIVENESS AGAINST MALARIA VECTORS IN AMAZONIA

<u>I. B. Rodrigues¹</u>, W. P. Tadei¹ & J. M. S. C. Dias³, ¹ Instituto Nacional de Pesquisas da Amazônia, caixa postal 478, Manaus, AM, Brasil, E-mail brandao@inpa.gov.br; ²Embrapa – Cenargen Brasília, Brasil. Funding: PPG7-FINEP / ABBOTT

The occurrence of malaria reports in the Amazonian region has shown an increasing number of cases, despite everything that has been done, in order to fight it, partly, due to the easimess of the development of mosquitos vectoring this disease within this region. Laboratory bioassays indicated Bacillus sphaericos as a promosing agent for controling species in this region, (Rodrigues et al. 1999), as na alternative for controling these vectors in their larval stage. Studies were carried out in this paper on the effectiveness of varied formulations of Bucillus phaericos 2362 in different natural breeding sites. The types of breeding site tested were: the ones in the wild , tanks in fish cujtures, the ones close to the headwaters and along the motorway. These selected breeding sites are the ones more frequently found within urban and rural areas in this region. Formulations of Bacillus sphaericos 2362 tested in these experiments are already industrialized in liquid and granulated form and applications occurred through the conventional method used by National Health Foudation. Formulations were SPHERICO^R - Geratee do Brasil, VECTOLEX from the United States, GRISELESF - Labiofam de Cuba and dosings used were differenciated according to breding site. Results obtained pointed out that the predominant species were A. triannulatus (42%), A. nuneztovari (34%), and A. albitarsis (24%) for the fishculture tanks, species classified as eusinatropic (Forattini et. al., 1993;1995). For breding site close to the headwaters the predominant species was A. darlingi (90%) the main vector for malaria in Amazonia and A. argyritarsis (10%). Formulation Spherico^R being effective in the dose 0.2ml/m2 in readings of up to 72 hours and for a fortnightly reaplication period. For breading sites along the motorway a relevant observed aspect lies in the residual lasting capacity of Vectolex found in these conditions which is fifteen days before the appearence of younger instars larvae and thirty days for recolonization of the breeding site, observed by two months of testing. The most effective formulations were Vectolex and Spherico, the former one presenting a greater risidual lasting capacity than the rest for the kinds of breeding sites that were studied. The formulated Grisselesf needs further testin for better conclusions.

Index Terms: Malaria, Bilogical Control, Anopheles.

[1634] FIRST RECORD OF CHRYSOPERLA EXTERNA PREYING THE CITRUS LEAF MINER PHYLLOCNISTIS CITRELLA

LJ.Ribeiro¹, E. Berti Filho¹ & M. B. Antonio¹, ¹Departamento de Entomologia, Fitopatologia e Zoologia Agrícola, Escola Superior de Agricultura Luiz de Queiroz, Universidade de São Paulo, Avenida Pádua Dias, 11, Piracicaba, SP, 13418-900, Brasil, Email lribeiro@carpa.ciagri.usp.br.

The Citrus Leaf Miner (CLM) *Phyllocnistis citrella* (Lepidoptera: Gracillariidae) was detected for the first time in Brazil, in the south of São Paulo State, in 1996. Now it is distributed all over the country, in citrus orchards with different varieties and ages. The Lacewings are important predators in citrus orchards, but, to date only two species have been registred attacking CLM: *Mallada boninensis* and *Mallada basalis*. Among the species present in Brazilian orchards, *Chrysoperla externa* (Neuroptera: Chrysopidae) is the most frequent one, preying mainly aphids, scales, mealybugs, spider mites and white flies. The predation of the CLM eggs, larvae of the first, second and third instars, and pupae by first, second and third larval instars of *C. externa* is recorded for the first time. New tests with other species have been carried out in laboratory to establish the importance of lacewings on the control of the CLM.

Index terms: CLM, lacewing, predator, biological control, citrus

[1636] PARASITISM RATE BY LYSIPHLEBUS TESTACEIPES (HYM.: APHIDIDAE) ON SCHIZAPHIS GRAMINUM AND APHIS GOSSYPH (HEM.: APHIDIDAE)

<u>S. M. M. Rodrigues</u>¹ & V. II. P Bueno¹, ¹Dept. of Entomology, Federal Univ. of Lavras, P.O. Box 37, Lavras-MG-BR, 37.200-000, E-mail: smmorais@ufla.br, vhpbueno@ufla.br

This work aimed to estudy the parasitism rate of the parasitoid Lysiphlebus testaceipes on Schizaphis graminum and Aphis gossypii with and without choice tests. For the tests, 10 colonies of S. graminum and 10 of A. gossypii with 20 nymphae of 2^{nd} and 3^{nd} instars were utilized. A female of L. testaceipes one day old, previously mated and without prior oviposition experience was utilized, its stayed in contact with the aphids for 24 hours. In with choice test, the parasitism rate was 67 and 46% for S. graminum and A. gossypii, respectively. In without choice test, a parasitism rate of 76% was obtained for S. graminum and a parasitism rate of 56% for A. gossypii. The aphid S. graminum showed more suitable for multiplication of the parasitoid L. testaceipes. Index terms: aphidis, aphidiid, biological control.

Symposium and Poster Session

[1637] LARVAL ENDOPARASITOIDS OF EPINOTIA APOREMA (LEPIDOPTERA:TORTRICIDAE) IN THE PROVINCE OF BUENOS AIRES, ARGENTINA

G. C. Rojas & G. G. Liljesthröm, CEPAVE. Calle 2 N° 584 (1900). La Plata. Argentina. E-mail cepave@museo.fcnym.unlp.edu.ar

Epinotia aporema feeds on different leguminosae and is one the most serious pest species of soybean. The larvae develop through 5 instars, which commonly live protected in a sort of cartridge constructed by the apical leaflets that remain attached one another by a silken web. In this preliminary study the incidence of larval endoparasitoids on cultivated (Glycine max and Trifolium pratense) and spontaneous (Galega officinalis and Melilotus albus) leguminosae were analysed in the localities of Magdalena and La Plata. Between January'97 and January'2000, 10-40 2^{nd} -3rd instar larvae were collected every 15 days and reared in the laboratory. The number of parasitoids and living pupae were recorded. With respect to the parasitism detected on larvae feeding on the diffferent leguminosae, the preference index Forage Ratio was calculated from the total number of parasitoids and larvae collected on each plant. A total number of 772 larvae were collected: 44.9% on G. Officinalis; 39.8% on M. albus; 11% on G. Max and 4.3% on T, pratense. The overall parasitism was 35.5% (n=274) detected from mid-spring until mid-winter, and parasitism on the different leguminosae was, respectively: 28.5%; 45.5%; 29.4% and 33.3%. Two endoparasitoids were found: *Bassus* sp (Hymenoptera:Braconidae) (n=114) and an undetermined species of Icheumonidae (Hymenoptera) (n=160). The *Bassus* sp. was detected on *M. albus* (n=112; FR=2.5) from November until July and *G. Max* (n=2; FR=0.02) in January. The Ichneumonid species was found on hosts feeding on all leguminosae: G. Officinalis (n=99; FR=1.34); G. Max (n=23; FR=1.3); T. Pratense (n=11; FR=1.6) and M. albus (n=27; FR=0.42), and except on M. albus (where parasitism was detected from mid-February until July), on the other leguminosae the parasitism was detected from November until July. These results suggest that the endoparasitoids coincide rather poorly spacially and that the spontaneus leguminosae would be important reservoirs for these endoparasitoids.

Index terms: Epinotia aporema, parasitoids, Bassus sp, Ichneumonidae, host plant.

[1638] ANALYSIS OF THE BIOLOGICAL CONTROL OF THE *DIATRAEA* SACCHARALIS AT DIFFERENT SPATIAL SCALES: LACK OF CONTROL OR POOR DATA SET?

M. N. Rossi¹, H. G. Fowler², M. B. Thomas¹ & H. C. J. Godfray¹ Leverhulme Unit for Population Biology and Biological Control, NERC Centre for Population Biology and CABI Bioscience, Imperial College, Silwood Park, Ascot, Berks. SL5 7PY, U.K., E-mail mrossi@ic.ae.uk;² Dept. of Ecology, Unesp, P.O. Box 199, Rio Claro, S.P. 13506-900, Brazil.

The biological control of Diatraea saccharalis is regarded as one of the best examples of successful classical biological control in Brazil. Since the introduction of the exotic parasitoid, Cotesia flavipe, from Pakistan at the end of 1970's, the decrease in the D. saccharalis infestation in sugarcane fields has been attributed to the effectiveness of this agent. Recently, the native Tachinid flics (Lydella minense and Paratheresia claripalpis) have also been implicated in the success, although they are less abundant than C. flavipes in sugarcane fields. Quantitative data confirming the actual contribution of these different agents to control of D. saccharalis is, however, rather scant. The purpose of this study was to investigate if there is any evidence of temporal density dependence between D. saccharalis and its parasitoids operating at different spatial scales. To answer this question, a large data set comprising information collected from two sugar cane mills (Barra and Sao Joao sugarcane mills, Sao Paulo State, Brazil) was analysed. The data set contained information on the number of *D. sacharalis, C. flavipes* and Tachinid flies sampled monthly per 'Talhao' (smallest spatial resolution level) from 03/1984 to 03/1997 and 01/1983 to 12/1996 for the Barra and Sao Joao sugar mills, respectively. Regression analyses were conducted on host density against the rate of parasitism per month of the different parasitoids during the whole period of the samples. These regressions were done at three spatial levels: global scale (the whole sugarcane mill); regional scale (the sugarcane mills divided into four smaller areas); and an intermediate scale (the sugarcane mills divided into seven small areas). The results revealed no clear evidence of direct density dependence at any spatial scale for any parasitoid species. Rather, there was evidence for inverse density dependence operating in the parasitoid-host interactions. Unfortunately, the nature of the data set and the way the data were collected limits the extent of the analysis and the ecological insights to be gained. Thus, to answer whether the parasitoids mentioned above have really decreased the density of D. saccharalis in sugar cane fields over the last twenty years, better time series are required, combined with experimental investigations on specific aspects of spatial and temporal population ecology. Index terms: Cotesia flavipes, Tachinidae, density dependence, spatial scale

[1639] FUNCIONAL AND NUMERICAL RESPONSE OF ORIUS INSIDIOSUS (HEMIPTERA:ANTHOCORIDAE) FED ON APHIS GOSSYPII (HEMIPTERA:APHIDIDAE)

<u>S. M. Mendes¹</u> & V. H. P. Bueno¹, ¹Depto. de Entomologia, Univ. Fed. de Lavras, Caixa Postal 37, Lavras, MG, 37200-000, Brazil, E-mail smmendes@ufla.br

The effect of densities 10, 20, 30, 40, 50 and 60 nymphs of 1st, 2nd and 3rd instars of *Aphis* gossypii Glover on food consumption of *Orius insidiosus* (Say) was studied in climate chamber at a temperature 25 ± 1 °C, $70 \pm 10\%$ RH and 12h photophase. Nymphs of 2nd instar showed a linear increase on prey consumption, showing a type I functional response. However, nymphs of 1st, 3rd, 4th and 5th instars and adults presented an increase prey consumption according to the density, tended to stability (type II functional response). There were a significant influence on search time and handling time at different densities, both to adult and different instars of *O. insidiosus*. In general, shorter times were recorded at higher prey densities. Concerning the numerical response, the viability of nymphs were 46,67; 67,65; 46.20, 82.35, 77.78 and 75.78% at different densities analized. There were no significant differences for pre-oviposition and oviposition periods at different densities of *A. gossypii*, which were 4.80 and 8.90 days respectively. The percentage of females which oviposited were 16.67, 50.00, 70.00, 90.00 and 66.67%. The number of eggs laid per females was affected by the different prey densities, which were 2.00, 11.33, 10.67, 21.30, 17.89 and 53.38 eggs. The viability of those eggs also showed influence of the different densities of *A gossypii*, which were 0.00, 50.11, 62.46, 57.86, 58.14 and 72.89%. Index terms: predation, prey density, aphid

[1640] BIOLOGICAL ASPECTS AND PREDATION OF ORIUS INSIDIOSUS (ILEMIPTERA: ANTIIOCORIDAE) ON CALIOTHRIPS PHASEOLI (THYSANOPTERA: THRIPIDAE)

<u>S. M. Mendes</u>¹ & V.II. P. Bueno¹, ¹Depto. de Entomologia, Univ. Fed. de Lavras, Caixa Postal 37, Lavras, MG, Brazil, E- mail smmendes@ufla.br

The biological aspects and consumption of Orius insidiosus (Say) fed on Caliothrips phaseoli (Hood) were studied in climate chamber at a temperature 25 ± 1 °C, $70 \pm 10\%$ RH and 12h photophase. The nymphal development period was on the average, 10.2 days, and not showing any significant difference for both males and females. The young phase consisted of 5 instars, each one lasting, on the average, 1.93, 1.72, 1.38, 1.80 and 3.10 for the 1st, 2nd, 3rd, 4th and 5th instars respectively. The nymphal viability was 68.46 %, with the greatest mortality occurred at the 2nd (16%) followed by 1st (13.67%) and 3rd (4.67%). O. insidiosus preyed, on the average, 73.72 C. phaseoli throughout its young phase. The total average consumption of nymphs increases with the successive instars, its being 6.09, 8.96, 11.38, 16.75 and 29.30 thrips from 1st to 5th instars, respectively. The females oviposited, on average, 77.82 eggs with a viability of 71.60% and an average embryonic period of 5.26 days. The females' longevity was significantly longer (21 days) than the males was 60.67 thrips.

Index terms: thrips, biological control, prey consumption

[1641] POS-INTRODUCTION OF THE NATURAL ENEMY AGENIAPIS CITRICOLA IN CITRUS GROVES IN JAGUARIÚNA AND AGUAÍ REGIONS, SÃO PAULO STATE, BRAZIL: PRELIMINARY RESULTS

L. A. N. de Sá¹, V. A. Costa², F. J. Tambasco¹, W. P. de Oliveira³, G. R. de Almeida¹ & R. A. A. Pereira¹, ¹ Lab. de Quarentena "Costa Lima", Embrapa Meio Ambiente, Cx.P. 69, 13820-000, Jaguariúna, SP, Brasil, lans@cnpma.embrapa.br; ²Lab. de Controle Biológico, Instituto Biológico, Cx.P. 70, 13001-970, Campinas, SP, Brasil; ³CNPq Fellowship Brasília, DF, Brasil.

Phyllocnistis citrella (Lepidoptera: Gracillariidae) is a pest of economic importance to the Brazilian citriculture because it is associated to the increase of citrus canker. In 1998, as part of a classical biological control program, the exotic parasitoid Ageniaspis citricola was imported from Florida, USA, in a partnership among Embrapa Environment (Brazilian Quarantine Laboratory), Gravena Manecol, ESALQ/USP and Fundecitrus. The objective of this work was to study the field control of P. citrella by this parasitoid, in comparison with the native and most abundant parasitoid Galeopsomyia fausta in citrus groves of Jaguariúna and Aguaí regions, State of São Paulo. In each grove, 3 releases of A. citricola adults were done at monthly intervals in Jaguariúna, and weekly intervals in Aguaí. The parasitoid was released in a central point of the orchard. To check parasitism, 100 leaves attacked by P. citrella were collected monthly in each area. It was observed that the native species number changed according to the region. In Jaguariúna, parasitism by A. citricola was 20.0% and by G. fausta only 5.6%, while in Aguaí A. citricola achieved values of 3.0% and G. fausta 22.1%. As the temperature and relative humidity were similar in both localities, this difference should be explained by the period of the releases combined with the vegetation of the area. In Jaguariúna, A. citricola was released at the beginning of the citrus branching process, when the occurrence of *P. citrella* was higher, thus helping its establishment and multiplication. The situation in Aguaí was different because the branching process was not on its course when the parasitoids were released. Also, the vegetation was more abundant in this locality than in Jaguariúna, and because G. fausta is a native parasitoid, possibly it was easier to find alternative hosts to multiply and survive. Collection of data from those areas will continue to verify how the parasites proportion will be in the next years.

Index terms: Phyllocnistis citrella, Galeopsomyia fausta, comparison, classical biological control.

[1642] SURVIVAL AND FECUNDITY OF ANAGYRUS KAMALI (ENCYRTIDAE) UNDER DIFFERENT STORAGE CONDITIONS

L. A. Sagarra¹, <u>C. Vincent²</u> and R. K. Stewart³, ¹ P.R.T. Ltd, Orange Grove Estate, Tacarigua, Trinidad & Tobago, West Indies (present address: 7, rue de Plaisance, 94130 Nogent-sur-Marne, France); ² Horticultural Research and Development Centre, Agriculture and Agri-Food Canada, 430 Boul. Gouin, Saint-Jean-sur-Richelieu, QC, Canada J3B 3E6; ³ Department of Natural Resource Sciences, Macdonald Campus of McGill University, 21,111 Lakeshore, Ste-Anne-de-Bellevue, Quebec, Canada H9X 3V9

The parasitoid, Anagyrus kamali Moursi [Hymenoptera: Encyrtidae], has been recently introduced into the Caribbean as a biological control agent against the hibiscus mealybug (HMB), Maconellicoccus hirsutus Green [Homoptera: Pseudococcidae]. Storage of A. kamali as part of a biological control program against M. hirsutus should not affect the longevity of female and male parasitoids when kept at $20\pm2^{\circ}$ C and fed ad libitum with droplets of pure honey, these were 40.3 ± 14.07 and 31.7 ± 9.57 days, respectively. Increase of the storage temperature from $20\pm2^{\circ}$ C to $27\pm2^{\circ}$ C decreased the longevity of insects fed on pure honey by about 10 days. Fed females did not resorb eggs during the first two weeks of storage at $20\pm2^{\circ}$ C. Parasitoid ovigenesis ceased when ovarioles/lateral oviducts were full. The lifetime fecundity of parasitoids stored at $20\pm2^{\circ}$ C wan ot significantly affected by a storage period of up to 14 days. Foraging activities and oviposition were the main factors influencing the lifespan of female A. kamali since regardless of the storage period, parasitoid oviposition period was not significantly different.

Index terms: Anagyrus kamali, Encyrtidae, Hibiscus mealybug, Maconellicoccus hirsutus, Pseudococcidae, survival, storage conditions. parasitism

Symposium and Poster Session

[1643] THE INFLUENCE OF TEMPERATURE ON DEVELOPMENT AND LONGEVITY OF APANTELES SUBANDINUS AND ORGILUS LEPIDUS (HYMENOPTERA: BRACONIDAE)

L. Salehi¹ & M. A. Keller², ¹Dept. of Crop Protection, The Univ. of Guilan, Rasht, Iran, E-mail: salehi@kadous.gu.ac.ir; ²Dept. of Applied and Molecular Ecology, The Univ. of Adelaide, Waite Campus, Glen Osmond, South Australia, 5064, E-mail: mkeller@waite.adelaide.edu.au

The rate of development and longevity of the two braconid endoparasitoids of larval potato tuber moth (PTM)), *Phthorimaea operculella* (Lepidoptera: Gelechiidae) was assessed at five constant temperatures: 15, 20, 25, 30 and 35°C under 24hr light and 50%RH. Parasitised and unparasitised larval PTM were reared in modified cages and supplied with excess potato tubers. *Apanteles subandinus* is better adapted to very low and high temperatures than *Orgilus lepidus*. At 35°C most *O. lepidus* did not complete development, dying mostly in the pupa stage. At high temperatures *A. subandinus* had an advantage over its host, while growth of *O. lepidus* was retarded compared with that of PTM. The results of this study predict that *A. subandinus* and *O. lepidus* should be well-adapted to the South Australian environment over the range of temperatures from 15°C to 35°C and the species are complementary due to their differing responses to temperature . The results suggest that parasitism could be increased by inoculative releases of *A. subandinus* are cooler and *O. lepidus* could be released later when weather is warmer.

Index terms: Apanteles subandinus, Orgilus lepidus, Phthorimaea operculella, temperature.

[1644] REPRODUCTIVE CAPACITIES OF TWO PARASITOIDS OF POTATO TUBER MOTH

L. Salchi¹ & M. A. Keller².¹Dept. of Crop Protection, The Univ. of Guilan, Rasht, Iran, E-mail salehi@kadous.gu.ac.ir; ²Dept. of Applied and Molecular Ecology, The Univ. of Adelaide, Waite Campus, Glen Osmond, South Australia, 5064, E-mail mkeller@waite.adelaide.cdu.au

Reproductive capacities of two braconids, Apanteles subandinus and Orgilus lepidus, endoparasitoids of larval potato tuber moth (PTM), Phthorimaea operculella (Lepidoptera: Gelechiidae) were investigated. The results showed following advantages of the two parasitoids when their reproductive capacity is compared: 1) The realised fecundity of O. lepidus is higher than A. subandinus when they are exposed to various densities of PTM at $24^{\circ}C$; 2) female O. lepidus has a greater number of ovarioles that allow it to produce more eggs than A. subandinus; 3) female O. lepidus does not decrease in size in laboratory, but A. subandinus becomes smaller when kept in continuously laboratory culture, perhaps due to inbreeding; 4) fecundity of female A. subandinus is higher than O. lepidus at high temperature; 5) A. subandinus has the advantages of shorter developmental time and more generations per annum than O. lepidus; 6) in both species, there is essentially no preoviposition period; 7) both species have greater fecundity than their host. The results indicate that these species should cause complementary mortality of PTM and thereby increase the degree of biological control than either species alone

Index term: Apanteles subandinus, Orgilus lepidus Phthorimaea operculella, reproductive.

[1645] PARASITISM OF *APHIDIUS COLEMANI* VIERECK (HYMENOPTERA: APHIDIIDAE) IN DIFFERENT DENSITIES OF *MYZUS PERSICAE* (HEMIPTERA: APHIDIDAE)

M. V. Sampaio¹, V. H. P. Bueno¹ & R. Pérez-Maluf¹, ¹ Dept. Entomologia, Univ. Fed. de Lavras, Caixa Postal 37, Lavras, MG, 37.200-000, Brasil, E-mail vhpbueno@ufla.br.

The green peach aphid, Myzus persicae, is an important pest in Brazil. This species cause significant crop losses in potato, sweet pepper, and tomato by feeding activity and virus transmission. The aphid parasitoid Aphidius colemani, is a efficient natural enemy of green peach aphid and the host density may significantly influence in enemy-host dynamics, sex ratio, and search behaviour of the parasitoid. The objectives of this research are to determine the functional response of the parasitoid *A. colemani*, by the number of mummies formed and it sexual ratio at a temperature 21±1°C and densities 20, 40, 60 and 80 M. persicae on sweet-pepper leaves into a glass tube (25cm x 4cm). Ten mated females A. colemani (24h old) were tested for each density, for a period of 2h. Also were evaluated it functional response to the number of hosts accepted, as well as it search behaviour with observations made on a stereoscopic microscope, at a temperature 23±1°C, densities 0, 4, 8, 16 and 32 *M. persicae* on leaf discs of sweet-pepper leaves (43mm) into a Petri dish (50mm). One mated female A. colemani (24h old) was then introduced for a period of 30min (15min for parasitism and 30min for first visit time) into a Petri dish. Ten females parasitoids were observed for each density. A. colemani's functional response was of type II, both to the number of mummies formed (12.4; 22.7; 33.0 and 31.6) as to the number of hosts accepted (0; 4.1; 6.8; 13.2; and 19.2), with a gradative increase in the number of hosts utilised with the increase in host density till this became stable. The sexual ratio tended to favour the females (57.2; 52.44; 62.6 and 54.38% of the emerged parasitoids), not showing any significant influence in host densities (P≤0,05). The number of touches made by the parasitoid's antennae on their hosts (encounters) continued to increase with the increase in host density, showing a brusque increase at the highest density (32 hosts), indicating an increase in the parasitoid's search where the density of M. persicae was highest. The time of the first visit of A. colemani showed no alterations at the different densities when the hosts were present (varying from 1526.9 to 1638.0 seconds) however the parasitoid remained on the leaf disk for less time (340.1 seconds) when no hosts were present.

Index terms: Biological control, parasitoid, aphid, host density

[1646] HOST PREFERENCE OF APHIDIUS COLEMANI VIERECK (HYMENOPTERA: APHIDIDAE) FOR MYZUS PERSICAE (SULZER) AND APHIS GOSSYPHI GLOVER (HEMIPTERA: APHIDIDAE)

<u>M.V. Sampaio¹</u>, V.II.P. Bueno¹ & J.C. van Lenteren², ¹Depto. de Entomologia, Univ. Fed. de Lavras, Caixa Postal 37, Lavras, MG, 37200-000, Brasil, E-mail vhpbueno@ufla.br, ² Laboratory of Entomology, Wageningen University, P.O. Box 8031, 6700EH, Wageningen, The Netherlands.

The majority of Aphidiidae parasitoids attack a range of host species. The aphid parasitoid Aphidius colemani accepts Aphis gossypii and Myzus persicae as a host and is considered a potential biocontrol agent against these aphids. The host preference of A. colemani for 2nd and 3rd instar nymphs of M. persicae and A. gossypii was evaluated by determining the percentage of parasitized hosts and by observation of the search behaviour of parasitoids. Host preference by measuring the percentage of parasitized hosts in non-choice tests at a temperature 21±1°C and density 20 aphids on sweet-pepper leaves. Ten mated A. colemani females of 24h old were tested for each host species during a period of 2h. The observation of search behaviour in choice and non-choice tests, was evaluated by the number of encountered hosts, accepted hosts, the total number of larvae encountered and by the percentage of hosts with parasitoid's larvae inside. The observations were made with a stereoscopic microscope at temperature of 23±1°C, and a density of 16 aphids on leaf discs of sweet-pepper leaves (45mm) in a Petri dish (50mm). One mated female A. colemani (24-48h old) was then introduced for a period of 15 min into a Petri dish. Ten females parasitoids were observed for each treatment. All aphids were dissected 48h after parasitism. In non-choice tests parasitism was 52 and 75% for *M.persicae* and *A. gossypii*, respectively, and this points at a preference for the species A. gossypii. There was no difference in the percentage of emergence (85.95% for A. gossypii and 80.99% for M. persicae). There were no differences in the time of first visit and the number of encounters between the parasitoid and the two species of aphids in choice and non-choice tests. Preference can be concluded from the best acceptance of A. gossypii and by highest number of parasitoid larvae found on this aphid in both tests. The correlation between the number of stings of the ovipositor/host and the number of parasitoid larvae found in the host was positive and highly significant (R=0.92 and p=0.0001), thus showing that it is possible to estimate parasitism by observing the number of stings with the ovipositor (accepted hosts). Based on the percentage of hosts with larvae, no preference could be measured in the choice tests but in the non-choice test, A. colemani preferred A. gossypii. Concerning superparasitism, it was found that always only one larvae of A. colemani was found alive in a host and none of the parasitized hosts presented embryo nymphs inside them.

[1647] BIOLOGICAL ASPECTS OF EXOTIC PREDATOR CRYPTOLAEMUS MONTROUZIERI (COLEOPTERA: COCCINELLIDAE), REARED ON PLANOCOCCUS CITRI IN LABORATORY

N. F. Sanches¹, **E. S. Silva²**, **L. P. Santos² & R. da S. Carvalho¹**, ¹Embrapa Cassava and Fruit Crops, C.P. 007, Cruz das Almas, Bahia, 44.380-000, Brazil, E-mail: sanches@cnpmf.embrapa.br; ²College of Agriculture – Federal University State of Bahia – Cruz das Almas, Bahia, Brazil. Project granted by Banco do Nordeste S.A. – ETENE/FINEP

The exotic predator Cryptolaemus montrouzieri has been used commercially in programs of biological control of mealybugs and aphids in several countries. The objective of this work was to study some parameters of the biology of that exotic predador regarding to its multiplication. It was studied the capacity of laying eggs, the period of larval appearance, the duration of the larval, pré-pupal and pupal phases, the sexual maturity and total cycle of this exotic predador under laboratory conditions. The study was carried out in the Laboratory of Entomology of Embrapa Cassava and Fruit Crops, under temperature of 26±1°C, relative humidity of 65±10% and 12 hours photophase. After the individualization of the eggs and appearance of the larva of the predador in Petri plates (5 cm of diameter), it was offered as feeding substratum for the predator, nymphs, adults and ovissacs of the mealybug Planococcus citri reared in laboratory, using pumpkin Cucumis maximus Jacarezinho " as alimentary substract. The period for larval appearance lasted, on average, 5 days. It was observed that the larval phase presents 4 instars or stages with average duration of 15.5 days (minimum: 14 days and maximum:17 days). The pré-pupa phase lasted, on average, 2.5 days (min.: 01 day and max.: 04 days). The pupal phase lasted on average, 7.3 days. The total cycle (egg to adult's emergency) lasted, on average 30.2 days (mín.: 28 days and max.: 32 days). The adults' medium longevity was of 72.4 days (min.: 02 days and max .: 122 days). The sexual maturity was reached, on average, 2.7 days after adults' emergency. The females presented high laying eggs capacity. On average they laid 811.4 eggs (min.: 197 and max.: 2.220) during all their longevity. The average daily laying capacity was of 16 eggs (min.: 4.4 and max.: 26.4) and average viability was 62% thus demonstrating high reproductive capacity of that predator species when reared in laboratory.

Index terms: biological control, insecta, biology.

[1648] FUNCTIONAL RESPONSE OF CYCLONEDA SANGUINEA (COLEOPTERA : COCCINELLIDAE) AT DIFFERENT DENSITIES OF THE APHID MYZUS PERSICAE (HOMOPTERA: APHIDIDAE)

L.V.C. Santa-Cecília¹, R. de C.R. Gonçalves-Gervásio¹, R.M.S. Tôrres¹, F.R. Nascimento¹ & , M.V. Sousa.¹, ¹EPAMIG-CTSM P.O.Box 176, 37200-000 Lavras, MG, Brazil. e-mail: soccilia@ufla.br

Among the coccinelides *Cycloneda sanguinea* (Linnaeus, 1763) stands out as an efficient predator, both at the larval and adult phase of several aphid species. With a view to studying the functional response, search and handling time of the prey by the predator *C. sanguinea*, an experiment was set up in climate chamber at 25 ± 2 °C, $70 \pm 10\%$ of RH and 12 hour's photophase. As the food, third stage nymphs of the aphid *Myzus persicae* (Sulzer, 1776) were given. For the study of the search and handling time, the randomized block design in factorial scheme, was employed, the factors being made up from 6 densities of the prey (40, 60, 80, 100, 120 and 140) and of the sex of the predator (male and female). In determining the intake, the same design was utilized, employing, however, the split plot scheme, in time, the plots being constituted of the different densities and the sub plots of the predator's sex, taking into consideration also the time factor (24 and 48 hours). The search time was longer for the males and decreased in a linear form with increase of the prey's density, the handling time was not affected either by the different densities and the site and or by the predator's sex. An increased consumption of preys in terms of the increase of its density was found.

Index terms: Insecta, predation, functional response.

ABSTRACT BOOK I – XXI-International Congress of Entomology, Brazil, August 20-26, 2000

[1649] BEMISIA TABACI BIOTYPE B (HEMIPTERA: ALEYRODIDAE) AND ITS PARASITOIDS: GUADELOUPE ISLAND AS A REPRESENTATIVE SITE OF THE CARIBBEAN

N. Snuvion¹, C. Pavis¹, A. Hue⁴, M. Rousseau⁴, G. Deivare⁴, F. J. Martine Boissot¹, ¹INRA, Centre Antilles-Guyane, Domaine Duclos, 97170 Petit-Bourg, C²27DAD Av Agronolis, BP 5035. , C. Pavis¹, A. Huc¹, M. Rousseau¹, G. Delvare², F. J. Morales³ & N. Guadeloupe, F.W.I., E-mail: sauvion@antilles.inra.fr ²CIRAD, Av. Agropolis, BP 5035, 34032 Montpellier Cedex 1, France ³CIAT, A.A 6713 Cali, Colombia.

Over the past decade, the whitefly Bemisia tabaci Gennadius has caused extensive damage to cucumber, melon and tomato on the Caribbean island of Guadeloupe (Lesser Antilles). Recent collaborations have led to the characterization by RAPD, with primers H9, H16 and F12, of B. tabaci from Puerto Rico, Guadeloupe, Martinique and Trinidad. We have observed the population dynamics of B. tabaci, on experimental plots of squash (Cucurbita moschata), and we have also identified their parasitoids. The study areas were located at two sites on Guadeloupe: Petit-Bourg (INRA-Duclos) exhibits acidic oxisols with low fertility, humid tropical climate; annual rainfall 2.8 m, annual PET 1.3 m, average temperature 23.5°C, while Petit-Canal (INRA-Godet) is characterized by neutral swelling clay soils, humid tropical climate with a marked dry season; annual rainfall 1.6 m, annual PET 1.5 m, average temperature 26°C. Both sites are surrounded by a mosaïc of sugarcane, food crop parcels and natural forest at less than one kilometer. It is of special value to perform such studies on Guadeloupe, because this one island exhibits a suite of vegetation, climatic and geographic conditions that are more often found individually on the other Caribbean islands. Our RAPD results show that Bemisia from Puerto Rico, Guadeloupe, Martinique and Trinidad is biotype B - the same as that found in Australia, Colombia, France and the USA. The observation of population dynamics revealed that the Bemisia populations at Duclos are small throughout the year - less than five adults per leaf. At Godet, however population sizes were generally larger, particularly during July, when as many as 20 adults per leaf could be found. Eight species of parasitoids were found at Duclos (Encarsia transvena, E. formosa, E. tabacivora, E. strenua group, E. parvella, E. aff. hispida, E. aff. basicincta and Amitus bennetti) and only three at Godet (E. transvena, E. tabacivora and E. nigricephala). At Duclos, E. transvena is the most abundant species throughout the year, and thus seems to be better adapted to humid conditions. From January to July, E. aff. basicincta and E. tabacivora are present and competing with E. transvena. The others are quite rare. Studies such as these will aid in developing a biological control component in a management strategy which will limit direct damages due to B. tabaci biotype B on cucurbitaceae or to minimize impact of begomovirus on tomatoes in Lesser Antilles and other world regions as well.

Index terms: IPM, population dynamic, whitefly, Encarsia, Amitus

[1650] COEVOLUTION OF CONTRARY CHOICES IN HOST-PARASITOID SYSTEMS

S. J. Schreiber¹, L. R. Fox², & <u>W. M. Getz²</u>, ¹ Department of Mathematics, Western Washington University, Bellingham, WA 98225, USA; ²Department of Biology, University of California, Santa Cruz, CA 95064, USA; ² Division of Insect Biology— California, Berkeley, CA 94720. USA, email: University of EPSM. getz@nature.berkeley.edu

Our study investigates host egg-laying and parasitoid search preferences in patchy environments. Previous work showed that when only host traits were allowed to vary among patches, populations playing an ESS strategy conform to an ideal-free distribution, make congruent choices (i.e. hosts and parasitoids preferentially select the same patches) and exhibit direct density-dependence in percent parasitism. However, host-parasitoid systems in the field show a range of density relationships and behavioral studies have shown that host-parasitoid systems can exhibit contrary choices (i.e. hosts avoid the patches favored by the parasitoids). We extend previous ESS analyses by permitting life history traits of the parasitoid as well as of the host to vary between patches. The results confirm the central role of reproductive ideal free distributions in evolutionarily stable systems. Specifically, if N_i and P_i respectively are the host and parasitoid equilibrium densities when the habitat only consists of a single patch of type i, then the ESS strategy for the host population in the patchy habitat is to lay the proportion $N_{i}(N_{1}+..+N_{n})$ of its total egg production in patch *i* and the ESS strategy for the parasitoid population in the patchy habitat is to spend the proportion $P_i(P_1+..+P_n)$ of its total search time in patch *i*. From these expressions, we show how variations in life history traits between patches lead to contrary choices or congruent choices, or lead to direct density-dependence, inverse density-dependence or density-independence in the distribution of percent parasitism. For instance, if there is a patch which is marginal for the hosts and parasitoids (i.e. the intrinsic rate of growth of the host and the survivorship rate of the parasitoid are low), then the populations exhibit contrary choices. We perform a stability analysis of the ESS and show that when a patch is marginal for the hosts and parasitoids, populations playing the ESS always stabilize intrinsically unstable within-patch dynamics. Index terms: evolutionarily stable strategy, ideal free distribution

[1651] PREDATORS OF FRUIT FLY ANASTREPHA SPP (DIPTERA, TEPHRITIDAE) COLLECTED WITH PIT FALL TRAPS IN PSIDIUM GUAJAVA ORCHARDS UNDER REGULAR APPLICATION OF INSECTICIDE

K.C.A. Senô¹ & J.C. Galli¹, ¹ Dept. of Fitossanidade, University of São Paulo State. Rod. Prof. Paulo D. Castellani – km 5, CEP 14884-900, Jaboticabal-SP, Brasil. E-mail: seno@asbyte.com.br; jcgalli@fcav.unesp.br

Due to the lack of information about natural biological regulation of Anastrepha spp (Diptera, Tephritidae) fruit fly population in Brazil, which difficult the implementation of integrated control programs for these insects, and the sanitation of fruit production, this research was developed in Vista Alegre do Alto, São Paulo State, and University of São Paulo State, in Jaboticabal-SP. This research was carried out with two objectives: a) to study the performance of apparatus for the capture of fruit fly predators (pit fall traps) in the soil; b) to study the fluctuation of predators. For a period of 12 months, starting on March 1999, insects of the Labiduridae family and other predators were captured. It was not observed statistical differences between populations of Labiduridae in areas treated and not treated with insecticide fenthion. The population fluctuation and influence of relative humidity on predators were discussed.

Index terms: Dermaptera, trap, natural enemies.

[1652] EFFECTIVE PRESERVATION METHODS OF THE ASIAN LADYBIRD, HARMONIA AXYRIDIS (COLEOPTERA: COCCINELLIDAE), APPLICATION STRATEGY FOR BIOLOGICAL CONTROL OF APHIDS COCCINELLIDAE), AS

& Y. N. Youn¹, ¹dept. Of Agriculture Biology, Coll. Of Agriculture, M. J. Seo¹ E-Mail 305-764. Korea. National Univ. Taejon, Chungnam Youngnam@Hanbat.Chungnam.Ac.Kr

progress in the knowledge of mass rearing and preservation methods of aphid predators has been considered as one of the most important conditions for the realization of their control potential, coccinellids have been widely used in biological control for over a century, and methods for using these predators have remained virtually unchanged. to use of a ladybird beetle for the biological control of insect pests properly, mass collection and efficient preservation of ladybird beetle overwintering population is very important, the asian ladybird, harmonia axyridis, is easily collected annually at overwintering sites from mid november to march in the next year, so it is able to store as adults without any special rearing methods, as a result of considering the effective preservation methods of h. axyridis, it was possible to preserve ladybird overwintering population in fabix plastic box or milk paper pack at 4°c and 8°c without diets over 4 months showing the 84% survival rate. also, in the case of preserving the 3rd and 4th instar larva with microwave popcorn, it was able to decrease cannibalism by reducing contact frequency between individuals. although preserving efficiency somewhat decreased, it was possible to store ladybird larva with microwave popcorn up to 10 days without preys, after preservation with microwave popcorn in the incubator at 10°c, the feeding ability related to preservation was investigated. in result, there was no difference in ability of prey feeding between the normal and preserved individuals. finally, the 3rd and 4th instar larva which were preserved with microwave popcorn were released in a strawberry greenhouse where the strawberry capitophorus aphid and the strawberry root aphid were occurred. after released, for a month, aphid densities were investigated per 1 week, that was a result of concentrative predation by released ladybird larva in that aphid density continuously decreased and then there was no rising of aphid density again after release.

index terms: preservation, harmonia axyridis, coccinellidae, biological control, aphids

[1653] EFFECT OF ANT TENDING ON BIOLOGICAL CONTROL OF THE PINK HIBISCUS MEALYBUG ON ST. CROIX, US VIRGIN ISLANDS

M. S. Serrano¹ & <u>S. L. Lapointe²</u>, ¹ USDA, ARS, U.S. Horticultural Research Laboratory, PO Box 3008 Kingshill, St. Croix VI 00851, USA; ² USDA ARS, USHRL, 2001 South Rock Road, Ft. Pierce FL 34945, USA, E-mail slapointe@ushrl.ars.usda.gov.

The pink hibiscus mealybug Maconellicoccus hirsutus was introduced to the Caribbean basin in 1993. Subsequently, it has spread throughout the Lesser Antilles, Puerto Rico and Northern South America. Recently it was detected in the US mainland as well as in Mexico, Belize and other Central American countries. Most Caribbean countries where the post has been detected have established biological control programs based on several natural encinies including the predatory coccinellids Cryptolaemus montrouzieri and Scymnus coccivora and the parasitoids Anagyrus kamali, Gyranusoidea indica and Leptomastix sp. (Hymenoptera: Encyrtidae). An introduced mealybug species can be considered a new resource for resident ant species commonly found tending native mealybug species. On St. Croix, US Virgin Islands, we have observed that pink hibiscus mealybug colonies are tended by at least three ant species. It is known that ant-tending can affect the effectiveness of parasitoids. Parasitism by A. kamali was reduced by 15 20% in ant-tended mealybug colonies compared with colonies not yet adopted by ants, or colonies where tending ants were artificially removed with an insecticide treatment. The impact of ant tending on the effectiveness of biological control on the island ecosystems of the Caribbean has been largely overlooked. Implementation of a biological control program should consider the potential of ants to disperse mealybugs and to contribute to pest outbreaks by diminishing the effectiveness of biological control agents. The impact of ants on biological control of M. hirsutus will be discussed.

Index terms: Maconellicoccus hirsutus, biological control, parasitoids.

[1655] A MICRO-OVIPAROUS TACHINID PEXOPSIS PILOSA (DIPTERA: TACHINIDAE) PARASITIC ON SCARABAEID BEETLES IN JAPAN

II. Shima & R. Ichiki, Biosystematics Lab., Graduate School of Social and Cultural Studies, Kyushu University, Ropponmatsu, Chuo-ku, Fukuoka 810-8560, Japan, E-mail shimarcb@mbox.nc.kyushu-u.ac.jp.

Pexopsis species of the tribe goniini are known as tachinid parasitoids of scarabaeid beetles, and are characterized by the micro-oviparous habit. female flies of this tribe lay incubated microtype eggs on the host plants of host insects. when eggs are swallowed by host insects, they hatch in the host midgut and first instar larvae penetrate the host haemocoel. pexopsis pilosa is commonly found in japan during may to early july, but its host has been unknown, we observed the oviposition habit of this fly and conducted an experiment in which adults of a scarabaeid beetle, pledina castanea, were parasitized. pexopsis pilosa lay microtype eggs on flowers, as well as leaves, of chrysanthenums. this suggests that flower eating scarabaeids may serve as hosts together with leaf eating bcetles. when broad leaves were supplied, female flies tended to oviposit on the marginal area of leaves. eggs are very peculiar in shape: elongate, 0.56-0.6 mm long and 0.36-0.4 mm wide; chorion covered with transparent secretion; black hardened area on anterior 3/5, bullet-shaped in dorsal view, with posterior margin enlarged and strongly serrate, bearing weak reticulation dorsally; posterior area of egg soft and translucent, slightly narrowed to rounded posterior apex, second instar larvae were found in the thorax of host beetles with respiratory funnel attached to the host thoracic spiracle or spiracular tube. no larva was found in other parts of the host body. it is possible that fly larvae fed on host thoracic muscles, when more than two eggs were consumed by a host, at most two reached 2nd instar, but only one mature larva survived and emerged from the dorsal intersegmental membrane of the host abdomen. females of p. pilosa have 173-192 ovarioles per ovary. in mature females four oocytes were found in an ovariole, of which one is developed. in addition, the vagina is well developed and coiled containing 1,143-2,102 eggs in mature females.

index terms: parasitoid, tachinidae, oviposition, ovarioles, pledina castanea.

[1654] COMPATIBILITY OF ENTOMOPATHOGENIC NEMATODES AND F-1 STERILITY FOR MANAGING SPODOPTERA LITURA (LEPIDOPTERA, NOCTUIDAE) : PARASITOID RESPONSES AND HOST SUITABILITY

R. K. Seth & V. Baweja, Department of Zoology, University of Delhi, Delhi 110007, India.

Potential of entomopathogenic nematodes (EPNs) in conjunction with inherited (F-1) sterility technique, was assessed for evolving an effective control strategy for a serious Indian pest, Spodoptera litura. Substerilizing gamma doses (100Gy, 130Gy) employed in the F-1 sterility technique were evaluated for determining the suitability of F-1 progeny of irradiated insects as potent hosts for the EPNs infectivity. The entomogenous nematodes belonging to families Heterorhabditidae and Steinernematidae were evaluated in the present studies. Infectivity tests were conducted using filter paper bioassay and soil Per cent host mortality in unirradiated S. litura larvae bioassay. caused hy Heterorhabditis sp. was higher (>90%) than the mortality caused by Steinernema glaseri (ca. 80%). Per cent parasitization in F-1 progeny of S. litura, at 100Gy, by H. bacteriophora, H. indicus and S. glaseri, were observed to be 80.3%, 72.5% and 60.0%, respectively. The parasitization efficiency was further reduced at 130Gy. Harvesting potential of the nematodes was reduced in F-1 hosts at both the doses, in comparison to normal. The emergence of dauers indicated a different pattern in different species. The harvesting was significantly more in Heterorhabditis sp. than in S. glaseri. For instance, in normal (unirradiated) insects, the harvesting of dauers of H. bacteriophora from host was up to the level of 3.64 x 10⁵, and dauer emergence was 1.27×10^5 in case of H. indicus, whereas dauer emergence was about 3.07×10^4 in case of S. glaseri. Soil bioassays were conducted to ascertain the searching efficiency of the EPNs towards F-1 host larvae, in comparison to EPNs responses towards unirradiated hosts. The interaction of host density and radiation was assessed on bioinfectivity of EPNs. Host searching efficiency was determined in terms of area of discovery. The searching efficiency was increased with increase in host density in normal as well as F-1 host larvae. Although the normal insect hosts elicited better parasitization response by EPNs than F-1 insect hosts, but the suitability of F-1 insects was reasonably demonstrated. This reduced response of parasitization in F-1 insect hosts could be attributed to the deleterious effects inherited in the F-1 progeny of sub-sterilized insects employed in F-1 sterility technique for pest suppression. These studies indicate that biocontrol strategy using EPNs might be integrated with F-1 sterility technique for the management of S. litura.

Index terms: Entomogenous nematodes, Heterorhabditis, Steinernema, integrated pest management, inherited sterility

[1656] CONTROL OF PLANTHOPPERS AND LEAFHOPPERS IN RICE BY THE SPIDER ATYPENA FORMOSANA

L. Sigsgaard¹, S. Toft² & S. Villareal¹, ¹Entomology and Plant Pathology Division, International Rice Research Institute, P.O. Box 3127, MCPO 1271 Makati City, Philippines, E-mail: l.sigsgaard@cgiar.org; ²Univ. Aarhus, Dept. of Zoology, Bldg. 135, DK-8000 Aarhus C, Denmark.

Atypena formosana (Araneae: Linyphiidae) is the most important linyphiid in the rice ecosystem and surrounding areas such as levees, bunds and grassy areas, and is already in the rice field shortly after crop establishment. Both adults and immatures are found in the rice stem or at the base of rice hills, with more spiders in the canopy at night. A. formosana hunt for nymphs of planthoppers and leafhoppers, Collembola, and small dipterans, and may be a significant predator of small-bodied pests such as hopper nymphs, being a possibly important part of the complex of natural enemies that check hoppers in unsprayed irrigated rice. Studies of functional and numerical responses of A. formosana have demonstrated its potential to control populations of brown planthopper (BPH), Nilaparvata lugens (Hemiptera; Delphacidae) and green leafhopper (GLH), Nephotettix virescens (Hemiptera: Cicadellidae). The predation rates of A. formosana on BPH and GLH are high when assessed in cage experiments. The best fit was obtained with Hollings type II equation using the random predator model. Biological control of BPH and GLH may depend on a high density of predators in the field early in the cropping season. In order to support a high density of Linyphilds in the field, a community of alternative prey would be advantageous, depending on the quality of the alternative prey. We assessed the survival and development time of A. formosana on four different diets; BPH, GLH, Collembola (Entomobryidae), a mixed diet, and a control of no food. Survival differed significantly among the diets. Survival to adult was poor on pure diets of GLH and BPH, and best on Collembola and mixed diets. Spiders developed fastest on the mixed diet and the Collembola diet. Fecundity of adult spiders was lowest on pure diets of BPH, GLH, and BPH and GLH mixed, while diets of alternative prey (Collembola, Drosophila) and other prey mixtures resulted in higher fecundities. The relevance of these findings to biological control of hoppers in rice will be discussed.

Index terms: Nilaparvata lugens, Nephotettix virescens, Collembola, biological control, alternative prey
Session 08 - ENTOMOPHAGOUS INSECTS AND BIOLOGICAL CONTROL

[1657] EVALUATION OF THE PREDACIOUS CAPACITY OF CRYPTOLAEMUS MONTROUZIERI (COLEOPTERA: COCCINELLIDAE) IN ORTHEZIA PRAELONGA, PLANOCOCCUS CITRI AND DYSMICOCCUS BREVIPES

E. S. Silva¹, <u>N. F. Sanches²</u>, L. P. Santos¹ & R. da S. Carvaiho², ¹College of Agriculture - Federal University State of Bahia – Cruz das Almas – Bahia; ²Embrapa Cassava and Fruit Crops, P. O. Box 007, Cruz das Almas, Bahia, CEP: 44.380-000, Brazil, E-mail: sanches@enpmf.embrapa.br.

Cryptolaemus montrouzieri is a predator largely used on biological control of mealybugs and aphids. The objective of this work was to evaluate the predacious capacity of this predator on three cochineals species: Orthezia praelonga, Planococcus citri and Dysmicoccus brevipes . The experiment was carried out at the Entomology Laboratory of Embrapa Cassava and Fruit crops, under temperature of 26±1°C, 65±10% RH and 12 hours photofase and under environmental conditions (temp.: 28±1°C ; 75±5% RH). Specimens of C. montrouzieri recently emerged were individualized in Petri plate (5 cm diameter). Twenty individuals of C. montrouzieri (10 individuals/each environment) were evaluated for each one of the studied species of cochineal. The mealybugs P. citri and D. brevipes were obtained by growing them in laboratories, using as substratum pumpkin Cucumis maximo. The cochineal O. praelonga was obtained from infested plants of barbados cherry grow under green house conditions. O. praelonga: the predator C. montrouzieri consumed on average 0.7 nymphs in the 1st instar, 1.8 nymphs in the 2nd instar. The predador fed exclusively on O. praelonga doesn't complete the ecdise process, ocurring death in all the observed larval phases. In the adult phase it was able to predate O. praelonga in all phases of its cycle. On average it consumed 26.3 nymphs; 4.6 adults and 6.1 ovissacs of the female. The medium longevity of the predator was of 2.3, 6.3 and 7 days, in the 1st and 2nd instar and adult phase, respectively. Under environmental conditions there were no significant alterations. *P. citri*: during its larval phase the predator consumed, in average 0.1- 3.2 - 12.9 and 25.3 adults of P. citri, respectively. In the adult phase the predator consumed daily, on average, 3.92 adults cochineals. The medium number of ovissacs predated by the 1st, 2nd and 3°s. larval instars of C. montrouzieri were 2 - 3.8 and 3.3, respectively. The medium duration of the larval phase of the predator was 13.3 days. D. brevipes: during its larval phase the predador consumed in average, 2.9- 5.8 - 8.8 and 31.2 adults of D. brevipes, respectively. In the adult phase the predator consumed daily, on average, 3.8 adult cochineals. The medium duration of the larval phase of the predator was 13.3 days. Under environmental conditions there were not significant alterations. Nymphs and adults of C. montrouzieri were able to feed on all three cochineals species, however on O. praelonga only the aduit phase of the predator showed efficiency.

Index terms: Insecta, biological control, predator.

[1658] PYRROLIZIDINE ALKALOIDS (PAS) ANTI-PREDATOR ACTIVITY AGAISNT INVERTEBRATE AND VERTEBRATE PREDATORS

K. L. Silva & J. R. Trigo, Depto. de Zoologia, IB, UNICAMP. P.O. Box 6109, Campinas, SP, Brazil. CEP 13033-970. E-mail: klucas@uol.com.br; trigo@obelix.unicamp.br

PAs are secondary plant compounds with an unique role in the tritrophic relationship among plants, herbivore insects and their natural enemies. PAs-plants are visited by adults of Ithomiinae and Danainae butterflies. These are warning colored butterflies and sequester PAs mainly on the families Boraginaceae (Heliotropium) and Asteraceae (Senecio and Eupatorium), and use them either as precursor of male pheromones or for chemical defense against vertebrate and invertebrate predators. The aim of this study was test the anti-predator activity of different structures of PAs in different concentrations against the golden orb-weaving spider Nephila clavipes (Tetragnathidae), a model of invertebrate predator usually found simpatrically with these butterflies, and against chickens Gallus gallus, a model of visually hunting predator. On this study we performed bioassays using 1,2-unsaturated PAs: integerrimine:senecionine (macrocyclic PA) in a proportion 89:11 (I*), the monoester senecicylretronecine (SR*), and the nccine base retronccine (R*). All were presented in free base (*BL) and N-Oxide (*NO) forms. In Nephila bioassays, pure PAs was dissolved in MeOH, and 10 (I were topically applied in 4 different concentrations (0.38x10-4, 1.53x10-4, 24.50x10-4, and 392.90x10-4 (moles/mg, N=30 each) on individual palatable preys (frozen bees Apis melifera). In chickens bioassays, 5 (1 of the PAs with the same concentration as above was applied on diptera palatable prey (larvae of Chrysomya putoria) in 3 different concentrations (98.2x10-4, 392.9 x10-4 and 1571.4x10-4 (moles/mg, N=20 each). INO was more effective against N. clavipes than IBL; all preys with 392.9x10-4 (moles/mg of these PAs were released by the spiders. In the same concentration, chickens released only 15% of preys with those PAs forms. Both RBL and RNO was ineffective against N. clavipes and chickens, even in the highest concentration. SRBL had lower effectiveness against N. clavipes than IBL; the same results were found in the bioassays with chickens. The responses of N. clavipes and G. gallus to PAs concentration were different: spiders were more sensitive to small quantities of PAs than chickens. But in both experiments, macrocyclic PAs had a superior anti-predator activity in relation to monoester PAs; in the same view, *NO forms had a superior activity against these predators than *BL forms of macrocyclic PAs. In fact, PAs are found in the N-oxide forms in insects and plants. By the way, the ineffectiveness of necine base against predators can explain the production of callimorphine, a insect-PA never observed in plants and biosynthesized from retronecine.

Index terms: Nephila clavipes, Gallus gallus, PAs concentration, PAs structure.

Symposium and Poster Session

[1659] PARASITODS OF PHYLLOCNISTIS CITRELLA IN RIO DE JANEIRO STATE, BRASIL

P.R.R.Silva^{1,2}; O.R.F.Azevedo¹; R.Silva-Fiiho¹; W.C.Rodrigues¹; V.A.Costa³; S.S.P.Sousa¹ & P.C.R. Cassino¹, ¹Dept. de Entomologia e Fitopatologia, Centro de Manejo de Pragas "Cinciunato Rory Gonçalves", UFRP, BR 465 Km 07, Seropédica, RJ, CEP 23890-000, BR., E-mail:pr.cassino@uol.com.br; ²E-mail:pramalho@fst.com.br; ³Instituto Biológico de São Paulo, Seção de Controle Biológico das Pragas, Rodovia Heitor Penteado Km 3.5, Campinas, SP, CEP:13001-970, E-mail: valmir@acuarium.com.br.

The use of natural enemies has became increasingly frequent as a technique of pest management. In addition to reducing the use of pesticides and their noxius effects, this technique also reduces production costs. Since its introduction in Brazil, the citrus leafminer (*Phyllocnistis citrella*) has been controled basically through the use of insecticides. In order to identify the natural enemies of *P. citrella* occurring in the state of Rio de Janeiro, leaves with larvae and/or pupae were collected in the cities of Rio Bonito and Araruama, located in the citrus-producing region of the State. The samples were taken to the laboratory of the "Centro Integrado de Manejo de Pragas Cincinnato Rory Gonçalves" at "Universidade Federal Rural do Rio de Janeiro", where they were placed in petri dishes in a climate controled room at $25 \pm to 2^\circ$ C, 70% humidity with 12 hour photophase. After a period approximately 20 days, adult pest and their natural enemies emerged. The parasitoids identified in the samples from Rio Bonito were *Galeopsonyia fausta* (Tetrastichinae) and *Cirrospilus* sp.(Eulophinae). In addition to these two parasitoids, *Horismenus* ap. (Entedoninae) was also identified in the samples from Araruama.

Index terms: Phyllocnistis citrella; Tetrastichinae; Eulophinae; Entedoninae; Integrated Management

[1660] EFFECT OF NEEM PRODUCTS APPLIED AS SPRAYS TO PARASITISED HOST EGGS ON ADULT EMERGENCE AND LONGEVITY OF TRICHOGRAMMA SP. NR. MWANZAI

S. Sithanantham & A.T.Haile, International Centre Of Insect Physiology & Ecology, P.O. Box 30772, Nairobi, Kenya Ssithanantham@Icipe.Org.

The egg parasitoid, Trichogramma sp. nr. mwanzai, is known to occur commonly on the eggs of Chilo partellus in Kenya. Studies were undertaken on the effect of three necm products applied as sprays to parasitised eggs of host (Corcyra cephalonica). The effect of the timing of the sprays at 1,4 and 7 days after parasitisation on adult emergence and longevity of Trichogramma sp.nr mwanzai was assessed. The neem products - Neem kernel cake powder (NKCP) @ 50g/l, neem seed oil (NSO) @ 30ml/l and crude neem seed kernel extract (NSKE) @ 50g/l - were compared with two synthetic insecticides - carbaryl @ 2.03g ai/l and lambdacyhalothrin @0.06g ai/l - and with an unsprayed check. In general, the neem products sprayed at 1 and 7 days after parasitisation did not affect the adult emergence. However, when applied at 4 days after parasitisation, two neem products NKCP and NSO - resulted in significantly lower adult emergence (44 and 66%) compared to the check (77%). Adult emergence in treatments with the two synthetic pesticides was, however, much lower than with the neem products at all the intervals tested. The longevity of the emerged adults was also not affected by the neem products when sprayed on host eggs at one day after parasitisation. When sprayed at 4 or 7 days, Nevertheless, these NSO and NSKE resulted in significant reduction in longevity. reductions in adult longevity were much less severe than observed with the two synthetic insecticides at the three intervals tested. The results indicated that sprays of neem products differed in their extent of effect on adult emergence and longevity, depending upon the interval between date of host egg parasitisation and spraying. All the neem products tested were much less adverse in their effect on adult emergence and longevity of the parasitoid in comparison to the two synthetic pesticides.

Index terms: Trichogramma, neem, adult emergence, longevity.

[1661] FRUIT FLY BIOLOGICAL CONTROL IN LATIN AMERICA: MINIMIZING THE RISKS POSED BY TEPHRITIDAE IN MEXICO AND CENTRAL AMERICA TO THE CONTINENTAL UNITED STATES

<u>I. Sivinski¹</u>, M. Aluja², K. Bloem³, T. Holler⁴, S. Lux⁵, R. Messing⁶, P. Rendon⁷, & R. Wharton⁸, ¹USDA-ARS, CMAVE, P.O. Box 14565, Gainesville, FL, USA, jsivinski@gainesville,usda.ufl.edu; ²Instituto de Ecologia, 91000 Xalapa, Veracruz, Mexico; ³USDA-APHIS-NBCI, 429 Meadow Ridge, Talhahasee FL 32312, USA; ⁴USDA-APHIS-PPQ, 1913 SW 34 St, Gainesville, FL 32614, USA; ⁵Center for Insect Physiology and Ecology, P.O. Box 30772, Nairobi, Kenya; ⁶Dept. of Entomology, University of Hawaii, 7370 Kuamo'o Rd., Kapa'a, HI 96746, USA; ¹USDA-APHIS-PPQ, 4A Ave., 12-62, Zona 10, Guatemala City, Guatemala; ⁸Dept. of Entomology, Texas A&M University, College Station, TX 77840, USA.

Dense populations of Mediterranean fruit fly (=medfly), Ceratitis capitata (Weid.), occur throughout Central America and much of South America. The northward spread of the medfly into Mexico, and ultimately into the continental United States, has been prevented by a sterile insect (=SIT) / bait-spray barrier maintained along the Guatemalan/Mexican border by the international organization MOSCAMED (United States, Mexico, and Guatemala). Recently, the barrier has become increasingly permeable. Additional control methods are necessary, and biological control may be one alternative. In addition to medfly, there are several pest species of the genus Anastrepha in Mexico and Central America. Biological control could aid local subsistence farmers and help protect the USA from pest-invasion. -- Classical biological control: There is an ongoing exploration for new parasitoids in the medfly's area of origin, east Africa. At present one species, Psyttalia near concolor, is colonized in Guatemala. Two species of Fopius are also being collected in Kenya. One is an egg-pupal parasitoid, and since it attacks a particularly vulnerable stage of the host it may be valuable in biological control. -- Conservation of natural enemies: Unlike the medfly in Latin America, Anastrepha spp. are attacked by a large number of native parasitoids. Increasing their numbers and focusing their foraging might amplify the effect of these parasitoids. One means of doing this is to plant native trees whose fruits are infested with non-pest species of Tephritidae. These harmless species share parasitoids with pests, and act as a reservoir and multiplier of natural enemies that can then move into agricultural environments. --Augmentative releases: Combined augmentative parasitoid releases combined with SIT can have a greater effect on fly numbers than either used alone. This synergistic 2-pronged attack may be an alternative to chemical controls where insecticides are difficult to apply (urban areas, organic-growing areas, nature preserves etc.). In Guatemala, 3 species of the genus Diachasmimorpha are being reared and released against medfly.

[1662] THE COMMON EARWIG FORFICULA AURICULARIA; BENEFICIAL OR PEST IN ORCHARDS?

<u>M. G. Solomon</u>, J. D. Fitzgerald, R. L. Jolly, & N. Pepper, Dept. of Entomology & Plant Pathology, Horticulture Research International, East Malling, Kent, ME19 6BJ, UK, E-mail mike.solomon@hri.ac.uk

Modern apple and pear trees are relatively small and smooth-barked, offering few sheltering sites for beneficial insects. Experiments were conducted to investigate the practicability of manipulating the numbers of beneficial insects in orchards by providing artificial refuges in the trees. The most commonly found species in the refuges was the common earwig, Forficula auricularia L. In orchard experiments to examine the impact of this insect on populations of the pear psyllid Cacopsylla pyricola, carwigs were removed and excluded from some trees, and numbers were artificially enhanced in others. Within three weeks of the beginning of the experiment, numbers of psyllid eggs and larvae on the 'earwigs added' trees were consistently lower than the numbers in the 'earwigs removed' trees (in most cases the numbers were halved). Laboratory studies have shown that earwigs are capable of consuming large numbers of psyllid eggs. Earwigs also consume plant material, and for this reason are sometimes regarded as a pest in apple and pear orchards. In the above experiments there was no evidence of damage to pear fruits. In laboratory experiments designed to investigate the propensity of earwigs for causing primary damage to apples, fruits of three apple varieties of contrasting skin toughness and tissue hardness were artificially ripened and earwigs were confined in boxes with individual fruits. The resulting damage was negligible in all but the most over-ripe fruits of the variety that had the weakest skin. This suggests that earwigs cause little primary damage to fruit in the orchard. It is evident that plant feeding by earwigs does not negate their value as predators.

Index terms: Forficula auricularia, Cacopsylla pyricola, predator, orchard, apple.

[1663] OCCURRENCE AND REDESCRIPTION OF *MEGAMELUS SCUTELLARIS* BERC (HEMIPTERA: FULGOROMORPHA: DELPHACIDAE) IN ARGENTINA, A CANDIDATE FOR BIOCONTROL OF WATERHYACINTH

A.J. Sosa¹, A.Marino de Remes Lenicov², R. Mariani² & <u>H. Cordo¹</u>, ¹ USDA, ARS, South American Biological Control Lab. (SABCL). Bolivar 1559 (1686) Hurlingham, Buenos Aires, Argentina. E-mail: hacordo@rnail.retina.ar; alesosa@infovia.com.ar; ² Facultad de Ciencias Naturales y Museo de La Plata (UNLP). Dep. Científico de Entomología. Pasco del Bosque s/n (1960) La Plata, Buenos Aires. E-mail: amarino@ museo.fonym.unlp.edu.ar; mariani@nuseo.fonym.unlp.edu.ar.

Megamelus scutellaris is a promising candidate for the biological control of waterhyacinth (Eichhornia crassipes). Two years of studies at SABCL showed that it appears to be strictly monophagous on waterhyacinth which suggests that - after all screening tests are completed - it will become a new agent for biocontrol of waterhyacinth. This is highly desirable since more agents are needed to complement those already in use in fighting this worldwide troublesome plant invasive in most countries with tropical climates. The genus Megamelus has 42 species of which 5 occur in the Neotropical region: M. bifurcatus (Brazil), M. electrae (Brazil and Puerto Rico), M. iphigeniae (Brazil), M. scutellaris (Argentina) and M. timheri (Guyana). M. electrae was mentioned in Trinidad as a candidate for biocontrol of waterhyacinth but its study was discontinued. M. scutellaris was found by SABCL in Argentina, from Buenos Aires to Formosa, and in Iquitos, Perú. There are no records about the host plants of the other three neotropical species of Megametus. M. scutellaris was described by Berg in 1883 based upon only one macropterous female specimen collected in Corrientes, Argentina, which is in the collection of the Museum of La Plata. Since this description is elementary and devoid of illustrations, we redescribe it adding the male (macro and brachypterous) and the brachypterous female. The diagnose characters used were the whole coloration pattern of body, relative lengh of rostrum, relative lengh of antennal segments I and II, lengh and denticulation of metatybial spur, configuration of anal segment and genital structures of male and female. We collected M. scutellaris in the provinces of Buenos Aires, Chaco, Entre Rios and Santa Fé of Argentina and in several sites on the Amazon river in Iquitos, Perú

Index terms: Waterhyacinth, biological control, Delphacidae, planthopper

[1664] INFLUENCE OF ISOLATED OR GROUFED CLIMATIC FACTORS ON CHRYSOPERLA EXTERNA (NEUROPTERA: CHRYSOPIDAE) ADULT POPULATIONS

B. Souza & C. F. Carvalho, Dept^o. de Entomologia, Univ. Federal de Lavras, C.P. 37, Lavras, MG 37200-000, Brasil, E-mail: brgsouza@utla.br

The influence of a particular climatic factor (rainfall, relative humidity, maximum, minimum or average temperatures) on a single day as compared to periods up to 30 days before sampling dates, on population density of *Chrysoperla externa* adults was studied. Sampling was made weekly with an entomological net on 20 citrus trees in an area of ca. 2 ha, between 13:00 and 17:00 h, from May 1992 to April 1996. Daily weather records were obtained from the UFLA's climatological station. Correlation studies between the number of adults caught and prevalent climatic conditions both on a single day or in periods up to 30 days before sampling dates were made, with evidence that the climatic factors studied influenced its population density in both situations. The greater the number of adverage climatic factors on the adult population density of *C. externa* adults was most affected by minimum and average temperatures regardless of the way the data were analyzed (single or more days) before sampling dates. A tendency was found for an increase in the correlation coefficient, as data of more individual days were included for the analysis in the 30-day period before sampling dates.

Index terms: green-lacewing, predator, rainfall, relative humidity, temperature.

[1665] FOOD AND CARCASS ANALYSES OF THE PREDATORY BUG HARMONIA AXYRIDIS (COLEOPTERA: COCCINELLIDAE) AS REFERENCES FOR THE ELABORATION OF ARTIFICIAL DIETS

O. Specty¹, C. Piotte², G. Febvay¹, B. Delobel⁴, J. Guillaud⁴, J.F. Pageaux³, A. Ferran² & <u>S. Grenier²</u>, ¹Labo. Biologic Appliquée, UA INRA 203, INSA Bât. 406, 20 av. Einstein, 69621 Villeurbanne France, E-mail specty@jouy.inra.fr; ²Entomologie et Lutte Biologique, SPE, INRA BP 2078, 06606 Antibes, France; ³Labo. Biochimie et Pharmacologie, INSA Bât. 406, 20 av. Einstein, 69621 Villeurbanne France.

The predatory coccinellid Harmonia axyridis feeds on aphids as natural food and can be produced on Ephestia kuehniella (E.k.) eggs as substitution food. But the mass rearing of this coccinellid on E.k. eggs is too expensive for a large scale use in biological control. In order to define artificial diets, we estimated the nutritional needs of the predator by analyzing the two kinds of foods and we evaluated the impact of each food on the body composition of the coccinellid. Biochemical analyses were mainly conducted on proteins, lipids and carbohydrates. E.k. eggs as well as young aphids (Acyrthosiphon pisum) are rich in amino acids (12 % of the fresh weight). E.k. eggs are 3 times richer in lipids than aphids, but on the contrary the aphids are 1.5 times richer in glycogen than E.k eggs content. Compositions of the coccinellid feeding either on E.k eggs or on aphids were compared at amino acids and fatty acids level revealing a strong influence of the food on predator. In a second step, according to available substrates, different diets will be formulated partly by computation. The quality of the predators obtained on newly developed diets or on adjustments of already available diets will be compared with that of control predators. These researches were conducted with the support of the European Commission via contract FAIR6 CT98- 4322.

Index terms: Harmonia axyridix, Ephestia kuehniella, Acyrthosiphon pisum, entomophage

[1667] SYNOMONAL EFFECT OF CHICKPEA VARIETIES ON THE EGG PARASITOID TRICHOGRAMMA CHILONIS (TRICHOGRAMMATIDAE: HYMENOPTERA)

M. Srivastava¹, A. V. N. Paul¹, <u>A K. Singh²</u>, & P. Dureja³, ¹Div. Entomology, Indian Agric. Res.Inst., New Delhi-110012; ² Dept. Zoology, University of Delhi, Delhi-110007; ³Div. Agric. Chem., Indian Agric. Res. Inst., New Delhi-110012, India

Chemical previously identified as synomones utilized by parasitoids have been found in significant quantities in food plants of host insects. In the present studies hexane extract of ten different varieties of chickpea (Cicer arietinum) L.) obtained from vegetative and flowering phase were assayed for the synomonal response from the egg parasitoid, Trichogramma chilonis Ishii. Hexane extract of different varieties of chickpea were analyzed by Gas Liquid Chromatography for determining their hydrocarbon profile which showed the presence of straight chain saturated hydrocarbons ranging from C14 to C29 in both phases. Different varieties of chickpea contained varying number and concentrations of these chemicals, which enhanced the activity of parasitoid. The quantity of individual hydrocarbons ranged from 0.002 to 11.036 mg/gm in the vegetative phase and 0.003 to 49.309 mg/gm in the flowering phase. In general, the hexane extract of flowering phase of chickpea varieties evinced better synomonal response as compared to vegetative phase from the parasitoids. The better response observed in certain varieties and at a particular phase could be attributed to the presence of higher concentration of favorable hydrocarbons or appropriate proportion of favorable and unfavorable hydrocarbons present in the varieties. Heneicosane in the vegetative phase and, heneicosane and tricosane in the flowering stage seem to be critical as observed in different chickpea varieties for the synomonal activity. Variety 'Pusa 256 RL: 1985' at the vegetative phase and variety 'Pusa 1003' at the flowering stage elicited highest response from the parasitoids. These findings could be used for integrated pest management programme. Index terms: Hydrocarbon profile, biological control, heneicosane, tricosane.

[1666] BIOLOGICAL CONTROL AGENTS: IMPLICATIONS IN HOME AND INTERIOR PLANTSCAPES

D. D. Sreenivasam & J. C. Luhman, Minnesota Dept. of Agriculture, 90 West PlatoBlvd., St. Paul, MN 55107-2094, USA, E-mail: dharma.sreenivasam@state.mn.us.

In Minnesota, most plant feeding insects live outdoors and reproduce during warm seasons when their host plants are growing. Several of these plant feeders move in and thrive indoors on plants in homes and offices. This study focuses on four common pests infesting indoor plantscapes, their host plants and biological control agents. They are: Citrus mealybug, Planococcus citri, longtailed mealybug, Pseudococcus longispinus, and obscure mealybug, Pseudococcus affinis; cotton aphid, Aphis gossypii, potato aphid, Macrosiphum euphorbiae, and pea aphid, Acyrthosiphon pisum; brown soft scale, Coccus hesperidium, hemispherical scale, Saissetia coffeae; and the twospotted spider mite, Tetranychus urticae. Some of the biological control agents being investigated at our new Biological Control Facility completed in August 1998 are: lady beetles most used as biological control agents, an exotic Cryptolaemus monstrouzieri to control mealybugs and scales and Hippodamia convergens to control aphids; a minute pirate bug, Orius insidiosus to control mites, aphids, mealybugs and scale crawlers; and a predator mite, Phytoseiulus persimilis to control spider mites. Primary plants currently used for rearing pests are: potato for mealybug, miniature rose and Hibiscus for aphids, Diffenbachia and citrus for hemispherical and brown soft scale, respectively, and bush and fava beans for twospotted spider mite. This research has quantified the methods developed for insect/mite and plant rearing under controlled conditions such as temperature, light, and relative humidity approximating home and office interior conditions. The results of this study are easily applicable to any interior plantscapes.

[1668] THE ENTOMOPIIAGUE TRICHOGRAMMA SPP. (INSECTA, HYMENOPTERA) A CHANCE OF BIOLOGICAL CONTROL IN THE TRID MILLENNIUM, IN ROMANIA

<u>Ciochia Victor¹</u> & Stanca Cristina², ¹ Str. Pavilioanelor CFR, Nr. 30, 2200 - Braşov, România, Europa; ²Str. Calea Cinsădiei, Nr. 23, bl. 104, sc. B, ap. 26, 2400 - Sibiu, România, Europa

To healthy life is conditioned by large - scale application or even generaliyation of biological and biotehnological means for phytophsgous insect population limitation. Entomophague of the *Trichogramma* genus as well as biopreparations are but a "small weapon" to be use by Man in his struggle to achieve a rational and responsible integration of all known means to limit the damage produced by different life froms of the animal and vegetable kingdoms as well as bacteria and viruses. The entomophagous insect *Trichogramma spp.* together with other biological insecticides reprezents a control tool for an ecological farming created for the purpose of Man's welfare, according to his creative power, without the survival of all life forms on the ball of dust called "Earth".

Symposium and Poster Session

[1669] SUITABILITY OF AUSTRALIAN *TRICHOGRAMMA* SPECIES (HYMENOPTERA: TRICHOGRAMMATIDAE) FOR BIOLOGICAL CONTROL OF STORED PRODUCT MOTHS

J. L. M. Steidle¹, **D. Rees² & E. J. Wright²**, ¹FU Berlin, Inst. f. Biologie, Angew. Zoologie / Ökol. d. Tiere, Haderslebenerstr. 9, 12163 Berlin, Germany, E-mail steidle@zedat.fu-berlin.de; ²SGRL, CSIRO Entomology, GPO Box 1700, Canberra ACT 2601, Australia

The three Trichogramma species T. brassicae, T. pretiosum and T. carverae were assessed for their suitability as biological control agents against Ephestia cautella and E. kuehniella. These moth species are important pests in food manufacturing and processing facilities in Australia. Parameters examined were longevity, fecundity on eggs of E. kuehniella, walking speed of adult wasps, reaction to moth scales, and host acceptance and host suitability of eggs of E. cautella and E. kuehniella. T. pretiosum and T. carverae performed better than T. brassicae in all traits examined apart from fecundity. T. pretiosum and T. carverae differ mainly in higher fecundity and host acceptance in T. pretiosum, and a better host finding ability (walking speed, reaction to moth scales) in T. carverae. The suitability of the Trichogramma species for use as control agents is discussed with respect to these results

Index terms: Trichogramma species, Ephestia species, parasitoids, biological control, stored product pests, suitability

[1671] UTILIZATION OF EOCANTHECONA FURCELLATA (HEMIPTERA: PENTATOMIDAE) FOR AUGMENTATIVE BIOLOGICAL CONTROL OF COMMON CUTWORM SPODOPTERA LITURA IN TARO FIELD IN THAILAND

<u>W. Suasa-ard</u>, National Biological Control Research Center Central Regional Center, Kasetsart University/National Research Council, P.O. Box 1 Kampaengsaen, Nakhon Pathom 73140, THAILAND

The predatory pentatomid *Eocanthecona furcellata* (Hemiptera: Pentatomidae) is found as the potential predator for biogical control of lepidopterous pests. Investigation utilization of this predator was conducted at the NBCRC-CRC, Kampaengsaen, Nakhon Pathom. Approximately 20,000 third instar nymphs were produced every month. Two locations of taro field in Nakhon Pathom province are selected as investigation site, 2 plots in each site, released and control plot each plot covering an area of 2 acres. Approximately 2000 of third instar nymph were released every two weeks internal during April-August 1999 in released plots. After inoculative release the population of *E. furcellata* developed well and increased to higher level than those of in the control plot in both locations. Two month after release *E. furcellata* showed satisfactory evidence to control over the population of common cut worm, *Spodoptera litura* (Lepidoptera: Noctuidae) in the released plots. Keywords: potential, predator, inoculative release

[1670] FORAGING CUES FROM DIFFERENT HOSTS USED BY THE GENERALIST PARASITOID LARIOPHAGUS DISTINGUENDUS (HYMENOPTERA: PTEROMALIDAE)

J. L. M. Steidle & J. Ruther, FU Berlin, Inst. f. Biologie, Angew. Zoologie / Ökol. d. Tiere, Haderslebenerstr. 9, 12163 Berlin, Germany, E-mail steidle@zedat.fu-berlin.de.

Although various aspects of the foraging process of parasitoids are examined so far, there are almost no studies on the mechanisms by which generalist parasitoids are able to find and recognize their various plant-host complexes. Therefore the present study was initiated with the pteromalid wasp *Lariophagus distinguendus*, a parasitoid of larvae and pupae of at least 11 beetle species from 5 families that develop within seeds of different plants. In bioassays combined with comparative chemical analyses, we examined the hypothesis that chemical cues present in all plant-host complexes enable the broad host range of *L. distinguendus*.

[1672] NATURAL ENEMY COMPLEX OF THRIPS PALMI IN THAILAND

W. Suasa-ard & K. Charernsom, National Biological Control Research Center Central Regional Center Kasetsart University/National Research Council, P.O. Box I Kampaengsaen, Nakhon Pathom 73140, THAILAND

Field survey and evaluation of natural enemies of *Thrips palmi* carried out both in the laboratory at NBCRC-Central Regional Center, Kampaengsaen, Nakhon Pathom and under field conditions in many localities in Thailand. The investigation revealed that *Megaphragma* sp. and *Ceranisus menes* Walker were important egg and nymphs parasites. Anthocorid predator, *Wollastoniella rotunda*, *Wollastoniella parvicuneus* and *Orius* sp., were also found as important predators of *T. palmi* in Thailand. Keywords: natural enemies, *Thrips palmi* Thailand

[1673] ATTEMPTS OF USING INDICENOUS PARASITOIDS AS A CONTROL AGENT TO *LIRIOMYZA TRIFOLII* IN GREENHOUSES IN JAPAN

<u>T. Sugimoto¹</u>, K. Ohno², A. Ozawa³ & K. Takezaki⁴, ¹Lab. of Entomology, Kinki Univ., Nara 631-8505, Japan, E-nxail sugimoto@nara.kindai.ac.jp; ²Lab. of Entomology, Miyazaki Univ., Miyazaki 889-2192, Japan; ³Shizuoka Pref. Agric. Experiment Station, Toyota 438-0803, Japan; ⁴Kagoshima Pref. Agric. Experiment Station, Kagoshima 891-0116, Japan.

Liriomyza trifolii was accidentally introduced into Japan in 1990 and is now injurious especially to crops in greenhouses almost all over the country. Recently, two species of parasitic wasps have been imported from Europe for a seasonal incculative biological control to this pest in greenhouses. However, it is desired to use indigenous parasitoids as its control agent from the following reasons; first a profitability of species more tolerant to a high temperature in the greenhouse in western Japan and next a necessity of suppressing a risk of exotic organisms to an indigenous ecosystem. In Japan more than 200 species of Phytomyzidae are recorded and about 30 species of parasitic wasps are listed up as a parasitoid of L. trifolii. Of these parasitoids eulophids as an idiobiont arc extremely dominant. They kill hosts by both parasitization and host-feeding. We selected the following 3 candidates as a heat-tolerant and effective parasitoid from eulophids commonly found in western Japan, comparing the relationships of their development, reproductive ability and flying ability to temperature. Of eulophids tested, Neochrysocharis formosa, N. okazakii and Hemiptarsenus varicornis were most adaptive to a high temperature. Especially, N. formosa flew actively in the wider range of temperature than H. varicomis. This may mean that the former species can be effective as a control agent during a longer season every year. Furthermore, our culture of the former two species were thelytokous and so profitable not only to a mass-production but also as a control agent. The preliminary release experiments in greenhouses proved that these eulophids were hopeful as a control agent to L. trifolii. Now, further experiments are carried out to select the most adaptive species to the Japanese greenhouse out of these three parasitoids.

Index terns: Liriomyza trifolii, indigenous eulophids, control agent, heat-tolerant

[1675] TEN YEARS OF INTERNATIONAL EXCHANGE AND QUARANTINE OF BENEFICIAL ORGANISMS BY THE BRAZILIAN QUARANTINE LABORATORY FOR BIOLOGICAL CONTROL

<u>F. J. Tambascu¹</u>, L. A. N. de Sá¹, E. A. B. de Nardo¹, F. Lucchini¹ & J. L. da Silva¹, ¹ Lab. de Guarontena "Costa Lima", Embrapa Meio Ambiente, Cx. P. 69, 13.820-000, Jaguariúna, SP, Brasil, tambasco@enpma.embrapa.br

The Brazilian National Quarantine Laboratory "Costa Lima" Embrapa Environment is the only one in the country authorized, since 1991, by the Ministry of Agriculture and Supply (MA) to introduce natural enemies for pest control and also other beneficial organisms for scientific research. It is also one of the mandates of the Laboratory to interact with foreign institutions for export of biocontrol agents. The Main Services provided by the Quarantine Laboratory are: 1) To prepare documents for interested professionals needed for the request of Permits of importation to be issued by the Ministry of Agriculture; 2) To assist interested professionals in locating suitable sources of biocontrol agents for introduction; 3) To collect and Evaluate information concerning import and export of natural enemies; 4) To provide information to the Ministry of Agriculture concerning safety and scientific aspects related to the convenience of each introduction, in consonance with a supporting Technical Committee attached to it, 5)To provide quarantine service; 6)To monitor releases and evaluate efficacy; 7)To collaborate with the International Research Institutions in the exploration and exchange of native natural enemies under a previous cooperative agreement. During these ten years of activities the laboratory has processed 95 introductions of biocentrol agents and other microorganisms involving 13 species of insects parasitoids, 2 of predators, 7 of mites, 2 of nematodes and 47 of microorganisms. Also several international biological control projects have received cooperation from the quarantine laboratory, including USDA-ARS, University of Florida, IITA, IRD, CIAT, Amsterdam University and others. The other activities carried out by the laboratory are: To collaborate with the Southern Countries Phytosanitary Committee (COSAVE) in the harmonization of the regulation related to the Biological Control in the Southern Countries; To manage the International Information System on Biological Control via the Internet http://www.bdi.org.br/bdt/biocontrol, with a discussion list biocontrol-l@bdt.org.br; To maintain a Data Base about Biologicai Control Agents in Brazil; To alert the public on the bringing organisms into Brazil that are not officially approved, providing pamphlets, information brochures, meetings, videos and lectures. The Brazilian Quarantine facility intends to be an overseas laboratory for foreign research institutions around the world in order to promote biological control programs.

Index terms: classical biological control, introductions, exportations, cooperations.

[1674] HOST DEFENSE BEHAVIOR OF THE EGG PARASITOID PARATELENOMUS SACCHARALIS (ITYMENOPTERA:SCELIONIDAE) IN THE FIELD

Keiji Takasu, Faculty of Agriculture, Kobe University, Kobe 657-8501, Japan, E-mail takasu@kobe-u.ac.jp.

Females of Paratelenomus saccharalis, a solitary egg parasitoid of Megacopta punctatissimum, remain near a host egg mass after oviposition to defend the egg mass from conspecifics or interspecifics. I conducted field studies to determine effectiveness of host defense behavior in the kudze patches in Kobe, Japan. Host egg masses consisting of 20-50 eggs were daily laid from 11:30am to 3:30pm, while P. sacharalis female actively searched for or oviposited on host egg masses from 4:00pm to 7:00pm or sunset. Single females that had oviposited on an egg mass in the late afternoon, remained a host egg mass until sunset or the following morning. When a female approached the egg mass where another female was ovipositing, the resident aggressively chased the intruder out of the egg mass. However, intruders often stayed near the egg masses after being chased by residents, and repeatedly attempted to oviposit in hosts. Laboratory experiments showed that although each P. saccharalis female stayed near a host egg mass after oviposition for more than 3-8 h in light condition, it effectively defend the hosts from a conspecific intruder only for less than 2 h. In the field, however, residents do not have to defend their host egg masses more than 3 h. because they usually reach and start ovipositing on host egg masses within 3 h before sunset, and both residents and intruders are not active after sunset. Although intruders still may stay in the host patches and superparasitize the hosts in the following morning, progeny of residents laid a night before would have more chance to survive in such superparasitized hosts than that of intruders. Thus, P. saccharalis females could increase reproductive success even through host defense effective only for a limited time.

Index terms: Paratelenomus saccharalis, Megacopta punctatissimum, host defense, host searching, diurnal activity

[1676] NON-SUITABILITY OF THE BRAZILIAN SUGARCANE BORER, DIATRAEA SACCHARALIS, (LEPIDOPTERA: PYRALIDAE) AS A HOST FOR PEDIOBIUS FURVUS (HYMENOPTERA: EULOPHIDAE)

F. J. Tambasco¹, **F. Lucchini¹**, **L. A. N. de Sá¹**, **E. A. B. de Nardo¹** & **J. L. da Silva¹**, ¹ Lab. de Quarentena "Costa Lima", Embrapa Meio Ambiente, Cx.P. 69, 13.820-000, Jaguariúna, SP, Brasil, tambasco@cnpma.embrapa.br

Pediobius furvus, a gregarious endoparasitoid native of Africa has been recovered from a wide variety of hosts in the families Pyralidae and Noctuidae and has been introduced for biological control programs for stalkborers in several places. In 1995, the Sugar Cane Research Center, COPERSUCAR, Piracicaba, São Paulo, Brazil, requested a series of importation of this parasitoid through the Brazilian Quarantine Lab for Biological Control Agents, Embrapa Environment to complement its biological control program of D. saccharalis. The two first introductions came from Nairobi, Kenya, and the parasitoid came in pupae of Chilo partelus. (Lep: Pyralidae). From those shipments a total of 904 healthy parasitoids emerged and pupae of D. saccharalis and Anticarsia gemmatalis were offered as hosts. D. saccharalis pupae were offered in different ages and substrates such as: free in petri dishes; inside sugarcane logs, and attached in corrugated cardboard. Parasitism was not achieved in any of these tests. In the third shipment parasitoids came in pupae of Sesamia sp. (Lep: Noctuidae) and 2.334 parasitoids emerged. At this time there were offered 3.045 pupae of D. saccharalis, 194 of A. gemmatalis, 149 of Spodoptera frugiperda, 14 of Heliotis virescens and 4 of Thyrinteina arnobia. Few parasitoids emerged from A. gemmatalis and S. frugiperda only enough to maintain a colony until the forth generation under laboratory conditions. There was no emergence from D. saccharalis. Some pupae were dissected and we found completely developed dead parasitoid larvae inside, in other cases were encountered very small encapsulated larvae of the parasitoid. More importation of P. furvus from other regions in Africa was carried out in 1998. Parasitoids were received from IITA, Cotonou, Benin and from ICIPE, Nairobi, Kenya. The last shipment was the most successful, and some parasitoids emerged from, D. saccharalis and A. gemmatalis but the percentage of parasitism, was less than 1%. At this time there were offered 7000 pupae of D. saccharalis and 750 pupae of A. generatalis to the imported insects and the F1 generation was offered 3300 D. saccharalis and 650 A. gemmatalis. After the second generation, all the parasitoids were sent to COPERSUCAR to be mass reared, but they did not survive very long.

Index terms: introduction, parasitoid, Chilo partelus, Sesamia sp., Noctuidae.

[1677] HOST LOCATION BEHAVIOR OF THE PARASITOID FLY, EXORISTA JAPONICA (DIPTERA: TACHINIDAE)

C. Tanaka¹, <u>Y. Kainoh¹</u>, S. Nakamura² & H. Honda¹, ¹Inst. Agr. & For., Univ. Tsukuba, Tsukuba, Ibaraki 305-8572, Japan, E-mail (YK): parasite@sakura.cc.tsukuba.ac.jp; ²JIRCAS, Tsukuba, Ibaraki 305-8686, Japan.

We examined the response of female Exorista juponica to an herbivore-damaged plant in a wind tunnel and the effect of host frass or its extracts on the host location of females in a small cage. We used the common armyworm, Mythinna separata Walker (Lepidoptera: Noctuidae), as a host for this fly and as an herbivore to damage corn plants. Experienced flies conditioned to oviposit on the host/corn plant complex were attracted mostly to the host/plant complex and required a relatively short time to arrive at the plant. Damaged corn plants without host larvae and their frass were also attractive. However, only a few experienced flies were attracted to the undamaged plants. These two responses indicate that the damaged corn plants without the herbivore present emit an attenuated signal odor for female flies. Host searching time in the patch and the number of patch visits were analyzed by using a frass-containing patch (9cm in diam.) which was excreted from host larvae, and the patches to which host frass extracts with various solvents were applied. E. japonica females were arrested in response to the frass-containing patch after contacting the frass with their front tarsi, thereby they spent most of the time on searching the patch and continued to visit it. The females also exhibited area-restricted search on the methanol extract of host frass that was applied to a 9-cm filter paper. It is suggested that E. japonica females employ chemicals from host frass as arrestant in close-range host location.

Index terms: Exorista japonica, Tachinidae, Mythimna separata, Noctuidae, common armyworm, damaged plant volatile, host frass, arrestant.

[1679] BIONOMICS OF AMBLYSEIUS LONGISPINOSUS (PHYTOSEIDAE) AND ITS EFFICACY AS A BIOLOGICAL CONTROL AGENT OF EOTETRANYCHUS CENDANAI (TETRANYCHIDAE)

T. Thongtab¹, <u>A. Chandrapatya¹</u> & G.T. Baker², ¹Dept. of Entomology, Kasetsart Univ., Bangkok 10900, Thailand, E-mail agramc@ku.ac.th; ² Dept. of Entomology and Plant Pathology, Box 9775 Mississippi Sta. Univ., Mississippi State, MS, USA 39762

The egg, larval, protonymphal and deutonymphal stages of Amblyseius longispinosus (Evans) that fed on Eotetranychus cendanai, required 2.02 ± 0.13 , 0.57 ± 0.71 , 1.02 ± 0.27 and 1.16 ± 0.53 days. The total developmental time was 4.79 ± 0.61 days. Female longevity averaged 14.61 \pm 2.88 days where 19.54 \pm 6.36 eggs/female or 1.33 ± 0.29 eggs/female/day were laid. Highest predation rate was detected at a density of 40-50. Amblyseius longispinosus could be employed as biological agent of *E. cendanai* both in laboratory and greenhouse conditions at the predator: prey ratio of 1: 30-1:50. Index terms: Amblyseius longispinosus, Eotetranychus cendanai.

[1678] SPATIO-TEMPORAL DISTRIBUTION OF CITRUS LEAFMINER AND ITS NATURAL ENEMIES IN SÃO PAULO STATE, BRAZIL

S. Ternes¹, O. Bonato^{2,3}, <u>L. A. N. De Sá</u>³ & H. M. Yang⁴, ¹fecc/Unicamp, Embrapa Informática Agropecuária, C.P. 6041, 13083-970 Campinas, São Paulo, Brasil; ²ird (Ex-Orstom), França; ³embrapa Meio Ambiente, C.P. 69, 13820-000, Jaguariúna, São Paulo, Brasil, E-Mail Lans@Cnpma.Embrapa.Br ⁴imecc/Unicamp, C.P. 6065, 13083-970, Campinas, São Paulo, Brasil.

The citrus leafminer (clm) phyllocnistis citrella stainton (lepidoptera: gracilariidae) was reported in brazil in 1996. this pest became a real threat for national citrus crops because of its association with xanthomonas axonopodis pv citri, bacterial agent of the citrus canker, the objective of this work was to analyse during different seasons and growing periods the population fluctuations of immature stages of clms and of its most commun natural enemies, obtained data would also be used to validate a deterministic model (under development at present) describing the dynamic of parasitoid-pest interactions, the experiment was realized in a plantation located in cordeirópolis, são paulo state, to avoid heterogeneity, a 9 years-old experimental field of citrus variety 'pera' was selected and divided in 10 blocks composted of 18 plants each. at each sampling operation, conducted monthly from may 1999 to april 2000, one plant per block was randomly selected. the plant was divided in 3 equal strata (basal, medium and apical) and one branch per stratum was collected, each branch received identification (block number and stratum) and was kept in plastic bag for further lab observations, to analyse tree shade effect, cardinal position of branches was also recorded. in the lab, the 15th first leaves of each branch were analysed under stereomicroscope (the youngest leaf of branch being always considered as the first one). the number of eggs, larvae (1^{mt} and 2nd instars) and pupae of clm and galeopsomyia fausta (the most common natural enemy in the region) was counted, the presence of cirrospilus 'sp.' (other native natural enemy) and ageniaspis citricola (exotic parasitoid released in areas closed to our experimental field) was also recorded. spatiotemporal distributions of clm were statistically analysed, datas will also be used to validate the simulation model under development, informations resulting from different simulations would help to assess the impact of parasitoid-pest interactions and the efficacy of biological control in the field.

index terms: *phyllocnistis citrella, galeopsomyia fausta,* paresitoid-pest interactions, modelling, spatio-temporal distribution, citrus.

[1680] PERISTENUS PARASITISM OF LYGUS LINEOLARIS IN MULTIPLE PLANT HABITATS

K. J. Tilmon¹, M. P. Hoffmann², B. N. Danforth¹ & W. H. Day², ¹Dept. of Entomology, Cornell Univ., Ithaca, NY 14853, USA, E-mail kjt6@cornell.edu; ²Beneficial Insects Research Lab., 501 S. Chapel St., Newark, DE 19713, USA..

The habitat range across which a parasitoid can locate hosts is an important aspect of its biology, and also has clear implications for biological control. How effective is a parasitoid at targeting a pestiferous host when the host is a habitat generalist whose location may be more variable and less predictable than a specialist's? The host species in this study, Lygus lineolaris (Heteroptera: Miridae), is native to and occurs throughout North America. One of the broadest herbivore generalists, it has been documented on 328 plant species of 55 plant families in 30 orders. It is pestiferous on an unusually broad range of annual and perrenial crops. In North America, a suite of both native and intoduced parasitoid species include *L. lineolaris* in their host ranges. Three of these species are Peristenus digoneutis (Hymenoptera: Braconidae), P. pallipes, and P. pseudopallipes. P. digoneutis, a European species parositic on L. rugulipennis, was collected in European alfalfa and released in the U.S. for biological control of L. lineolaris. Its geographic range expansion has been monitored in alfalfa, and overlaps the geographic ranges of both P. pallipes and P. pseudopallipes. But given the broad range of plant habitats where L. lineolaris occurs, what is the parasitoid species richness and abundance encumbering the host taxon in different habitats? Stated another way, in which habitats will the various species track the host? The purpose of this study has been to survey patterns of parasitism in *L. lineolaris* in plant habitats other than alfalfa, the habitat of introduction for *P. digoneutis*. These habitats include strawberry (a high-value crop in which L. lineolaris is a key pest), weed species, rye/vetch cover crops, and old-fields. We are assessing parasitism by Peristenus species in these environments. Though sample analysis for all species and habitats was not complete at the time of writing, so far we have found P. digeneutis parasitism of L. lineolaris in strawberry, rye/vetch, and on Erigeron sp. in naturalized habitats. Thus, P. digoneutis finds and parasitizes its generalist host in multiple plant habitats.

Index terms: Peristenus digoneutis, Peristenus pallipes, parasitoid, host location

[1681] QUANTITATIVE MASS PRODUCTION OF THE STINKBUG PREDATOR PODISUS NIGRISPINUS (HETEROPTERA: PENTATOMIDAE)

<u>J.B. Torres</u>¹, W.S. Evangelista Junior¹ & J.C. Zanuncio², ¹DEPA-Fitossanidade, Univ. Federal Rural de Pernambuco, Av. Dom Manoel de Medeiros S/N – Dois Irmãos 52171-900 Recife, PE. E-mail: jorge@nelore.npde.ufrpe.br. ²DBA, Univ. Federal de Viçosa 36571-000 Viçosa, MG.

The stinkbug predator Podisus nigrispinus has been implemented for defoliators control in Brazil and other countries. Although, easily reared in laboratory on factitious preys, nymphs and adults maintenance in room environment is onerous due to time consuming and physical space required. Thus, this study aimed to evaluate the methodology developed by Manessman Fi-El Florestal using plastic box for nymphs rearing and adapt a new methodology to P. nigrispinus adults maintenance. Plastic boxes Sanremo™ 6-litter volume with food and water provided on cover were used for nymphs. Adults were hold in acrylic cages (20 x 20 cm), containing 10-cm absorbent paper strips for egg laying. Nyinphs were studied at 150, 200, 250 and 300 individuals per box; and adults at 8, 10, 12, 14 and 16 pairs per acrylic box. As food was used the same factitious prey provided in mass rearing Tenebrio molitor (Coleoptera: Tenebrionidae) larvae. For nymphs was evaluated the parameters nymph survivorship, developmental time, female and male body weight and food consumed. For adults was evaluated the total number of eggs produced and eggs per female, number of T. molitor larvae killed, female longevity and egg production as a function of killed prey. Based on Cluster analysis, 200 and 250 nymphs per box and 10 and 12 pairs per acrylic cage were the best densities. The female preference for egg laying was higher ($\chi^2 = 5.5^{\circ}$, p < 0.05) on paper strips than on acrylic box wall. Although nymph rearing in box provides reduction in labor and space, survival was low ranging from 25 to 75% according to density per box (r = -0.79, p < 0.01). Acrylic boxes used as recipient for adults maintenance showed adequacy for this purpose. However, in further investigations is recommended to use more strips of paper per cage to enhance egg collection. In addition, should be also considered the time of male in mating to increase female longevity and reduce food consume.

Index terms. Asopinae, biological control, mass rearing, oviposition.

[1683] CANDIDATE INSECTS FOR THE BIOCONTROL OF THE PLANT PILYTOPARASITE *PSITTACANTHUS* SP. (LORANTHACEAE) IN THE REGION OF THE PANTANAL, MATO GROSSO DO SUL STATE, BRAZIL

<u>M. A. F. Uchôn</u> & Caires, C. S. Laboratório de Controle Biológico de Insetos, Universidade Federal de Mato Grosso do Sul, Caixa Postal 04, CEP 79200-000 Aquidauana, MS, Brazil. E-mail <uchoa@nin.ufms.br>

The mistletoes, Psittacanthus spp., (Loranthaceae) are hemiparasitic plants that can be characterized as pests. They parasitize, and frequently, kill, wild plants, of urbane arborization and cultivated fruit trees, causing serious losses for the Brazilian fruticulture. The multiplication of this plant occurs only by seeds which are swallowed and spread by the feces of birds which feed on the fruits. Its control is very difficult, being carried out only by cutting the infested branches, because the use of herbicides damages the host plant. The objetive of this study was to investigate the occurrence of insects infesting fruits of Psittacanthus in the Cerrado and the south Pantanal region, with a view to using them as agents in the biological control of this pest. Unripe and mature fruits were collected in various localities of the muncipalities of Aguidauana (20° 30' S / 55° 47'40" W, 173 m) and Anastácio (20° 29' S / 55° 49' W, 170 m), Mato Grosso do Sul State, during the period of 29.07.1998 to 17.09.1999. Some 23.916 fruits (49 samples) of Psittacanthus sp. infesting 15 species of plantas from 10 Families were avaluated: Astronium sp., Myracrodruon sp. and Tapirira sp. (Anacardiaceae); Cordia sp. (Boraginaceae); Cecropia sp. (Cecropiaceae); Terminalia cattapa and Terminalia sp. (Combretaceae); Sapium sp. (Euphorbiaceae); Melia azedarach (Meliaceae); Acacia sp., Anadenanthera sp. and Enterolobium sp. (Mimosaceae); Artocarpus sp. (Moraceae); Psidium guajava (Myrtaceae) and Salix sp. (Salicaceae), totalizing a biomass of 59,016 kg, Some 1751 larvae were obtained, 1745 of Lonchaeidae (Diptera) and six of Lycaenidae (Lepidoptera). The adults were reared in the laboratory from last instar larvae, that were leaving fruits to pupate. Some 1520 adults of Neosilba McAlpine, 1962 (Lonchaeinae) and six adults of Thecla echelta Hewitson 1867 (Theclinae). The larvae of *T. echelta* occurred in fruits of *Psittacanthus* sp. parasitizing *Cecropia* sp. and *Anademanthera* sp. The only flies reared from the fruits of *Psittacanthus* sp. were of the genus Neosilba. However, the effect of the larvae of these lonchaeids on the germination of Psittacanthus sp. is still unknown. T. echelta feeds on the cotyledons, the embryo and on viscinia, hindering the germination of the seeds. This butterfly was seen to be the most promising as a candidate species for the biocontrol of Psittacanthus sp., although its incidence during the period was low.

Index terms: Neosilba spp., Lonchaeidae, Thecla echelta, Lycaenidae, mistletoe

[1682] PRACTICES OF IPM ON VEGETABLES IN HONG KONG

W. Tsang, Hong Kong Council of Early Childhood Education & Services, 103-6 Nam Wai House, Upper G/F, Nam Shan Est., Kowloon

The challenge for us all therefore is to increase agricultural productivity with a sustainable manner. However, higher productivity cannot be separated from ecological considerations. Integrated Crop Management means optimal farming practised in a sustainable manner. ICM is thus the only way ahead., and IPM is an important component of ICM. We implement organic farming for the production of green food, e.g. safe vegetable without contamination of chemicals, chemical pesticides are abandoned absolutely in the Garden farm of Hong Kong Council of Early childhood Education & Services (CECES). With a principle of sustainable development and decontamination of the environment, we have been cooperated with the Guangdong Entomological Institute on the implementation of an IPM program with biological control of vegetable pests in the Garden Farm since 1994. 1.Biological control by periodic releases of Trichogramma spp. (to control asian corn borer & diamond backmoth, white butterflies etc), entomopathogenic nematode (Steinernema carpocapsae, to control Debia undalis, Pieris rapae, Plutella xylostella, Prodernia litura, Phillotreta vittata), some predatory ladybirds & lacewings, sex pheromones traps (to kill adults of asian corn borer & daimonbackmoth), microbial insecticides (Bacillus thuringiensis, Beauveria bassiana & Nuclear polyhedrosis to control pests of Lepidoptera, Diptera & Coleoptera). Sometimes the botanical pesticides (such as garlic juice and derris) were used too. 2. Physical control was adopted also.(yellow pots, yellow sticky boards and silver gray plastic film were used for controlling aphids; sweet-and-sour liquor was applied as a trap-killer of tobacco cutworm). 3. Diversity in cropping. Crop rotation (Maize-radisheggplants; cucumber-onion-.peas; radish-spinach-cucumber) in the Garden Farm was applied as a husbandry method of precluding some vegetable pests and soil-borne diseases like Fusarium wilt on cucumber, tomatoes, and eggplants. Inter-cropping with a symbiotic mutualism manner (eggplant + onion; celery + peas; cabbage + onion; spinach + carrot) was implemented.

Index terms: IPM, ICM, organic farming, biological control, physical control, diversity.

[1684] CLASSICAL BIOLOGICAL CONTROL OF THE SPINY BLACKFLY, ALEUROCANTIIUS SPINIFERUS (HEM.: ALEYRODIDAE), AN ECONOMIC STUDY

M.A. Van den berg¹, G. Höppner² & J. Greenland¹, ¹ Institute for Tropical and Subtropical Crops, Private Bag X11208, Nelspruit, 1200, South Africa, E-mail jenny@itsc.agric.za; ²Inyoni Yami Irrigation Scheme, P.O. Box, Tshaneni, Swaziland.

The spiny blackfly, Aleurocanthus spiniferus (Hem.: Aleyrodidae) has been a major pest in some citrus orchards and home garden citrus and rose trees in Swaziland and South Africa since the early 1990's. Direct crop losses and control costs due to infestations by the spiny blackfly were studied at the Inyoni Yami Irrigation Scheme at Tshaneni, Swaziland. This amounted to R476 000 (= US \$79 000) for the 1995/96 season. Furthermore, it was estimated that the control costs incurred by home gardeners in the towns of Barberton, Nelspruit, and White River, South Africa, amounted to at least R100 000 (= US \$16 500). Classical biological control of A. spiniferus by the introduced parasitoid, Encarsia cf. smithi (Hym.: Aphelinidae) has been achieved with an average parasitism of almost 80%. Because of this classical biological control, no further crop losses occurred since the 1996/97 season and no chemical control was necessary for this pest during the following three seasons. However, in citrus orchards at Letaba Estate, Tzaneen and in Graskop town where the spiny blackfly spread to without the parasitoid E. cf. smithi being present, A. spiniferus remains an important pest. The amount spent to achieve biological control of the spiny blackfly, including the project overheads, amounted to R169 750 (= US \$28 000). If this amount is compared to the direct losses and control costs of a single season, the expenditure to establish biological control was exceptionally cost effective. A benefit ratio was calculated at 3.4.

Index terms: Aleurocanthus spiniferus, Encarsia cf. smithi, establishing cost, benefit ratio

[1685] BIOLOGICAL CONTROL OF GONIPTERUS SCUTELLATUS (COLEOPTERA: CURCULIONIDAE) IN PORTUGAL

A. Vaz, C. Valente & M. Serrão, RAIZ - Inst. de Investigação da Floresta e do Papel, Herdade da Torre Bela, apartado 15, 2065 Alcoentre - Portugal

The Eucalyptus Snout Beetle Gonipterus scutellatus Gyll. (Coleoptera: Curculionidae) is an Australian eucalypt defoliator that acquires pest status in all regions where introduction have occurred. This insect was recorded for the first time in Europe in 1976. Coming from the North of Spain it was detected in Portugal in 1995. Considering the economic impact of *Eucalyptus globulus* plantations in Portugal, the Research Institute for Forestry and Paper (RAIZ) began in 1996 to monitor the spreading area of the beetle. At that time the insect was present only in a small area of the NW of Portugal occurring now in approximately two thirds of the country. In 1997 RAIZ and the Forest Services (DGF) started a program aimed to control the beetle with the egg parasitoid Anaphes nitens Gir. (Hymenoptera: Mymaridae). Due to the reduced amount of available parasitoids a rearing facility was established in 1998. The first releases took place in 1997, in a systematic release point distribution along the NW region of the country, followed by releases in commercial eucalypt plantations. Since 1998 all releases where done in commercial forest, in cooperation with eucalyptus forest enterprises. Parasitism rates have been monitored since 1997 showing an increase in areas where parasitoids were released. Results are presented and discussed to evaluate the biological control program of *G. scutellatus* with *A. nitens*.

Index terms: Eucalyptus snout beetle, natural enemies, Anaphes nitens, Eucalyptus pests.

[1687] EFFECT OF DIATRAEA SACCHARALIS TREATED EGGS ON CRISOPIDS LARVAE

<u>L. Vicira¹</u>; G. Bissolli¹; P. Fortes¹, S. A. De Bortoli¹, J. E. Miranda¹ & A. T. Murata², ¹Dept. de Fitossanidade, Univ. Estadual Paulista, CEP 14884,900, Jaboticabal, SP, Brasil. ²Dept. de Biologia, Univ. de São Paulo, 14040-901, Ribeirão Preto, SP, Brasil (FAPESP Fellowship), E-mail: murataat@asbyte.com.br.

The crisopids are found in different agroecosystems, and they have great importance to the biological control. These insects are susceptible to the action of chemical products applied in the crop fields. This experiment had the objective to study the susceptibility of crisopids larvae to aqueous extracts of Azadirachta indica and Bougainvillea spectabilis. The extracts were made from leaves (0,5 Kg) and water (5 l). The work was carried out in lab conditions $(25 \pm 2 \,^{\circ}\text{C}, 70 \pm 10\% \,\text{RH}$ and 12 h photophase). It was used 3° instar larvae of Ceneochrysa cincta in multiple choice tests, being the larvae fed on Diatraea saccharalis eggs treated with plant extracts. The tests were accomplished in Petri dishes of 25cm of diameter releasing so larva at the dish center. It was evaluated the fatal number of larvae in each treatment during 10 minutes and the total number of consumed egg 24 h later. The results showed that 48.5% of insects went to the eggs treated with B. spectabilis extract, and 22.8% went to the eggs treated with A. indica, respectively. From this results it can be concluded that the two extracts have repellent to the crisopids larvae.

Index terms: Ceraeochrysa cincta; Azadirachta indica; Bougainvillea spectabilis insecticide.

[1686] EFFECTS OF CONVENTIONAL PESTICIDES ON THE PREIMAGINAL DEVELOPMENT OF *TRICHOGRAMMA CORDUBENSIS* (HYMENOPTERA: TRICHOGRAMMATIDAE)

Vieira, A. V.¹, <u>L. M. Oliveira</u>¹ & P. V. Garcia¹, ¹Univ. dos Açores, Dept^o. de Biologia, Rua da Mãe de Deus 58, P-9500 Ponta Delgada, Açores, Portugal. e-mail: ziza@notes.uac.pt

The effects of seven pesticides on different phases of egg to adult development (<24, 24/48, 48/72, 72/96, 120/144, 192/216 hours) of Trichogramma cordubensis (Vargas & Cabello) (Hymenoptera: Trichogramatidae) were analysed. One organophosphorus insecticide (Trichlorfon), one organochlorine insecticide (endosulfan), two pyrethroids (Deltamethrin and Lambda-cyhalothrin), a commercial formulation of Bacillus thuringiensis subsp. Kurstaki, and two fungicides (Acetamide+Dithiocarbamete and Basic copper sulphate) were selected. All the tests were carried out with fresh solutions of commercial insecticides, applied on the parasitized host eggs at the recommended concentration and an amount of water of 1000 l/ha. The controls were sprayed with distillate water. One Potter Tower equipment (Burkard, Rickmanswort, U.K.) was used for spraying parasitized host eggs. Analyses of variance (ANOVA) were conducted on all data. Where statistical differences existed between data sets (p<0.05), Student-Newman-Keuls tests were used to separate the differing treatments. The pesticides applied on different development phases did not affect parasitoid development times, except the endosulfan that delayed for one day the parasitoid preimaginal development. With few exceptions, the number of parasitized host eggs that turned black (i.e., with prepupa parasitoids) did not differ significantly between both the pesticides and the control. The first four pesticides (chemical insecticides) significantly affected the adult emergence rates, while for the other products the emergence rates were similar with the control values. Adult's longevity was very short when applied endosulfan or Trichlorfon (<1 and <2 days, respectively). With the other products longevity varied from 10 to 16 days. Globally, endosulfan was the pesticide more noxious to the preimaginal development of T. cordubensis, therefore the use of such product should be avoided when this species is present in the ecosystems.

Index terms: Trichogramma cordubensis, insecticides, fungicides

[1688] THE ITALIAN SPECIES OF ERETMOCERUS HALDEMAN (HYMENOPTERA: APHELINIDAE) AND THEIR ROLE AS BIOLOGICAL CONTROL AGENTS

<u>G. Viggiani</u>, Univ. Napoli"Federico II", Dept. Entomologia e Zoologia Agraria, Via Università, 100, 80055 Portici, Italia. E-mail: genviggi@unina.it

The genus Eretmocerus Haldeman includes 56 described species, but only about 40 are recognized as valid species. All of them are known as parasitoids of whiteflies. Taxonomic studies on this rather peculiar group of aphelinids increased last decade for the need of a correct identification of species, mostly potential biocontrol agents of Bemisia (tabaci complex), but we are rather far from a definitive characterization of several populations. At present the taxonomy of Eretmocerus is mostly based on the characters of the antennae and on the number of setae on the mid lobe of the mesoscutum. In fact, this group of parasitoids shows a relatively high interspecific morphological homogeneity in contrast to a pronuanced intraspecific variability. A survey on the Italian species of Eretmocerus started several years ago (Viggiani and Battaglia, 1983) and was continued in recent years with a sampling of parasitized whiteflies on wild plants, cultures in open field and on protected crops. Species of Eretmocerus have been obtained from the following hosts: Aleurolobus wunni, Aleurotuba jelinekii, Bemisia afer, Bemisia (tabaci complex), Parabemisia myricae, Siphoninus phillyreae and Trialeurodes vaporariorum. E. debachi, an introduced species, is the dominant parasitoid of the Japanese bayberry whitely Parabemisia myricae, at present a very rare pest in southern Italy (Viggiani, 1996). Another introduced species, E. eremicus, commercialized for the control of Bemisia tabaci complex, has been found on Trialeurodes vaporariom and in competition with the aphelinid Encarsia pergandiella. Another species, allied to E. roseni, as been obtained from the same host. E. longicornis resulted a rather rare parasitoid of Aleurolobus wunni and A. jelinekii, as E. roseni, parasitoid of B. afer. A dominant and widely spread parasitoid of Bemisia (tabaci complex) is Eretmocerus mundus. It shows variations in several characters (relative dimensions of the funicular segments, clava length, etc.), which are under study to clarify their biosystematic significance. E. mundus is active on several plants and causes naturally very high level of parasitization. Index terms: Bemisia, Parabemisia, Trialeurodes, parasitoid, whitefly

[1689] BIOLOGICAL STUDIES ON ENCARSIA PORTERI (IIYMENOPTERA: APHELINIDAE)

<u>M. M. Viscarret</u>, S. N. López & E. N. Botto, Insectario de Investigaciones para Lucha Biológica. IMYZA-CNIA-INTA Castelar. C. C. 25 (1712), Buenos Aires Argentina. Email: mviscarret@ciudad.com.ar.

Encarsia porteri is an heterotrophic parasitoid whose females develop as primary endoparasitoids of whiteflies nymphs, and the males as primary endoparasitoids of lepidopteran eggs. This wasp is the more frequently found attacking the ARG1 biotype of the Bemisia tabaci complex, a very important pest on cotton crops in the Argentinian Northeast. Knowledge about the biology of E. porteri is poorly known and its potential as a biological control agent for whiteflies has not been evaluated throughly. Therefore the objective of this study was to determine some biological parameters of this parasitoid. Host preference, developmental time and longevity for the female and the male of E. porteri were estimated on biotype ARG1 of B. tabaci complex and different species of lepidopteran eggs. The prefered nymphal stages of the whitefly by the parasitoid for oviposition and host feeding were 3 and 4. No female was observed to feed/oviposit on a nymph previously visited and used for the parasitoid. The mean developmental time (±SE, in days) for the female was: on tomato 19.2±0.40 and on cotton 23.40±0.58, being the first value significantly smaller than the second (K-W=19.46, P=0.00). Mean longevity (\pm SE, in days) of the female was: on tomato 18.59 \pm 2.68, and on cotton 20.55 \pm 1.59. There was no significantly differences between these values (F=0.44, P=0.51). The percentage of E. porteri males emerged from A. gemmatalis eggs (25%) was significantly greater than the percentage observed on eggs of Diatraea saccharalis (2.15%), Sitotroga cerealella (3.55%) and Cydia pomonella (7.72%) (F=5.01, P=0.03). Mean developmental time (±SE) of the E. porteri male on A. gemmatalis eggs (17.28±0.12 days) was smaller than the observed for the male emerged on D. saccharalis, S. cerealella, C. pomonella and Epinotia aporema. The developmental time on D. saccharalis was significantly greater than that observed on S. cercalella and E. aporema (D.s. 22.3 ± 0.64 days, S. c. 19.61 ± 0.44 days, C. p. 20.58 ± 0.40 days, E. a. 19.16 ± 0.13 days, F=49.85, P=0.00). The estimated mean longevity (\pm SE, days) for male of E. porteri was: on D. saccharalis 27.50±9.00, on A. gemmatalis 23.63±1.34, on C. pomonella 19.69±2.39, on E. aporema 15.71±1.36 and on S. cerealella 15.58±2.80.

Index terms: Encarsia porteri, heterotrophic parasitoid, host preference, developmental time

[1690] ENVIRONMENTAL AND PREY INTERACTION ON THE DEVELOPMENT AND REPRODUCTION OF THE STINKBUG PREDATOR PODISUS NIGRISPINUS

L.M. Vivan¹, J.B. Torres², F.S.L. Veiga² & J.C. Zanuncio³, ^{1.2}DEPA-Fitossanidade, Univ. Fed. Rural de Pernambuco, Av. Dom Manoel de Medeiros S/N, Dois Irmãos 52171-900 Recife, PE, E-mail Ivivan@yahoo.com; ³DBA, Univ. Federal de Viçosa, 36571-000 Vicosa, MG.

The stinkbug predator Podisus nigrispinus (Dallas) has been a source of natural control in various cropping systems in Brazil. It occurs widespread throughout the American continent under different environmental and prey conditions. Thus its development and reproduction were studied under laboratory ($28 \pm 1^{\circ}$ C, $53 \pm 5\%$ RH and 14 h of photofase) and open sided greenhouse (30 ± 5°C, 61 ± 23% RH and 12-13 h of natural photophase) conditions preying on tomato leafminer Tuta absoluta (Meyrick) caterpillars and the mealworm Tenebrio molitor L. pupae. Duration of the nymphal stage of this predator was similar between prey under laboratory conditions, however, it was delayed when fed on T. absoluta caterpillars in open sided greenhouse. Nymphs and adults of P. nigrispinus were heavier when fed with T. molitor in laboratory and greenhouse. Females and males showed similar weight with both preys and environmental conditions. Higher nymphs mortality was observed during 2nd instar for both prey and conditions, with viability from 32.3 to 50.0% for the nymphal stage. No differences were observed for female longevity between prey and environmental conditions. Number of egg mass, number of eggs and number of eggs per egg mass were similar between environmental conditions but higher for female fed on T. molitor than those females fed on T. absoluta. Females of P. nigrispinus maintained their body weight throughout lifetime between environmental conditions preying on the same prey, but higher body weight was observed at day 10 for females fed on T. molitor pupae under open sided greenhouse conditions. Oviposition rate was higher for females fed on T. molitor pupae than those fed T. absoluta in both conditions. *P. nigrispinus* decrease its performance preying on *T. absoluta* but it can develop and reproduce with this prey under fluctuating climatic conditions.

Index terms: Asopinae, biological control, temperature, Tuta absoluta, prey quality

[1691] FIELD AUGMENTATION OF ORIUS STRIGICOLLIS FOR THE CONTROL OF INSECT PESTS

C. L. Wang¹, C. T. Yseng² & P. C. Lee³, ¹Taiwan Agricultural Research Institute, Wufeng, Taichung, Taiwan, ROC, E-mail clwang@wufeng.tari.gov.tw; ² Tainan DAIS Poutzu Branch Station, Chiayi, Poutzu, Tainan, Taiwan, ROC; ³Kaohsiung DAIS, Kaohsiung, Taiwan, ROC.

Orius strigicollis is an effective predator of small insects with a feeding preference for thrips. This anthocorid bug can be found on many horticultural crops both in greenhouses and in open field, but usually at low densities. In the laboratory at 25[], one Orius bug ate more than 200 thrips (Thrips palmi), or 500-600 spider mites (Tetranychus kanzawai) during its whole life when sufficient prey was supplied. Mass rearing techniques for these flower bugs have been improved in recent years in Taiwan Agricultural Research Institute. Large numbers of flower bugs can be obtained in the laboratory by supplying O. strigicollis with bean (Glycine max) sprouts as plant food and ovipositional substrate, and flour moth (Ephestia cautella) eggs as preys. This facilitated studies on the effect of mass releasing of O. strigicollis as biological control agent under field conditions. Field experiments were conducted on eggplants grown in open fields in central Taiwan in 1998 and 1999. Depending on the size of the eggplants, thousands of 2-3 days old Orius nymphs were released to produce an average density of approximately one Orius nymph per leaf. In this way, Orius flower bugs were released every week for a period of 6 weeks. The number of Orius increasing with each release and reaching a maximum density of 0.8 per leaf. Densities of thrips, spider mites and whiteflies (Bemisia argentifolii) declined gradually after release of the flower bugs, and differences between this treatment and chemical control areas appeared 4-6 weeks after the first release. The control effect lasted for at least two months. The surfaces of the eggplant fruits showed less insect damage were evidently better than those from the chemical control areas.

Index terms: Thrips palmi, Tetranychus kanzawai, Bemisia argentifolii, eggplant, biological control.

[1692] PRELIMINARY OBSERVATIONS ON DIETARY SELF-SELECTION BY MANDUCA SEXTA: DO PARASITIZED LARVAE CHOOSE NOT TO CHOOSE?

L.-W. Wang¹ & <u>S. N. Thompson</u>¹, 1 Anal. Chem. Instrumentation Facility & Dept. of Entomology, University of Calif., Riverside, CA., U.S.A., 92521

This study examined the self-selection behavior of terminal instar Manduca sexta larvae, parasitized by Cotesia congregata, in relation to blood trehalose level. Earlier investigations have established that parasitized larvae maintained on sucrose-free diets or on reduced sucrose diets have an equivalent blood sugar level as normal insects reared on the same diet. In parasitized larvae this is due to enhanced induction of gluconeogenesis and blood sugar formation. The maintenance of blood trehalose suggested that dietary selfselection based on blood sugar level is preserved during parasitism. The findings presented here, however, indicate that parasitized larvae may alter their self-selection behavior. Newly molted unparasitized fifth instar larvae given a choice between a sucrose diet lacking casein and a casein diet lacking sucrose, select, over a three day period, the protein and carbohydrate diets in a ratio of approximately 2:1. In contrast, parasitized larvae given the same choice, select a ratio of 1:1, the same ratio as control parasitized and normal larvae given a choice between two diets of the same mixed protein and carbohydrate composition. Although the results suggest the absence of self-selection behavior in parasitized insects, when larvae are preconditioned on the sucrose or protein diet they initially select the alternate diet, in the same manner as normal larvae treated similarly. This demonstrates that parasitized M. sexta larvae are fully capable of dietary selfselection, and that the final 1:1 ratio of protein and carbohydrate consumed represents a different intake target than that of normal larvae. The above findings were related to blood sugar formation in parasitized and normal larvae that were allowed to self-select on alternate diets.

Index terms: Nutrition, parasitism, carbohydrate, protein, trehalose

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Session 08 - ENTOMOPHAGOUS INSECTS AND BIOLOGICAL CONTROL

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[1693] RESOURCE PARTITIONING BY TWO ICHNEUMOND PARASITOID SPECIES (HYMENOPTERA) OF A LONGICORN PEST, OEMONA HIRTA (COLEOPTERA: CERAMBYCIDAE), IN NEW ZEALAND

O. Wang & C. Shi, Entomology and IPM Laboratories, Plant Protection, Institute of Natural Resources, Massey University, Private Bag 11122, Palmerston North, New Zealand, E-mail Q.Wang@massey.ac.nz

The longicorn borer, Oemona hirta (Fabricius), is a New Zealand native beetle. It has become an important pest of many introduced crops in New Zealand such as citrus, apple, persiminon, grape, etc. and shelter belt trees, such as poplar. This feature has made the species subject to overseas quarantine interest because it can quickly establish and attack trees and vine crops overseas once introduced accidentally. Because the borer larvae bore into the branches and trunks, making chemical control impractical, alternative control approaches including biological control need evaluating. Host utilization and sex allocation of two ichneumond parasitoids, Xanthocryptus novozealandicus (Dalla Torre) and Compoplex sp., of O. hirta were studied in New Zealand. These parasitoids are idiobionts and their secondary sex ratio is female-biased, which may be a function of host size. Females of both species are significantly larger than males, and females allocate the sex of offspring depending on the size of host larvae, laying female-producing eggs on significantly larger host larvae. X. novozealandicus is larger in body size and shorter in ovipositor length than Campoplex sp. and consumes late instar larvae or pre-pupae in shallow galleries while the latter attacks early to middle instar larvae in deep galleries. This pattern suggests that the parasitoids avoid competition as ecological homologs between species.

Index terms: Cerambycidae, Ichneumonidae, Oemona hirta, parasitoids, Xanthocryptus novozealandicus, Campoplex, sex allocation, host utilization

[1695] INDUCTION OF FEMALE-EGG OVIPOSITION BY HIGH ILLUMINATION IN A PARASITOID, HAPLOGONATOPUS ATRATUS (HYMENOPTERA: DRYINIDAE)

<u>Y, Y, Yamada</u> & K. Metsugi, Entomology Lab, Faculty of Bioresources, Mie Univ., Tsu, Mie 514-8507, Japan, E-mail yamada-y@bio.tnie-u.ac.jp

We discovered that a solitary parasitoid, Haplogonatopus atratus, host-specific to the small brown planthopper, Laodelphax striatellus, is likely to lay female eggs under high illumination. We provided a 3rd-instar host to a female parasitoid in a 4.5-ml transparent vessel. The female usually caught the host within a few minutes after it had been placed into the vessel, and laid an egg into it. We sexed the egg by videotaping the oviposition behaviour and observing the movement of the sting (Yamada & Kawamura, 1999). By using a light beam from a fiber optic ringlight and florescent lights we let the parasitoid lay an egg under illuminations of 200, 1500, 3000, 5000, 10000, 20000, 40000, 60000 lux. The parasitoid was placed under each illumination 5 min before a host was provided. The proportion of male eggs was on an average 80.2 % for 200 lux and 76.7% for 1500 lux, 62.3 % for 3000 lux. The proportion ranged from 26.7% to 36.7% under illuminations of 5000 lux and over. In the next experiment, the illumination was changed from low (200 or 1500 lux) to high (5000 and 40000 lux) or from high to low when the parasitoid stopped moving her abdominal tip and fixed it on a point on an intersegmental membrane between the host abdominal tergites to insert an egg into the host. The egg was usually laid 20-40 seconds after the abdominal tip was fixed. When the illumination was changed from high to low, the proportion of males was 51.3% for 40000 lux and 53.3% for 5000 lux. On the other hand, when the illumination was changed from low to high, the proportion of males was 46.7% for 5000 lux and 73.3% for 40000 lux. These suggest that it takes time for high illumination to have an effect on female-egg oviposition, that the time changes with intensity of illumination, and that high illumination retains an effect for some time after the high illumination is stopped. In the third experiment, high illumination (5000 and 40000 lux) was stopped just before a host was provided, and 5 and 10 min before. With increasing time spans, the proportion of males gradually increased for the two illuminations: 45.3%, 61.5%, and 71.7% for 5000 lux; 41.3%, 57.3%, and 71.7% for 40000 lux. The effect of high illumination almost disappeared about 12 min (10 min plus a few minutes after a host is provided) after the high illumination was stopped, irrespective intensity of illumination.

Index terms: Laodelphax striatellus, sex ratio, sex allocation, haplodiploidy, illumination.

[1694] MASSIVE PARASITISM OF GRASSHOPPERS BY TACHINID MAGGOTS

D. W. Whitman, D. J. Otto, & M. A. Lamb, 4120 Dept. of Biology, Illinois State University, Normal, IL 61790, USA. dwwhitm@ilstu.edu.

In 1997, 82% of adult lubber grasshoppers (Romalea microptera) (fam.: Romaleidae) from south Florida. USA contained maggots of the tachinid parasitoid Anisia serotina (fam.: Tachinidae; subfam.: Goniinae) Ninety-two percent of 50 females and 72% of 50 males were parasitized. The number of maggots per grasshopper ranged from 0 to 63 and averaged 7.0 \pm 3.3 (SE). There was a strong trend, but no significant difference in the mean number of maggots per male (5.1 \pm 1.4 (SE) (n=50) vs. per female (8.9 \pm 1.8) (n=50). Parasitized grasshoppers had high mortality. The population density of this grasshopper fluctuates widely in nature. For example, the densities of grasshoppers (#/100 m²) at the most dense field sites in 1994, 1997, & 1998 were 900, 8, & 0.6 adults/100 m², respectively. This represents more than a 1000-fold decrease in grasshopper densities from 1994 to 1998. Perhaps the tachinid parasitoid is driving these strong changes in grasshopper population density.

Index terms: Romalea microptera, Anisia serotina, parasitoids, Romaleidae, Tachinidae

[1696] FECUNDITY OF EURYGASTER INTEGRICEPS AND EURYGASTER AUSTRIACA IN LABORATORY CONDITION AND NATURE

T. Yilmaz¹ & <u>M. Kivan²</u>, ¹thrace Agric. Res. Inst., Edirne; ²dept. Of Plant Protection, Agric. Faculty, Univ. Of Trakya, 59030, Tekirdag, Turkey, E-Mail Tzfbitkikoruma@Superonline.Com.

The sunn pests, eurygaster spp. (heteroptera, scutelleridae) are among the most important insect pests of wheat in turkey, the most severe losses caused by e.integriceps and e. austriaca in thrace region, by e. integriceps in the southern anatolia and also by e. maura in central anatolia. overwintered adults, nymphs and new-generation adults cause damage by feeding on wheat throughout the plant's development. primary method for controlling sunn pests in turkey is chemical spraying which is conducted on all fields where sunn pest densities exceed the economic damage threshold, biology, ecology and control of e. integriceps have been studied in detail. however, economic threshold should be reviewed and improved; crop losses should be assessed and also reproduction of sunn pests according to insect species and different localities. so, this study was carried out to determine and compare that the fecundity and oviposion period of these two species at 27±2 °c, 65±5 % relative humidity and 16:8 hr photoperiod in laboratory and field conditions, which was recorded by thermohigrograph. as a result, the data estabilished were shown table 1. mean oviposition time and number of eggs and egg masses per female of two species were not different significantly in laboratory and also in nature (p>0.05). however, the fecundity in laboratory was lower than nature, because the conditions were different. average of 20.5 °c and 62 % relative humidity were recorded durig the experiments in the field, it was concluded that in terms of egg production and egg laying period differences between e. integriceps and e. austriaca were not significant in both conditions.

Index terms: eurygaster integriceps, eurygaster austriaca, fecundity, oviposition

Symposium and Poster Session

[1697] EVALUATION OF THE INTERACTIONS BETWEEN GALLERIA MELLONELLA (LEPIDOPTERA: PYRALIDAE), ACHROIA GRISELLA (LEPIDOPTERA: PYRALIDAE) AND THE PARASITOID APANTELES GALLERIAE (HYMENOPTERA: BRACONIDAE)

G.C. Zacarin¹, N. Gobbi² & J. Chaud-Netto¹, ¹Dept. of Biology, Inst. of Bioscience, Email gzacarin@rc.unesp.br. ²Centro de Estudos Ambientais (CEA). ^{1,2} Univ. Estadual Paulista (UNESP), Ave. 24-A, n.1515, Rio Claro-SP, Brasil. Zip: 13506-900.

Females of the wax moths Galleria mellonella and Achroia grisella, deposit its eggs in the comb cells of the beehives. After the eclosion, each caterpillar begins feeding of honey and later on the wax of the comb, building many tunnels of silk and feces in the whole beehive. The method of chemical control of the moths is unsatisfactory, basing on fumigation and the use of this method causes inevitable contamination in the products of the beehive. The biological agent used against the moths is the endoparasitoid Apanteles galleriae. In this work the preferential host species was determined to the activity of posture of Apanteles galleriae. The reproductive capacity of females of this endoparasitoid was evaluated in fifth instar caterpillars of Galleria mellonella and Achroia grisella fed with standard diet and diets enriched with protein; the effect of the development of Apunteles galleriae females in caterpillars of Galleria mellonella or Achroia grisella on its capacity to discriminate one of those hosts, and the reproductive capacity of females of Apanteles galleriae in fifth instar caterpillars of Galleria mellonella and Achroia grisella, with variable weight, were also evaluated. The parasitoids were maintained in flasks of 30 ml with bored caps covered with net, where the food was placed (diluted honey or diluted honey + pollen). The caterpillars and the adults of Galleria mellonella and Achroia grisella were maintained in metallic recipients with caps covered by very fine metallic mesh, containing food (comb and artificial diet). The tests were accomplished in clean and sterilized Petri dishes. Females of Apanteles galleriae preferred to parasitize caterpillars of Achroia grisella, on the average, in 67% of the accomplished tests, independently of the proportion of available caterpillars of the two hosts species. Females of the 5th generation of parasitoid developed in Galleria mellonella or Achroia grisella caterpillars preferred to parasitize caterpillars of Achroia grisella, and that preference didn't depend on the number of available caterpillars of the two lepidopterous species. The corporal weight of the host interfered in the sex ratio of the obtained parasitoids. In caterpillars of larger weight the investment in female descendants was larger than in males, and in caterpillars of smaller weight it happened the inverse.

Index terms: parasitoid, nutrition, biological control, preferential parasitism, fitness

[1698] DETERMINATION OF THE THERMAL LIMITS OF TRICHOGRAMMA PRETIOSUM (PIRASSUNUNGA STRAIN), ON THE EGGS OF ANTICARSIA GEMMATALIS

B.A. Zachrisson! & J.R.P. Parra², ¹Instituto de Investigación Agropecuaria de Panamá (IDIAP), P.O. Box 6782, Panamá 5, Panamá, E-mail bazsalam@sinfo.net; ²Dept. Of Entomology University of São Paulo, São Paulo, Brazil, E-mail jrpparra@carpa.ciagri.usp.br.

The object of this investigation was to define the inferior (Tb) and superior (Ts) thermal limits, also to establish the optimum temperature (To), for the development of Trichogramma pretiosum. This will allow the adaptation of the parasitoid at thermal variable conditions. In this way, the eggs of Anticarsia gemmatalis that were collected in the soybean fields of Pirassununga, São Paulo, Brazil; were transferred to the laboratory to wait the emergence of T. pretiosum strain. For the multiplication in the laboratory, it was used the alternative host Anagasta kuehniella, and latter at the emergence of the T. pretiosum were submitted to the parasitism on eggs of A. gemmatalis. For the massive rearing of the natural host it was used an artificial diet based on bean, wheat germ, soybean protein and casein. To reach the proposed objective, the A. gemmatalis were summited to the T. pretiosum for a five-hour period at 25°C. Then they were transferred to climate chambers at different temperatures (18, 20, 22, 25, 28, 30 and 32°C), with photo phase of 14 hours and relative humidity of 70 ± 10%. An evaluation of the duration period of the cycle egg-adult and the viability of the parasitoid were done. From these parameters it was determined the thermal inferior limits by the hyperbole method and the superior limit by a non-lineal model proposed by Sharpe and Demichelle in 1977 (modified by Shoofield and collaborates in 1980). The duration of the cycle egg-adult varied from 7 to 22 days for 32 and 18°C, respectively. The viability was high, finding between 86 and 96 %. The inferior thermal limit was of 11.7°C, presenting a thermal constant (K) of 123.12 degree-days, with a determination coefficient (\mathbb{R}^2) of 0.9532. The thermal superior limit (Ts) was of 31.7°C, observing a determination coefficient of 0.99. The optimum temperature (To) for the development of T. pretiosum (Pirassunanga Strain) was of 30°C. Index Terms: Trichogramma pretiosum, Anticarsia gemmatalis, biological control, sovbean.

[1699] RATES OF PARASITISM BY METEORUS RUBENS AND M. GYRATOR ON THEIR INSECT HOSTS

F. N. Zaki¹; K.T. Awadallah² and, M.A. Gesraha,¹. 1- Pests and Plant Protection Dept., National Research Centre, Cairo, Egypt. E-mail fnazir@frcu.eun.eg. Fax: (202) 3601877. 2- Biological Control Lab., Fac. of Agric., Cairo University.

Rates of parasitism by the two braconid parasitoids, *M.rubens* (gregarious parasitoid) and *M. gyrator* (solitary parasitoid) were estimated in association with certain lepidopterous pests in four governorates in Egypt, *i.e.*, Giza, Fayoum, El-Gharbia and El-Sharkia. *M.rubens* were most predominant and most effective than *M. gyrator*. Associating with *Agrotis ipsilon*, the main host of *M.rubens*; rates of parasitism in different localities were represented by a general mean of 14.5%. With the other two hosts, *Sesamia cretica* and *Spodoptera exigua*, the respective general means were 2.2 and 5.2%. As for *M. gyrator M. gyrator*, *S. exigua* and *Heliothis* spp., respectively.

[1700] BIOLOGICAL CONTROL OF THE CITRUS LEAFMINER (LEPIDOPTERA: GRACILLARIDAE) IN NORTHWEST ARGENTINA

M.P.Zamudio¹, <u>E.Willink¹</u>, D.Figueroa¹, G.Zaia¹, S.Toledo¹, & H.Salas¹, ¹Estación Experimental Agroindustrial Obispo Colombres, C.C.n^o 9, Las Talitas, (4101) Tucumán, Argentina. E-mail: sanceaoc@tucbbs.com.ar.

The presence of the citrus leafminer (CLM) Phyllocnistis citrella was first observed in citrus groves of northwest (NW) Argentina at the end of 1995, where it affected tender leaves and shoots of citrus plants. It spread very quickly throughout the citrus growing region and, after its establishment, chemical pesticides were used in excess, in an attempt to control the CLM. The need for a classical biological control programme was evident, and the encyrtid Ageniaspis citricola was selected because of its host specificity, dispersal capacity and high reproductive potential. The project was funded by the citric producers gathered in the Asociación Fitosanitaria del Noroeste Argentino (AFINOA). After a few attempts to bring A. citricola from the United States and Spain, the successful introduction was made from Perú at the beginning of 1998, and after a quarantine period, a massive breeding program was established at the Estación Experimental Agroindustrial Obispo Colombres (EEAOC) in Tucumán Province. The parasitoids were reared in an air conditioned glasshouse, using the technique developed by Hoy in Florida, USA. A. citricola was released into the natural environment both as adults and as pupae about to emerge, which had been placed in plastic bags containing leaves with the parasitoidized leafminer. In this way A. citricola was at first introduced into all citrus growing habitats in the northwest Argentina provinces of Jujuy, Salta, Tucumán and Catamarca. In many habitats the parasitoid flourished but in others it remained scarce or did not become established at all. For this reason, additional parasitoids were subsequently released into the less colonized areas. A total of 23,500 Ageniaspis were released between February and May 1998, and an additional 56.510 were liberated during the summer 1998/99. During March 1999 a survey was made throughout NW Argentina to evaluate the establishment of A.citricola. In Tucumán Province 75% of the CLM pupal chambers were parasitoidized, in Jujuy 44%, in Salta 43%, but in Catamarca only 5% of the pupal chambers were affected. Further studies are thus needed to ascertain whether the rate of parasitoidism by A.citricola is determined by climatic conditions.

Index terms: Phyllocnistis citrella, Ageniaspis citricola, biocontrol

[1701] HYMENOPTERAN NATURAL ENEMIES IN A EUCALYPTUS PLANTATION IN IPABA, STATE OF MINAS GERAIS, BRAZIL

T. V. Zanuncio¹, J. C. Zanuncio¹, J. II. Schoereder² & G. P. Santos³, ¹ Depto de Biologia Animal, Univ. Federal de Viçosa, 36.571-000, Viçosa, MG, BRAZIL. E-mail: zanuncio@mail.ufv.br; ² Depto de Biologia Geral, Univ. Federal de Viçosa, 36.571-000, Viçosa, MG, BRAZIL; ³ EMBRAPA-CTZM/DBA-Univ. Federal de Viçosa, 36.571-000, Viçosa, MG, BRAZIL.

Due to the increase in areas planted with Eucalyptus species in Brazil many harmful insects are now established in such plantations. The objective of this research was to study the hymenopteran natural enemies in a transect of *Eucalyptus*/native vegetation/*Eucalyptus* and to look at the effect of these native areas upon populations of such insects. This work was carried out at Ipaba in the State of Minas Gerais, with two samplings per month with Malaise traps, from April 1996 to March 1997. Sampling points were located 100 meters from each other in a transect starting in one Eucalyptus plot, crossing an area of native forest and reaching another Eucalyptus plot. Insects collected were separated, quantified and identified in the Laboratory of Forest Entomology, of the Federal University of Viçosa, in Viçosa, State of Minas Gerais, Brazil. A total of 3,636 individuals of Aculeata and Parasitica Hymenoptera, representing 85 morpho-species was collected and allocated to family. Of the Aculeata series, 68.2% of the individuals belong to the Formicidae, Mutilidae, Pompilidae, Sphecidae and Vespidae families, while the remaining 31.8% belong to species of Bethylidae, Braconidae, Chalcididae, Eulophidae, Evaniidae and Ichneumonidae within the Parasitica series. The number of species at each sampling point was higher at those located at the borders and inside the native forest. Larger numbers of individuals were collected at the sampling points Ea100 (Eucalyptus plot at 100m from the native forest), Mn1 (inside the native forest at 100m from the Eucalyptus plot), Tran1 (at the transition Eucalyptus/native forest) and Mn2 (inside the native forest at 200m from the Eucalyptus), with 587, 412, 390 and 382 individuals respectively.

Index terms: Diversity, fragmentation, remnants of native vegetation

[1702] EXPLORATION IN ARGENTINA FOR POTENTIAL BIOLOGICAL CONTROL AGENTS OF *HELIOTROPIUM AMPLEXICAULE*, AN INVASIVE WEED IN EASTERN AUSTRALIA

M.C. Zapnter¹, D.T. Briese², W. Pettit³, G. Perez-Camargo¹ & G. Serra⁴, ¹Facultad de Agronomía, Universidad de Buenos Aires, 1417 Buenos Aires, Argentina; ² CRC for Weed Management Systems and CSIRO Entomology, GPO Box 1700, Canberra 2601, Australia; ³CSIRO Entomology, CERZOS / CONICET, 8000 Bahía Blanca, Argentina; ⁴Facultad de Agronomía, Universidad de Córdoba, Córdoba, Argentina.

Blue Heliotrope, Heliotropium amplexicaule Vahl, is a perennial, spreading broad-leaf weed of temperate South American origin. It was introduced into Australia in the late 19th century as a garden ornamental and now occurs in four states. In northern New South Wales and southern Queensland it has undergone rapid recent spread, in both cultivated pastures and areas of native vegetation. It is considered a serious weed in these areas because it competes with desirable summer pasture species and is toxic to stock. Conventional methods, including herbicide use have had limited success in reducing its impact and have not stopped its spread. In late 1998, a project was initiated in Argentina to survey for potential biological control agents in the native range of the H.amplexicaule, and evaluate their potential to control the weed. This poster outlines the results of field surveys and laboratory research on four candidate agents, including a preliminary openfield experiment to determine their host-range. Three study areas were selected and visited periodically to evaluate insect densities and damage to plants. Colonies from the four insects have been established on their natural host to study their biology. As a result of the studies, two insects, the defoliating chrysomelid beetle, Deuterocampta quadrjuga, and the flea-beetle, Longitarsus sp., have been selected for further study in quarantine in Australia. Index terms: Heliotropium amplexicaule, biological control

[1703] THE RELATIONSHIP OF STEM BORER COMPOSITION IN MAIZE TO PARASITOID DIVERSITY

G. Zhou & W. A. Overholt, International Center of Insect Physiology and Ecology, P.O. Bos 30772, Nairobi, Kenya

stemborers of maize were sampled in kenya in three different ecological zones; the humid lowland coastal zone, the semi-arid midaltitude eastern province, and the moist midaltitude lake victoria basin. several parasitoids of stemborers were collected, but two species, cotesia flavipes and cotesia sesamiae were dominant and accounted for about 85% of all parasitoids recovered. in the coastal area, three stem borer species were found. chilo partellus was the dominant species (63%), followed by chilo orichalcociliellus (25%), and sesamia calamistis (8%). a disproportionate number of c. flavipes were recovered from c. partellus compared to the other stemborer species, the parasitism of c. partellus by c. flavipes was 3.5% on average between 1992 and 1998; then the parasitism of c. orichalcociliellus was 1.1%, the parasitism OF S. CALAMISTIS was 0.4%. at sites where c. partellus are abundant and c. orichalcociliellus and s.calamistis are less abundant, the parasitism by c. flavipes reached a mean of 8.5%. in other areas, c. flaivpes caused only 1.6% parasitism, suggesting that the old association of c. flavipes/c. partellus was the optimal combination for population development of c. flavipes. the stemborer composition had little effect on c. sesamiae parasitism. average parasitism of both s. calamistis and c. partellus by c. sesaming was about 2.2% and the parasitism of c. orichalcociliellus was 1.5%. in the eastern province, the main stemborer species were c partellus (85%), s. calamistis (9%) and buseola fusca (2%). b. fusca was found at less than 50% of the sampling sites. in areas where b. fusca was found, parasitism by c. flavipes was as low as 4%, but in non-b. fusca areas, it reached a mean of 11.6%. additionally, in non-b. fusca infested areas, parasitism of total stemborers by c. sesamiae was 2.6%, whereas in b. fusca infested areas, parasitism was 6.5%. as the proportion of *b.fusca* increased, parasitism by *c. flavipes* decreased, but parasitism by *c. sesamiae* increased. in the lake victoria basin, *c. partellus* was the most abundant speices (72%), followed by b. fusca (12%), eldana saccharina (12%), and s. calamistis (3%). the b. fusca density was low, but it was found at all the sampling sites. average parasitism of c. partellus by c. flavipes was 1.4%. parasitism by c. sesamiae was 3.2% and b. fusca was the predominant host (85%) for this parasitiod. in areas where e. saccharina was abundant (>15%), parasitism by both c. sesamiae and c. flavipes was very low (<2% for both species). the higher the proportion of e.saccharina, the lower the parasitism by c.flavipes.

[1704] APPLIED TECHNOLOGY OF PEST CONTROLLING BY TRICHOGRAMMA FROM ARTIFICIAL HOST EGG IN SHANXI, CHINA

<u>Y. Zhou</u>, J. Ren, X. Zhang, M. Lian & T. Li, (Institute of Plant Protection, Shanxi Academy of Agricultural Sciences, ² Changfeng St., Taiyuan, Shanxi, 030006 P. R. China BSNY@public.ty.sx.cn)

A number of Trichogramma from artificial host eggs have been transported from Guangdong to Shanxi since 1994. A controlling test of Helicoverpa armigera (Hubner) by Trichogramma chilonis Ishii and Trichogramma dendrolimi Matsumura from artificial host eggs was carried out in cotton fields in 1998. Trichogramma were gotten out into the field in the egg period of the 2nd and 3rd generations of *Helicoverpa armigera* in Bt transgenosis pest-resistant cotton field. The parasitic ratio of Trichogramma chilonis and Trichogramma dendrolimi were 56.8-565.9% and 36.8-38.2% respectively. Both Trichogramma had better effect than CK. After treatment, the residual larval population of Helicoverpa armigera was not higher than the controlling index of the residual larva for 100 plants. It meant that the technology is feasible. For the common field, similar results were gained when Trichogramma was gotten out in second generation of Helicoverpa armigera, but the controlling effect was not as good as expected for that of the third generation. A controlling experiment of Helicoverpa armigera in tomato field by Trichogramma chilonis from artificial host eggs was carried out in Taiyuan in 1997– 1998. The parasitic ratio got 52.0-71.1%. The decrease ratio of the corrected larval population was 95.0% if Bt preparation in 200 times was adopted. It is an effective method to combine Trichogramma chilonis from artificial host eggs with Bt preparation for Helicoverpa armigera in tomato fields. Some satisfying results were also obtained from the controlling test of Ostriniae furnacalis by Trichogramma chilonis from artificial host eggs in Taiyuan and Qinshui in 1998. It was going to be 1555 ha. of using Trichogramma from artificial host eggs for pest control from 1994 to 1998.

Keywords: Trichogramma chilonis Ishii, Trichogramma dendrolimi, Helicoverpa armigera, Ostriniae furnacalis, attificial host eggs

[1705] RISK-SENSITIVE FORAGING FOR MATES IN A PUPAL MATING BUTTERFLY, HELICONIUS HEWITSONI

E. I. Deinert¹, ¹ Organization for Tropical Studies, Duke University, 410 Swift Ave., Durham, N.C. 27705, U.S.A. E-mail: deinert@cro.ots.ac.cr.

A central theme in sexual selection theory is that there are costs associated with mate choice. Individual behavior, therefore, should reflect changes in the associated costs and benefits. For example, when response to predation risk alters male interactions with future potential mates, male response to such risk should depend on the relative value to the resource, for example the relative opportunity for obtaining a copulation. This study examines the mate locating and risk taking behavior of a pupal-mating butterfly, Heliconius hewitsoni, as a function of changing pupal maturity. Male H. hewitsoni locate female pupac, visit them repeatedly, and then 26-24 hours before female eclosion compete for access to the pupae and the teneral females. Males assess pupal maturity and adjust their searching and risk taking behavior according to changes in the opportunity for mate acquisition. Males visited pupae throughout the 9 day pupal phase and visits increased in frequency and duration as the pupae aged. Male response to simulated predation attempts at the pupal site depended on changing mating opportunity as reflected by changing pupal maturity. Captured males took significantly longer to return to pupae than uncaptured control males. However, time to return to site of capture was significantly less when pupae where close to eclosing than when pupae were days from eclosing. In response to constant predation risk males shift from a risk-averse to a risk-prone mate locating strategy as pupae increase in value.

Index terms: Heliconius hewitsoni, Lepidoptera, mate location, predation

[1707] PARASITE RESISTANCE AND SEXUAL SIGNAL TRAITS: DOES UNDERSTANDING INSECT IMMUNITY HELP US UNDERSTAND INSECT MATING SYSTEM?

M.Siva-Jothy, M.Siva-Jothy@sheffield.ac.uk

Hamilton & Zuk provided perhaps the best framework for understanding how intersexual selection for good utilitarian genes (in this case, genes for parasite resistance) might work. I will present results from long-term studies of calopterygid damselflies whichreveal (a) that male sexual signal traits are honest signals of parasite resistance (b) the signal and the immune system share a common physiological pathway, (c) aspects of immune regulation that are at odds with current ideas and (d) that time-constrained development and parasite-resistance may interact and influence many aspects of the mating system.

[1708] SINGING AND SCALES: VARIATION IN SEXUAL SIGNALS OF CRICKETS SUBJECT TO PHONOTACTIC PARASITOIDS

<u>R. J. Knell</u>, School of Biological Sciences, Queen Mary and Westfield College, Mile End Road, London E1 4NS, UK, E-mail R.Knell@qmw.ac.

[1706] SEXUALLY TRANSMITTED DISEASES AND THE EVOLUTION OF

INSECT MATING SYSTEMS

Sexually transmitted diseases (STDs) are common in the animal kingdom, and are capable of causing considerable pathology. Reports are now beginning to appear describing a variety of such parasites from insects, including nematode worms, mites, microsporidia and fungi. Hosts reported include coleoptera, lepidoptera and diptera. One possible reason for the small numbers of reported cases is that STDs are less likely to occur in temperate insects because an element of vertical transmission will be necessary in many potential hosts to ensure transmission between generations, and this vertical transmission will lead to strong selection for reduced virulence. STDs may prove to be common in tropical insects, and I will discuss the possible role of STDs in the evolution of insect mating systems, with particular reference to parasite mediated sexual selection and the evolution of polygamy.

Index terms: Sexually transmitted disease, mate choice, evolution, sexual selection

<u>M. Zuk¹</u>, J.T. Rotenberry¹, & L.W. Simmons², ¹Dept. of Biology, Univ. of California, Riverside CA 92521 USA; ²Dept. of Zoology, Univ. of Western Australia, Nedlands 6009 W.A. Australia.

Signals used to attract mates are also often conspicuous to predators and parasites, and their evolution via sexual selection is expected to be checked by natural selection. The calling song of the field cricket *Teleogryllus oceanicus* has been influenced by the presence of acoustically-orienting parasitoid flies in part of the crickets' range. We examined this song variation at a variety of scales; in the Hawaiian Islands, where the parasitoid occurs, the song differs from that in either the continent of Australia or the island of Moorea in French Polynesia. Song differences between two islands of Fiji are not as distinct as those among the three Hawaiian islands where the parasitoid accurs. Within the Hawaiian chain, a significant portion of variation of song can be attributed to differences in prevalence of infestation with the fly, and in any one parasitized population, individual crickets are more likely to harbor larvae if their song contains a longer series of continuous pulses. Variation is also greater between parasitized groups are more widely geographically separated. These countervailing effects of sexual and natural selection have numerous implications for the maintenance of variation in sexually selected traits

Index terms: phonotactic parasitoid, sexual selection, Teleogryllus oceanicus

[1709] FIGHT OR FLIGHT? - ALTERNATIVE REPRODUCTIVE TACTICS IN CARDIOCONDYLA ANTS

S. Cremer & J. Heinze, LS Biologie I, Univ. Regensburg, Universitätsstrasse 31, D-93040 Regensburg, Germany

In many species of animals, alternative reproductive phenotypes co-occur, which show different behavior and occasionally even different morphology. Proximately, alternative phenotypes may be either based on a genetic polymorphism or on different environmental conditions acting on the same genotype. In the ant genus Cardiocondyla, two different male morphs exist which differ strikingly in behavior, morphology, and physiology. Winged Cardiocondyla males leave the colony several days after their eclosion and mate outside the nest with alien virgin queens. Before dispersal, however, they may also attempt to mate with virgin queens in their natal colonies. Wingless, "ergatoid" males, on the other hand, stay in their natal nests and only there mate with virgin queens. In contrast to the docile winged males, ergatoid males are highly aggressive towards each other and use their strong mandibles to fight for access to the virgin queens. Freshly eclosing rivals are typically killed by adult ergatoid males and therefore most colonies contain only as single ergatoid male at any time. Whereas spermatogenesis is completed and testes have degenerated in winged males when they reach sexual maturity (as is generally the case in male Hymenoptera), spermatogenesis continues throughout the whole life span of ergatoid males (Heinze & Hölldobler 1993; Heinze et al. 1998). Proximately, the production of winged males can be induced in the laboratory by different manipulations, all related to environmental stress. Male morph thus is not genetically determined but depends on propagated by winged males and dispersing queens under unfavorable conditions, the under favorable conditions the colony can grow quickly due to ergatoid males and nondispersing queens.

Index terms: Cardiocondyla wroughtonii, male dimorphism, morph determination Heinze, J. and B. Hölldobler. 1993. Fighting for a harem of queens: physiology of reproduction in Cardiocondyla male ants. Proc Natl Acad Sci USA 90: 8412-8414 Heinze, J., B. Hölldobler and K. Yamauchi. 1998. Male competition in Cardiocondyla ants. Behav Ecol Sociobiol 42: 239-246

[1710] SCALING RELATIONSHIPS AS 'REACTION NORMS': INSIGHTS FOR THE EVOLUTION OF BEETLE HORNS

D.J. Emlen, Division of Biological Sciences, Univ. Montana, Missoula MT, 59812-1002, U.S.A.

I discuss a framework for studying the evolution of morphology in insects, based on the concepts of "phenotypic plasticity" and "reaction norms". I illustrate this approach with the evolution of exaggerated horns in beetles. Most morphological traits scale with body size (large individuals have larger traits than smaller individuals), and I propose that scaling relationships in insects are best viewed as reaction norms. I present data from three independent origins of beetle horns and suggest that the evolution of horns has resulted from genetic changes in the slope and shape of the scaling relationships. In each case, the evolutionary enlargement of horns resulted in non-linear (sigmoid) scaling relationships. I use the "reaction norm" perspective of scaling relationship evolution to suggest why this might be.

[1711] THE INHERITANCE OF FEMALE PREFERENCE FUNCTIONS IN A MATE RECOGNITION SYSTEM

M. G. Ritchie, Environmental & Evolutionary Biology, Bute Medical Building, University of St Andrews, St Andrews, Fife, KY16 9TS Scotland. E-mail: mgr@stand.ac.uk.

Mate Recognition Systems play a major role in sexual selection and speciation, yet few studies have analysed both male and female components in detail. Here female preference functions have been characterised for the tettigoniid bushcricket *Ephippiger ephippiger*, and the inheritance of male song and female preference functions followed in crosses between subspecies. Songs are disproportionately determined by sex-linked genes, as has been predicted by some recent reviews. However, in contrast to other studies, there is no evidence for a role of maternally derived sex-linked genes in female preference, or of maternal effects. Reasons for disproportionate linkage of sexually selected traits will be discussed. At the genetic level, there is a mis-match between peak preferences and male song, consistent with an evolutionary history of persistent directional preferences. The pattern of inheritance described could contribute to the process of speciation via the evolution of new Mate Recognition Systems, as hybrid hemizygous males could be discriminated against by heterozygous females.

Index terms: Ephippiger ephippiger, mate recognition system, sex-linkage, female preference, speciation

[1712] DIET-DEPENDENT FEMALE CHOICE FOR MALES WITH iGOOD GENESI

I. Lesna & M. W. Sabelis, Section Population Biology, University of Amsterdam, Kruislaan 320, 1098 SM Amsterdam, The Netherlands, E-mail: lesna@bio.uva.nl.

We showed previously (Nature 401: 581-584, 1999) that a local population of the soil predatory mite, Hypoaspis aculeifer, harbours genetic variation in preference for two prey species: the bulb mite, Rhizoglyphus robini, and the copra mite, Tyrophagus putrescentiae. Here, we show that in terms of population growth rate the bulb-mite-preferring line outperforms the copra-mite-preferring line irrespective of whether it is reared on copra mites or bulb mites alone. Hence, there is no evidence for a trade-off in reproductive performance. However, hybrids outperform the selected lines when fed on copra mites, but have intermediate reproductive success when fed on bulb mites. On a mixed diet of the two prey species hybrids also outperform the selected lines. Thus, rather than trade-off relations, heterozygote advantage explains the maintenance of genetic variation in prey preference in the laboratory culture, as well as at a small spatial scale in the field. To investigate the likelihood of hybridization, mate choice of the selected lines was analysed experimentally. It was found that mate choice of the selected line is assortative on a prey diet where this line is superior in reproductive success, but when hybrids are superior. disassortative mating predominates. Thus, diet-dependent switches in mate choice are implicated in the maintenance or breakdown of genetic variability within local populations.

Index terms: Genetic polymorphism, hybrid advantage, mate choice, assortative mating, disassortative mating, predators

[1713] LEK PARADOX RESOLVED: EMPIRICAL EVIDENCE FOR GENETIC VARIANCE IN CONDITION AND IN CONDITION DEPENDENCE

<u>S. Kotiaho</u>, L. W. Simmons & J. L. Tomkins, Dept. of Zoology, Univ. of Western Australia, Nedlands, WA 6009, Australia. E-mail: jkotiaho@cyllene.uwa.edu.au

Sexual selection through female choice is common even in the absence of direct fitness benefits arising from the choice. To explain costly female choice in such instances, genetic benefits in the form of "good genes" have been invoked. However, it is a long held expectation that there will be little genetic variance in fitness related traits because directional selection will tend to drive beneficial alleles to fixation. Therefore, it seems evident that there is little potential for female choice to result in genetic benefits giving rise to the so called "lek paradox". Recently a theoretical solution to the lek paradox has been offered in the form of a genetic model based on two robust assumptions: first that traits are dependent on condition and second that condition itself has high genetic variance. In this paper, we present results from experiments with the dung beetle *Onthophngus taurus* which show that there is female preference for a behavioural sexual trait (courtship rate), that the trait covaries positively with condition, that this covariance has significant genetic variance and finally that there is significant genetic variance in condition itself. Our set of experimental tests support a genetic model that explains the maintenance of costly female choice based on indirect genetic benefits, and thereby provide empirical evidence for the resolution of the lek paradox.

Index terms: Onthophagus taurus, good genes, indirect genetic benefits, sexual selection.

[1714] PARADOX(ES) OF THE LEK: CAN GENETIC VARIANCE OF SEXUALLY SELECTED TRAITS BE MAINTAINED BY GENOTYPE × ENVIRONMENT INTERACTION?

M. D. Greenfield¹ & F.-y. Jia², ¹Dept. of Entomology, Univ. of Kansas, Lawrence, KS 66045, USA, E-mail greenfie@ukans.edu; ²Dept. of Entomology, Kansas State Univ., Manhattan, KS 66506, USA, E-mail fjia@oz.oznet.ksu.edu.

When traits experience directional selection such as that imposed by sexual selection, their genetic variance is expected to diminish. Nonetheless, theory and findings from sexual selection predict and demonstrate that male traits favored by female choice retain substantial amounts of additive genetic variance. We explored this dilemma, a "paradox of the lek," through an ecological genetic approach and focused on the potential contributions of genotype x environment interaction to maintenance of additive genetic variance for male signal characters in the lesser waxmoth, *Achroia grisella* (Lepidoptera: Pyralidae). We artificially selected genetic variants for two male ultrasound signal characters, signal rate (SR) and peak amplitude (PA), that influence female attraction and then examined the phenotypic plasticity of these variants (high and low SR and PA lines) under a range of environmental conditions expected in natural populations. Our split-family breeding experiments indicated that two signal characters, SR and PA, and several developmental characters in both high and low SR and PA lines displayed considerable phenotypic

plasticity among the environments tested. Moreover, strong genotype \times environment interactions leading to crossover between high and low SR lines were found for SR and developmental period. Therefore, neither high nor low SR genetic variants would achieve maximum attractiveness and fitness in every environment, and those variants producing unattractive signals with low SRs under normal conditions may remain in populations provided that gene flow across environments or generation overlap are sufficiently high. We speculate that the phenotypic plasticity for SR and developmental period is adaptive in *A. grisella* populations experiencing a range of temperature and density conditions. Females mating with attractive (high-SR) males may be assured of obtaining good genes because 1) these males sire offspring that develop more rapidly and 2) a crossover for developmental period may parallel that for SR. Such parallel crossovers may be expected wherever good genes sexual selection mechanisms operate.

Index terms: genetic variance, genotype \times environment interaction, lek paradox, phenotypic plasticity, sexual selection, waxmoth.

[1715] EVOLUTION OF CONSPECIFIC EGG-CARRYING BEHAVIOR: ANCIENT AND INFANT EXPRESSIONS IN THE HETEROPTERA

<u>R. L. Smith¹</u> & A. Kaitala², ¹Dept. of Entomology, Univ. of Arizona, Tucson, AZ 85721, USA bobsmith @ag.arizona.edu ² Dept. of Biol., Univ. of Oulu, Finland.

Evolutionary biologists interested in reproductive behavior approach their studies with the expectation that males and females should exhibit adaptive traits refined by natural and sexual selection. This view suggests predictions that drive most research in behavioral ecology, and the predictions are usually approximately validated because most reproductive patterns are mature with traits well shaped to serve individual fitness. However, occasionally we encounter reproductive patterns that serve one sex imperfectly and perhaps the other not at all. Such outcomes may result from constraints, or the pattern of interest may be very young and not have had time for evolutionary refinement and gender coadaptation. Giant Water Bugs and the Golden Egg Bug both exhibit egg-carrying behavior, but the manifestations of this pattern differ dramatically between the two taxa coincident with their relative ages. The Giant Water Bugs (Belostomatidae) is an ancient family of predaceous aquatic Heteroptera whose fossils date to mid-Jurassic or earlier. Males of all extant belostomatid species brood eggs and we infer from fossil studies that paternal brooding evolved well over 150 million years ago. In the subfamily Belostomatinae, (> 100 spp. in 5 genera), males carry eggs attached to their backs by their mates. This system is obligatory and characterized by a constellation of perfected traits consistent with optimality predictions. Supportive adaptations include refined intersexual communication and cooperation, absolute paternity assurance, precision in oviposition, and efficient brooding. Giant Water Bugs make few reproductive mistakes and are unable to cheat. Egg carrying by belostomatids is evolutionarily stable and sexually symmetrical regarding costs and benefits. The Golden Egg Bug, Phyllamorpha laciniata is a terrestrial phytophagous coreid bug tied to its circum-Mediterranean host plant, Paronychia argentea. Females of this species inevitably deposit their eggs on living conspecifics, both male and female. Due to ant predation, carried eggs enjoy a dramatic survival advantage over those experimentally placed on the host plant or dead bugs. A sister species Phyllamorpha lacerata oviposits on Paronychia and not on other bugs indicating that egg carrying in P. laciniata is a recently evolved apomorphy that distinguishes this single species. Neither egg encumbered males nor females show special brooding behavior. Oviposition on conspecifies is comically clumsy and imprecise, egg carrying is not accompanied by supportive adaptations, and eggs carried by males are rarely if ever fertilized by the carrying male. Egg carrying clearly benefits mothers but not encumbered non-mothers or male carriers. Females may be selected to reciprocally exchange eggs but otherwise the system fails most optimality predictions, is clearly in a state of evolutionary flux, and contrasts vividly with the water bug system.

[1716] MONANDRY AND POLYANDRY AS ALTERNATIVE LIFESTYLES IN A BUTTERFLY

N. Wedell, Ecol. & Evol. Group, School of Biology, Univ. of Leeds, Leeds LS2 9JT, UK

Butterflies show considerable variability in female mating frequency ranging from strictly monandrous to highly polyandrous species. Degree of polyandry also varies within species, with some females only mating once and others mating multiply. One reason for multiple mating is to obtain nutritious male donations that increase both the longevity and fecundity of females. Despite the presence of male nutrient donations, some females of the green veined white butterfly (Pieridae: Pieris napi) never mate more than once. Here I examine this apparent paradox by assessing to what degree polyandry is under genetic control using a full-sib analysis. Degree of polyandry has a genetic component and appears to be traded-off against reduced longevity when denied the opportunity to mate more than once. There is also a trend across families between degree of polyandry and reduced lifetime fecundity when forced to be monandrous. It is possible that female P. napi display different reproductive strategies, with some females relying on male donations to realize their potential fecundity whereas others rely on their own resources for egg production. In nature, genetically polyandrous females may be prevented from mating multiply due to unfavourable weather. The trade-off between degree of polyandry and longevity when singly mated may aid the maintenance of genetic variability in female mating frequency in this species. Possible reasons for these different reproductive strategies are discussed. Index Terms: Sexual selection, mating systems, Lepidoptera, multiple mating

[1717] MEIOTIC DRIVE, SPERM COMPETITION AND THE EVOLUTION OF MULTIPLE MATING BY FEMALE STALK-EYED FLIES (DIOPSIDAE)

<u>G. S. Wilkinson</u>, C. Fry, S. Toll & J. Swallow, Dept. of Biology, Univ. of Maryland, College Park, MD 20742, USA, E-mail gw10@umail.umd.edu.

Sex chromosome meiotic drive causes distorted progeny sex ratios due to differential gamete development and transmission. We have recently discovered X chromosome meiotic drive (X^b) in two species, *Cyrtodiopsis whitei* and *C. dalmanni*, of sexually dimorphic stalk-eyed flies from south-east Asia. Epiflourescent microscopy reveals that male flies which carry X^D fail to exhibit normal sperm development. Approximately half of the sperm in a developing bundle fail to elongate normally and, therefore, are presumed to bear Y chromosomes since such males produce all female progeny. We determine the outcome of competition between sperm from males with or without X^D chromosomes by utilizing two populations of *C. whitei* from perinsular Malaysia and northern Thailand which differ in body color. Results reveal that X^D sperm are competitively inferior to normal X sperm – over 95% of progeny from pair-mated females are fathered by normal X sperm. Such intense sperm competition is expected to favor multiple mating by females in populations that are female-biased. We test this idea by estimating remating interval, population sex ratios, and frequency of X^D chromosomes in seven populations of *Cytodiopsis whitei* and *C. dalmanni* found in Thailand, Malaysia, Sumatra and Borneo. Using a population phylogeny derived from mitochondrial sequence data we infer the pattern of evolution between the frequency of the drive chromosome and the pattern of female mating behavior. These results are discussed in the context of sex chromosome covolution and the evolution of sexual dimorphism.

Index terms: Cyrtodiopsis whitei, Cyrtodiopsis dalmanni, meiotic drive, polyandry

[1719] POLYANDRY, MULTIPLE MATING AND OFFSPRING ENVIRONMENT - WHY DO FEMALE DUNGFLIES RE-MATE?

T. Tregenza, Ecology & Evolution Group, School of Biology, University of Leeds, Leeds LS2 9JT, UK. E-mail gentbt@leeds.ac.uk

Why females frequently mate with more than one male remains poorly understood, particularly in those species which experience no obvious direct benefits of matings. To make progress in understanding polyandry we need to identify benefits females experience as a result of mating with more than one male, independent of any differences due to increased numbers of matings (which may be with the same male). I conducted a study in which groups of female yellow dung-flies (*Scathophaga stercoraria*) were allocated either a single mating, two matings with one male or two matings with two different males. Additionally, all potential parents were genotyped for the allozyme phosphoglucomutase (PGM) using gel electrophoresis. Because differences in PGM genotype have previously been associated with differences in larval performance in relation to rearing temperature, the eggs laid by each female were split and reared under 3 different temperature regimes. The hatching success of eggs, and the sex, mass, development time and genotype of all the emerging adult offspring were determined. This revealed no direct effect on hatching success, or on offspring life history traits of different mating regimes, although there are significant effects of interactions between larval rearing temperature and female mating regime. This suggests that costs and benefits of multiple mating and polyandry can involve complex interactions between offspring and their environment. I will discuss these results and the interactions between PGM genotype, offspring life-history traits and female mating pattern. Index terms: Dung fly, Polyandry, Scathophaga stercoraria, Sexual selection.

[1718] FITNESS BENEFITS OF SPERM COMPETITION FOR FEMALE FIELD CRICKETS

L. W. Simmons, Dept. of Zool., Univ. of Western Australia, Nedlands, WA 6907, Australia, E-mail lsimmons@cyllene.uwa.edu.au

I have examined the adaptive significance of polyandry using the Australian field cricket Teleogryllus oceanicus. Previous studies of polyandry have examined differences in offspring production by females mated multiply to a single male or females mated mutiply to different males. Here I combine this approach with a study of parantage of offspring produced in the later group. I use naturally occuring polymorphisms at the beta-esterase locus to assign parentage, and to vary male and female genotypes in experimental matings. If polyandry increases female fitness by avoiding genetic incompatebility I predict that i) on average, females mated multiply to different males should produce more offspring of greater fitness than females mating the same number of times with a single male; ii) a male that induces greater offspring production in females that mate multiply with that males should have a higher paternity when in competition with males inducing lower offspring production; iii) male genotype relative to female genotype should influence offspring production in females multiply mated to single males; and iv) offspring production by females multiply mated with different males should vary with heterogeneity in the genotypes of mutiple partners. I found that i) females multiple mated to two males had a higher proportion of their eggs hatching than did females mating twice with a single male. Offspring fitness parameters were not effected. However, ii) when in sperm competition, a males fertilization success was not related to his success in fertilizing eggs when a female mated with him alone; iii) there was no effect of relative male and female genotype on hatching success when females mated multiply with single males; and iv) there was no effect of heterogeneity in genotypes of two males in competition on hatching success. These results support the notion that sperm competition between mutiple males increases offspring production for females. However, they provide little evidence that this effect arises due to genetic incompatability. Sperm competition success was not related to offspring fitness. Thus, the notion that competitively superior sperm produce competitively superior offspring is not supported either. The reason for increased fertilization success under sperm competition requires further study. Index terms: Teleogryllus oceanicus, polyandry, sperm competition, fitness

[1720] SEXUAL BEHAVIOR OF LONGHORN BEETLE MIGDOLUS FRYANUS WESTWOOD (COLEOPTERA: CERAMBYCIDAE)

<u>J. M. S. Bento¹</u>, T. M. C. Della Lucia², E. F. Vilela² & W. S. Leal³, ¹Dep. Entomol., Fitop. e Zool. Agrícola, ESALQ-USP, 13418-900, Piracicaba-SP, Brasil, E-mail jmsbento@carpa.ciagri.usp.br; ²Depto. Biologia Animal, UFV, 36571-000, Viçosa-MG, Brazil; ³Laboratory of Chemistry Prospecting, NISES, Tsukuba, Ibaraki 305-8634, Japan.

The longhorn beetle *M. fryanus* is restricted to South America. The larvae bore into the plant root system and destroyed different crops such as sugarcane, coffee, eucalyptus, grape and others. Adults males are alate and live, in average, two to three days; adults females are wingless and live for 30 days or more. From November to March in Southeastern of Brazil, the newly emerged individuals mate after a characteristic nupital flight. The attraction of the males towards the females is mediated by a strongly female sex pheromone, restricted to a narrow range of time during each day and influenced by daily climatic factors. Females remain on the soil level with only head and thorax exposed for a short period of time from 8:00 AM until noon. Once copulated with one or more males return immediately into the soil to various depths for egg-laying. On the other hand, the males remain on the ground from 7:00 AM to 3:00 PM, when return in to the soil. The possible reason for a different exposition time of the sexes, during the attraction period, is due to temperature and predation that could affect especially females. The sequence of mating is present.

Index terms: sex pheromone, attraction, mating.

[1721] ASSORTATIVE MATING, SEXUAL SELECTION, HAPLODIPLODY AND THE EVOLUTION OF SOCIAL BEHAVIOR IN INSECTS

<u>K. Jaffe</u>, Departamento de Biología de Organismos, Universidad Simón Bolívar, Apartado 89000, Caracas 1080A, Venezuela, kjaffe@usb.ve

Computer simulations of sexual reproduction among haploid, diploid and haplo-diploid organisms showed that strategies in which females produce males asexually are evolutionary stable, displacing pure sexual organisms in interbreeding populations. Haplodiploidy seems to drives evolution with a different dynamics than pure diploidy. Haplodiploidy allows for a faster adaptation to a rough fitness landscape than pure diploidy. Haplo-diplod organisms showed higher probabilities for fixing alleles coding for altruistic behavior than diploid ones, and so did organisms reproducing with assortative mating. The results allow to predict that during phylogenetic evolution of sexual organisms, diploidy will be replaced by haplo-diploidy when the appropriate mutations occur, but that the reverse is unlikely. For the study of the evolution of social behavior, a theoretical game was developed. It was based on the eventual evolution of social behavior through development of altruistic cooperative care of the offspring or extended parental care. Alleles coding for five different strategies were simulated: 1- No care: A parent invested nothing in the offspring. 2- Communal care: A parent invested in any offspring irrespective of it was his own. 3- Open care: A parent invested half its acre-energy in its own offspring and half in any other offspring. 4- Opportunistic care: A parent invested only in its own offspring but its offspring could receive care from open or communal parents. 5- Closed care: A parent invested only in its own offspring and its offspring could not receive care from any other adult. The results suggest that social behavior without social synergy is very unlikely. Social behavior should emerge in evolution when cooperation improves synergistically the corresponding egoistic behavior and when alleles coding for altruistic or social behavior can be rapidly fixed in the population, by strategies such as haplo-diploidy, assortative mating, and probably others. The main conclusion thus is that social behavior has to be economically more efficient than the corresponding solitary behavior. Data are presented showing that this prediction is supported by laboratory and field observations in ants, termites and wasps.

[1723] FUNCTIONAL POLYGYNY IN ECTATOMMA TUBERCULATUM (OLIVIER) (HYMENOPTERA: FORMICIDAE)

R. R. Hora¹, <u>E. F. Vileln¹</u> & J. II. C. Delabie¹, ¹ Departamento de Biologia Animal, Universidade Federal de Viçosa, Viçosa, MG, Brazil, 36571-000. e-mail: evilela@mail.ufv.br; ²Laboratório de Mirmecologia, CEPEC/CEPLAC/ Universidade Estadual de Santa Cruz, Itabuna, BA, Brazil, 45600-000. e-mail: delabie@nuxnet.com.br.

Colonies of Ectatomma tuberculatum were collected from South Bahia (Brazil) cocoa plantations with the objective of studying their population structure. Twenty one monogynous and 18 polygynous colonies were found, while queens were not found in a further three colonies. This species appears to be optionally polygynic. The number of queens in the polygynous colonies varied from 2 to 44, with an average of 5.9 fertilized queens. In these colonies, the number of larvae, cocoons and workers was larger than in colonies with a single queen. The behavioral categories of queens studied in laboratory showed that, most of the time, queens remained still in the nest on activities other than egg laying. Queens received grooming; however, such behavior was not made by them on other individuals. All queens laid eggs and were inseminated. The results prove the existence of functional polygyny in E. tuberculatum, without any apparent dominance, and supernumerary queens probably originating from re-adoption into the nest. There was no aggressive behavior in relation to egg-laying queens or to fresh eggs. Eggs from different queens were found joined together in the nests, in one single pile. Fresh eggs were directly, or indirectly, taken to the pile by workers or by the queen itself. No significant difference was observed between the number of oocytes and the number of yellow bodies among queens, proving that queens have similar fertility. On the other hand, queens differ according to the number of times they remained on the pile. Functional polygyny may have occurred as a response to environmental conditions on cocoa plantations of South Bahia, and this has allowed E. tuberculatum to form a component of the mosaic of arboreal dominant ants.

Index terms: Ponerinae, queen number, behavior, ant, reproduction, applied entomology

[1722] HYPERSENSITIVITY AND PLANT BEHAVIOR AGAINST PARASITES

G. Wilson Fernandes & D. Negreiros, gwilson@icb.ufmg.br

Hypersensitive reaction is a widespread mechanism by which plants resist the attack by herbivores, particularly galling insects. In a long term study we have evaluated the importance of hypersensitive reaction against a leaf galling insect. We also show that this induced mechanism is equaly important in other systems and that it is widespread in the plant kingdom. We argue that this plant mechanism of attacked cell localization and death may drive more general patterns of gall distribution among habitats in scales ranging from local to global.

Index terms: plant hypersensitivity, plant defenses, induced responses, Gall richness

[1724] PROCESSING OF ACOUSTIC SIGNALS IN THE AUDITORY SYSTEM OF GRASSHOPPERS: POSSIBLE CONSTRAINTS ON SIGNAL TYPES

B.Ronacher, Inst. of Biology, Humboldt-University, 10099 Berlin, Germany, email: Bernhard=Ronacher@rz.hu-berlin.de

To find a mate, many gomphocerine grasshopper species rely strongly on elaborate and highly diverse acoustic signals which constitute an important barrier against hybridization. It is the temporal patterns of a song rather than its carrier frequency content that carries species-specific information. As a consequence, the processing of the temporal pattern of conspecific signals by the receiver's auditory system is crucial for mate recognition. At the level of auditory receptors there are 50 to 100 elements per ear, which convey their spike trains to a set of interneurons located in the metathoracic ganglion, which perform first important stages of preprocessing. Higher-order interneurons ascending from the metathoracic ganglion then deliver this preprocessed and condensed information to neurons within the brain, where the final decision about acceptance or rejection of acoustic signals takes place. Most interestingly, in different grasshopper species the local thoracic and the ascending neurons, which are clearly homologous according to their morphological features, also exhibit very similar physiological characteristics. This conservation of physiological properties of auditory neurons was observed in species as different as *Chorthippus bigutalus* and *Locusta migratoria*. At present, we would conclude that there seems to exist a basic 'all-purpose equipment' of auditory neurons at the level of thoracic and ascending interneurons, which is common to very different grasshopper species and has not been changed by much during the evolution of highly diverse communication signals. Looking the other way round, this basic preprocessing machinery (from receptors up to ascending neurons) probably also has imposed constraints upon the possible signal types during the evolution of acoustic communication systems. In their spike trains, the auditory receptors do faithfully encode the songs of very different grasshopper species. Thus, we find no 'labeled-line' filtering at this stage. In addition, the receptors transmit also information about rather subtle intra-specific differences between songs of different grasshopper males. This has been demonstrated by application of stimulus reconstruction methods and spike-train classifications to the spiking responses of auditory receptors (Machens et al., in prep.). These theoretical approaches could lead to a deeper understanding of how the physiological properties of the auditory pathway of grasshoppers may have favoured certain signal types.

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[1725] NEUROPHYSIOLOGICAL ANALYSIS OF ACOUSTIC SIGNALS IN CRICKETS: TEMPORAL PATTERN AND SOUND LOCALIZATION

G.S. Pollack, V. Givois, & Z. Faulkes, Dept. of Biology, McGill Univ., 1205 Dr. Penfield Ave., Montreal, PQ, Canada H3A 1B, E-mail: GPOLLACK@BIO1.LAN.MCGILL.CA.

An important component of acoustic communication is sound localization; the recipient of a signal must localize its source so as to direct its behavior appropriately. In insects, sound direction is determined by comparing sound intensity at the two ears. The "localizability' of a signal depends on its acoustical properties; e.g., the relation between signal spectrum and interaural intensity difference is well documented. Our recent experiments demonstrate that another important feature of acoustic signals, temporal pattern, also affects localizability. Sound intensity is reported to the central nervous sytem by auditory receptor neurons (ARNs), which produce more action potentials as intensity increases. ARN responses are also affected by stimulus temporal pattern. Songs of the cricket Teleogryllus oceanicus consist of minutes-long trains of rapidly repeated sound pulses. Such stimuli cause habituation of ARNs; the number of action potentials decreases for successive sound pulses. Habituation increases with intensity, and herein lies a problem for computing interaural intensity difference. Habituation is greater in ARNs serving the ear where intensity is higher. As a result the interaural difference in ARN responses declines as habituation builds up; under extreme conditions the difference approaches zero, and in some individuals it may even reverse in sign. Another potential code for sound direction is interaural latency difference; ARN latency decreases with increasing intensity, resulting in interaural latency differences of up to several msec. Latency is also affected by habituation, increasing for successive responses. However, unlike the change in response strength, the change in latency is independent of intensity and thus is similar for ARNs of both ears. Interaural latency difference thus remains constant as may be a more reliable cue for sound direction. Some aspects of central neural circuitry also suggest that latency difference may be an important cue. Habituation of ARNs is a universal phenomenon, in vertebrates as well as insects, and may be an unavoidable consequence of the high rates of action potential production that characterize auditory systems. Because of its effects on encoding of localization cues, habituation may be a physiological constraint that has helped to shape the temporal structures of acoustic signals, as well as in the ways in which interaural cues are analyzed in the central nervous system.

Index terms: Teleogryllus oceanicus, sensory physiology, communication, hearing

[1726] MATE SAMPLING STRATEGIES AND MATE CHOICE IN THE ORTHOPTERA: IMPLICATIONS OF NEUROETHIOLOGICAL STUDIES

<u>R. Balakrishnan¹</u>, D. von Helversen², & O. von Helversen², ¹Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012, India, Email:rohini@ces.iisc.ernet.in; ²Institute for Zoology II, University of Erlangen, Staudtstrasse 5, 91058 Erlangen, Germany.

The rules of auditory information processing derived from neuroethological studies may constrain and allow prediction of strategies of mate sampling and mate choice in acoustically signaling insects. Theoretical models and studies of mate sampling often assume either simultaneous or sequential sampling of the songs of potential mates. Using the duetting grasshopper Chorthippus biguttulus as a model system, we argue that the pooling of auditory information from the two ears by the song pattern recognition mechanism would restrict such grasshopper species to sequential sampling, since only one song pattern can be evaluated at a given time. The nervous system of crickets can simultaneously represent two independent song patterns, allowing females to perform simultaneous sampling in a chorus of singing males. The mechanism of selective attention would, however, restrict the number of simultaneously sampled songs to two: the loudest song on each side. Evaluation of more than two songs would necessarily be a sequential process. With regard to fixed threshold versus relative (best of n) choice models of mate choice, we suggest, on the basis of playback experiments evaluating female response probability, that C. biguttulus may in fact use both mechanisms. The strong discrimination of females against the songs of one-legged males operates as a fixed choice criterion. Female response depends on the evaluation of a number of song parameters, including the ratio of syllable: pause duration, syllable shape, spectrum, and verse amplitude modulation, which may be weighted differently by different females, allowing trade-offs between these parameters. Verse length appears to be an important parameter in choosing between the songs of different males. The response probability of a female to a given song model in a sequentially presented series depends on the quality of the other song patterns presented, that is, it is modulated by the acoustic context. This suggests that C. biguttulus is at least capable of relative (best of n) choice by sequential sampling. A given species may thus use fixed choice thresholds for certain parameters and relative choice for others. Index terms: Chorthippus biguttulus, grasshopper, cricket, auditory, song.

[1727] THE FUNCTION OF COURTSHIP IN GRASSHOPPERS RELATED TO CHORTHIPPUS ALBOMARGINATUS (ORTHOPTERA: GOMPHOCERINAE)

<u>V.Yu. Vedenina</u>¹ & O.v. Helversen², ¹Inst. for Information Transmission Problems, Bolshoi Karetnyi per. 19, Moscow 101447, Russia, E-mail vedenin@iitp.ru; ²Zool. Inst. II, Staudtstr. 5, Erlangen 91058, Germany

Some gomphocerine grasshoppers demonstrate an elaborate courtship behaviour. Courtship song can consist of many sound elements with different temporal patterns. Some visual signals can be also integrated into the courtship: rhythmic movements of head. have similar and quite simple calling songs but completely different and complex courtship songs. Can the complex courtship be a component of reproductive isolation between these species? To clarify this question, we studied whether any zones of sympatry for these species exist. On the territory of Ukraine and Moldova, we found two species of this group: Ch. albomarginatus inhabiting the norhern areas of the countries and Ch. oschei occurring in the southern areas. The analysis of the song and leg-movement recordings revealed that two species overlap in their distribution within a distance of about 200 km. In this area, not only males demonstrating courtship typical for one or another species have been found, but also individuals with intermediate courtship characteristics (in terms of temporal parameters of the song and leg-movements) were revealed. Moreover, the song patterns varied greatly from one specimen to another and showed irregularities within each specimen. In behavioural experiments, the females from these localities were found to respond to the courtship of both species. The data obtained indicate that the courtship was not the component of reproductive isolation between Ch. albomarginatus and Ch. oschei. Since the song of Ch. albomarginatus consists of a series of four pattern elements while a more elaborate song series of Ch. oschei includes seven elements and is additionally accompanied by visual signals, an evolutionary aspect of the complexity of the courtship pattern is discussed.

Index terms: Chorthippus oschei, sibling species, courtship song, temporal pattern.

[1728] DUETTING IN PHANEROPTERID BUSH-CRICKETS

K. G. Heller, Dept. of Zoology II, Univ. of Erlangen-Nuernberg, Staudtstr. 5, D-91058 Erlangen, Germany, F-mail kheller@biologie.uni-erlangen.de.

In the acoustic communication of bush-crickets usually the male produces the acoustic signal and the female approaches him phonotactically. The hearing capabilities of both sexes are typically quite well adapted to the frequency range of these songs. However, in two families, in Phaneropteridae and Bradyporidae, the females of many species respond acoustically to the male song and the males approach them phonotactically or both sexes move phonotactically towards each other. In the Phaneropteridae, female acoustic responding seems to be the ancestral condition found in the vast majority of species. The carrier frequency of male songs within this large family (more than 2000 species worldwide) varies according to body and wing size, spanning at least 4 octaves. For the females, however, which differ quite often from the males in these dimensions, other song frequencies than in males are produced most efficiently. Since both sexes must hear each other, song frequencies are expected to diverge not too much and some process of coevolution must occur. In a comparative study of about 40 phaneropterid species (14 genera) the majority belonging to the tribe Barbitistini I have examined the relationships between body dimensions and carrier frequency in both sexes. Phaneropterid acoustic duets are also well known for their unusually narrow and short time relationships between male and female signals, often occurring within 0.1s. There are, however, also many species with much longer intervals between male and female signal. Using the same set of species and additional data from literature, I have correlated the male-female time relationships to morphological and phylogenetic parameters. In small and short-winged species the fastest duets are found, while in some long-winged species intervals in the range of seconds between male and female can be observed. The reasons for these differences and for the loss of acoustical responding in some species are discussed in relation to the mating system of bush-crickets and the predation pressure on these insects, Index terms: Barbitistini, Poecilimon, acoustic communication, signalling.

[1729] PROCESSING OF CARRIER FREQUENCY AND SIGNAL EVOLUTION IN SOME BARBITISTINI (ENSIFERA)

A. Stumpner, Neurobiology, Institute for Zoology and Anthropology, Georg-August-University, Berliner Str. 28, D-37073 Goettingen, Germany. E-mail: astumpn@gwdg.de

Among bushcrickets of the group Phaneropteridae, the Barbitistini have highly developed acoustic communication. The males produce relatively complex temporal patterns and the females respond with a short click of constant delay to the trigger element in the male song. The carrier frequency of male and female song may be similar (around 20 to 35 kHz in different species of Barbitistes) or may differ (male: 16 kHz, female 28 kHz in Ancistrura nigrovittata (S. Dobler et al. 1994. J. Comp. Physiol. A 175:303)). When comparing certain parameters of body size with carrier frequency, it is quite obvious that males of A. nigrovittata have unusually low song frequency. The frequency range of the auditory organs or of broadly tuned interneurones (e.g. omega-neurone 1, ON1) does not differ much between different species and is similar to next related species in the genus Poecilimon. Therefore, such a broad hearing range can be assumed to be primitive in the Barbitistini. However, certain interneurones (ascending neurone 1, AN1) transferring information from the thorax to the brain, show prominent frequency processing by receiving frequency dependent inhibitions. The resulting frequency range of excitatory response appears to be adapted to the carrier frequency of the male song. Correspondingly, we see strong inhibition above 20 kHz and below 12 kHz in A. nigrovittata (A. Stumpner 1997, J. Exp. Biol. 200:1089), while we see only low frequency inhibition and no high frequency inhibition (up to 50 kHz) in Barbitistes species. If a pharmacological blocker for certain types of inhibition (picrotoxin) is applied to the nervous system, the frequency tuning of AN1 changes in Ancistrura (A. Stumpner 1998, J. Neurophysiol. 79: 2408) and Barbitistes. In both, frequency dependent inhibition is eliminated and AN1 becomes a broadly tuned neurone similar to ON1. Therefore, it seems that in certain interneurones broad excitation and some frequency dependent inhibition existed already in primitive Barbitistini. During speciation a change in inhibition and not in excitation changed the properties of these neurones. Obviously, in A. nigrovittata the male song carrier frequency was lowered in the course of evolution. While it cannot be excluded that this was a consequence of a preexisting 16 kHz-filter (in the sense of 'sensory exploitation'), the species-specific tuning of AN1 in different species makes it more likely that the neuronal filtering properties followed the lowered song frequency in a coevolutionary process. This allowed A. nigrovittata males to reduce interference with songs of related species, and build up a more effective contrast to those species, the males of which produce similar temporal patterns (especially B. ocskayi).

Index terms: Ancistrura nigrovittata, Barbitistes, hearing, song frequency, neurophysiology.

[1730] A MIS-MATCH IN AN AUDITORY SEXUAL COMMUNICATION SYSTEM

M. G. Ritchie, Environmental & Evolutionary Biology, Bute Medical Building, University of St Andrews, St Andrews, Fife, KY16 9TS Scotland. E-mail: mgr@stand.ac.uk.

Most studies of the evolution of auditory sexual communication systems have suggested that stabilising selection will lead to the coevolution of male and female components. Hence one would expect to see a broad match between the distribution of males traits and sensitivities or preferences of females. Yet sexual selection emphasises that females may prefer extreme values of signals in males, particularly if these are indicator traits. It may also be the case that female preferences are substantially mis-matched from the distribution of a trait in males, especially if biases have arisen in a context other than sexual communication. Example of such mis-matches have been described in frogs and fishes. Here I describe preliminary studies of the preferences which females of the bushcricket Ephippiger ephippiger have for song which varies in spectral structure. Female preference is peaked at values well outside of the range normally found within the species. The strength of this preference has been explored by varying other song parameters (amplitude, chirp structure) to infer to what extent females will trade-off other traits in a preference hierarchy. Results suggest that the preference for high frequencies is robust. The distribution of carrier frequency within the Ephippigerinae is examined to infer if a preference for high frequencies represents a synapomorphy within the group. Females of two other species seem to lack such a mis-matched preference.

Index terms: Ephippiger ephippiger, feale preference, sexual selection, sensory bias, acoustic communication.

[1731] THE FUNCTION OF NUPTIAL FEEDING IN THE TETTIGONIID STEROPLEURUS STALI: FIELD EVIDENCE REFUTES THE PATERNAL INVESTMENT IIYPOTILESIS

K. Vahed, C. Braines & B. Davies, Centre for Earth, Environmental & Applied Sciences, Univ. Derby, Derby DE22 1GB, U.K., E-mail: K.Vahed@Derby.ac.uk.

The spermatophores of tettigoniids consist of an ampulla which contains the sperm and a gelatinous spermatophylax which the female eats following copulation. One hypothesis for the function of the spermatophylax is that it is maintained by selection for paternal investment in offspring. Male Steropleurus stali produce some of the largest spermatophylaces of all tettigoniids: a single spermatophore can represent over 40% of male body weight. Previous studies indicate that there is pronounced last-male sperm precedence in S.stali. Therefore, in order for the spermatophylax to function as paternal investment, eggs benefitting from the spermatophylax nutrients of the male must be laid before the female re-mates. Here, we present the results of a field study, based in the Sierra Guadarrama mountains, Spain (in August/September 1998 & 1999), designed to test whether or not this is possible. The mean duration of the sexual refractory period of females in the field was four days (range 3 - 7 days), during which time females laid an average of 12 eggs (range 0 - 41 eggs). However, field caught, sexually receptive females were found to contain an average of 27 mature eggs (range: 13 - 59 eggs). These mature eggs can have no further nutrients added to them and will be laid, and fertilized, before eggs that mature subsequently. Therefore, the eggs laid during a female's refractory period are unlikely to benefit from the spermatophylax nutrients received from the most recent mating. Consequently, the large spermatophylax of S.stali is unlikely to function as paternal investment.

Index terms: Katydids, nuptial gifts, paternal investment, spermatophylax

[1732] SINGING OUT OF TURN: SATELLITE BEHAVIOUR IN AUSTRALIAN PHANEROPTERINE BUSHCRICKETS

W. J. Bailey, Dept. of Zoology, University of Western Australia, Nedlands, Perth 6907; E-mail: wbailey@cyllene.uwa.edu.au

Duetting amongst acoustic insects is surprisingly common and insects that engage in this behaviour presumably do so to maintain a pair bond between courting partners. The interval between duetting partners is usually short preventing the intrusion of competing males. In this way duets are seldom subject to take-overs. But where the duet interval is long and follows a complex signal acoustic satelliting is possible with the satellite inserting a distracting signal within an alpha male's song. I report duetting and, to my knowledge, the novel behaviour of acoustic satelliting in phaneropterine katydids (bushcrickets). Male and female Elephantodeta nobilis (Phaneropterinae: Tettigoniidae: Orthoptera) duet with the female responding to the male's long and complex call. The duetting or alpha male's call consists of four parts where the initial sections carry information on species-identity and perhaps on male quality. The length of this section of the call can be over 5 seconds. The second two parts of the call act as triggers for the female response, where the female replies with a brief signal some 570 ms after the trigger-pulse. Non-calling males are attracted to the duet and often use this tactic to gain access to females. They insert a volley of clicks some 200 ms before the alpha male's trigger to which the female sets the timing of her response. I tested the effectiveness of the satellite's call on female phonotaxis within a two-speaker arena and although females preferred the alpha male they were nevertheless attracted to the satellite calls time regardless of relative intensity of the calls. All males appear able to adopt satellite behaviour regardless of their developmental state, however, recently mated males are more inclined to satellite than call as alpha males. Such males are able to re-mate within minutes of mating and in doing so provide an extremy small spermatophore. It is suggested that satellite behaviour may be an adaptive tactic controlled by the relative apportioning of energy between spermatophore development and calling. I discuss the apposible role of satellite calling within the context of female choice. Index terms: *Elephantodeta nobilis*, Phaneropterinae; Tettigoniidae, acoustic; alternative

strategies.

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[1733] PREDATION BY GLEANING AND AERIAL HAWKING BATS: ITS EFFECT ON THE EVOLUTION OF HEARING AND SOUND COMMUNICATION IN TWO GROUPS OF KATYDIDS IN PANAMA

H. Römer, I. Teppner & A. Lang, Institute of Zoology, Karl-Franzens-University, A-8010 Graz, Universitätsplatz 2, Austria. E-mail: roemer@kfunigraz.ac.at

This study combines field and laboratory investigations of acoustic behavior and neurophysiology in two groups of neotropical katydids (Orthoptera) with contrasting predation pressure by different guilds of bats. The overall aim was to relate the patterns of variability of several traits between species, and between Pseudophylline and Phaneropterine katydids, to the underlying selective processes which generate these. We test the hypothesis that the Pseudophylline species, due to predation pressure by gleaning and passively listening bats have evolved a reduced sensitivity to airborne sound and This may be advantageous for detecting increased substrate vibration sensitivity. conspecific signals in a noisy environment. By contrast, most Phaneropterine species are good flyers and thus subject to predation by aerial hawking insectivorous bats, and have evolved sensory and central nervous traits that enable them to escape from a bat attack in flight. This includes increased sensitivity of the ears through enlarged auditory spiracles and probably increased ultrasonic sensitivity of certain interneurones. In particular we have focussed on the consequences of these adaptations for intraspecific acoustic communication, and how environmental gradients in predation pressure and noise influences the detection of conspecific signals. Signal Detection Theory (SDT) was used to examine the ability of katydids to detect these sounds and bat sonar in the field, based on long-term recordings of identified interneurones. A portable neurophysiological recording device and natural sound stimuli (or signals varied with respect to intensity, duration and redundancy), were employed for playback experiments performed on a rainforest transect. The rate of "hits", "misses" and "false alarms" in the various microhabitats and at different times of day/night were determined, and special attention was given to the degree of noise on the transmission channel. In another approach we have established preparations of the two INs in habitats selected for their different bat communities, i.e. open space and open cluttered space compared to highly cluttered space, together with a hat-detector for longterm recordings. This analysis will tell us how much of the neuronal activity was elicited by ... bat-like" or ... katydid-like" sound.

[1734] VIBRATIONAL COMMUNICATION IN ORTHOPTERA

A.A. Benediktov & <u>R.D. Zhantiev</u>, Moscow State Univ., Moscow, 119899, Russia, Email: zhantiev@1.entomol.bio.msu.ru

Vibrational communication is widespread in many insect orders. But among Orthoptera which use for communication mostly sound signals it can be found rather seldom. Untill recently vibrational signals (VS) have been recorded only in some Tettigonioidea (Ephippiger, Meconema). Besides it is known that such signals can be produced by some species of Acridoidea (Oedipodinae) and Grylloidea (Arachnocephalus). For the first time we have studied VS in two species of Tetrix (Tetrigoidea) and Arachnocephalus vestitus (Mogoplistidae, Grylloidea). For recording VS piezo-electric receivers were used. Tetrigids males produce signals of the three types: calling, rivalry and courtship, using mostly middle legs which do not produce any visible movements. Besides, body tremulation and periodical openings of wings can be seen. All the VS consist of more or less distinct pulses united into rythmically repeated groups - echemes and sequences. At least calling and courtship have distinct species-specific characters. Males of A. vestitus produce VS by percussive drumming of palps or tip of abdomen and also use tremulation of front and middle legs. The VS recorded by us are produced by the males only in the presence of females and therefore can be considered as courtship ones. The females answered the males with abdominal percussion. Comparison of vibrational communication in different groups of Orthoptera shows that VS are produced with the use of percussion and visible or invisible tremulation. In the latter case vibrations are emitted, as we expect, by rhythmic isometric contractions of muscles. The VS frequency depends on the features of the substrate. The temporal patterns of these signals are rather complicated - mostly not less than those of sound signals of Orthoptera. In all investigated orthopterans vibrational communication is likely to be a secondary phenomenon. The transition from sound communication to vibrational one leads to decrease of range of communication but on the other hand also reduces decamouflaging effect. Domination of vibrational communication in the abovementioned orthopterans is determined by specific features of their behaviour and first of all by the features of their populations and communities. Index terms: vibrational signals, communication, Orthoptera.

[1735] SERAGLIOS AND SIGNALING IN BLADDER GRASSHOPPERS

M. J. van Staaden¹ & II. Römer², ¹Dept. of Biological Sciences and JP Scott Center for Neuroscience, Mind & Behavior, Bowling Green State Univ., Bowling Green, OH 43403, USA, E-mail mvs@caspar.bgsu.edu; ²Institute for Zoology, Univ. of Graz, A8010, Austria.

Communication mechanisms bringing mates together to achieve syngamy are key components of the specific mate recognition system. Understanding the evolution of such systems and their role in the process of speciation requires knowledge of both proximate mechanisms underlying a particular sensory modality as well as the ultimate behaviors they mediate. While the former can be directly investigated, aspects of the mating system (e.g. breeding tactics, territoriality, sexual selection, dispersal) must often be inferred indirectly. We investigated an ancient, endemic African grasshopper with unique exaggerations of anatomy and behavior for long-distance acoustic communication. Bullacris membracioides (Pneumoridae), is a nocturnal, cryptic and specialized herbivore, with extreme sexual dimorphism. Winged, adult males have a conspicuously inflated abdomen absent in micropterous adult females. An alternative male morph does not call or fly, but is capable of mating adult females. Pneumorid acoustic signaling is unusual in several respects: although atympanate they harbor 12 mechanosensory organs for sound reception [van Staaden & Römer, Nature 394, 773]; four signals are produced by three different mechanisms; and roving primary males produce highly exaggerated signals. B. membracioides locate mates by antiphonal duetting that is asymmetrical in terms of mechanism, signal intensity and degree of stereotypy. Males achieve transmission distances of ± 2 km by combining high amplification, sensitive hearing, and exploiting optimal weather conditions. The differential female response is mediated by serial ears, and depends on intensity but not temporal structure of the male call. Viscous population structure means that alternative males mate only in a seraglio of females who tend to be his relatives. Morphometric data suggests that this form is not simply neotenic but presumably the result of selection for both high and low risk strategies in an unpredictable environment created by patchy habitat with cyclical drought and fire. Genetic analyses indicate that competition amongst primary males determines which individuals monopolize key mating areas and enjoy high reproductive success. Despite the exaggerated male signal and a large intersexual difference in active signal space, there is little evidence for sexual selection by females. The evolution of bladder grasshopper signals and mating system will be interpreted within a phylogenetic context, and the potential for coupled sender and receiver precursors will be discussed. Index terms: Bullacris membracioides, Pneumoridae, acoustics, trimorphism, mating

Index terms: Bullacris membracioides, Pneumoridae, acoustics, trimorphism, mating systems

[1736] THE EVOLUTION OF SIGNALING MECHANISMS IN KATYDIDS AND THEIR RELATIVES (ORTHOPTERA: ENSIFERA: TETTIGONIOIDEA)

<u>P. Naskrecki</u>, Dept. of Ecology and Evolutionary Biology, University of Connecticut, Storrs, CT 06269, USA, E-mail piotr@neca.com.

Acoustic communication in the Tettigonioidea (katydids and relatives) employs a gamut of mechanisms of sound production, both substrate mediated and airborne. Although the primary mode of communication in Tettigonioidea is based on airborne signals produced by wing stridulation, other mechanisms have evolved independently in different clades of the superfamily. The most basal mechanism seems to be ambidextrous tegminal stridulation, present in members of the Prophalangopsidae. Within the Tettigoniidae there is a tendency to develop asymmetrical stridulatory mechanisms, with only a few known cases of acoustic ambidexterity (Nedubini). Several lineages have evolved alternative mechanisms of communication, and the complete loss of acoustic communication is known in others. At least two lineages, Meconematinae and Phyllophorinae, exhibit the "explicit" loss of tegminal stridulation, not coupled with the complete wing loss (anaptery). The latter occurred at least three times independently within Tettigoniidae (subfamilies Mecopodinae, Tettigoniinae, and Phasmodinae). Some neotropical Pseudophyllinae show a tendency for switching from airborne to substrate communication despite well developed tegminal stridulatory apparatus in males. Tremulation in such species exhibits highly species-specific, often very complex patterns. Several theories have been proposed to explain this behavior. A few lineages of katydids are known to use at least two, and often three independent modes of communication simultaneously. Some Copiphorinae produce airborne signals along with the substrate tremulation and feet drumming, and palpal drumming accompanies stridulation in some Pseudophyllinae. In addition to acoustic communication, some Tettigoniidae employ sound in their defensive behavior. Tegminal, femoro-abdominal, and labral stridulation is known to be employed as a defensive mechanism in several lineages. Usually both sexes, and in the case of the last two mechanisms also nymphs, produce defensive sounds. Female tegminal stridulation has evolved at least three times independently in katydids. The stridulatory apparatus of the females is either homologous or independently derived from that of the males. Index terms: stridulation, tremulation, Tettigoniidae, Prophalangopsidae

[1737] BEHAVIORAL AND EVOLUTIONARY SIGNIFICANCE OF THE DIVERSITY OF STRIDULUMS AND CALLING SONGS IN CRICKETS

L. Desutter-Grandcolas, ESA8043 CNRS, Lab. Entomologie, Muséum National d'Histoire naturelle, 45 rue Buffon, F - 75005 Paris, FRANCE. E-mail: desutter@mnhn.fr

The structure and functioning mechanism of the stridulum have direct consequences for the sounds taxa are able to emit. In crickets, the stridulum consists in a sound generator and a resonator, which are sharply tuned; the calls are characterized by their rythm and by their carrier frequency, which corresponds to the resonant frequency of the resonator. The biological and phylogenetic diversity of crickets shows a much larger array of stridulums than usually considered (Desutter-Grandcolas 1995, 1997a, 1998a,b). Similarly, "unusual" calls have been documented, among which broad frequency modulations, pulse duration 3 to 6 times longer than usually admitted in cricket calls and poorly resonant calling songs (Desutter-Grandcolas 1997a, 1998a,b). Combined analyses of tegmina and songs actually reveal that several functional types of stridulum exist in crickets. They also demonstrate that the "unusual" calls are emitted by perfectly functional stridulums, even though the structures of the tegmina are more or less deeply modified. Conversely, a mismatch between the tegmina results in an irregular (both in time and frequency) burst of sound (Desutter-Grandcolas 1998c). These data have direct consequences for our understanding of cricket biology and evolution. Most singing crickets have stereotyped calls and their stridulums correspond to one functional type. Exceptions concern other stridulum types and "unusual" calls, which have appeared convergently in distantly related cricket taxa. If one also consider the evolutionary lability documented in some cricket clades for acoustic behavior (Desutter-Grandcolas 1997b,c), the ensuing pattern for cricket evolution is extremely complex. It is argued that the factors responsible for the effectiveness of calling songs shoud be reconsidered and that a better understanding of these could help to clarify the evolution of acoustic communication in crickets.

Index terms : Orthoptera, Grylloidea, Acoustic communication, Stridulation.

[1739] SEXUAL SELECTION, SPECIES ISOLATION, AND CHARACTER DISPLACEMENT IN MALE SONG AND FEMALE PREFERENCE FOR SONG IN THE FIELD CRICKET GRYLLUS TEXENSIS

<u>D. A. Grav</u>¹ & W. II. Cade^{1,2}, ¹Biological Sciences, Brock University, St. Catharines, Ontario, L2S 3A1, Canada, E-mail dgray@spartan.ac.brocku.ca; ²President's Office, The University of Lethbridge, Lethbridge, Alberta, T1K 3M4, Canada.

Cricket calling song was historically viewed as a species isolating trait. Renewed interest in sexual selection subsequently promoted the view that the temporal structure of song may be influenced by sexual selection via female choice acting on naturally occurring song variants. Here we use the Texas trilling field cricket, Gryllus texensis, in an attempt to integrate the species isolating and sexual selection viewpoints. We examine male song and female preference for song across a broad geographic area encompassing allopatric populations, as well as populations sympatric with G. rubens, a cryptic sibling species best distinguished by pulse rate differences in calling song. By testing the offspring of fieldcaught females, we were able to address the following questions: (1) are female phonotactic preferences sufficiently strong to act as effective pre-zygotic isolating mechanisms? (2) is there any evidence for reproductive character displacement in either male song or female preference for song? (3) is there evidence of genetic effects on male song and/or female preference for song?, and (4) are the genes for male song and female preference genetically correlated? Together these questions help define the role that sexual selection may play in speciation, either as a factor promoting speciation directly or simply maintaining species integrity following divergence due to other causes. At the time of abstract submission, we have obtained the following partial answers: (1) virtually all females of both species show a very strong preference for conspecific song, although a significant proportion also show response > 0 to heterospecific song, (2) *G. texensis* populations do not differ with respect to allopatry/sympatry with G. rubens. We also tentatively conclude that genetic effects are likely, and that the male and female components may be genetically correlated, although genetic analyses are not yet complete. Further work will examine the behavior of laboratory-produced hybrids.

[1738] THE EVOLUTION OF MATING SYSTEMS IN SHORT-TAILED CRICKETS (GRYLLIDAE: ANUROGRYLLUS SPP.)

T. J. Walker¹, ¹Dept. Entomology and Nematology, Univ. Florida, P.O. Box 110620, Gainesville, FL 32611-0620, USA, E-mail: tjw@ufl.edu.

Unlike prototypical crickets, short-tailed crickets have vestigial ovipositors and construct complex burrows in which mothers lay their eggs and care for their young. During mating, the spermatophore is held by the male rather than attached to the female. Sexual behavior has been studied in three species: Anurogryllus arboreus, A. muticus, and A. celerinictus. Males of all three call for limited periods beginning after sunset. Their calling songs are long-sustained trills with pulse-repetition rates of 65 to 185 per second, depending on species and temperature. In A. muticus (in Panama) and A. celerinictus (in Jamaica), males either call the entire singing period from thumb-print like depressions that they construct at the entrances to their burrows to amplify and direct their calls, or they call for several minutes at many stops as they move over the surface. Depression-calling males should primarily attract flying females, because their calls are directed upward. Males that intersperse locomotion with calling may primarily attract burrow-inhabiting females to their calls. In addition, they may be searching for the burrows of nonphonotactic but receptive females as they wander. Females of these two species may rear more than one brood. A. arboreus (in Florida) is flightless and univoltine, and females rear a single-brood. Males most often call from perches about 1 meter up but also call from the ground, either at the entrance to their burrows or away from any burrow but without wandering. Females attracted to calling males mate at the site of calling. If at the male's burrow, the mating occurs within the burrow and the male yields his burrow to the female afterwards. The calling period of A. arboreus is more limited than the other two species and males without burrows spend most of the night silently searching for the burrows of receptive females. Females will mate in their burrows shortly after the final molt but will usually not leave their burrows to go to a calling male, even if nearby, for 1 to 2 weeks. Mating lasts an average of 16 minutes on perches and about 40 minutes in burrows or on the surface. Males calling on perches may mate with as many as three females during a calling period of less than 1 hour. Once mated, females no longer go to calling males but will mate additional times if found in their burrows. Loss of flight and adaptation to temperate climates in A. arboreus accounts for some of the differences in mating systems between it and the other two species.

Index terms: Anurogryllus arboreus, Anurogryllus muticus, Anurogryllus celerinictus, phonotaxis, acoustics

[1740] SINGING UNDER PRESSURE: CALLING BEHAVIOR AND MATE ATTRACTION IN CRICKETS SUBJECT TO PHONOTACTIC PARASITOIDS

M. Zatk & G.R Kolluru, Dept. of Biology, Univ. of California, Riverside CA 92521 USA; E-mail: mzuk@citrus.ucr.edu.

The field cricket *Teleogryllus oceanicus* is subject to an acoustically-orienting parasitoid fly, *Ormia ochreacea*, where both have been introduced in Hawaii. Males are therefore experiencing a relatively recent change in selection pressure on calling behavior. Other research in similar systems in North America has suggested that satellite behavior may evolve as a male strategy to avoid parasitization, but in Hawaii, although field populations contain substantial numbers of silent males, these tend to be more heavily infested, not less, perhaps because these individuals are too depleted to call. Experimentally-infested males show a decrease in calling rate, which appears to be costly because they also atract fewer females. Spermatophore production is also significantly reduced by infestation, even early in larval life when relatively little tissue damage has been produced by fly larvae. Females are also less likely to mount and mate with infested males. Index words: sexual selection, *Teleogryllus oceanicus, Ormia ochreacea*. [1741] EVOLUTION OF ULTRASONIC SIGNALING IN LEPIDOPTERA: DISCRIMINATION OF MATING CALLS FROM BAT ECHOLOCATION SIGNALS AND THE EXPLOITATION OF ANTI-PREDATOR RECEIVER BLAS BY SEXUAL ADVERTISEMENT

M. D. Greenfield¹ & T. Weber¹, ¹Dept. of Entomology, Univ. of Kansas, Lawrence, KS 66045, USA, E-mail greenfie@ukans.edu.

Hearing, and specifically ultrasonic hearing, is a widespread phenomenon among Lepidoptera that is generally believed to have evolved under the selection pressures imposed by insectivorous, echolocating bats. Sound production, however, is much less ubiquitous, and in various species it functions in sexual advertisement and courtship. The evolution of these lepidopteran signaling systems against the background of bat predation and the means by which lepidopterans discriminate mating from predator signals are major problems in animal communication. We addressed these problems in the lesser wax moth, Achroia grisella (Lepidoptera: Pyralidae), a species in which pair-formation is accomplished via male-produced pulses (100 µs) of ultrasound (100 kHz) attractive to females. A. grisella are sensitive (threshold < 50 dB SPL) to a wide range of ultrasonic frequencies, enabling them to hear the echolocation signals of both aerial-hawking and substrate-gleaning bats. Both flying and running moths exhibit defensive behaviors, dropping to the ground and cessation of locomotion, respectively, in response to simulated bat echolocations. We determined that female A. grisella discriminate the mating signals of advertising males from bat echolocations on the basis of the faster pulse rates (> 60 s⁻¹) of mating signals. Terrestrial defensive behavior is elicited by a slow rate of lengthy (≥ 1 ms) pulses, features of most searching phase bat echolocations. Unlike other insects that perceive and evade insectivorous bats, the perception of and negative responses to predators probably preceded acoustic signaling in A. grisella and other acoustic Lepidoptera. Thus, the acoustic signaling system may have originated via exploitation of an ancestral receiver bias, but development of a positive receiver response, and a possible shift in a signal character (pulse rate), must have occurred subsequently. We suggest various processes that may have allowed this radical evolutionary development and call attention to the potential role that the perception of predators and associated negative responses may have played in the evolution of signaling systems via exploitation of receiver hias.

Index terms: acoustic communication, female choice, Lepidoptera, sensory bias, sexual selection, waxmoth.

[1742] BATS, MOTHS, AND POETRY: THE EVOLUTION OF ACOUSTIC COMMUNICATION IN TIGER MOTHS (LEPIDOPTERA: ARCTHDAE)

W. F. Conner, Department of Biology, Wake Forest University, P.O. Box 7325, Winston-Salem, NC 27109, USA, E-mail conner@wfu.edu

Tympanal sound receptors clearly evolved in response to selective pressures provided by echolocating insectivorous bats. Tiger moths (Arctiidae) secondarily evolved tymbal organs with which they answer the echolocation cries of bats with broadband clicks. The presence of both sound reception and production set the stage for the repeated evolution of intraspecific ultrasonic communication systems for the purpose of detecting, finding, and obtaining mates. The use of ultrasonic signals in courtship will be documented for the species *Cycnia tenera*, *Euchaetes bolteri*, *Syntomeida epilais*, and *Empyreuma affinis*. The use of ultrasound in courtship has evolved a minimum of five times with the Arctiidae. Ultrasound use in courtship has evolved a minimum of five times with the Arctiidae: once within the subfamily Lithosiinae, once within the tribe Arctiini, once within the tribe Callimorphini, once with the tribe Phaegopterini and once within the tribe Euchromiini.

Index terms: Lepidoptera, Arctiidae, ultrasound, courtship

[1743] THE DYNAMICS OF SEXUAL SELECTION AND THE EVOLUTION OF NOVEL ACOUSTICAL SIGNALING IN HAWAIIAN DROSOPHILA

K.Y. Kaneshiro, Center for Conservation Research & Training, Univ. of Hawaii, 3050 Maile Way, Gilmore 406, Honolulu, Hawaii 96822, USA, E-mail kykanesh@hawaii.edu.

It has been suggested that sexual selection and the dynamics of sexual selection have played a critical role in the evolution of the tremendous speciation of Drosophilidae in the Hawaiian Islands. During periods of small population size, there is strong selection for females that are less choosy in mate selection which results in an increased frequency of less choosy females in subsequent generations of small population size. It is suggested that such conditions result in a shift in gene frequencies toward the genotypes of the less choosy female. Perturbation of the balanced genetic system results in a destabilized genetic condition and the break-up of co-adapted genetic elements, which in turn, promotes the generation of novel genetic recombinants previously not present in the population. These novel genetic elements then provide the raw material upon which natural selection or sexual selection can operate in the population's ability to adapt to the new habitat or to changing environmental conditions. Some selection experiments involving morphological characters will be used to illustrate the pleiotropic effect of the sexual selection system and this model will be used to explain the four different mechanisms of acoustical signaling observed among the Hawaiian Drosophila species. While wing vibrations are known to produce acoustical signals among dipteran species, several species of Hawaiian Drosophila also produce sounds by vibrating two pairs of muscles that adjoin the thorax and abdomen. Other species produce a high frequency sound which is beyond the sensitivity level of the typical receptor found in Diptera, i.e. the arista. Still other species are able to modulate the frequency of their wing vibrations resulting in a much more complicated set of signals previously unknown for dipteran species. It is suggested that the novel acoustical signaling mechanisms in the Hawaiian Drosophila are pleiotropic results of shifts in the sexual selection system during founder events or during population bottlenecks.

Index terms: mate choice, small population size, speciation, founder event, genetics.

[1744] EVOLUTION OF APOSEMATIC SIGNALS IN MUTILLID WASPS (HYMENOPTERA)

G. Tschuch¹ & D. J. Brothers², ¹Inst. f. Zoologie, M.-Luther-Univ., Domplatz 4, 06099 Halle, Germany, E-Mail tschuch@zoologie.uni-halle.de; ²Univ. of Natal Pietermaritzburg, School of Botany and Zoology, Private Bag X01, Scottsville, 3209 South Africa.

Female mutillid wasps are extremely robust and have a very powerful sting. This enabled the evolution of aposematic signals although these insects are solitary and their strategy is k-selection. Mutillid wasps have evolved aposematic signals in a mutimodal fashion, involving optical (conspicuous bright contrasting colours), mechanical (acoustic, vibrational), and chemical signals. The present paper deals with the acoustic and chemical signals. Acoustic and vibratory signals are produced by stridulation, the stridulatory file being on the third metasomal tergum. The airborne signals have a broad spectrum with many harmonics. This may be important for aposematic acoustic signals because potential predators are phylogenetically very different or because the signals may have evolved in Mullerian mimicry to hissing by vertebrates. The chemical signals in mutillid wasps are produced by secretions of the mandibular glands, containing a cocktail of allomones. Apart from ketones, alcohols and acetophenone, probably acting as substances that are toxic or unpleasant to some predators, alkylpyrazines and other chemicals which may act as warning signals have been found. They are perceptible by manunalian and avian predators even at very low concentrations. The reason for multimodality of the signals will be discussed. Parts of this study were financially supported by the Deutsche Forschungsgemeinschaft grant number Ts 53/1-1 and Ts 53/1-2 (to GT) and the University of Natal Research Committee (to DJB).

Index terms: Mutillidae, stridulation, allomone.

Symposium and Poster Session

[1745] EVOLUTION OF SOUND AND VIBRATION PRODUCING ORGANS IN HETEROPTERA AND HOMOPTERA - AUCHENORRHYNCHA

M. Gogala, Prirodoslovni muzej Slovenije, (Slovenian Museum of Natural History) Presernova 20, SI-1001 Ljubljana, Slovenia, E-mail: matija.gogala@uni-lj.si.

During the last 30 years it became clear that communication with vibrational signals is widely spread in Heteroptera and Homoptera Auchenorrhyncha. Another discovery was that in Heteroptera various stridulatory structures are not the basic vibrational or sound producing mechanisms. Much more common, but not easily recognizable, is the presence of structures producing low frequency vibrational signals with a frequency range between 50 and 250 Hz. These signals are certainly not produced by different reasonably well known stridulatory organs which produce also in vibrational communications mainly broad band medium frequency signals (500 Hz - several kHz). Body vibrations are produced in some systematic groups by a tymbal mechanism (e.g. Cydnidae) and in others by simpler body part vibrations (e.g. Pentatomidae). Similar structures situated in the first abdominal segments are present in planthoppers, leafhoppers, and other related groups of Auchenorrhyncha with the sole exception of the singing cicadas that possess specialized tymbal membranes and use the airborne sound for communication. But even in this case the tymbals are situated in the same part of the insect body and every year more additional sound producing structures and mechanisms become known in this group of Homoptera also. In other Auchenorrhyncha, the basic type of acoustic signals are also low frequency vibrations produced by the longitudinal and/or dorsoventral muscles in the first two addominal segments. Probably in most cases the muscle action is enhanced and modulated by tymbal structures. Therefore, it is evident that a vibration-producing structure in the first two abdominal segments is an old acquisition in the evolution of all Hemiptera. Other sound or vibration producing organs such as stridulatory organs or wing clapping mechanisms developed independently in various groups of Hemiptera. Index terms: Hemiptera, acoustics, communication

[1746] THE ROLE OF ACOUSTIC COMMUNICATION IN SPECIATION OF PLANTHOPPERS (HEMIPTERA: FULGOROMORPHA)

H. Hoch, Museum für Naturkunde, Humboldt-Univ., Invalidenstr. 43, D-10115 Berlin, Germany, E-mail hannelore.hoch@rz.hu-berlin.de.

To ensure survival and reproductive success of a given species, it is essential for conspecific individuals to communicate, i.e., to interact, so as to pass on information to potential partners. Generally, mobile, sexually reproducing organisms have developed specific mate recognition systems (SMRS) which may consist of optical, chemical, tactile or acoustic signals, or a combination thereof. In case the SMRS of two given populations diverges - regardless whether by natural or by sexual selection, or by genetic drift - to a point where conspecific partners fail to recognize each other as such, reproductive isolation is the result. Thus, the two populations have attained species status. An excellent model to study the evolution of SMRS is obligately cavernicolous planthoppers in Cixiidae from Hawaii. In troglobitic planthoppers, the main element of the SMRS is lowfrequency vibrational signals produced in a specialized abdominal structure and transmitted via the legs to the host plant, roots of native trees. Thus, we can expect a high selection pressure on the maintenance of a signal structure that will serve its purpose most effectively. Our research on Oliarus polyphemus from lava tubes on Hawaii Island revealed: 1) as compared to epigean planthoppers, all cave populations studied display a simplified call structure, with single signals consisting of more or less homogenous pulse trains, 2) within a given population variation is usually low, and 3) in Hawaii, O. polyphemus populations from different lava tubes showed high variation among populations. The results of playback experiments suggest that at least some of the populations studied are reproductively isolated, i.e. they can be regarded as separate species. The evolution of this species complex is most likely independent of adaptive processes as all O. polyphemus populations studied colonize very similar types of habitat. A study is under way to investigate the genetic information underlying the differentiation of the SMRS within the O. polyphemus species complex. At present, our research focuses on the period gene which is expected to provide insight in the genetic basis of signal structure. This information will not only contribute to our understanding of the time frame within which the observed divergence may have occured, but will be integrated with other empirical data sampled over the past decade, such as structure and size of O. polyphemus populations, life history, reproduction and migration rate, to develop a mathematical model to describe speciation processes.

Index terms: Cixiidae, Oliarus polyphemus, cavernicolous species, SMRS

[1747] FREQUENCY DISCRIMINATION IN CICADAS: A FRAMEWORK FOR EVOLUTION OF COMPLEX SIGNALS?

P. Fonseca

ABSTRACT NOT RECEIVED

[1748] DEVELOPMENT AND UTILIZATION OF ANAPHE INFRACTA

II. Akai & T. Nagashima, Department of Agriculture, Tokyo University of Agriculture, Funako, Atsugi, Kanagawa 243-0034, Japan

Anaphe silkmoths behave as a group in their feeding, molting and movement during their larval stage, and the offspring from a single mother moth collaborate to make a huge silk nest. They belong to Thaumetopoeidae in Notodontoidea. Anaphe silkmoth makes a very large silk nest, about 25 X 15 cm in diameter, which contains numerous individuals in a single cocoon. Our interest in this insect is in the following : 1) Are they social insect? 2) How they collaborate to make their silk nest? 3) What are the structural characteristics of the cocoon and cocoon filaments? We will describe preliminary findings on this moth and its silk. An egg mass laid on a leaf is covered with a thick blanket containing scales and silk fibers originating from the moths. Matured larvae collaborate to make a huge silk nest which is composed of a common silk shell and numerous individual cocoons. A special stimulating vapor released from the silk nest causes the skin to itch when touched by the hand. Following degumming of cut nest, we no longer feel this sensation which means that the stimulating chemical is contained in sericin of the cocoon filaments. Each silk filament is extremely flat in cross section and compact, without any fine porous structure. Degumming of a bisected Anaphe silk nest was impossible by usual method, and a new method was developed.

Index terms: Anaphe, stimulating vapor, silk nest, cocoon filament, degunuming method

[1749] ANALYSIS OF SOME IMPORTANT FACTORS AFFECTING OVIPOSITION AND LONGEVITY OF THE ECTOPARASITIC WASP LAELIUS PEDATUS (HYMENOPTERA: BETHYLIDAE), A PARASITOID OF DERMESTIDE PESTS

A.-G. Al-Kirshi¹, II. Bochow², W. E. Burkholder³, Ch. Reichmuth⁴, ¹General Department of Plant Protection, P. O. Box 12724, Sana'a, Yemen; E-mail alkirshiabdul@y.net.ye; ²Humboldt-University of Berlin, Faculty of Agriculture and Horticulture, Department of Phytomedicine and Phytopathology, Lentzallee 55-57, Berlin 14195, Germany; ³USDA-ARS, Department of Entomology, 1630 Linden Drive, University of Wisconsin, Madison, W 53706 U.S.A; ⁴Federal Biological Research Center for Agriculture and Forestry, Institute for Stored Product Protection, Königin-Luise str 19, Berlin 14195 Germany.

The present study was designed to analyse the factors of temperature, relative humidity and diet and their effect on oviposition and longevity of the wasp L. pedatus as a possible antagonist to use it in biological control of dermestide pest in the store. Most egg-laying activity of the wasp occurred at temperature levels of 25°C - 28°C. Oviposition was not possible at 15°C and below. At 28°C and 50 - 60 % relative humidity a single female was able to deposit 52.3 \pm 6.3 eggs on the larvae of Trogoderma angustum. The average number of eggs per female and day was 1.42 ± 0.2 . The egg-laying activity occurred at both low and high relative humidity. The average numbers of eggs laid at extremely low humidity levels below 10 % and at high humidity levels above 90 % at a temperature of 28° C were 62 ± 12.6 and 25 ± 8 per female, respectively. Longevity of the female wasp increased with decreasing temperature down to 15°C and could also be prolonged by supplying the wasp with a diet of honey. The average life time of females fed with only host larvae lasted from 3 weeks at 35°C up to till 16 weeks at 20°C. At 28°C and 50 - 60 % relative humidity, about 80 % of the deposited eggs (n = 107) developed to adults. This number indicates, by consideration of the natural mortality of the larval and pupal stages, that the eggs' hatching rate was higher than 80 %. The total developmental time from eggs to adults under these conditions lasted 34.7 ± 1.8 days (n = 150). The observed biological characteristics of L. pedatus render the wasp a suitable agent to control dermestide pests like Trogoderma granarium, T. angustum and Anthrenus verbasci. However, field investigations in the store are needed to verify these results.

[1750] FRAGRANCE COLLECTION BY MALE EUGLOSSINE BEES, EUGLOSSA TOWNSENDI (IIYMENOPTERA, APIDAE) IN FLOWERS OF CRINUM PROCERUM

A. K. Braga¹ & C. A. Garófalo, Depto. Biologia, Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto-USP, 14040-901, Ribeirão Preto, SP, Brasil, E-mail: ¹ akbraga@usp.br.

Male euglossine bees collect fragrances from the flowers of orchids and other plants, and broken and decaying vegetation, and store them in their tibial organs. The exact function of these fragrances is not entirely understood, but they possibly play a role as pheromones. Fragrance collecting by males of Euglossa townsendi from Crinum procerum was observed on the campus of the University of São Paulo, Ribeirão Preto, State of São Paulo, Brazil, in December 1998, February, March, November and December 1999, and January 2000. The plants were grown in a study plot, 12.25 m^2 (2.85 x 4.30m), established near the laboratory. The number of flowers on each of the inflorescences of *C. procerum* ranged from 6 to 8, and each flower had 6 tepals. The pattern of daily visitation by males was determined by continuous observations from 0700 to 1800h during 22 days. The males (n= 141) visited C. procerum inflorescences from about 0730 to 1600h, but most of them (n= 77) were active between 0900-1200h. When the males arrive at the inflorescences, they hover in front of one or more flowers for some seconds and then land near the edge of the tepals on the ventral (n = 70 cases) or dorsal (n = 45 cases) surface. After that they begin to brush on the surface of the tepals with their front tarsi. This activity is often interrupted when the males fly off the tenals to hover near the flower and to transfer the fragrance from the front tarsi to the hind tibiae. After finishing the transference of the fragrance, the males land and brush again, repeating the cycle of brushing and hovering several times until they fly away. The time of permanence of the males at the flowers ranged from 4 to 58 min (x = 22.6 \pm 12.3 min; n = 100) and they spent 123-2886 sec (x = 1105 \pm 657.3 sec; n = 100) brushing on the surface of tepals and from 3 to 991sec (x = 252.3 ± 187.4 sec; n = 100), transferring perfume from the front tarsi to the hind tibiae. The fragrancecollecting behavior showed by the male Eg. townsendi was similar to that described for other Euglossini species. The pattern of daily visitation of Eg. townsendi to the inflorescences of *C. procerum* resembled the pattern of visitation to artificial bails observed for males of several other species. The identification of the components of floral fragrances produced by C. procerum could explain why males Eg. townsendi have rarely been attracted to artificial baits.

Index terms: Euglossini, behavior, floral fragrance.

[1751] OVIPOSITION BEHAVIOR AND BIOLOGICAL CHARACTERISTICS OF TWO PHORID FLY PARASITOIDS OF THE LEAF-CUTTING ANT ATTA LAEVIGATA

M. A. L. Bragança & A. Tonhasca Jr., Universidade Estadual do Norte Fluminense, CCTA/LPP, 28015-620, Campos dos Goytacazes, RJ, Brazil. E-mail: braganca@uenf.br

Phorid flies Neodohrniphora spp. are common parasitoids of several species of leafcutting ants, and Atta laevigata hosts at least two species not yet described of that genus. Ovipositing females of two species of Neodohrniphora were collected in the field and released singly inside an observation chamber placed between a laboratory nest of A. laevigata and its foraging arena. One of the phorids (SP1) approaches the front or side of the ant head and apparently introduces the ovipositor in the host foramen magnum. The other species (SP2) approaches the ant gaster from behind and seems to insert the ovipositor through the anal opening of A. laevigata. The A. laevigata workers usually defend themselves from attacks of SPI by leaning on the medial and posterior legs, and attacking the fly with the anterior legs and jaws. The workers attacked by SP2 curl the gaster inwards to avoid the oviposition and try to "kick" the fly with the posterior legs. These movements suggest an attempt to scare away the fly. Unlike SP2, SP1 is not generally able to oviposit in the loaded ants because leaf fragments hinder its approach. The number of successful attacks/h (mean ± 1 s.d.) for SP1 (4.9 \pm 3.4, n = 26) was significantly larger (t = 4.91, P < 0.0001) than for SP2 (1.1 ± 1.9, n = 28). Dead parasitized workers were deposited by nestmates in nest refuse piles and identified by the presence of a phorid puparium betweem their jaws. This presence indicates the migration of SP2 larva from the gaster to host head. Attacks of SP1 and SP2 resulted in 46% and 19% of ants being parasitized, respectively. Adult flies emerged about 35 days after oviposition. The head width of ants (mean ± 1 s.d.) attacked by SP2 (3.5 \pm 0.6 mm, n = 162) was significantly larger (t = 5.77, P < 0.0001) than the head width of ants attacked by SP1 (3.1 \pm 0.5, n = 111). Since SP1 and SP2 select hosts of different sizes, and phorids in general affect the foraging behavior of Atta spp., both parasitoids shoud have an additive effect on reducing foraging activity of A. laevigata.

Index terms: Phoridae, Neodohrniphora, parasitism

[1752] NEST ARCHITECTURE AND NESTING BEHAVIOR OF ALEPIDOSCELES FILITARSIS (APIDAE, ANTHOPHORINAE)

<u>G. Cilla¹</u> & J. F. Genise², ¹Laboratorio de Icnología, Museo Argentino de Ciencias Naturales, Angel Gallardo 470, (1405) Buenos Aires, Argentina. E-mail: <u>gcilla@muanbe.gov.ar</u>, ² Departamento de Icnología, Museo Paleontológico Egidio Feruglio, Fontana 140, (9100) Trelew, Chubut Argentina. E-mail: mel002@infovia.com.ar.

The nest architecture and behavior of a species of the genus Alepidosceles (Emphorini) is reported herein for the first time. Data on nesting behavior of Alepidosceles filitarsis were obtained in La Rioja, Argentina, during December 1999. Several females were nesting in gravelly to sandy, well insolated, soil, having scattered plants of flowering Portulaca sp. from which the bees collected pollen. There was a single female per nest. In contrast to many Emphorini, bees did not bring water to soften the substrate during excavation. The soil was excavated with the mandibles and pushed outside the tunnel with lateral movements of the abdomen and the hind pair of legs. During the excavation of the nest, the sand was deposited around the entrance, forming a tumulus of loose soil (diameter ranging from 4.2 cm to 6.7 cm). The tumulus showed around the burrow entrance a distinct, more consolidated tube, like a "chimney" (length ranging from 0.7 cm to 1.6 cm). Although this chimney was not constructed actively by the bee, it was probably cemented by some secretion considering that it remained standing even when the wind blown up the rest of the tumulus. The main tunnel was excavated at a right angle from the soil surface (0.5 cm of diameter and length ranging from 3.3 cm to 4.6 cm). It showed from two to three lateral tunnels, at inclined angles, which leaded to series of cells. Abundant stones in the soil commonly produced sharp deviations of tunnels. The deepest cell of a series might contain either the oldest or the youngest larvae, suggesting that the direction of cell excavation was indistinct. Cells were provisioned with a ball-shaped mass of pollen. Eggs were laid in the lower side of pollen mass. Foraging took place during the morning and midday, when flowers were open, whereas in the afternoon, when the availability of flowers decreased, the construction activities were most important. Key words: bee, nests, excavation, foraging

[1753] THE LANGUAGE AND DIALECTS OF THE SOUTHERN GREEN STINK BUG NEZARA VIRIDULA, AN INSECT WHICH COMMUNICATES THROUGH PLANTS

<u>A.Čokl.</u> M. Virant-Doberlet & N. Stritih, Dept. Invertebrate Physiol., Natl. Inst. Biol., Večna pot 111, P.O.Box 141, SI-1001 Ljubljana, Slovenia, E-mail andrej.cokl@uni-lj.si

The southern green stink bugs Nezara viridula (Pentatomidae, Heteroptera) communicate in the premating time with chemical and vibratory signals. Vibratory signals constitute songs which are transmitted between communicating partners through plants as bending waves. The presence of a male triggers a female to emit the calling song to which a male responds with the calling and courtship song. The latter induces female courtship song emission which preceeds copulation. Males sing the rival song when courting the same female and females emit the repelling song when not ready to mate with courting males. Such a song repertoire has been confirmed in populations from Australia, Brasil, Florida, France, Guadalupe, Greece, Italy, Japan and Slovenia. The dominant frequency peak of their songs lies between 80 and 150 Hz and spectrally different and frequency modulated subunits are present within the same pulse and/or pulse train. Spectrally different and frequency modulated subunits decrease extensive intensity variations with distance as characteristic at nodes and antinodes for pure tones in standing wave conditions. The average duration of pulses and pulse trains differs between different populations more in the calling than courtship songs and the repetion time of song units varies extensively between them. Despite of different temporal structure normal communication could be shown between the Slovenian and Brazil, Florida and Italian and Guadalupe and Greece populations. Hybrids between the bugs from Brazil and Slovenia emitted songs which varied distinctly from parental and described differences could be attributed to genetic factor. Some parameters were intermediate between the parental ones and some were apparently sex-linked. Males showed vibrational directionality on a plant mediated by the female calling song. Intensity differences measured with Laser Doppler vibrometer between adjacent points on stem and petioli at relevant distances of about 1 cm were high enough to release differential nerve activities of vibration receptor cells of different legs. Males recognize the female calling song mainly by the duration of pulse trains when the frequency of the latter lies between 80 and 200 Hz. Males are more tolerant to prolonged artificial signals but stop responding when signals are shorter than the range of duration variation of natural ones. This phenomenon may be explained by signal prolongation due to echoing when transmitted through plants.

Index terms: Heteroptera, Pentatomidae, vibrational communication, mating behaviour.

[1754] APOCRINE SECRETION OF AMYLASE AND EXOCYTOSIS OF TRYPSIN ALONG THE MIDGUT OF *TENEBRIO MOLITOR* LARVAE

P. T. Cristofoletti¹, A. F. Ribeiro² & W. R. Terra¹, ¹Depto. de Bioquímica, Instituto de Química, Universidade de São Paulo, C.P. 26077, 05513-970 Brazil, E-mail ptcristo@quim.iq.usp.br; ²Depto. de Biologia, Instituto de Biociências, Universidade de São Paulo, C.P. 11461, 05422-970, Brazil.

Amylase and trypsin were purified from Tenebrio molitor midgut larvae and used to raise antibodies in a rabbit. A western blot of T. molitor midgut homogenates, after sodium dodecyl sulfate-polyacrylamide gel electrophoresis using amylase and trypsin antiserum, showed only bands co-migrating with the purified enzymes. The antiserums were used to localize the enzymes by immunofluorescence and immunogold labeling. Amylase occurs in a few regularly disposed anterior midgut cells. Non-amylase-secreting anterior midgut cells are supposed to be water-absorbing cells based on morphology and dye movements. Amylase is found inside vesicles originating from Golgi areas that seem to fuse one with another before their release together with the now disorganized apical cytoplasm (apocrine secretion). Trypsin precursors concentrate inside small vesicles near the apical cytoplasm of posterior midgut cells, suggesting an exocytic mechanism of secretion, followed by putative trypsin activation. Apocrine secretion is thought to be an adaptation to enhance the dispersion of secretory vesicle contents released from an water-absorbing tissue, whereas exocytosis is an efficient secretory mechanism in an water-secreting tissue. Index terms: digestion, enzyme, microapocrine, immunocytochemical study, peritrophic membrane

[1755] BEHAVIOR OF HEDYPATHES BETULINUS (COL., CERAMBYCIDAE) ON ILEX PARAGUARIENSIS

M. d'Ávila¹, J. V. C. Guedes¹, S. H. B. Dornelles¹ & E. C. Costa¹, ¹Departament of Crop Protection, Santa Maria Federal University, 97105 900, Camobi, Santa Maria, RS, Brazil, E-mail jvcguede@carpa.ciagri.usp.br.

The larvae of *Hedypathes betulinus* (Klug, 1825) (Coleoptera: Cerambycidae) feed on Paraguay tea (*llex paraguariensis*) and causes a relevant economic loss to plants and determines the use of the chemical control which is ineffective in most of the cases. The trial was carried out in the experimental area of the Crop Protection Department of the Federal University of Santa Maria in Rio Grande do Sul State - Brazil, to study the behaviour of mating, egg-laying, feeding and movement of beetles on the Paraguay tea plants (*l. paraguariensis*). These behaviour were monitored during four days (24 h day every one hour) in two screen cages, envolving a branch of a plant and containing two adult couples of *H. betulinus*. When approaching a female, the male tried to copulate immediately and usually mated several times during the day mainly between 2 and 6 p.m. and on along the branch. Egg-laying was more frequent on branches between 15 and 20 mm in diameter. The adults showed limited movement and sedentary behaviour.

Index terms: pest, Hedypathes betulinus, forest plant

[1756] HOW WELL DOES FOGGING SAMPLE A HIGH CANOPY EPIPHYTE?

M.D.F. Ellwood' & W.A. Foster', 'Dept. of Zoology, Univ. of Cambridge, Downing Street, Cambridge, CB2 3EJ, United Kingdom, E-mail: mdfe2@cam.ac.uk

It is widely postulated that rainforest canopies accommodate unusually high numbers of arthropod species. However, the canopy of most rainforests is incredibly difficult to access. Not surprisingly, this makes ground-based collection techniques seem more attractive. Since Erwin's landmark fog in 1981, many workers have opted to collect data by fogging canopies with insecticide. As a result, estimates of arthropod diversity in tropical rainforests, and even global biodiversity, have largely been based on data derived from fogged samples. Understanding the limitations of fogging is therefore important and widely relevant. New ascension techniques have allowed us to work within tree-crowns of the emergent dipterocarp species, Parashorea tomentella. One of the most common epiphytic plants in emergent trees is the Bird's Nest Fern, Asplenium nidus. This epiphytic fern, which commonly reaches dimensions of 2m x 3m, and weights of approximately 200 kg, may support a greater diversity of arthropods than the tree-crown of its host. However, fogging only sampled a fraction of the animals associated with this fern; essentially those on its extremities. Moreover, as the stunned arthropods fell to earth, those from the fern became inextricably mixed with the tree-crown fauna. A new fogging protocol has enabled us to make a precise distinction between fern samples and tree-crown samples. Thus, we can assess how well fogging samples the arthropod inhabitants of this epiphytic fern, and to what extent true canopy diversity could potentially have been underestimated in this study.

Index terms: Asplenium nidus, Parashorea tomentella, arthropods, diversity, tropical rainforest

[1757] DIAPAUSE TO FACILITATE THE REARING OF *HELICOVERPA* ARMIGERA (HBN.) (LEPIDOPTERA, NOCTUIDAE)

<u>E. Figueiredo¹</u> & A. Mexia², ¹DPPF/SAPI, Inst. Sup. Agronomia, Tapada da Ajuda, 1349-017 Lisboa, Portugal, ²INIA/EAN, Quinta do Marquês, 2784-505 Oeiras, Portugal; E-mail elisalacerda@isa.utl.pt.

Introduction: Consanguinity is a major problem in the laboratory rearing of *II. annigera* and some other noctuids. Normally, consanguinity is avoided through careful crosses of insects from different origin and periodical rearing refreshing.

However, another possible achieve, specially in small labs or in labs where H. armigera is only marginally studied, consists in rearing this insect only when it is necessary to run experiments by inducing and breaking diapause. Methodology: Based on information from Murray & Wilson (1991), the diapause was obtained submitting L2 larvae to a temperature from 17 to 19°C and an 11L: 13D photoperiod feeding on artificial diet based on maize. These conditions applied on L1 result in a high mortality level and after L2 the rate of no diapausing pupae increases a lot. Diapause condition was confirmed by the observation of the eyespots on pupal stage A (Shumakov & Yakhimovich, 1955). The weight was registered and the quantification of pupae malformations was done. Weight of pupae from larvae reared under conditions of 25°C temperature and 16L: 8D was also registered as well as weight of larvae from the diapausing insects progeny; data was used to carry out an ANOVA analysis using Statistica®. Time and conditions necessary to break diapause was also reported. Results and discussion: Diapausing pupae were stored at 15°C in obscurity for 2-3 years without having apparent reduced progeny. Weight from diapausing pupae $(0.337 \pm 0.036 \text{ g})$ was not significantly different both from their descendent pupae (0.317 \pm 0.030 g) and from normal rearing ones (0.328 \pm 0.033 g) (p=0.204; d.f.=1, 89), either considering both sexes or each one separately, which could be an indication of no redution in the progeny of diapausing insects. Nevertheless, irregular pupation was very frequent. The proportion of malformed pupae reached 30% (27.5-31.4%). In most of them larval exuvia remained in the head frontal region (hormonal irregularities?). Some larvae also died from disease and/or other causes, to which they are more sensitive in those inadequate rearing conditions. Diapause break could be achieved by submitting pupae to 20-25°C and 16L: 8D during about a month. Compared to males, females should be submitted to lower temperatures during some days to avoid their tendency to emerge first. Index terms: storing insects, diapause induction, diapause breaking

[1758] INTERSPECIFIC AND INTRASPECIFIC VARIATIONS IN APHID HONEYDEW: IMPACT ON THE MUTUALISM WITH ANTS

M. K. Fischer, W. Völkl & K. II. Hoffmann, Dept. Anim. Ecol., Univ. Bayreuth, 95440 Bayreuth, Germany; E-mail: melanie.fischer@uni-bayreuth.de

The honeydew composition of eight aphid species was studied. These species occupy different feeding niches (root, root collar, stem, leaves) on tansy (Tanacetum vulgare) and show a different host range (monophagous on tansy, oligophagous on perennial composites, polyphagous on various plant families). The honeydew sugar composition and the relative amounts of the detected sugars varied significantly between aphid species but not within different age classes of a particular aphid species. The monosaccharids glucose, fructose and the disaccharid sucrose were always present in the honeydew of all aphid species, while large concentrations of the trisaccharids melezitose and erlose were detected only in four species: the monophagous Metopeurum fuscoviride, the oligophagous Coloradoa tanacetina and Aphis vandergooti and the polyphagous Brachycaudus cardui. Neither the feeding niche nor the host range of aphid species seemed to be correlated with honeydew composition. By contrast, the quantitative honeydew production depended on the feeding niche of the aphid. Species sucking on leaves or on the shoot tip produced less amounts of honeydew than species feeding on the main stem or on the roots. Qualitative and quantitative honeydew production also help to explain the relationship with honeydew-collecting ants. Lasius niger, the most frequent ant species in the study area, attended aphid species dwelling on roots or stem, which produce large amounts of honeydew. The honeydew of unattended aphid species, which accumulated on neighbouring leaves, was collected only when it contained large proportions of trisaccharids. The other aphid species were disregarded by L. niger and often served as prey.

Index terms: Metopeurum fuscoviride, Aphis vandergooti, Coloradoa tanacetina, Brachycaudus cardui, Lasius niger.

[1759] WHAT IS SEXY ABOUT FIELD CRICKET COURTSHIP SONG?

M. J. Fitzpatrick, D. A. Gray & W. H. Cade. Dept. of Biological Sciences, Brock Univ., 500 Glenridge Ave., St. Catharines ON, Canada, L2S 3A1 E-mail: mf94az@badger.ac.brocku.ca.

The field cricket mating system is composed of three song types used by males. Calling song is used to attract females from distances, aggressive song is used for territorial aggressions between conspecifics, and courtship song is necessary for mating. Much is known about calling song phonotaxis in field crickets. In the Texas trilling cricket, Gryllus texensis (formerly G. integer), females have a net stabilizing selection for the average male calling song. The courtship song is far less studied across all field crickets. We used G, texensis as a model to investigate if females show preferences for characters in the male courtship song. Both correlational and experimental trials have shown that females were selecting males using courtship song. Composed of two types of sound pulses, high frequency and low frequency ticks, females were selecting for shorter time intervals (silences) between the ticks - termed Gap 1. This gap was also correlated with male condition such that males with long silences were significantly in poor condition (light for their body size) when compared to males having short silences. Both Gap 1 and condition were repeatable, an indication of the amount of variation that can be attributed to consistency among males, suggesting a possible genetic basis. If heritable, females can increase the probability of mating with a genetically superior male by selecting against long Gap 1 durations - a potential example of the good genes model of selection. Index terms: Gryllus texensis, female choice, sexual selection

[1760] BEHAVIOR OF ACTINOTE PELLENEA PELLENEA (LEPIDOPTERA: NYMPIIALIDAE) IN SE BRAZIL OVIPOSITING IN ITS FOOD-PLANT EUPATORIUM INULAEFOLIUM

R.B.Francini¹, **A.V.L.Freitas**², ¹ Museu de História Natural, FAFIS, Univ. Católica de Santos, Rua Euclides da Cunha, 247, 11065-902, Santos, SP, Brasil, E-Mail francini@unisantos.com.br, ². Mus. Hist. Nat., IB-UNICAMP, .CP-6109, Campinas, SP, 13083-970, Brazil, E-mail: baku@atribuna.com.br. Financial support: FAPESP, CNPq, CAPES.

The oviposition by many females in a unique food plant seems to be a common fact in Actinote butterflies and it was already observed in six species. In this work, emphasis was given to A. pellenea pellenea and observations were made in two areas in SE Brazil: the "Vale do Rio Cubatão" (VRCUB), and "Morro do Japui" (JAPUI), SP. Females always lay eggs in clusters on the underside of mature leafs (n>500 observations in more than 50 sites in SE Brazil). Oviposition size ranged from 86 to 1266 eggs (mean = 479.2, SD = 228.93, n = 56) in JAPUI, and from 100 to 833 (mean = 422.3, SD = 199.01, n = 26) in VRCUB. After laid, eggs are light yellow, changing to orange and finally red (2 days before eclosion) and in this work, less than 10% of the eggs by oviposition are infertile although the percentage of ovipositions with infertile eggs were high (JAPUI = 94% and VRCUB = 71%). Multiple ovipositions in one plant are common, and up to three different ovipositions can be found in a single leaf. Of these observations, the following questions emerged: (1) is the choice of the food-plant by the female random ? (2) the presence of an previous ovipositions will affect the size of the following ? (3) is the foodplant choice owed mainly to habitat factors or the characteristics of the plant ? Were studied 23 plants of E. inulaefolium in JAPUI, and 11 in VRCUB. The distribution of those plants in VRCUB was random but in JAPUI was not as indicated by the dispersion index. The number of ovipositions by plant were not random in both places, being grouped, and similar to a negative binomial. In all cases of double oviposition in the same leaf, the "new" ones (lighter eggs) were significantly lower than the "old" (darker eggs, tending to red). There were no significant correlation between the number of oviposition icating to req. Increase were no significant correlation between the number of oviposition in each plant and habitat and plant characteristics as: plant height and an "appearance index" (calculated in relation to the sizes and distances of the three nearest neighbors). Also the number and density of eggs by eviposition was not correlated with some leaf characters as area, orientation and inclination. Due to the highly unstable nature of the environments originally accupied by the host plants of *A. pellenea*, the pressures should be in the direction of (Wing many every fast, without choreirs the above. It is the above. in the direction of raying many eggs very fast, without choosing the plants. However, chemical actors were not evaluated, and could be important in defining the first ovicusitions, serving as cues to the following females. Index terms; super-oviposition, habitat diversity.

[1761] THE CHANGES OF SIGNALS IN MALE-FEMALE DUETS OF THE DEPHALICIDAE LEAFHOPPER, NEPHOTETTIX NIGROPICUTUS

M. Fukui & S. Nakao, Lab. of Insect Physiology, Graduate School of Agriculture, Kyoto Univ., Kitashirakawa, Kyoto 606-8502, Japan. E-mail mfukui@kais.kyoto-u.ac.jp.

In Japan, at least four Dephalicidae leafhoppers (Nephotettix nigropicutus, N. virescens, N. cincticeps, N. malayanus) are sympatrically distributed in the subtropics and tropics: N. nigropicutus and N. virescens inhabit on rice plant as common host plant in the tropics, N. nigropicutus, N. virescens and N. cincticeps on the rice plant in the subtropics, N. nigropicutus and N. malayanus on the gramineous Leersia hexandra in the subtropics and tropics. The distinct differences in male-female vibrational duets of the four sibling species indicated presence of pre-mating barrier, i.e. sexual isolation, among them. That also suggested that N. nigropicutus appear to be more discriminating than other three sibling species in choosing between mates of their own and that of other species. On the other hand, the production of vibrational courtship signals in females as well as males of planthoppers gave a contrary explanation towards choosy females: males appear to be more discriminating than females in choosing between mates of their own and other species, although other aspects of sex roles do not seem to be reversed in planthoppers (Andersson, 1994). As a first step to verify above two hypotheses, we have reconfirmed male-female courtship signals (duets) in Nephotettix nigropicutus. After a sexually receptive male spontaneously produced a advertising call, consisting of single trill and ca.12 chirps, female soon responded to him a answer call with two to four simple trills. This male-female duet was repeated twice or three times. Furthermore the male answered her with a call having two to four increased number of trills and the female called the male back again; the result was continuous duets between receptive partners until male copulatory attempt. Female trill in a duet was slightly different from that in spontaneous calling signal that was sometimes advertised by a sexually receptive female. The differences of signals between duet and spontaneous calling in both sexes may be resulted from the conspecific recognition and the proper mate recognition. We present more evidence for the changes in a reciprocal signaling involving both sexes. That biological significance will be also discussed.

Index terms: Nephotettix nigropicutus, vibrational courtship signal, male-female duet

[1763] FORAGING BEHAVIOR OF EPICHARIS BEES (HYMENOPTERA, APOIDEA, CENTRIDINI)

M. C. Gaglianone, Depto. Biologia, Pós-Graduação em Entomologia, FFCLRP, Univ. de São Paulo, Av. Bandeirantes, 3900, 14040-901 Ribeirão Preto (SP) Brasil, E-mail: mcrisgag@usp.br.

Epicharis is a Neotropical group of solitary and ground-nesting bees, more abundant and diversified in the "Cerrado" of central Brazil. Besides pollen and nectar, Epicharis females collect floral oils that are used in nest construction and, mixed with pollen, as larval food. The aim of this work is to describe and analyse the foraging behavior of Epicharis bees on flowers, mainly on Malpighiaceae, the only floral oils source known for these bees. The observations were made in a "Cerrado" ecosystem, in Luiz Antônio, SP, Brazil. Twelve species of Epicharis, belonging to subgenera Epicharis, Hoplepicharis, Epicharoides, Epicharitides, Triepicharis and Anepicharis, were found on flowers from August to May. Flowers of Bignoniaceae, Oxalidaceae, Vockysiaceae and Rubiaceae were used as nectar sources for both males and females. In flowers with tubular corolla, the bees always come into the flowers through its opening and can pollinate. The females collected pollen on flowers of Solanaceae, Styracaceae and Leguminosae by vibration -"buzz behavior" Twelve of the eighteen observed species of Malpighiaceae were visited by females of Epicharis to collect pollen and floral oils. The pollen collecting by E. cockerelli and E. nigrita was observed only on flowers of Byrsonima intermedia (Malpighiaceae). The analysis of the scopae and containing of brood cells of E. nigrita indicate that B. intermedia was the only source of pollen for this bee species in the study area. The behavior of the bees on Malpighiaceae is very similar among the species from different subgenera of Epicharis. The female lands on the center of the flower, grasps the base of the flag petal with her mandibles and scrapes the elaiophores on the undersurface of the sepals, using specialized setae disposed in fore and middle basitarsi, to collect floral oils. The female can gather pollen immediately after oil gathering, in the same flower, raising her hind legs and vibrating the body. The pollen grains of Byrsonima intermedia are dry and fine and, during vibration, they are expelled from the anthers and adhere to the ventral side of the bee body. The female can also perform visits for collecting only pollen or oil. Females collected only oil from flowers of Banisteriopsis spp., Peixotoa reticulata, Mascagnia cordifolia and Heteropterys byrsonimifolia. The small anthers and humid, larger pollen grains, when compared to those of B. intermedia, do not favor buzzing behavior. There is no specificity in the interactions between Epicharis bees and species of Malpighiaceae, in relation to oil foraging.

Index terms: Apidae, buzzing, floral resources, oil-gathering behavior, pollination

[1762] BOLL WEEVIL: BIOLOGY IN ALTERNATE HOST BY ARTIFICIAL OVIPOSITION

<u>D. Gabriet</u>¹, ¹Inst. Biológico. CP 70. CEP 13001-970. Campinas, SP. Brazil. E-mail ceib@dglnet.com.br Project "Integrated pest management of the cotton boll weevil in Argentina, Brazil and Paraguay-ICAC/04".

Alternate host play a significant role in boll weevil survival, especially during host-free periods. It was determined boll weevil life cycle when reared at noncotton plants and the longevity but feeding with cotton squares. The eggs or 1st instar larvae were transferred from cotton squares to flower bud of Hibiscus tiliaceus, Hibiscus rosa-sinensis, Hibiscus schizopetalus, Hibiscus sabdariffa, Abelmoschus esculentus and Gossypium hirsutum (control). The flower bud's stalks of the potential hosts were surrounded by cotton moistened with distilled water to promote enough humidity for larval development. The buds were each placed in plastics recipients kept in climatic chamber at 21°C photoperiod 14:10 (L : D) for 17 days. After that the flower buds were removed and sheltered by a glass recipient covered with a nylon screen to arrest the adults later on transferred to similar recipient bigger than the first one. Both recipients (emergence and feeding adults) were kept in the laboratory at 24°C, R U 70 % photoperiod 14:10 (L : D). The adults received every other day one cotton square and were maintained isolated from emergence to death. As soon as boll weevil died the sex was recognized and established the longevity. The percentage of adults was the following: Hibiscus rosa-sinensis 34.0, Gossypium hirsutum 30.0, Hibiscus schizopetalus 16.7, Hibiscus tiliaceus 10.0, Hibiscus sabdariffa 6.7 and Abelmoschus esculentus 6.7%. The life cycle of female and male was, respectively to H.rosu-sinensis 24.1 and 23.7, G. hirsutum 25.3 and 25.5, H. schizopetalus 26.0 and 24.7, H. tiliaceus 25.3 and 25.7, H. sabdariffa 26.0 and 32.0 and Abelmoschus esculentus 26.8 and 26.8 days. The mean weight of female and male was, respectively to H. rosasinensis 1.9 and 1.9, Gossypium hirsutum 2.1 and 1.9, H. schizopetalus 1.4 and 1.6, H. tiliaceus 1.8 and 1.9, H. sabdariffa 0.5 and 0.7 and A. esculentus 1.8 and 1.4 mg. The longevity of female and male was, respectively to H. rosa-sinensis 106.2 and 73.2, G. hirsutum 66.3 and 47.1 H. schizopetalus 78.0 and 54.0, H. tiliaceus 53.5 and 70.5, H. sabdariffu 2.5 and 18.0 and A. esculentus 88.0 and 56.4 days. The results showed that boll weevil can be developed in all species investigated however the adults mean weight was very low if confronted with boll weevil from cotton field (5.8 mg) in spite of that if at all the female could be able to lay eggs in them the best was II rosa-sinensis that presented bigger percentage of adults, minor life cycle, bigger longevity and adults mean weight near to control Gosypium hirsutum.

Index terms: Anthonomus grandis, alternate host, life cycle, longevity

[1764] DOES THE FRUIT SIZE INFLUENCE THE PARASITISM OF FRUGIVOROUS LARVAE BY EUCOILINAE SPECIES?

J. A. Guimaraes¹, M.F. Souza Filho², R. A. Zucchi¹, N. B. Diaz³, ¹ Dept. de Entomologia, Fitopatologia e Zoologia Agrícola (ESALQ/USP), Av. Pádua Dias 11, CP 9, CEP: 13418-900, Piracicaba – SP, Brasil, e-mail: jaguimar@earpa.ciagri.usp.br; ² Instituto Biológico, CP 70, CEP: 13001-970, Campinas – SP, Brasil; ³ Museo de La Plata, Dep. Científico de Entomología, Pasco del Bosque s/n, 1900, La Plata, Argentina. (research supported by FAPESP).

The species of Eucoilinae (Hym.: Cynipoidea: Figitidae) are larval-pupal parasitoids of cyclorrhaphous dipterous. Several species have been associated with tephritids (fruit flies) and lonchaeids larvae. Some species of these dipterous cause serious damage to fruit crops. In order to minimize their damage, the biological control with hymenopterous parasitoids has been used. In fact, the biological control with parasitic wasps has increased, but in some cases these parasitoids have not given satisfactory results. This is due to the little knowledge about basic studies, mostly on taxonomy, biology, behavioral aspects and trophic relations. As the fruit fly larvae develop inside fruits, it is very important to know the influence of the fruit size on the parasitism by hymenopterous parasitoids. Thus, fruits of different sizes from twenty species were evaluated in this study. The fruit size ranged from about 1g (Citharexilum myrianthum, Verbenaceae) to 240g (Mangifera indica, Anacardiaceae). The fruit samples were collected in several localities of the State of São Paulo, Brazil. Six species of Eucoilinae (Aganaspis pelleranoi, A. nordlanderi, Dicerataspis flavipes, Lophencoila anastrephae, Odontosema anastrephae and Trybliographa sp.) have been reared in association with fruit-infesting tephritids. However, the fruit size influence on the parasitism by eucoiline was determinated only for the three most common species - A. pelleranoi, I., anastrephae and O. anastrephae. There were no significant correlation between the size of fruits (estimated by weight) and the percentage of parasitism for these species. Probably this fact is due to the behavior observed for A. pelleranoi, in which female is able to get into big fruits searching for frugivorous larvae. This behavior has not been observed to others eucoiline species yet. Index terms: Hymenoptera, Eucoilinae, Diptera, Tephritidae, parasitoids

[1765] GOING WALKABOUT: MOVEMENTS OF INDIVIDUAL ADULTS IN A BREEDING POPULATION OF THE SPECKLED BUSHCRICKET, LEPTOPHYES PUNCTATISSIMA

M. J. Hall¹, D. J. Robinson¹ & J. Rheinlaender²

¹Dept. of Biological Sciences, Open Univ., Milton Keynes, MK7 6AA, UK, E-mail: mj.hall@open.ac.uk; ²Johan Wolfgang Goethe-Universitat, Zoologisches Institut, Siesmayerstrasse 70, Postfach 11 1932, D-6000 Frankfurt, Germany.

The speckled bushcricket, Leptophyes punctatissima, has been little studied in the wild. Duncan (1960) carried out some limited field observations in an oak-birch wood in the UK during the 1950s. On the basis of that study, plus some observations on a laboratory population, he concluded that (1) newly-emerged nymphs are found on shrubs and lowgrowing herbs; (2) late-instar nymphs and adults move up into the trees where they remain relatively inactive except for some increase in activity immediately before oviposition, which takes place in late August and September; and (3) towards the end of their life, in October, the adults become scattered. We have been studying a wild population of L. punctatissima in northern Germany. Individuals were marked soon after emerging as adults and their movements were then followed around the clock until the peak of the breeding season was over. Like Duncan, we found that newly-emerged nymphs are mostly found in low-growing vegetation, that there is some tendency for late-instar nymphs and adults to move up into the tree canopy, and that adults initially are relatively inactive. There were however some major differences between our observations and his. The movement from low to high vegetation was much less clear-cut than the behaviour he described: we found early-instar nymphs high in the tree canopy, for example, while many adults remained in low-growing vegetation. More important, once they became sexually mature (about a week after eclosion) the adults were far from inactive. Both males and females 'went walkabout', moving long distances and travelling between different trees and different vegetation types. Initially L. punctatissima was localised in a few pockets with a high concentration of late-instars and adults but, once the walkabout started, the population rapidly became much more thinly and widely spread. The implications of this

behaviour for mate choice and mating success in these insects will be discussed. Reference: Duncan, C. J. (1960) The biology of *Leptophyes punctatissima* (Bosc.) (Orthoptera: Tettigonidae). *Entomologist*, 93, 76–78.

Index terms: Leptophyes punctatissima, bushcricket, movement, life cycle.

[1767] CLADISTIC ANALYSIS OF NEOTROPICAL GENERA OF PHILEURINI (COLEOPTERA, SCARABAEIDAE, DYNASTINAE)

S. Ide, Centro de Sanidade Vegetal, Instituto Biológico, Av. Cons. Rodrigues Alves 1252, São Paulo SP 04014-900, Brazil, E-mail ide@biologico.br.

The tribe Phileurini was established in 1847 by Burmeister. It includes more than 35 genera and 220 species predominately distributed by the Southern Hemisphere, with species also occurring in the United States, China. Korea and Japan. In the Neotropics 142 species in 20 genera were recorded. The monophyly of the tribe is assured by an expanded mentum that covers almost entirely the first pair of palpomeres. A phylogenetic hypothesis was proposed for the Neotropical Phileurini genera employing the methodology of phylogenetic systematics. The transformation series (binary or multistate) were polarized through the out-group comparison. The available species of Phileurini genera *Cryptodus*, Eophileurus, Hovophileurus, Pseudosyrichthus, Rhizoplatys, Syrictes, and some Dynastini (Allomyrina, Chalcosoma, Dynastes, Golofa, Megasoma, Xylotrupes) and Cyclocephalini (Cyclocephala) species were selected as outgroups. In a previous analysis, only taxa at generic level were considered. However, some of them were polymorphic and were broken up into monomorphic units, so each terminal is based on a unique set of character states. Parsimony analysis was performed with software Hennig& employing mh* and bb* algorithms and operated in Windows[®] environment by TreeGardner. Character evolution was traced by Clados computer program. The analysis based on matrix with 29 terminal (including an hypothetical ancestor) taxa and 34 characters with 58 derivate states resulted in two equally parsimonious cladograms (118 steps, CI = 49, RI = 70). The strict consensus cladogram (119 steps, CI = 48, RI = 69) presented the following relationships: ((Cnemidophileurus, Actinobolus) ((Haplophileurus, Chiliphileurus) (Archophileurus/ (Microphileurus ((Metaphileurus/1, Metaphileurus/2) ((Oryctophileurus, Amblyodus) (Trioplus, Goniophileurus)))) (Archophileurus/2 (Mictophileurus (Amblyoproctus/1, Amblyoproctus/2) ((Hemiphileurus/3 (Hemiphileurus/2 (Hemiphileurus/1 (Planophileurus, Palaeophileurus)))) (Paraphileurus (Phileurus/3 (Phileurus/1, Phileurus/2 (Ceratophileurus (Homophileurus/1, Homophileurus.2))))))))). Mentum with a Philcurus/2 depression supports the monophyly of Neotropical Phileurini. Platyphileurus was removed from the tribe as result of the analysis.

Index terms: Platyphileurus, Cyclocephalini, Dynastini, phylogenetic systematics.

[1766] EFFECTS OF MATING FREQUENCY ON FEMALE REPRODUCTIVE OUTPUT IN THE CAT FLEA, CTENOCEPHALIDES FELIS (SIPHONAPTERA: PULICIDAE)

M. H. Hsu¹ & W. J. Wu¹, ¹Dept. of Entomology, National Taiwan Univ., 106 Taipei, Taiwan, E-mail catflea@mail.ht.net.tw

Multiple mating behavior of the female cat flea *Ctenocephalides felis* was confirmed in this study, and its effects on fecundity and fertility were investigated as well. Fertility of mated females was close to nil within 7 d following removal of males, but it was resumed when females were exposed to males again on day 7. Multiply mated females displayed significantly higher fecundity (400.3 eggs per female) and fertility (182.8 viable eggs per female) than singly mated females (61.7 and 19.0, respectively), suggesting that multiple mating by females is an advantageous strategy for cat fleas. Duration of 1st mating was 63.1 min on average. High ratio (55.56%) and short duration (34.0 min) of impotent mating hint that cryptic female choice may be involved during copulation. Low hatchability (29.8 – 45.7%) of eggs in multiply mated females indicates that the nonviable eggs may have some functional significance. Index terms: fecundity, fertility, mating duration.

[1768] COOPERATION AND DIVISION OF LABOR BETWEEN UNRELATED INDIVIDUALS IN THE ANT *PACHYCONDYLA 'INVERSA*'

J. Heinze¹, K. Kolmer¹, B. Trunzer² & B. Hölldobler², ¹ LS Biologie I, Univ. Regensburg, Universitätsstrasse 31, D-93040 Regensburg, Germany, ² Biozentrum, Univ. Würzburg, Am Hubland, D-97074 Würzburg, Germany.

Instead of starting a new colony solitarily, young queens of the neotropical ponerine *Pachycondyla inversa*' may cooperate during colony founding (pleometrosis). In contrast to many other ants, where founding queens have enough body reserves to produce their first young, queens of *Pachycondyla inversa*' have to forage for food. In pleometrotic associations, one queen specialises for this risky task, whereas the others do not leave the nest. Division of labour is strongly affected by antagonistic interactions: the dominant queens aggressively force the most subordinate queen to leave and forage. The frequency of attacks increased with the duration since food was last added to the foraging arena. Multilocus DNA fingerprinting suggests that co-foundresses are unrelated. Our study therefore is the first demonstration of status-related division of labour among unrelated individuals in eusocial insects. It stands in contrast to previous assumptions that cooperation among co-founding queens may be group-selected. Index terms: Ponerinae, dominance hierarchy, colony founding, pleometrosis

ABSTRACT BOOK I – XXI-International Congress of Entomology, Brazil, August 20-26, 2000

[1769] SPECIES RICHNESS AND SEASONAL ABUNDANCE OF MALE EUGLOSSINE BEES (HYMENOPTERA: APIDAE) IN A SEMIDECIDUAL STATIONAL FOREST OF THE SÃO PAULO STATE

B.M.V. Jesus¹ & C.A. Garófalo, Depto. Biologia, Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto-USP, 14040-901 – Ribeirão Preto, SP, Brasil, E:mail: ¹bmvjesus@usp.br.

Seasonal changes in species richness and abundance of male euglossine bees were determined by attracting individuals with three chemical baits: cineole, eugenol and vanillin. The study was conducted at Mata da Virginia, one of the biggest remnants of semidecidual stational forest of the São Paulo State. The forest has 2 072 ha and is located in the Municipios of Matão and Tabatinga (21° 38' S and 48° 32' W). Male euglossine bees were sampled by collecting them as they were attracted to chemical baits. The baits were presented for 3 consecutive hours between 0900 and 1300h, on absorbent paper pads suspended 4 m apart from the twinges by a string 1.5 m above the ground. The census was made monthly from January to December, 1996. A total of 814 individuals belonging to 4 genera and 10 species were captured. Euglossa pleosticia was the most abundant species (44.6% of the males collected) followed by Eufriesea violacea (38.1%). Eulaema nigrita (8.1%), Euglossa fimbriata (3.7%) and Euglossa annectans (3.3%). The other species, Euglossa truncata, Euglossa securigera, Euglossa cordata, Euglossa violaceifrons and Exacrete smaragdina were less frequently sampled, representing only 2.2% of the total sample. The number of species sampled in each season was similar (n = 8) but the abundance of bees was strongly seasonal, and the greatest number (n = 639) was attracted during the wet/hot season (September-March). Euglossa pleosticta and El. nigrita were recorded every month while Ef. violacea was attracted to baits only in November and December, Of the 10 species sampled, five were attracted to only one chemical (cineole). four were attracted to two (cineole and eugenol, Eg. truncata and Eg. annectans, or cineole and vanillin, Ef. violacea and El. nigrita) and one (Eg. pleosticta) was attracted to all three chemicals. When compared with other studies carried out in the São Paulo State, our results indicate: 1 - species richness higher than those found at Santa Carlota Farm, Santana Section, Cajuru, and at Estação Experimental de Zootecnia, Sertãozinho, and lower than those found at Santa Carlota Farm, Itaoca Section, and Serra do Japi, Jundiai; 2 - species composition more similar to that found at Serra do Japi: 3 - bee abundance highest at Mata da Virginia and 4 - seasonal abundance pattern similar to those related in other studies.

Index terms: Euglossini, diversity, bees, phenology.

[1771] INTERACTION BETWEEN PREDATORY BEE EATER AND DEFENCE-ATTACKING GIANT HONEYBEE $APIS\ DORSATA$

<u>G. Kastberger¹</u>, ¹ Department of Zoology, University of Graz, Austria. Supported by the Austrian scientific foundation, grant P13210-BIO, and epo-film Graz.

The South-East Asian Giant Honeybee (Apis dorsata) is named as "giant" because it is bigger than other honeybee species. It builds large nests of up to 2m wide. As many as 200 colonies may aggregate on a single tree. It is also known as the most ferocious stinging insects on earth. Visual or mechanical disturbance by unusual movements or vibrations nearby the nest may excite the colony, thus initiating alarm, defence and attack. Then several thousands of individuals may be recruited within seconds to persue the predator even for a kilometre or more. We investigated defense behaviours in Apis dorsata in Assam (Northeast India) when interacting with raiding bee eaters in an aggregation of fifty Giant honeybee (Apis dorsata) colonies on a bee tree in Assam, India. We filmed two scenarios with an Arriflex camera at 150 frames per second, first, when the bee eater passed parallel to a nest, threatening only the sunny side of the colony, and second, when the bird passed a nest laterally in perpendicular direction, eliciting attacking swarms from both sides of the colony. In the first scenario, we assessed around 500 bees in the attacking swarm, comprising 2-3 per cent of colony members. These bees followed the bird and continued patrolling the canopy during the subsequent minutes. We also found the first evidence for intercolonial group defense in Apis dorsata, which means that colonies or parts of them, which were not directly threatened, joined the defense action of the threatened colony. In the second scenario, the colony released around 100 bees from that side of the nest which was directly threatened from the approaching bird, and 200 bees from its opposite side which had only viewed the disappearing bird. We discuss how unthreatened nests or parts of them can be challenged for mass attack. Bees at the more shadowed nest sides may mobilise for mass attack to a less extent than the sunny sides. Consequently, the more active parts of the nests may respond to threatening cues faster and with a greater guard force. As honeybee colony defense is incited by alarm pheromones, two further non-visual ways are proposed that less threatened nests or parts of them may get aroused to join the mass attack. Firstly, the guards of threatened colonies may release their alarm pheromones directly at unthreatened colonies to make them join in an intercolonial group response. Secondly, the pheromone cloud may be dragged by air streams, such as those induced by raiding birds, to unthreatened nests.

Index terms: Giant Honeybee

[1770] RELATIONSHIP BETWEEN MICROHABITAT AND BODY SHAPE IN ADULT PASSALID BEETLES (COLEOPTERA, PASSALIDAE)

Y. Johki¹, M. Kon² & K. Araya³, ¹Showa Women's Univ., Setagaya, Tokyo, 154-8533 Japan; ²School of Environmental Science, Univ. Shiga Prefecture, Hikone, Shiga, 522-8533 Japan; ³Graduate School of Human and Environmental Studies, Kyoto Univ., Sakyo, Kyoo, 606-8501 Japan, E-mail: <u>johki@swu.ac.jp</u>

Passalidae are the family of Coleoptera, belonging to the superfamily Scarabaeoidea, and most species occur in the humid tropics. The subsocial behavior of them has often been cited in the entomological literature. It has also been known that passalid beetles show some morphological adaptations in the adult body shape to their microhabitats. In order to know the relationship between adult body shape and microhabitats, we made measurements of the adult body shape and field observations on the microhabitats for about fifty species belonging to eight genera of the Passalidae. The proportions of (elytra length)/(body length) and (elytralwidth)/(body length) are remarkably uniform among all the species examined, whereas body thickness greatly varies both among genera and species. We found that flatter species are living under the bark of logs and the species with flattened and widened front tibiae living in the detritus-like microhabitats. Index terms: morphology, adaptation, ecology

[1772] PREDICTABILITY OF AGGRESSIVENESS IN THE GIANT HONEYBEE APIS DORSATA

G. Kastherger¹ & H. Köfer¹, ¹ Department of Zoology, University of Graz, Austria. Supported by the Austrian scientific foundation, grant P13210-BIO.

The South-East Asian Giant Honeybee (Apis dorsata) is named "giant" because it is bigger than other honeybee species; it builds large single-comb nests up to 2 metres wide; and as many as 200 colonies have been observed to aggregate on a single tree. A. dorsata is also known as the most ferocious stinging insect on earth. Visual or mechanical disturbance of the nest, like objects moving before the colony or touch the nest surface may initiate alarm, defence and attack. Within seconds, several thousands of individuals could be recruited to persue the predator even for a kilometre or more. Despite decades of studies there is a high degree of unpredictibility of the state of a colony in respect to its readiness for attack. A model for systematic and quantitative analysis of the whole range of defenseand attacking behaviour is still lacking. We investigated the condition under which mass attack, as the last link in the chain of defensive behaviour, can be released in colonies which had been proved as undisturbed. Therefore, several colonies were treated successively under standardized conditions placing mechanical shocks. Documentation of the behaviour was done by conventional video and infrared recordings. Individual and colony parameters were evaluated by OPTIMAS image-analysis software. Temperature and light intensity were continuously recorded by a data logger device. It takes between 15 seconds to several minutes to bring a colony in such an arousal state that bees start to attack. It obviously depends on various factors like temperature, time of day, past history of disturbance (such as sensitization or habituation to stimuli), colony state (whether cluster or comb nest, comprising brood cells or not, whether ready to migrate or scheduled to stay longer, etc.), when and how the colony starts to attack a predator. After having placed mechanical disturbance, guard bees are recruited for mass attack only in certain areas of the nest. In a first reponse to the mechanical shock, hot bees from the inner layers of the nest come out to the surface, ready to attack at the next occasion. During mobilization of attacking guards, structural changes of the nest were detected and quantified by two parameters: first, the body temperature of surface bees increased, in particular of those roofing bees which were concerned to the stimulus; and second, the whole nest increased in size. However, we observed in longer-lasting experiments that both criteria which provided some information about the state of mobilization were finally not correlated to the state of readiness of the colony to attack. It is assumed that the main process to prepare the colony to start an attack within parts of a second takes place on a pheromonal level.

Index terms: Giant Honeybee / Apis dorsata / mass attack / recruitment / mobilization / aggressiveness

Session 09 – ETHOLOGY

Symposium and Poster Session

[1773] SEASONAL CHANGE IN DAYLENGTH REGULATES INCIDENCE AND INTENSITY OF DIAPAUSE IN A MOTH

<u>Y. Kimura¹ & S. Masaki²</u>, ¹Aomori Agric. Exp. Sta., I-1 Sakaimatsu, Kuroishi 036-0389, Japan, E-mail DZF03663@nifty.ne.jp; ²12-13 Matsubara Higashi-1, Hirosaki 036-8141, Japan, E-mail Sinzo.Masaki@mb4.seikyou.ne.jp.

The bivoltine life cycle of the cabbage moth Mamestra brassicae in Japan is mainly regulated by the larval photoperiod that determines the type of pupal development: winter diapause in short days, and nondiapause or summer diapause in long days. In Hirosaki (40°30'N), the critical daylength for winter diapause induction is about 14 h under stationary conditions. However, the egg and larva are highly sensitive to change in daylength, and this response plays an important role in the seasonal adaptation. Adults from overwintering pupae eclose between mid May and early July, so that early-growing larvae of their progeny develop under increasing daylengths before the summer solstice, but late-growing ones under decreasing daylengths thereafter. When larvae were reared under simulated natural daylengths increasing from 15.3 to 16 h, or decreasing from 16 to 15.3 h at 20 °C, both incidence and intensity of summer diapause were higher in the former conditions than in the latter. A similar difference was observed between larvae grown under the natural conditions from late May to late June and those from early to late July. This response would subserve to fine tuning of the adult eclosion time. As adults of the first generation of the year begin to eclose in late July, their progeny would grow under daylengths within the range preventing winter diapause if stationary. In the second generation, however, the probability for overwintering became higher in simulated natural daylengths than in the comparable stationary ones. For example, daylengths decreasing from 15 to 14 h and from 14.5 to 13.5 h during the larval stage induced 43 and 99% of the pupae to enter winter diapause, respectively, although stationary 14.5 and 14 h daylength gave 2 and 57% winter diapause, respectively. Moreover, the intensity of winter diapause was greater in the decreasing daylengths than in the comparable stationary ones. A similar tendency was observed among larvae reared during different periods under natural conditions from late July to early September.

Index terms: Mamestra brassicae, changing photoperiod, seasonal adaptation.

[1774] DEGRADATION OF TEMPORAL PARAMETERS OF A GRASSHOPPER SONG IN THE FIELD

F. Lang & <u>N. Elsner</u>, Dept. of Zoology, Univ. of Göttingen, Berliner Str. 28, D-37073 Götingen, Germany, E-mail nelsner@gwdg.de, Supported by Deutsche Forschungsgemeinschaft (DFG EL 35/18-1).

In gomphocerine grasshoppers the recognition of conspecific songs depends on their frequency content and temporal pattern. In Chorthippus biguttulus males show amplitude modulation frequencies of 20-40 Hz, and females of more than hundred Hz. Our study demonstrates the degradation of the temporal patterns of these non-resonant songs in the natural low grassland habitat of this species. Behavioral studies show that female songs cannot be recognized by males over distances longer than 120 cm, whereas the songs of males are recognized by females over distances of at least 210 cm. Further, it could be shown that female songs, the modulation of which had been low pass-filtered at 100 Hz, were as attractive for males as natural songs. Songs which only contained modulation frequencies below 75 Hz, however, were no longer attractive for males, indicating that the frequency components between 75 and 100 Hz are essential for the recognition of female songs. As the male songs do not contain these high modulation frequencies, the recognition distance of male songs is not as strongly effected by the physical properties of the habitat as that of female songs. By sound measurements in low vegetation, it was found that modulation frequencies above 75 Hz are strongly degraded, which in dense vegetation could only be observed to a minor extent. In search of an explanation for this effect, we measured the echoes of short sound pulses. While in low vegetation a great number of echoes was found, this was not the case in dense vegetation. By an evaluation of the echoes it was deduced that in low vegetation in a distance 120-150 cm the delay of the echoes is long enough to account for a masking of amplitude modulations in the sensitive frequency range of 75-100 Hz. These findings possibly represent a mutual adaptation of the temporal pattern and the sound intensity in this subfamiliy of acridids, which have specialized on acoustic communication with fast amplitude modulations, for which non-resonant stridulation at low sound intensity is a prerequisite.

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[1775] ADDITIONAL OBSERVATIONS ON NESTING BIOLOGY OF PTILOTHRIX PLUMATA (APOIDEA, ANTHOPHORIDAE)

S. Laroca¹ & <u>M. C. de Almeida¹</u>, ¹Depto. de Zoologia, Univ. Federal do Paraná, Caixa Postal 19020, 81531-990 Curitiba, PR, Brazil, E-mail slaroca@netpar.com.br

During the field phase of an ecological and biogeographical study of the wild bee communities in a cerrado (savanna) of the northeastern of Paraná [Sengés-Jaguariaíva region], we had the opportunity to find nests of some species of these organisms. Recently, one of us (MCA) discovered two aggregations of Ptilothrix plumata, an oligolectic species, in the walls of two termite nests. As nesting biology of bees is adequate subject in the search of adaptations which could be correlated with the survival of this bee in the peculiar biotopes of this ecotonal vegetation of southern Brazil, we judge to be worthwhile to report our additional observations on this species. P. plumata is a member of Melitomini, one of the anthophorid groups whose species have a tendency toward having narrow spectrum of flower visitation. As an example of this specialization is the relatively well known dependence of Melitoma segmentaria on the pollen of certain species of Ipomoea (CAMILO, GARÓFALO & SERRANO, 1993: Revia bras. Ent. 37: 145-156). P. plumata is the most abundant of the three species (Ptilothrix relata and Ptilothrix fructifiera) in the area, in spite of being one of the rarest when its abundance is compared with those of predominant bees collected in a census done in two years of collecting efforts. P. plumata is a medium sized bee (10.12 mm of total length), whose females are predominantly brown ferruginous, with well marked yellow hairy band on the four basal tergites. In the present work we report our observations on aspects as nesting site and substrate, nesting construction, ontogeny, interactions among neighbor nest owners (females), as well as natural enemies in this ecotonal region of cerrado. Most of the informations are complementary to those of IHERING, 1904: Revta Mus. Paulista 6: 461-HIGHMARD, 100; Deutsche Ent. Zeitschr, pp. 227-237; PICKEL, 1928; Bol. Biol., S. Paulo, 14: 135-143; MICHENER & LANGE, 1958; Univ. Kans. Sci. Bull.39: 69-96, and MARTINS, GUIMARÃES & DIAS, 1996: J. Kans. Entomol. Soc. 69: 9-16. Index terms: neotropical, cleptolectic-bee, oligolectic-bee, nest, Brazilian-savanna.

[1776] BIOETHOLOGY OF PHYLLOCNISTIS CITRELLA IN APULIA (SOUTH ITALY)

M. Pizza, T. Moleas, Dip. Di Biologia e Chimica Agro-Forestale ed Ambientale, Università di Bari, V. Amendola 165/a, 70126 Bari, ITALY, E-mail: maria.pizza@agr.uniba.it.

The Lepidoptera Gracillariidae Phyllocnistis citrella was reported for the first time in Apulia on citrus, at the end of August 1995. Since then, several studies have been carried out to investigate its bioethology in Mediterranean environments. In order to assess the infestation pattern of the leaf miner, many samplings and monitoring operations have been conducted in the orange grove of the experimental farm "Martucci", which belongs to the University of Bari, located in Valenzano and in some citrus-growing farms in the province of Taranto. On the grounds of the observations made, it has been demonstrated that: this insect occurs suddenly and spreads widely between the end of June and early July, generally when maximum temperatures have achieved 30°C for a few days; conversely, on the spring flush the typical symptoms have never been recorded; the insect activity stops around mid-August, when dry and hot conditions limit plant vegetative growth. In this period relative moisture can even reach 40%, with a monthly mean of 60 to 65% and irrigation does not allow new vegetative flush. On the other hand, from September throughout October, the infestation resumes massively and P. citrella generations overlap; the infestation can continue in Winter; until February, all the insect stages may be found at the same time, even a few sporadic eggs. These phenomena can be observed on lemon, the sole plant which continues to grow also in the Winter time, when temperatures are mild; until February, larvae and pupae may be found also on leaves fallen on the ground; pheromone traps have never proved effective against P. citrella, although the sexual pheromone has been tested at different amounts (0.1 mg, 1 mg and 10 mg of Z7, Z11hexadecadienal). Indeed, the first sporadic captures have occurred in October, during the full autumn infestation; chromotropic traps, both white and yellow, have registered the insect presence since July, after the infestation outbreak. White traps, despite the low capture levels, have proved to be more effective than the yellow ones; the parasitoids which have emerged from laboratory-reared leaf miner larvae belong to the *Pnigalio* genus (Hymenoptera, Eulophidae). They have been collected in very low number, with a parasitisation rate below 1%. A release trial with Ageniapsis citricola (Hymenoptera, Encyrtidae) in the Summer has failed, infact this parasitoid has never reached its adult stage, although, in some cases, it has pupated.

Index terms: Mediterranean environments, Z7, Z11- hexadecadienal, Pnigalio, Ageniapsis citricola

[1777] HYBRID MALE STERILITY AND COURTSHIP ANALYSIS IN DROSOPHILA BUZZATH CLUSTER SPECIES (DIPTERA, DROSOPHILIDAE)

L.P. de B. Machado, J. P. de Castro e L. Madi-Ravazzi, UNESP, Rua Cristovão Colombo, 2265, CEP 15054-000, S.J. Rio Preto, S.P., Brazil.

A good correlation between reproductive isolation and phylogenetic relationships has been found in several groups of Drosophila species. In the Drosophila repleta group the establishment of subgroups and complexes made on the basis of morphological and cytological evidences is supported by tests of reproductive isolation. Among species in the repleta group, the buzzatii cluster, due to its polymorphism and polytipism, is an excellent material for ecological and speciation studies. In previous work the reproductive isolation in crosses among strains of that cluster were analyzed and some interspecific crosses involving Drosophila seriema, D. serido B, D. koepferae and D. buzzatii strains were completely sterile. In interspecific crosses involving other strains these species, F1 hybrids were produced but they did not yield F2 progeny. In the present work, data on copula occurence and courtship duration obtained in the analysis of flies from parental sterile crosses and on spermatozoon mobility observed in F1 hybrids that did not yield F2 are presented. Copula did not occur during one hour of observation and the spermatozoon also did not show mobility at any of the analyzed stages (3, 7, 9 and 10 days old). There was also a high variation in courtship average duration and in the percentage of males that courted the females. The reproductive isolation mechanisms indicated by these observations were pre and pos-zygotic, as supported by the absence of copula and male sterility. Data obtained also showed different degrees of reproductive compatibility among the strains classified as same species but from distinct geografic localities. CAPES. Index terms: reproductive isolation, hybrid inviability,

[1779] EDGE EFFECT ON GROUND BEETLES

T. Magura¹, B. Tóthmérész² & T. Molnár¹, ¹Dept. of Zoology, Kossuth L. Univ, P. O. Box 3, Debrecen, H-4010, Hungary, E-mail magura@tigris.klte.hu; ²Ecological Inst., Kossuth L. Univ., P. O. Box 71, Debrecen, H-4010, Hungary.

Classical edge effect hypothesis states that diversity is higher in ecotones than in adjacent assemblages. Forest edges are a type of ecotone, which is interpreted on the meso-spatial scale and on the community level. This study was initiated to evaluate ground beetle (Coleoptera: Carabidae) diversity in relation to forest edge between an oak-hornbeam forest and herbaceous grass, because of the significance of the edge effect to the wildlife management and the increasing need and demand for the management of animal species. Our hypothesis was that the diversity of ground beetles would be higher in the forest edge than in the forest interior. We also examined the environmental variables that may be important for distribution of ground beetles, and thus can influence edge effect. Samples were taken along three repeated forest-grass transects using pitfall traps at the Aggtelek National Park in Hungary during two years. The study revealed significant edge effect on the ground beetles. Shannon diversity increased significantly along the transects from the forest towards the grass in both years. The diversity of the ground beetles were significantly higher in the forest edge and the grass than in the forest interior. Ground beetles of the forest, forest edge and grass can be separated from each other by ordinations, both on the species composition and abundance, suggesting that all three habitats have a distinct species assemblage. Moreover, indicator species analysis (IndVal method) detected significant edge associated species. Based on this approach, using both the specificity and fidelity of the ground beetles we have distinguished five groups of species: habitat generalists, grass-associated species, forest generalists, forest specialists, and edge-associated species. Multiple linear regression analyses proved that relative air moisture, temperature of the ground and cover of the herbs are the most important factors determining the diversity of ground beetles along the transects. The other studied factors (air temperature, cover of leaf litter, shrubs, and canopy, and prey abundance) had not significant influence on the diversity in the studied situation. Our results show that the high diversity of forest edges due to the edge-associated species and the presence of species characteristic to the adjacent habitats. It emphasises the significance of forest edges in nature conservation, serving as source habitat for dispersal processes, contributing the recolonisation of ground beetles after habitat destruction or other disturbance

Index terms: ground beetles, forest edge, diversity, indicator species, nature conservation.

[1778] IS *ELASMOPALPUS LIGNOSELLUS* BEHAVIOR INFLUENCED BY SMOKE OF BURNED SUGAR CANE?

D.C. Magri¹, E.R. Lima¹, E.F. Vilela¹, O. DeSouza¹ and P.A. Viana², ¹DBA/UFV 36571-000, Viçosa, MG and ² EMBRAPA/CNPMS, C. postal 151, 35701-970, Sete Lagoas, MG. E-mail: demagri@carpa.ciagri.usp.br.

The effect of smoke and ashes from burned sugar cane in the calling behavior and oviposition of Elasmopalpus lignosellus (Zeller) (Lepidoptera: Pyralidae) was studied. Calling behavior was observed under 25 ±2°C, 60-80% RH and photophase of 14 h, in the laboratory at the Federal University of Viçosa. Forty virgin females, each one in a cage (replications) were submitted to one of the following treatments: 1- Treatment 1 (room 1control): white paper towel inside each cage; 2 - Treatment 2 (room 2- smoke followed by ashes): smoke was offered in the first day and ashes from the second day; 3- Treatment 3 (room 3- ashes): ashes were offered everyday. Daily observations of the insects at 10 min intervals were made during the scotophase, for five days. As a result, females submitted to treatments 2 and 3 called more time compared with the control. We also evaluated the influence of odors from the burned sugar cane in the oviposition behavior of E. lignosellus, using three treatments and 25 replications per treatment, as following: Treatment 1 (control) the substratum for oviposition was white paper towel; Treatment 2 (smoke followed by ashes): paper towel was previously impregnated with smoke and on the second day it received ashes from the sugar cane combustion; Treatment 3: ashes were placed in each substratum. As a result, we obtained in treatment 2, twice the number of eggs compared to treatments 1 and 3, what indicates that the smoke of sugar cane combustion is an oviposition stimulant for E. lignosellus females.

Index terms: Pyralidae, lesser cornstalk borer, sexual pheromone, oviposition stimulant

[1780] AGREGGATION, CLUTCH SIZE AND OVIPOSITION BEHAVIOR IN DROSOPHILA PHALERATA

<u>M. Martins</u>¹ & B. Shorrocks², ¹Dept. of Zoology, Museu paraense Emilio Goeldi/CNPq/MCT, P. O. Box 399, Belem Pará, Brazil, E-mail marlucia@mueugoeldi.br; ²Dept. of Biology, University of Leeds, Leeds LS2 9JT,UK b.shorrocks@leeds.ac.uk

Drosophila is one of most diverse group of insects, with more than 3000 species in the world and a high number of local species and many species utilizing the same type of resource. Drosophila has been used as model to explain the coexistence of insects that exploit a resource in ephemeral patches. The aggregation model proposed by Shorrocks & Rosewell (1979) satates that aggregation of superior competitor produces refuges for inferior competitors and increases the species coexistence. It requires a higher degree of intraspecific versus interespecific aggregation in a pair of competing species. Ives proposal (Ives, 1988) to estimate the realative strength of aggregation effect and competition within and between species is based in the assumption that a female lays a single egg during a visit. In order to develop a method of analysis that will help to see how the real world might map onto theoretical possibilities, this research was developed to estimate the clutch size on D. phalerata, a dominant specie in the drosophilid fungal guild, under laboratory conditions. Cluth size here was defined as the number of eggs laid per female per visit. Experiments were conducted with different combinations of number of patches (pieces of mushoroom), number of females, and observation interval, with control of females (maturation, nutrition, temperature and light of the room) and patch quality. The flies were filmed on the patches for a fixed interval of time to record number of visits. The number of eggs laid in each patch was counted after each observation interval. The clutch size for D. phalerata was clearly greater than one, around 9 eggs per female visit, but follows a negative binomial distribution with k value about 0.4. The number of eggs laid was positively correlated to time and number of visits, but the oviposition behaviour presented some complexity. The was a slight tendency that one previously visited patch could be revisited more often than expected. However the was no evidence for non-random (aggregate) oviposition behaviour across patches. It was not possible to distinguish visiting behaviour from oviposition behaviour, and, in this case, more specific (manipulative) experiments will be necessary.

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[1781] LIVING ON A HAIRY SURFACE: MOVEMENT AND FEEDING BEHAVIOR OF GRATIANA SPADICEA (COL:CHRYSOMELIDAE: CASSIDINAE) ON ITS HOST PLANT SOLANUM SISYMBRIIFOLIUM (SOLANACEAE)

<u>L. Medeiros</u>¹ & G.R.P. Moreira², ¹ - DeBQ - UNIJUI - CP 560 - Ijuí, RS - CEP: 98700 000 / PG em Entomologia UFPR/Curitiba, PR. Email: lenicem@main.unijui.tche.br. ² -Depto de Zoologia - UFRGS. Av. Paulo Gama, 40, RS. CEP: 90046-900

Many plant attributes are involved with their adequability to herbivorous insects. The trichomes can directly act on movement and feeding of these insects. Both larvae and adults of Gratiana spadicea are associated with only one host plant, Solanum sisymbriifolium, whose leaves bear simple and stellate trichomes, which can be glandular and non glandular. We performed some behavioral tests and anatomic studies to determine whether the trichomes of S. sisymbriifolium act as a barrier to G. spadicea movement and feeding. Optical and scanning electron microscopy studies showed that the legs of G. spadicea larvae present a heavily sclerotized and hooked, apical podite (the tarsungulus), which is involved with the larvae attachment. At the first three instars, it is hooked on the stellate trichome rays (near 80% of the cases) during movement of the first three instars. Fifth instar larvae insert the tarsungulus tip directly into the leaf epidermis (71,9% of the cases). Speed tests performed with first and fifth larval instars showed that they are not able to move on smooth surfaces. When stellate trichomes were removed, the speed of first instars larvae was enhanced, but it did not change for the fifth instar larvae. The legs of the first larval instar are shorter than the central ray of the trichomes, so they cannot reach the leaf epidermis from which they feed upon. Neither larvae nor adults ingest the trichomes, which are removed from the leaf. First and second instars macerate the trichome rays to get access to the leaf epidermis. The remaining instars and adults remove the trichomes entirely. Feeding choice trails that were performed, where leaf discs with variable trichome densities were offered, showed that both larvae and adults preferred shaved compared to high density S. sisymbriifolium leaves. The mean distance between the stellate trichomes on discs with low trichome density was 0,53 mm, providing enough space for the first instars larvae (mean head width = 0,4 mm) to feed, without removing the trichome rays. The data suggest that S. sisymbriifolium stellate trichomes function as a barrier to the movement and feeding of G. spadicea, mainly to the larvae at the first instars. On the other hand, such a barrier is overcome by G. spadicea morphological and behavioral adaptations, represented respectively by hooked apical podites and remotion of the stellate trichomes.

Index terms: plant trichomes, plant physical defenses, behavioral adaptations

[1782] OVIPOSITION BEHAVIOR OF *CONOTRACHELUS HUMEROPICTUS* (COLEOPTERA: CURCULIONIDAE).

<u>C.M.D'A. Lopes</u>¹ and N.M. Silva²,¹IDAM, Rua Paraíba, Conj. Celetrazon, Rua 4, Casa 5, Adrianópolis, Manaus, AM, Brazil, 69057-000, E-mail consuelo@inpa.gov.br. ² Fac. de Ciências Agrárias, Univ. do Amazonas, Campus Univ., Manaus, AM, Brazil, 69077-000, E-mail neliton@argo.com.br.

Conotrachelus humeropictus is the major pest of cupuaçu fruit (Theobroma grandiflorum), causing 57.7% losses. The female lay egg endophitically in young fruit. The larvae feed on the fruit pulp, placenta, and lately on seeds. Limited information is available of the biology of this pest. This research was conducted to evaluate the oviposition behavior of C. humeropictus. The study took place at Training and Capacity Center (CENTRER-AM/EMATER), at Route AM-010, km29, Amazon, Brazil. After two months of fruit development cages were installed in 0.5 hectare of cupuaçu orchard. Each fruit were exposed to one male and one female. The treatments consisted of two periods: 6:00-18:00 h, and 18:00 to 6:00 h (next day) and 8 repetitions. The statistical analysis consisted of mean comparation test at 5% level. No statistical difference was observed for oviposition during, the periods evaluated, means of 1.068±0.479 (day hours), and 0.975± 0.219 (night hours). The majority of the oviposition occurred at the middle of the fruit for both periods. The females made several punctures in the fruit to feed, thus after ovipositing. The perforations were predominately grouped, though, single perforations were observed. Index terms: cupuaçu fruit borer, cupuaçu pest, Sterculiaceae.

[1783] CHARACTERISTICS OF COURTSHIP SONGS IN SEVERAL JAPANESE GREEN LACEWINGS (CHRYSOPIDAE) AND THE CROSSING EXPERIMENTS BETWEEN SOME STRAINS WITH DIFFERENT SONGS

K. Niiiima & Y. Suzuki, Lab. Entomology, Fac. Agriculture, Tamagawa Univ., Machida, Tokyo, Japan, 194-8610, E-mail nkeiko@agr. tamagawa. ac. Jp.

Green lacewings communicate by exchanging substrate-borne signals during courtship behaviors. Characteristics of these courtship songs in several Japanese species including some genus were described. The waveform, fundamental frequency and length and interval of volley are compared between species. Each species has specific signals and intraspecific reproductive isolation was considered to be achieved by this specific difference. These songs were produced by abdomen vibrating or jerking in many cases. But Brinckochrysa kintoki has a developed file-like structure in 2nd sternite and it is considered to be used for producing songs. Recently, foreign strains of *Chrysoperla* carnea are introduced into Japan for biological control of aphids. The songs of this widespreading species showed different characteristics depending on their habitat. Especially, the song of German strain is different from that of Japanese strain. So some crossing experiments between Japan strain and foreign strain were conducted. In a petridish(+9cm), most lacewings succeeded in mating between same strains in an hour, while none of them succeeded between Japan and German strain. The male selected same strain female by choice. When a pair of different strain was kept in a small cage for several days, they crossed at low ratio. The calling phenotypes of the F1 hybrids exhibited intermediate and they could cross easily each other. In a small cage (25 cm3) with a plant infested by aphids, mating ratio between Japanese and German strains was very low (0-10%) in 24 hours. These results suggested that the possibility of crossing between native and foreign strain seemed to be low in the fields.

Index terms: acoustic communication, reproductive isolation, waveform, Chrysoperla carnea, Brinckochrysa kintoki

[1784] WILL BE CERATITIS CAPITATA COMPETING WITH ANASTREPIIA FRATERCULUS?

D.R.S. de Oliveira¹ & <u>M.C.G. Pansera-de-Araújo¹</u>, ¹Dept. of Biology and Chemistry, Univ. Reg. do Noroeste do Estado do RS, R. S. Francisco, 501, Ijui, RS, Brazil. CEP. 98700-000. E-mail pansera@main.unijui.tche.br.

The South American fruit fly, Anastrepha fraterculus and Ceratitis capitata, an introduced specie, are highly polyphagous and known to attack several cultivated and wild fruits. These two species caused severe internal and external damages to orchards. The objective of this paper was verify the incidence and the viability of A. fraterculus and Ceratitis capitata in cultivated and wild fruits. The fruit flies were collected in the town of Ijui/RS from fruits of Psidium catleianum; Crysophyllum gonocarpum; Eugenia uniflora; Prunus persica; Psidium guajava; Prunus sp; Campomanesia xanthocarpa, in two years (1998 and 1999). The fruits were kept in plastic containers with sterilized garden soil and after 15 d the pupae were collected. Then, the pupae from each fruit were transferred to separate screen wooden cages (25x25x25cm) where the adult flies emerged and were provided with food and water sources through cotton wicks. The adults were counted and the viability pupae-adult verified. In the first year (1998), all the adults emerged were A. fraterculus with a differential viability and longevity fruit dependent ($\chi^2 = 17,632$; gl=6). In the second year (1999), only A. fraterculus emerged from the wild fruits while A. fraterculus and C. capitata infested the cultivated species (Prunus persica, Prunus domestica). The specie C. capitata infested 90% of Prunus persica, and 15% of Prunus domestica, and showed a high rate of pupae-adult viability (from 56% to 74%). The less viability pupae-adults were from A. fraterculus emerged of Campomanesia xanthocarpa (47%). The inviability causes were parasitoids (Brachonidae and Ichneumonidae). The occurrence of two or more species occupying niches in a definite space, interacting among them, exploiting a set of quality resources and ecological conditions, define a community. This knowledge of the community structure and the viability pupae-adults is relevant to decide how to manage the agroecosystems.

Index terms: Community; niche, viability, parasitoids

[1785] DISTRIBUTION OF SCAPTOCORIS CASTANEA POPULATION IN THE SOIL PROFILE

L. J. Oliveira¹, A. B. Malaguido² & S. De Angelis³, ¹Soybean National Research Center/ Embrapa Soja - C.P. 231, 86001-970-Londrina, PR. Brazil. e-mail: lenita@cnpso.embrapa.br, ² Fundação MT, C.P. 79, 78705-040 -Rondonópolis-MT-Brazil, ³ UNESP-Botucatu, SP- Brazil.

During the last five soybean growing seasons, the populations of brown root stink bug, Scaptocoris castanea (Hemiptera: Cydnidae) have increased, specially in the Central Region of Brazil. This bug is poliphagous, sucking roots of cotton, soybean, corn, rice, beans, pasture, as well as weeds, delaying growing or killing the plants. Surveys were carried out during one year to record S. castanea distribution in the soil profile, in three areas close to each other in Sapezal county, MT, Brazil. Every week, soil samples (50cm x 25cm x 120cm deep) were randomly removed and nymphs and adults were counted. The insects were returned to the soil shortly after sampling counting at different layers (0-10 cm, 10-20 cm, 20-30 cm, 30-40 cm, and 40-50 cm, 50-60cm, 60-70cm, 70-80cm, 80-90cm, 90-100cm, 100-110cm and 110-120cm depth). The population increased during Summer (December to March) and decreased in the colder months when adults and nymphs were deeper in the, probably in diapause, inside chambers. Adults and nymphs could be found in the soil around the year, but adults predominantly from December to early March; last instar nymphs were more abundant from May to August. In the colder months, more than 60% of population, specially older nymphs, were concentrated below 30 cm, in the soil seeking for more stable environmental conditions to survive the until the establishment of the Summer crops. From May to early October, nymphs were found until 120 cm depth in the soil. At the end of spring and during the summer, the population was concentrated at 10 to 30 cm, near the plant roots. During the hot and rainy months, the population concentrated above 20 cm, where the amount of roots is greater. Adults were more abundant in December-February and the flights were more frequent and intense from February to March. S. castanea active stages were capable of moving relatively large vertical distances to avoid temporary adverse conditions by going deeper into the soil. This ability must be considered in the choice of dates for sampling, as on hot days and in dry periods, the population may be underestimated if a superficial soil sample layer is sampled.

Index terms: Hemiptera, Cydnidae, soil insect, fluctuation, soybean

[1786] THE PREDATORY BEHAVIOR OF ZELUS LEUCOGRAMMUS, (HEMIPTERA: REDUVIDAE) IN CERRADO-SAVANNA, BRAZIL

<u>C. M. Paro, K. Del-Claro & F. R. Oliveira</u>, Univ. Fed. Uberlândia, Inst. Biology, PG-Ecology, CP 593, Zip: 38400-902, Uberlândia, MG, Brazil. e-mail: cmparo@yahoo.com

Although Reduviidae is one of the most common and diverse taxa of Heteroptera there are few informations about its behavior in natural environments. In this study we investigated the predation behavior of Zelus leucogrammus, a Brazilian Reduviidae poited out as potentially interesting to biological control, in natural conditions. We made 6 hours of direct observations in the field (60 sessions, 6 minutes each session, between July, 1997 and March 1999). The study site is a savanna field in the Gloria's farm, Uberlândia, Minas Gerais state, Brazil. Z. leucogrammus presents 5 nymph instars and are bivoltine. These predators insects possess morphologic adaptations, (trichomes and adhesive substance in its legs), that qualifie them to capture fast and flying preys. During the capture behavior, the predator's body is tilted about 75° in relation to the substratum, with the first pair of legs returned upward and moved away 45° approximately. It stays in this position until the capture of the prey. It was observed that the principal prey of Z leucogramus is Enchenopa brasilienses (Hemiptera: Membracidae) that jumps to avoid the attack. In the predation act, if there is the possibility of a new capture, Z. leucogramus arrests the died prey in the adhesive trichomes on the front legs, so that it can capture a new prey. This behavior of conduce a dead prey in the leg, is also presented during food dispute with other individuals or during the escape of predators.

Index terms: Zelus leucogrammus, Reduviidae, biological control, predatory behavior, cerrado-savanna.

[1787] SEX RATIO VS. FOUNDRESS NUMBER IN POLLINATING FIG WASP, PEGOSCAPUS CF. TONDUZI (HYMENOPTERA: AGAONIDAE), IN FICUS EXIMIA (MORACEAE)

<u>R. A. S. Pereira</u>¹ & A. P. Prado¹, ¹Dept. de Parasitologia, Univ. Est. de Campinas, C.P. 6109, CEP 13083-970, Campinas-SP, Brasil, E-mail: rodrigo@unicamp.br

Pollinating fig wasps females enter the syconium (inflorescence) of Ficus, pollinate, lay eggs in the ovary of some pistillate florets and die. When the syconium ripens, the wasp offspring emerge and mate inside. Generally, a few numbers of females (foundresses) enter the syconium, increasing the population level of inbreeding and the local mate competition (LMC). In order to study the foundress number effect over the offspring sex ratio; 25, 37 and 40 syconia of three individuals of F. eximia were sampled in Campinas/SP (22°54'S, 47°03'W), Brazil, during April to June 1999. Near the offspring emergency phase syconia were open to count the number of foundresses. Then, each syconium was closed and placed separated in plastic flasks so all the insects could emerge. Foudresses number vs. offspring sex ratio were analysed graphically and compared with three quantitative models for predicting haplodiploid sex ratio. In each of the three samples the proportion of males rise with increasing foundress number. However, observed data were more female biased the values predicted by models. Present data suggest that foundresses adjust their offspring sex ratio according to the intensity of the LMC. In two samples were observed 22 and 48% of syconia lacking foundresses, but with wasp offspring and seeds, indicating that these syconia were colonised and foundresses reemerged after. This fact is known in fig wasps, but disregarded in previous sex ratio studies based on observational data. Foundresses re-emergence possibly affects analysis decreasing the precision of the foundress number estimate. The experimental study controlling foundresses number may be a way to avoid re-emergence problems, but with the disadvantage of manipulating wasps, what could affect results (Support: Fapesp). Index terms: Ficus, fig wasp, Agaonidae, sex ratio, local mate competition.

[1788] MALE AGGRESSION IN POLLINATING (*PEGOSCAPUS CF. TONDUZI*) AND NON-POLLINATING (*IDARNES* SPP.) FIG WASPS (IIYMENOPTERA: AGAONIDAE), ASSOCIATED TO *FICUS EXIMIA* (MORACEAE)

R. A. S. Pereira¹ & A. P. Prado¹, ¹Dept. de Parasitologia, Univ. Est. de Campinas, C.P. 6109, CEP 13083-970, Campinas-SP, Brasil, E-mail: rodrigo@unicamp.br

Pollinating fig wasps females enter the syconium (inflorescence) of *Ficus*, pollinate, lay eggs in the ovary of some pistillate florets and die. Non-pollinating fig wasps females do not enter the syconium and lay eggs in the ovary of florets from outside through the syconium wall. When the syconium ripens, the wasp offspring emerge and mate inside. The pollinating species (*P. ef. tonduzi*) and the non-pollinating genus *Idames* show wingless males. Males of *Idames* spp. are aggressive during mating phase, on the contrary of pollinating species. To study the extent of injury on *P. ef. tonduzi* and *Idames* spp. males due to aggressive fighting around 25 syconia of three individuals of *F. eximia* were sampled in Campinas/SP (22°54'S, 47°03'W), Brazil, during April to June 1999. Syconia near the offspring emergency phase were placed individually in plastic flasks so all the insects could emerge. Wasps were frozen and males were inspected for injury. The extent of injury on each male was assessed by adding up points according to a sequence of scores (one to eight) proposed by Murray (Anim. Behav. 35:488-506. 1987), ranked by the importance of each type of injury. The extent of injury by wasp or "lifetime extent of injury" (LEI) and the percentage of the extent of injury by wasp or "lifetime higher in *Idames* spp. than in *P. ef. tonduzi*, according to table below.

Severe injuries, with scores ≥ 8 , took place in 13% of individuals of *ldarnes* spp. (median = 9; maximum score = 10,5). In *P*, cf. *tonduzi* was observed two severe injuries (scores 8 e 9) out 936 individuals observed. These data indicate an absence of aggression among males of pollinating species, suggesting that injuries were accidental due to syconia manipulate in laboratory. It is suggested on literature that males' aggressive behaviour evolve in high local mate competition situations, but in *P*, cf. *tonduzi* the absence of life history of this species (Support: Fapesp).

Index terms: Ficus, fig wasp, Agaonidae, male aggression, local mate competition.

[1789] ETOLOGICAL ASPECTS OF ORYZOPHAGUS ORYZAE (COLEOPTERA; **CURCULIONIDAE) IN WATER- SEEDED RICE**

H. F. Prando¹, D. R. Sosa-Gómez² & G. H. Rosado Neto³, 'EEI-Epagri, Cx. Postal 277, 8301-970, Itajaí SC. E-mail: híprando@zaz.com.br; ²Embrapa Soja sosa@cnpso.embrapa.br; ³Zoologia/Entomologia UFPR E-mail: pgento@ufpr.br E-mail:

In most water-seeded rice cultivation in Southern Brazil, the main insect pest is Oryzophagus oryzae. However, there are few works devoted to the etological study of this species. With the purpose of investigating the behavior of this species in water-seed rice cultivation, the present work was conducted in Itajaí Experiment Station- EPAGRI- Itajaí, SC, Brazil, in the 1997/98 and 1998/99 growing periods. The rice cultivar tested was Epagri 108. The adult was evaluated for feeding and oviposition behaviors. The larvae were observed from egg eclosion up to their introduction into the soil. The survival period of first instar larvae in the absence of food was also estimated. The predatory insects of the first instar O. oryzae larvae were observed at laboratory. Adults O. oryzae feed lengthwise among the veins of leaf parenchyma cuticle, leaving whitish stripes on the leaves. The leaf injuries vary from 2 - 40 mm long to about 1 mm wide. The average injured area amounts to 51.24 mm² per female, and 15.52 mm² per male, in a 24- hour period. In the waterseeded rice, the adults feed on the seed epicotyl and radicle, injuring 1.06 seedlings/couple/day. They can feed under water and may remain up to 11 days under distilled water. The oviposition takes place on leaf sheaths. The female selects the oviposition site, makes a scission with jaws, rotates 180^{9} C, introduces the ovipositor into the scission and lays one egg at a time into the aerenchyma. After eclosion the larvae remain for 1-1.5 days feeding on the inside part of the leaf, open circular orifices and leave. They make their way through the water and into the soil by gravity, and then towards the roots. The first instar larvae open galleries inside the roots, while the subsequent instars perforate and cut the roots. They live strictly in aquatic medium as free ectophytic larvae. However, first instar larvae are endophytic, having only a short ectophytic stage, that goes from their going out of the leaf up to entering the root. They move slowly, do not present natatory appendices and can only survive in still waters, mud and waterlogged soil. Most predatory insects from first instar larvae, collected on rice plants in the water, belong to at least three species of the Dytiscidae family. One of this species consume in average six larvae of O. oryzae per hour, under laboratory conditions. Index terms: rice weevil, behavior, natural enemies, Dytiscidae, damage.

[1791] SEASONAL VARIATION AND EFFECTS OF LARVAL FEEDING RESOURCES ON HELICONIUS ERATO (LEPIDOPTERA: NYMPHALIDAE) ADULT BODY SIZE

D. Rodrigues¹ & G. R. P. Moreira², ¹ CPG Ecologia, Inst. Biociências, Univ. Federal do Rio Grande do Sul. Av. Bento Gonçalves, 9500, Prédio 43422. Porto Alegre, RS, BR. Cep. 91.540-000 Cx. Postal 15007, E-mail drodrig@vortex.ufrgs.br; ²Depto. de Zoologia, Inst. de Biociências, Univ. Federal do Rio Grande do Sul. Av. Paulo Gama, 40. Porto Alegre, RS, BR. Cep. 90.046-900, E-mail grpm@if.ufrgs.br. 1 Financial support: CAPES

Adult body size, one of the most important life history component, varies strongly within and between Heliconius erato populations. In this study, it is determined whether such a variation is temperature related or caused by temporal changes in hostplants (Passifloraceae) used by the larval stage. The study area was located in the Barba Negra Forest, Barra do Ribeiro County, Rio Grande do Sul State. A H. erato phyllis population was sampled every 45 days from March 1997 to October 1998, to assess temporal variation in adult body size and on hostplants (Passiflora misera and Passiflora suberosa) used by the larval stage. Effects of P. misera and P. subcrosa on larval growth and adult size were determined in laboratory (25 ± 1 °C, 14L: 10D), when consumption rates were experimentally altered. Also, the effects of these hostplants species on growth rate and size were tested under winter (15 °C) and summer (25°C) temperatures. The field data showed that adults where larvae feed only upon P. suberosa are smaller than those fed on P. misera. The adults emerge with a larger size during the summer compared to other seasons. The larvae feed selectivily on P. misera even when the dominant passion vinc in a given place is P. subcrosa. They only change hostplant, from P. misera to P. subcrosa, during fall and winter, a period in which P. misera vines are completely defoliated. The feeding trials carried out in laboratory showed that there is a strong correlation between larval consumption rates of these two passion vines and adult size. They also confirmed that the adults emerge at a larger size when their larvae are reared on P. misera compared to those fed upon *P. suberosa*. There is no influence either of winter or summer temperatures on *H. erato phyllis* adult size determination. Thus, the temporal variation on H. erato phyllis adult size in a given place is primarily determined by the type, corresponding availability and quality of hostplants used by the larval stage.

Index terms: host-plant selection, heliconian butterflies, passion vines, temperature.

[1790] EGG HATCHING IN AEDES CASPIUS MOSOUITOES

D.M. Roberts¹, ¹Dept. of Biology, Sultan Qaboos Univ., P.O.Box 36, Al-Khod 123, Sultanate of Oman.

Acdes caspius larvae were collected from salt marsh pools on Masirah Island in Oman and reared to adult. Eggs laid by the females on damp pottery (nullipars were autogenous; parous were blood-fed) were used in the experiments. Single eggs of Acdes caspius, when undisturbed had a very low rate of hatching (0.8+0.5%), but when the water was agitated daily (by tapping the container for 30s), the hatching rate of 23.8+5.2% was significantly higher (F-ratio = 15.5, p<0.001). When reared in batches of 50, the hatching rate of agitated eggs became very much greater (undisturbed = 3.6+2.1%, agitated = 78.4+5.6%; F-ratio = 102, p<0.0001). Furthermore, when the undisturbed eggs that had failed to hatch after 14 days were then agitated daily, hatching increased from 3.6+2.1% to 17.2+ 3.7%. Mechanical disturbance of the eggs thus has a major effect on egg hatching. However, the increased hatching among eggs kept in batches of 50, compared with solitary eggs, showed that other factors (possibly chemical) also stimulate hatching. To investigate the age at which eggs became sensitive to water agitation, different batches of 50 eggs were agitated for 30s at either 4, 5, 6, 7, 9 or 11d after egg-laying. Hatching started on the 4th day, reached a maximum on the 5th day and then declined. Eggs which were flooded with water for 3d, dried out for 2d, then reflooded a 2^{nd} and a 3^{rd} time, had a very low hatching (18.8+6.2%) compared with continuously flooded eggs agitated every day. Increased hatching due to reflooding observed by other workers may therefore be the result of agitation during reflooding.

Index terms: Mechanical stimulation, flooding, Oman

[1792] GUSTATORY RESPONSE AND NUTRITIONAL SUITABILITY OF INDIVIDUAL NECTAR SUGARS FOR PIERIS BRASSICAE

I. Romeis & F. L. Wäckers, Institute of Plant Sciences, Applied Entomology, Swiss Federal Institute of Technology (ETH), Clausiusstr. 25/NW, 8092 Zürich, Switzerland, email: waeckers@cto.nioo.knaw.nl.

Most Lepidoptera feed during the adult stage on carbohydrate-rich food sources, primarily floral nectar. This adult feeding generally increases their longevity and fecundity. However, nectars are very complex food sources and little is known about the effects of individual nectar compounds on the gustatory response and the nutritional suitability for a nectar feeder. We have studied these effects for the large cabbage white, P. brassicae, using 0.5M solutions of the three main nectar sugars: sucrose, fructose and glucose. In no-choice experiments, food deprived *P. brassicae* females showed a gustatory response after tarsal or proboscis contact to sucrose and fructose only. They failed to respond to glucose. All three sugars tested increased longevity significantly in comparison to water fed control insects. Sucrose yielded the strongest effect, followed by fructose and glucose. Both lifetime fecundity and the daily oviposition rate were increased by a glucose diet. While fructose had no effect on fecundity, oviposition was almost totally suppressed in sucrose fed females. Out of 10 females kept on a sucrose diet, six laid no eggs at all, while four females produced only a few infertile eggs. Our results indicate that there is no absolute correlation between the gustatory response of *P. brassicae* females and the sugars nutritional suitability with respect to different important fitness-parameters. Index terms: Fecundity, food ecology, lepidoptera, longevity

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[1793] VARIABILITY IN THE BEHAVIOURAL RESPONSE OF THE ONION FLY TO N-DIPROPYL DISULFIDE

J. Romeis, D. Ebbinghaus & J. Scherkenbeck, BAYER AG, ZF-WFB, Agricultural Research Centre, Building 6220, 40789 Monheim, Germany.

The onion fly, *Delia antiqua*, is a specialist herbivore attacking only onions and closely related *Allium* species. *N*-dipropyl disulfide (DPDS) is the major headspace component of cut onions. A number of laboratory and field studies have shown that onion flies are attracted to this volatile plant kairomone. However, the insects' response was found to be highly variable. Using behavioural bioassays we found that DPDS is attractive to female onion flies but does not stimulate oviposition. The response of female onion flies to DPDS was strongly concentration dependent. The physiological state of the flies (i.e. mating status, egg load, age) also affected their responsiveness to this compound. Mated females and females with a high egg load responded significantly more strongly to DPDS than unmated females or females which had oviposited on cut onions prior to the experiment. The response of both sexes of onion flies to DPDS varied with age but females were always more attracted to this kairomone than males. The responsiveness of males reached a maximum at an age of 6-7 days after which it declined. The responsiveness of females of females of 21 days after which the experiment.

Index terms: Behaviour, Delia antiqua, diptera, kairomone, olfaction

[1795] A NEW RECORD AND BREEDING HOST PLANT FOR A SPECIES OF THE D. FLAVOPILOSA GROUP (DROSOPHILIDAE, DROSOPHILA)

R. C. O. Santos¹ & M.B. Martins², ¹Univ. Federal do Para, P. O. Box 479, Belem, CA 66075-900, **BR**, E-mail rcos@ufpa.br ²Dept. of Zoology, Museu Paraense Emílio Goeldi, P. O. Box 399, Belem, CA 66040-170, BR, E-mail marlucia@museu-goeldi.br.

Drosophilidae has at least 8 anthophilic genera. As many as 100 flower species have already been identified as being used for breeding by Drosophila species. The flavopilosa group of Drosophila, with 12 Neotropical species, represents a good example of specialization by these flies for this type of resource. The *flavopilosa* group bred and fed preferentially in flowers of the Solanaceae. They all present morphological and reproductive characters associated with flower utilization. Presently, living flowers of 12 species of Cestrum and one species of Sessea (Santos, unpublished data), both genera of Solanaceae, are known as breeding resources for these flies. However, the breeding sites remain unknown for 5 of the 12 species of the flavopilosa group. In Brazil, geographical distribution data for these species are scarce. Only 6 species have been registered in the South and Southeast regions of Brazil, which are the most intensely collected in the country. In 1998, an inventory of Amazonian flower drosophilids was initiated. As result of this work, for the first time, a natural breeding site for Drosophila melina (flavopilosa group) was recorded in Belém, Pará. Forty-five individuals (29 males and 16 females) of these files were reared in the laboratory from 2,397 living flowers of *Cestrum lacvigatum*, collected between March and May 1998 at the Museu Goeldi Research Campus (12° 706" S 48 ° 26'43" W). The adults took between 10 and 13 days to emerge. The previous records of Drosophila melina are from Santa Lucia, B.W.I., Panama and Colombia, without any information regarding natural breeding sites.

Index terms: Cestrum laevigatum, breeding site, living flowers, Amazonian region

[1794] A SILK-NEST WEAVING ANT *CAMPONOTUS SENEX* (HYMENOPTERA: FORMICINAE) IN A BRAZILIAN SAVANNA

<u>J. C. Santos</u>¹ & K. Del-Claro¹, ¹Inst. de Biologia, Univ. Fed. Uberlândia – Uberlândia, MG, CP 593, Cep 38400-902, Brazil. e-mail: jcsantosbio@hotmail.com

Camponotus (Myrmobrachys) senex, occurs in most forested areas of South and Central America and it is one of the six species of the very large and cosmopolitan genus Camponotus known to incorporate larval silk in nest construction. There are few information in literature about biology and ecology of the major part of the species of Camponotus and in this sense must be regarded as an evolutionary advanced form. In this study we investigated the nest construction behavior (N = 6) of C. senex in field (Gloria's farm – UFU – cerrado vegetation) and laboratory (Laboratório de Ecologia Comportamental e de Interações - LECI/UFU). More than a hundred hours of "ad libitum" observation (all occurrence sample, and also by a VHS film) revealed that workers conduce larvae between its mandibles and when stimulated by antennal stroking of workers, the larvae swing their heads back and forth while expelling silk threads. The weaving proceeds, a second group of workers gather sand particles, bits of detritus, and plant fragments and insert them into the fresh silk sheets. A third group of workers bite into the loose silk, specially at the points of contact with leaf surface tightening and smoothing the sheet as a whole. The nests have oval shape having until 65cm in diameter $(45,5 \pm 20,29; X \pm 1 \text{ SD}; N = 4)$ and until 716,1g in weigh $(364,62 \pm 311,89; X \pm 1 \text{ SD}; N = 4)$ = 4), but it depends of host plant and building material. A nest (21 cm in diameter) consisted of approximately 32.000 workers and one queen. Another nest (44 cm in diameter) owned 30 queens and more than 50.000 workers. Workers can take guard of the host plant against intruders and potentially can benefit the plant by the removal of herbivores.

Index Terms: Camponotus, silk-nest, cerrado, weaving-ant, ant.

[1796] THE ENERGETICS OF NECTAR FEEDING IN THE ANT CAMPONOTUS RUFIPES

P. E. Schilman & F. Roces, Theodor-Boveri-Institut, Dept. of Behavioural Physiology and Sociobiology (Zoology II), Biocenter, Univ. of Würzburg, Am Hubland, D-97074 Würzburg, Germany, E-mail schilman@biozentrum.uni-wuerzburg.de.

Forager animals are often assumed to be designed by natural selection so as to maximise the rate of food intake. This implies that animals must be able to evaluate the quality of a food source not only by assessing its energy content, but also by considering the time and energy invested in food intake. Ants trained to visit artificial feeders, providing continuous flows of nectar, appear therefore to be appropriate model systems to address the questions how animals assess rates of food intake, how this assessment controls foraging decisions, and how sugar requirements of the colony modify the individual foraging behaviour. For that, the time spent by a forager at the nest and at the feeder, as well as the amounts collected were recorded under controlled conditions in the laboratory. The results showed that: I) the sugar starvation of the colony modified the amount of nectar collected by an individual forager as well as the time spent in the nest between collecting visits, and 2) the forager crop load increased and the visit-time decreased with increasing nectar flow-rates, i.e., even though ants spent more time at the feeder, they collected less nectar. This means that ants do not stop drinking after a fixed time nor after a given crop load has been reached, but both factors are important in their decisions. The fact that the forager behaviour is modified by both the sugar starvation of the colony and the nectar flow-rates is important in relation to the foraging strategies of the whole colony. The forager does not collect nectar for it own sustemance but for colony members. It is noteworthy that for low flow-rates, ants do not fill the crop completely (just by drinking loager at the source), so they do not appear to try to maximise their energy gain per trip. One hypothesis to explain these unexpected results could be that the energy expenditure exceeds the energy gain while foraging. That seems not to be the case, because our measurements on the energy expenditure while foraging and the carbohydrate reserves in the hemolymph, obtained by recording of CO2-liberation and HPLC techniques, showed that the energy budget is not the limiting factor. Considering the time investment as the relevant variable, two alternative hypotheses could be advanced to explain partial crop loads: 1) shorter time at the food source would decrease the probability of risk predation at the source; 2) timesaving at the expense of reduced nectar loading would result in a higher probability of information exchange between workers in the nest, thus allowing nestmates to exploit more profitable resources in benefit of the whole colony. Further experiments may allow to discern between the decision-making systems in ants favoured by natural selection. Index terms: foraging, metabolism, crop load, flow-rates, time.

[1797] THIRTEEN HOUR COURTSHIP IN VINEGAROONS: A PRESCRIPTION FOR FEMALE CHOICE AND MALE INVESTMENT

J. O. Schmidt, Southwestern Biol. Inst., 1961 W. Brichta Dr., Tucson, AZ 85745, USA, E-mail ponerine@dakotacom.net

The vinegaroon, Mastigoproctus giganteus, is the largest living member in the small ancestral arachnid order Uropygida. These animals, best known for their ability to spray concentrated acetic acid solutions, are nocturnal, secretive, rarely encountered, and difficult to maintain in captivity. Although almost nothing is known about their reproduction, life-history strategies, or behaviors, they are generally assumed to have simple behaviors. During this investigation it became apparent that the courtship and reproductive behaviors of vinegaroons are far from simple. To the contrary, they possess one of the most complex and elaborate courtship systems reported from arthropods: a system ideally suited for both males and females to evaluate potential partners and make reproductive decisions based on investments, potential reproductive fitness, and costs. The courtship averages 13 hours (SD=2, n=48) and involves four distinct and cooperative phases: chase and grapple; dancing; generating; and pressing. If any of these phases fails, insemination does not occur. Female reproductive costs include producing, incubating, and initial rearing of offspring. Male costs are the generation of a complex spermatophore. In addition, both sexes incur considerable time costs during the courtship, time which otherwise could be invested in foraging or other activities. Over 200 courtships were staged in the laboratory with variables manipulated to determine the effect of an individual's mating status, size, recency of mating, age, time of season, and physical defects on female choice and male investment. Virgin females are generally more receptive than previously mated females, very small males are accepted by females, though they appear to be at a slight disadvantage to large males, and both males and females are able to mate during their second and third adult summer seasons and during any part of the season. Females exert their choice most frequently by attempting to block male advances during the crucial chase and grapple phase during which the male must grab the female's sensory legs and hold them in his chelicerae. Females sometimes will attempt to break courtship by refusing to allow the male to advance from the dancing to the (spermatophore) generating phase, or by refusing to accept the male spermatophore during the transition between the generating and pressing (spermatophore into the gonopore) phases. Males exhibit choice by refusing to court females, a behavior that most frequently occurs within 24 hr of a previous mating. Both sexes are heavily armed and can easily injure or kill each other; however, the importance of this risk factor is not easily evaluated, as only one individual was ever killed during a courtship trial, and that occurred when two females were placed together.

Index terms: Mastigoproctus giganteus, whip-tail scorpion, spermatophore

[1798] LEK ATTRACTIVENESS IN CERATITIS CAPITATA

Todd E. Shelly, United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection & Quarantine, Hawaii Plant Protection Center, P. O. Box 1040, Waimanalo, Hawaii 96795, E-mail tshelly@lava.net; Hawaiian Evolutionary Biology Program, University of Hawaii, 3050 Maile Way, Honolulu, Hawaii 96822, USA, E-mail tshelly@hawaii.edu.

I tested the null hypothesis that females of the Mediterranean fruit fly, Ceratitis capitata, were equally likely to visit leks composed of males with high versus low mating success. In laboratory trials, the observed distribution of mating among males differed significantly from that expected by chance, owing primarily to the higher than expected numbers of individuals with low (mated 0-1 days over 6 consecutive observation days) or high (mated 4 or more days mating scores. [In reference to these scores, I termed these two groups as 'low' and 'high' maters, respectively.] In the field, greater numbers of female sightings were made at artificial leks of high maters than low maters. This result apparently reflected a greater calling propensity among high maters. Slopes of female sightings versus calling level did not differ significantly between leks of low and high maters, suggesting that the observed relationship between calling activity and female sightings was independent of male mating status. Following the same protocol, I conducted a second experiment to examine whether males used the signals of conspecific males to locate lek sites and, if so, whether signal attractiveness varied with male mating ability. Attraction of males to calling conspecifics was far weaker than that observed for females, and over five different trials a total of only seven male sightings were made at any of the established leks.

Index terms: Ceratitis capitata, lek, pheromone.

[1799] INDIVIDUAL MATERIAL COLLECTION AND FORAGING TRIP DURATION IN MISCHOCYTTARUS DREWSENI (HYMENOPTERA, VESPIDAE)

E.R. Silva & E.Giannotti, Universidade Estadual Paulista – UNESP – Instituto de Biociências Departamento de Zoologia – Av. 24A, cp. 199, Rio Claro, SP., Brazil. e-mail: érsilva@rc.unesp.br

The objective of this work is to verify the individual specialization of workers of Mischocyttarus drewseni in the collection of nectar, wood pulp, prey and water and determine the duration of the foraging trips. In order to do so, 132 hours of observation were made on 12 colonies in post-emergence stage in the Rio Claro campus of Unesp. The foragers were marked with automotive paint in the mesosomal region, allowing the identification of each individual wasp, making it possible to distinguish their foraging habits and verify the time of departure and arrival on the nest, thus determining the duration of the collection trips. From 32 individuals observed, 21.8% collected only nectar, 46.8% collected two of the four sampled items, mainly nectar and prey, 28.1% collected three of the items, specially nectar, prey and wood pulp and 3% collected all four items. The duration of the trips varied according to the material collected. Nectar collections lasted an average of 24.3±19.8 min and prey collections 22.8±17.7 min, while the wood pulp and water collections had an average duration of 8.3±3.4 min and 2.1±0.7 min, respectively. This way we were able to demonstrate that there is no individual specialization of foragers during the collection of materials, since great part of the wasps are apt to collect the majority of the items, a characteristic of the less derived groups of social vespids. It was also established that the collection of food resources has a longer duration when compared to the collection of other items.

Index Terms: Mischocyttarus drewseni, social wasp, foraging activity

[1800] FEEDING PREFERENCE OF *PHTHIA PICTA* (HEMIPTERA: COREIDAE) BY FRUITS OF THREE CULTIVARS OF TOMATO.

<u>R. A. da Silva</u>¹, G. S. Carvalho¹, R. F. P. da Silva¹ & P. C. Bogorni², ¹Dept. Fitossanidade, Univ. Fed. do Rio Grande do Sul, P.O. Box 776, Porto Alegre, RS 90001-970, BRAZIL, E-mail: ricadaime@zipmail.com.br; ²Depto. de Entomologia, ESALQ/USP, Piracicaba, SP, Brazil.

Phthia picta is considerate one of the most important pests of the tomato culture (Lycopersicon esculentum), becoming difficult to produce fruits with commercial quality. The damage happens because of the puncture that nymphs and adults make in the fruits for feeding, prejudicing its development and making orifices that facilitate the entrance of other insects and microorganism. This study was carried out in the Laboratório de Entomologia, Departamento de Fitossanidade, Faculdade de Agronomia, UFRGS, Porto Alegre, RS, aiming at the evaluation of the feeding preference of adults of P. picta among fruits of three cultivars of tomato (Empire, Santa Clara and Carmen) and the "fidelity" of this bugs to Empire cultivar. The assays were developed using a free choice test, disposing one green fruit of each cultivar in a cylindrical vat of glass (15cm of diameter x 10cm of height) covered with voil. It was used adults of the second laboratory generation, 10 insects (group A) for an assay of feeding preference and 6 insects (group B) for an assay of "fidelity". To group A were offered, in the same time, fruits of three cultivars during 18 days before the first evaluation; to group B was offered a fruit of Empire cultivar since the first nymphal stage. It were carried out four repetitions for each assay, with three days of interval. Each repetition consisted to submit the groups A and B for a period of 24 hours without food, after to offer fruits of the three cultivars and to observe the behavior of the insects. For each insect feeding in the period of evaluation (each 5 minutes in the first hour and each 15 minutes of the first until the fourth hour) was attributed one point for the corresponding cultivar. In the intervals among repetitions were offered a fruit of each cultivar to group A and a fruit of Empire to group B. The results showed that the insects of group A preferred to feed on Empire (69% of the points). In the group B, 84% of the points were registered to Empire, indicating the "fidelity" of the bugs for this cultivar. Index terms: Lycopersicon esculentum, insecta, bug, puncture.
[1801] RANDOM MATING SECONDARILY DERIVED FROM LMC (LOCAL MATE COMPETITION) IN A GALL APHID, *NEOTHORACAPHIS YANONIS*

<u>Y. Tosaka¹</u>, T.Nishida¹ & N.Ohsaki¹, ¹Lab. of Insect Ecology, Graduate School of Agriculture, Kyoto Univ., Kyoto, 606-8502, JAPAN, E-mail juza@kais.kyoto-u.ac.jp

We examined a hypothesis that equal sex allocation observed in a gall aphid, Neothoracaphid vanonis was secondarily derived from LMC in the ancestral state. N. yanonis has five generations a year, with the fundatrix, i.e., the overwintered generation, forming a gall on a leaf surface of Distylium racemosum. The first generation shift to Quercus serrata, the secondary host and there reproduce parthenogenetically for a few generations before the third generation return again to D. racemosum. The third generation produced male and female nymphs, which disperse, develop to adults, and then mate. The numerical sex ratio of the nymphs at birth was female biased (1:2), but the males were just twice larger than females, resulting in equal investment for either sex as predicted by Fisherian theory. Observations on the mating system suggested random mating to occur because (1) multiple mothers laid nymphs within a single leaf, (2) newly hatched nymphs. particularly female nymphs dispersed from the natal leaf, and (3) reproductive adults were also highly dispersing. In spite of the suggested random mating, dissection of mother aphids revealed that almost all (97%) mothers produced two sons though the clutch size varied from 2 to 10, with the average of 6. The constant male production has been traditionally regarded as the evidence of LMC under varying resource condition (Ymaguchi, 1985). However, we found that constant male production occurs even under random mating. This suggestion that LMC might be once common in the native habitat. Thus, we tentatively conclude that the present random mating in N. yanonis may have derived from LMC in the ancestral state.

Index terms: Fisherian theory, sex ratio, constant male production.

[1803] INTRASEXUAL COMPETITION FOR VIRGIN FEMALES, AND MATURATION STRATEGY IN A FOLIAGE SPIDER CHIRACANTHIUM JAPONICUM (ARANEAE: CLUBIONIDAE)

M. Toyama. Parsimmon and Grape Research Center, National Institute of Fruit Tree Science, 338-1 Mitsu, Akitsu, Hiroshima 739-2494, Japan, E-mail tym@akt.affrc.go.jp.

Chiracanthium inponicum is a foliage spider and commonly found in Japan in open fields. This spider shows sexual differences in body shape and maturation timing; males have larger chelicelae and longer legs than females, and they mature usually before females, i.e. protandry. It is supposed that males compete for mating with virgin females and intrasexual selection acts on these sexual dimorphic traits in males through the competition because they show prematuration mate guarding. To examine male-male reproductive interaction and measure selection acting on adult-male traits in a natural population, I followed marked and released mature males for three consecutive generations from 1994 to 96 in the wild. As expected, replacements of guarding males, where in a general way larger males replaced relatively small prior residences, often occurred. The mating number in marked males was ranged from 0 to 5, and selection favored males with larger body size and early maturation. Although chelicerae and 1stlegs were used in male-male contests, I could not find selection acting on them, perhaps because of the large variation in male body size and the low occurrence ratio of direct male-male competition. This study also found a positive relationship between body size at maturity and the time of maturation in males in contrast to negative correlations are observed in most other spiders, and two peaks in frequency distributions of these male characters respectively. In addition, in these distributions and the distribution of the time of female maturation there were large differences among years and sites. This dynamics of male size at maturity and maturing timing in this spider may be explained by an alternative strategy where each individual spider decides maturation to maximize mating success expected under it's own growth conditions.

Index terms: Chiracanthium japonicum, protandry, sexual dimorphism, intrasexual selection, alternative reproductive strategy

[1802] AGING AND TOMATO LEAFLET POSITIONS INFLUENCE ON OVIPOSITION OF *BEMISIA TABACI* BIOTYPE "B" (HEMIPTERA: ALEYRODIDAE)

L. C. Toscano^{1,3} & A. L. B. Júnior¹, ¹ Depto. Fitossanidade, Univ. Estadual Paulista (UNESP), Via de Acesso Prof. Paulo Donato Castellane, s/n. Jaboticabal, São Paulo, Brasil. 14870-000. Itoscano@fcav.unesp.br; aboicajr@fcav.unesp.br.

The experiment was aimed to evaluate the influence of aging and leaflets positions of tomato on oviposition of Bemisia tabaci Biotype "B", using the free choice test, at a greenhouse (2x3x2m). There were utilized Bruna VFN (Agroflora) hybrid. At 30, 45 and 60 days of age, each plant was artificially infested with 100 adult-whiteflies. After 24 hours, two complete leaves were collected one from superior part and other inferior part, and it was determined the number of eggs/cm². It was adopted the complete randomized block design, 3x2x3 (3 = three different ages; 2 = height of the part collected-inferior and superior; 3 = leaflet positions in relation to the steam-basis, middle and apex) Factorial designing with 6 repetitions per treatment. At 30 day, the plants showed to be more preferred to oviposition (2.52 eggs/cm²) than at 45 (0.77 eggs/cm²) and 60 days (0.35 eggs/cm²). In the superior part, the favorite positions to oviposition were the apex and the middle (3.03 and 1.70 eggs/cm², respectively), being lower the preference to the basis (0.20 eggs/cm²). However, in the inferior part the preferential position was the basis (1.49) in relation to middle and apex (0.30 and 0.54 eggs/cm², respectively). It might eggs/cm be concluded that 30-day tomato plants showed to be more preferred e to oviposition of whitefly and for an effective sampling, there should be collected leaflets from apex and middle from the superior part and from basis when collected from inferior part. Index terms: Insecta, Lycopersicon esculentum, whitefly, sampling

(1804) DAILY PERIODICITY OF MATING- AND OVIPOSITING- BEHAVIOR IN DIAMONDBACK MOTH

II. Uematsu¹, K. Yoshikawa¹ & K. Nakata¹, ¹Laboratory of Applied Entomology, Faculty of Agriculture, Miyazaki University, Miyazaki, 889-2192, Japan, □E-mail a0a401u@cc.miyazaki-u.ac.jp.

A pair of newly emerged diamondback moth, Plutella xylostella, was introduced to a test tube (30 X 200 mm) with host plant, cabbage or Japanese radish. The test tubes were placed outdoors for three days. Behavior of the insects and number of eggs deposited on the host plant were noted once an hour to clarify the daily periodicity of mating- and ovipositing-behavior. Studies were made in May, June, September, October, November, December and January. Diamondback moth mated actively after the sunset, i.e., the peak was from 9 p.m. to 0 a.m. and from 7 to 10 p.m. in May-June and September-October populations, respectively. In winter season, they mated not only after sunset but also in daytime. Mean number of mating behavior per a female in the three days was 1.8 (maximum 5). Duration of mating lasted 3 hr or more in cooler seasons, although it was shorter than 2 hr in warmer seasons. Ovipositonal behaviors were most frequently observed before and after sunset in warmer seasons. In winter, however, the insect tended to lay eggs in daytime. There was a positive correlation between night temperature and proportion of number of eggs deposited in the night (Ng / TE), (here, NE: Number of eggs deposited in the night, TE Total number of eggs deposited in the night and daytime of the next day). When the night temperature was higher than 10 C, NE/TE was greater than 0.5. When the night temperature fell below 5 C, no eggs were deposited in the night. The temperature lower than 7 C seemed to suppress the oviposition in the night. Index terms: Plutella xylostella, reproductive behavior, winter, warm seasons

[1805] OVIPOSITION BEHAVIOR OF NEOMEGALOTOMUS PARVUS

<u>M. U. Ventura</u>¹ & A. R. Panizzi², ¹Departamento de Agronomia, Universidade Estadual de Londrina, Caixa Postal 6001, Londrina, PR 86051-970, BRASIL. E-mail mventura@uel.br ²Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), Caixa postal 231, Londrina, PR 86001-970, BRASIL.

This research deals with *Neomegalotomus parvus* behaviors related to choosing the crevices on pigeon pea, *Cajanus cajan* (L.) Millsp., pods to lay eggs. Blocking of antenna, tarsi, eyes, or abdomen, and all structures simultaneously, did not affect the site of the pod (crevices) chosen to lay eggs. Oviposition occurred mainly in the afternoon. Most eggs being laid from 4-6 P.M. Females behaviors were observed. Females move antennae alternately up and down. Dabbing/antennation is accomplished, first with antenna and then with antenna and labial tip. The ovipositor is exposed and swept over the surface of the pod, leading oviposition. Eggs are held together with an adhesive substance. Mechanoreceptors were observed on the ovipositor.

Index terms: Heteroptera, Alydidae, oviposition site selection, oviposition cicardian rhythm.

[1807] HOST LOCATION AND OVIPOSITION IN THE ORUSSIDAE (HYMENOPTERA), A BASAL PARASITIC WASP FAMILY

L. Vilhelmsen¹, N. Isodoro², F. Bin², H. H. Basibuyuk³ & D. L. J. Quicke⁴, ¹Zoological Museum, University of Copenhagen, Universitetsparken 15, DK-2100 Copenhagen, Denmark; ²Institute of Agricultural Entomology, Perugia University, Borgo XX Giugno, 06121 Perugia, Italy; ³Department of Biology, Cumhuriyet University, 58140, Sivas, Turkey; ⁴Center for Population Biology, Unit of Parasitoid Systematics, CABI Bioscience UK Centre (Ascot), Department of Biology, Imperial College at Silwood Park, Ascot, Berkshire, SL5 7PY, and Department of Entomology, The Natural History Museum, London SW7 5BD, UK

Anatomical studies and behavioral observations indicate that Orussidae use vibrational sounding to detect suitable oviposition sites. During host location, vibrations generated by tapping the tips of the antennae against the wood are picked up by the basitarsal pads on the fore legs, transmitted along the basitarsi to the tibia and through haemolymph to the subgenual organs, where they are transduced into nerve impulses. The apical antennomeres are distinctly shaped and have the cuticle thickened distally. The external wall of the fore tibiae have thin-walled areas distally on their posterior parts. Internally, large subgenual organs are situated opposite the thin-walled areas; each organ consists of 300-400 scolopidial units suspended between a lateral cuticular spine, a ventral sheet, and a median ridge. The fore basitarsi have weakly sclerotised basitarsal lines proximally and membraneous basitarsal pads distally. The ovipositor is several times the length of the body of the wasp. When at rest, it extends all the way into the prothorax, where it is coiled before extending posteriorly to lie between the 3rd valvulae distally. The ovipositor lies in a membraneous ovipositor sac attached posteriorly to the proximal parts of the ovipositor apparatus and the posterior margin of S7. In the ovipositor apparatus, the anterior parts of the 2nd valvifers are displaced and expanded anterodorsally, inverting the 1st valvifers and the base of the ovipositor. When in use, the ovipositor is extended and retracted by median apodemes situated on the anterior margins of abdominal sternites 3-7. Longitudinal muscles between the apodemes allow the latter to grip the ovipositor in troughs between them. The ovipositor extends from the abdomen from the distal tip of S7; an internal trough on \$7 serves to guide the ovipositor into the wood. Despite the alterations observed in the ovipositor apparatus of Orussidae, the musculature is almost complete and the mode of operation presumably not much different from that of other Hymenoptera.

Index terms: Vibrational sounding, subgenual organ, internalized ovipositor, evolution of parasitism

[1806] FEEDING BEHAVIOR OF NEOMEGALOTOMUS PARVUS

<u>M. U. Ventura</u>¹ & A. R. Panizzi², ¹Departamento de Agronomia, Universidade Estadual de Londrina, Caixa Postal 6001, Londrina, PR 86051-970, BRASIL. E-mail mventura@uel.br ²Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), Caixa postal 231, Londrina, PR 86001-970, BRASIL.

Laboratory studies with Neomegalotomus parvus nymphs in multiple-choice tests indicated that seeds of pigeon pea, lablab, and soybean were visited first than seeds of common bean. Percent dabbing/antennation resulting in probing and percent probing resulting in feeding was higher on common bean (97%) and pigeon pea (87%) seeds than on lablab (55%), soybean (50%) or rice. (5%) seeds. In tests using 10 nymphs/petri dish, a higher number of flanges was deposited on seeds of pigeon pea (41) than on common bean, lablab, soybean (< 11) or rice (0). After two, four and five days, nymphs located seeds of pigeon pea preferentially than seeds of the other foods tested. In tests with 1 nymph/dish, no significant differences were found in the number of flanges deposited on seeds of pigeon pea, common bean and lablab (ca. 30); < than 5 flanges were deposited on soybean and none on rice seeds. In no-choice tests, the average duration of a feeding session and the longest feeding session was greater on lablab and, to a some extent on common beans than on pigeon pea, soybean or rice seeds. The number of feeding sessions was greater on seeds of common bean, pigeon pea and soybean compared to those on lablab or rice. Tests with N. parvus adults, indicated that pigeon pea seeds were located faster, followed by common bean, soybean and rice. When pods were used, dabbing/antennation time was shorter on pigeon pea than on soybean, and probing time was longer on soybean than on pigeon pea or common bean. On pigeon pea, 100% of the insects probed the food, while on common bean and soybean pods, and on rice panicles these values dropped to 71.8%, 46.0%, and 10.5%, respectively. Adults showed similar feeding time on pigeon pea, common bean and soybean pods, and did not feed on rice panicles. Electronic microscopy analysis indicated two apical lobes with 12 peg sensilla on the labium tip. Sensilla tips stained with silver nitrate solution indicated permeability of the cuticle and, therefore, their relationship with taste. Index terms: Heteroptera, Alydidae, food preference, food selection

[1808] THE DIFFERENCE OF ADULT ECLOSION RHYTHM BETWEEN DIAPAUSE AND NON-DIAPAUSE PUPAE IN THE ONION FLY, DELIA ANTIOUA

<u>Y. Watari</u>, Lab. of Biotechnology, Ashiya Univ., Rokurokuso-cho 13-22, Ashiya, Hyogo 659-8511, Japan, E-mail ywatari@ashiya-u.ac.jp

Influence of pupal diapause on adult eclosion rhythm of *Delia antiqua* was investigated. When diapause and non-diapause pupae were exposed to various LD cycles (photoperiods) at 15, 20 and 25°C, both emerged as adult closely to light-on, but the phase of adult eclosion varied according to the length of the photoperiod and temperature. In short photoperiods (LD 2:22, 4:20, 8:16 and 12:12), the adult eclosion reached a peak before light-on, but after light-on in long photoperiods (LD 16:8 and 20:4). The peak of eclosion after light-off was also delayed at lower temperatures. In each LD cycle and temperature, moreover, there was a significant difference in the phase of adult eclosion between diapause and non-diapause pupae; the eclosion peak of the former was always earlier than the latter after light-off, thus suggesting carry-over effect of pupal diapause. When diapause and non-diapause pupae were transferred to constant darkness (DD) after having experienced LD 12:12 at 15, 20 and 25°C, both showed circadian rhythmicity in the adult eclosion. Although the free-running periods increased as temperature decreased, the non-diapause pupae always that longer free-running period than the diapause counterparts. This strongly suggests that the observed difference of adult eclosion phase between diapause and non-diapause pupae at LD cycles is due to the difference of their free-running periods.

Index terms: circadian rhythmicity, photoperiod, temperature.

[1809] LEAF AREA CONSUMPTION OF Urbanus esmeraldus (LEPIDOPTERA: HESPERIIDAE) IN Centrosema pubescens, Clitoria fairchildiana AND ALTERNATE FEEDING

J. G. N. Wendt¹ & A. G. Carvalho¹, 1Depto. de Produtos Florestais, Univ. Fed. Rural do Rio de Janeiro, Seropédica, RJ 23851-970, Brasil. E-mail: wendt@ufrrj.br and acacio@ufrri.br.

The lepidopterouses, in a general way, are a reflex of what they consume and this fact evidence the importance for the organism. This way the quality and the amount of food consumed in the larval phase affect the growth, time of development and weight directly. This work had as purpose to study the leaf area consumption in the five larval instars of Urbanus esmeraldus (Lepidoptera: Hesperiidae) in Centrosema pubescens, Clitoria fairchildiana and alternate feeding, with Centrosema pubescens and Clitoria fairchildiana. These Leguninosae are considered of extreme importance for the replanting of degraded areas and fixation of nitrogen. The study was driven in the Laboratory of Forest Entomology of the Institute of Forests of the Universidade Federal Rural do Rio de Janeiro in 1998. The medium temperature during the conduction of the experiment was of 23,74 $^{\circ}$ C ± 1.43 °C, while the relative humidity of the air was of 74,35% ± 13,7%. The leaf area consumption of the caterpillars, in cm², in the five larval instars for the treatment C. pubescens was of 0,540; 1,212; 6,837; 27,761 and 123,880. The caterpillars fed with C. fairchildiana the leaf area consumption it was of 0,106; 1,565; 5,649; 24,553 and 111,600 and in the alternate feeding it was of 0,646; 1,904; 6,066; 27,064 and 138,980. The leaf area consumed by the caterpillars of first instar, in *C. fairchildiana*, was inferior to the other treatments presenting statistical difference (Tuckey 5%). However, the consumption in the fifth instar in the alternate feeding was superior statistically to the others. Index terms: Defoliate, Degraded areas

[1810] CIRCADIAN TEMPERATURE PATTERNS IN TWO CECIDOMYIID GALLS OF MACHILUS THUNBERGII (LAURACEAE)

Chi-Ming Yang¹, Wen-Yang Jen¹ & <u>M. M. Yang²</u>, ¹ Institute of Botany, Academia Sinica, Nankang, Taipei, Taiwan 115, R.O.C.; ² Dept. of Entomology, Nat. Chung Hsing Univ., 250 Kuo Kuang Rd., Taichung, Taiwan 402, R.O.C. E-mail: mmyang@dragon.nchu.edu.tw.

The temperature of two Daphnephia cecidomyiid galls of Machilus thunbergii leaf was recorded with a copper-thermocouple being plugged into the gall chamber and were compared with those of the air and soil, and relative humidity. They are oval-pointed and obovate galls and distributed in the northwestern and southeastern sides of Datun Mt. range in the Yangmingshan Mt. National Park at northern Taiwan. From the macroscopic view, the temperature of gall inside always follows that of the air outside. From the microscopic view, however, a general circadian temperature pattern was observed under whatever temperature condition. While the air temperature risen between midnight to midday, the gall temperature was always higher than the former until the maximal; then while the air temperature fell from midday to midnight, the gall temperature was always lower than the former until the minimal. In addition, the discrepancy between the gall and air temperature was gradually amplified during the rising period, and that gradually narrowed down during the falling period. Therefore, two circadian transition points existed at around midday and midnight each day. However, the above circadian rhythm disappeared during the cold wave period. In such weather condition, the temperature of the gall chamber is always lower than that of the air. It is apparent that the gall wall plays no role as a temperature insulator at all for the insect living inside. We propose that the circadian rhythm of gall chamber temperature is a function of the circadian behavior of the insect residing inside the gall. Further studies are necessary for identifying the behavior contributed to the gall temperature fluctuation. Index terms: circadian thythm, Daphnephia, Taiwan

[1811] INSECTS IN THE TROPICAL LAND-USE MOSAIC – THE IMPACT OF AGRICULTURAL AND FOREST DEVELOPMENT

<u>A. D. Watt</u>¹, L. Gormley¹, P. Zborowski², N. E. Stork³ & A. Gillison⁴, ¹Centre for Ecology and Hydrology, Banchory Research Station, Hill of Brathens, Glassel, Banchory AB31 4BY, Scotland, UK E-mail adw@ceh.ac.uk; ²PO Box 867, Kurunda, QLD 4872, Australia; ³Cooperative Research Centre for Tropical Rainforest Ecology and Management (Rainforest CRC), James Cook University, Cairns Campus, P.O. Box 6811, Cairns Qld 4870, Australia; ⁴Center for International Forestry Research, PO. Box 120,Yungaburra 4872, Queensland, Australia.

There is an urgent need to quantify the effects deforestation and land use change on the diversity of arthropods in tropical forest areas. This paper will summarise recent research in Latin America, West Africa and South-East Asia on the impact of land use mosaics, or 'disturbance gradients', on a range of insect groups, particularly ants, butterflies and beetles. Studies on these gradients have focussed on uncleared forest, logged forest, forest plantations with both native and non-native tree species, rubber plantations of different types and a range of agricultural land uses. In each cased the diversity, species composition and, in some cases, the trophic structure of the insect development can be very harmful to biodiversity, there are many opportunities for minimising the negative impacts of such development.

Index terms: ants, butterflies, beetles, biodiversity, deforestation.

[1812] INSECT DIVERSITY AND TROPICAL RAINFOREST MANAGEMENT

N. Stork

ABSTRACT NOT RECEIVED

[1813] GROUND BEETLE DIVERSITY AND ASSEMBLAGES FROM FORESTS IN FLANDERS: A BASELINE STUDY

<u>K. Desender</u>¹, D. De Bakker¹, V. Versteirt¹, B. De Vos², D. Van Den Meersschaut ²& K. Vandekerkhove², ¹ Dept. Entomology, RBINSc, Vautierstr. 29, B-1000 Brussels, Belgium, E-mail: kdesender@kbinirsnb.be; ² Inst. Forestry and Game Management, AMINAL, Gaverstraat 4, B-9500 Geraardsbergen.

Most woodlands in Flanders nowadays are highly fragmented or degraded, mainly due to excessive human interference in the past. Forests now cover less than 10% of the total surface only, but are relatively well known concerning their historical ecology. During recent years, several efforts have been directed towards increasing our knowledge on distribution, ecology and population genetics of forest organisms, in particular invertebrates. Within the context of effects of forest fragmentation, or forest quality in general, several regional projects and impulse programmes have been launched. One of these is an inter-institutional baseline study on the occurrence and bio-indicative values of terrestrial invertebrates in a large number of Flemish forests. Carabid beetles were identified from 56 forest stands, distributed in 40 forests within the region of Flanders (Belgium), and sampled by means of pitfall trapping during a complete year cycle (1997-1998). More than 30.000 individuals from some 120 ground beetle species were obtained. Beetle diversity (per sampling site) is higher in humid valley forest, but decreases for larger forest complexes (decreased edge effect?), as can be deduced from multiple regression analyses. In previous studies, we obtained already analogous results and came to the conclusion that large and ancient forests in Flanders showed a low total species richness, but a much higher number of typical stenotopic forest ground bettes as compared to smaller woods. Multivariate analyses (classification, indirect and direct gradient analyses) of the quantitative beetle data for the 56 sampled forest plots show that carabid beetle assemblages are highly structured. About five more or less well defined ground beetle communities can be distinguished in this dataset. These include (1) stenotopic species from large historical forests on somewhat higher elevation, species from (2) shady forest plots ou rather heavy soil, (3) humid valley forests on rich and heavy soil, (4) humid to wet marshy forest on poor soil and (5) dry forests on sandy soil, mainly pine woods. Each of these assemblages is characterized by a number of ecological indicators, several of which are illustrated and discussed, with notes on their distribution and dispersal power. These results serve as a necessary baseline for future site-assessment studies, investigations on the influence of forest management practices and studies aimed at elucidating the influence of single enrvironmental or historical factors on the recent distribution of forest carabids in the region of Flanders.

Index terms: Carabidae, ecological indicators, fragmentation.

[1814] ENTOMOFAUNA AS A BIOINDICATOR OF THE IMPACTS OF SILVICULTURAL OPERATIONS

A. J. Laranjeiro¹, E. Berti Filho², R. C. Sartório³, S. Silveira Neto², ¹Equilíbrio Proteção Florestal, Piracicaba/SP, Brasil; ²Departamento de Entomologia – ESALQ/USP, Piracicaba/SP, Brasil; ³Aracruz Celulose, Aracruz/ES, Brasil.

This research was carried out in order to determine and quantify the impacts of the forest management operations during one cycle of eucalypt plantation (circa 7 to 8 years), by studying the interaction among the eucalypt plantation, the underbrush and the natural reservoirs through the monitoring of the entomofauna in the plantations of Aracruz Celulose in the State of Espirito Santo, Brazil. The results obtained to date made possible the characterization of the several environments studied, the reservoir of natural woods, the plantation of clonal eucalypt and the regions bordering them, during the seasons of the year and the silvicultural phases. The main entomofaunistic parameters used to characterize the environments and silvicultural phases were frequency, abundance and diversity index, but the parameter most efficient for the monitoring was the Shannon-Wiener diversity index for morphospecies. It was possible to estimate the biodiversity index of the whole community collected by light and Malaise traps by analyzing the insects of the Order Lepidoptera captured with the light trap. The ten most abundant species associated exclusively to mature or young eucalypt plantation were identified. The study showed a positive interaction between the reservoir and the eucalypt plantations increasing the diversity of the entomofauna. The effects over eucalytp harvesting were observed on the community of insects in the three environments, but the definite patterns for the mature plantation, were recovered two years after the new planting. Index terms: eucalypt, management, entomofauna, bioindicator.

[1815] EFFECTS OF FORESTRY ON MOTH COMMUNITIES

<u>I. Okochi</u>, Insect Management Lab., Forestry and Forest Products Research Institute, Matsunosato-1, Kukisaki, Inashiki-gun, Ibaraki 305-8687, JAPAN, E-mail ohkou04@ffpri.affrc.go.jp.

Forestry may strongly affects local biodiversity through the repeated cutting and planting of single tree species. Moths are one of the largest groups that mainly depend on the leaves of plants, and species composition of many of these plants is directly affected by forestry. Therefore, the influence of forestry on forest biodiversity may be able to be monitored by changes in moth communities.

The moth communities of a primary forest in central Japan and a managed forestry area adjacent to the primary forest were compared by light trap collection on 1993, 1994, 1995, and 1998. Three plots were set in primary forest, of which two were along the stream and one on the ridge. We selected three stands as a representative of forestry areas: an open site after cutting, a remnant secondary deciduous forest, and a Sugi cedar (*Cryptomeria japonica*) plantation. The result showed that the moth communities in the forestry area were different from those in the primary forest, although the species composition fluctuated from year to year. The forestry area was rich in grassland species, while the primary forest was rich in forest species. Sugi plantation forest had the poorest species composition. This suggest that the core primary forest should be protected as a source and a refuge of the forest species, but also that the secondary forest surrounding it may have a role as a habitat for forest moth species. Open sites after clear-cutting may be habitat for grassland species.

Index terms: Moth community, Lepidoptera, biodiversity, forestry, primary forest

[1816] ENVIRONMENTAL DIVERSITY IN A *EUCALYPTUS* PLANTATION AFFECTS NUMBERS OF *SARSINA VIOLASCENS* (LEPIDOPTERA: LYMANTRIDAE) ADULTS?

J. M. M. Pereira¹; T. V. Zanuncio¹; O. T. Dall'Oglio¹ & <u>J. C. Zanuncio¹</u>, Dep. de Biologia Animal, Univ. Federal de Viçosa, 36.571-000 Viçosa, MG, BRAZIL, E-mail: zanuncio@mail.ufv.br.

Since environmental heterogeneity can reduce populations of Lepidoptera pests in Eucalyptus cloesiana plantations, the objective of this research was to study the impact of strips of native vegetation within these plantations on adult numbers of Sasina violacons (Hindh-Schreffer, 1856) (Lepidoptera Lymninidae) collected with light traps installed in two Eucalyptus plantations. The first one with strips of native vegetation (system WS) while the second had no such strips (system NS). S. violascens adults were collected from October 1993 to April 1994 with two samplings for each point every 15 days. This Lepidoptera species was collected with light traps as following: trap number 1- in a area of native vegetation; trap number 2- at the border of this area; trap number 3- at 250 meters from the border of this area in a Eucalyptus plantation; trap number 4- at 500 meters from the border of this area in a strip of native vegetation (system NS) or in a plantation of Eucalyptus (system WF); trap number 5- in a plantation of Eucalyptus at 750 meters from the border of the area of native vegetation. A total of 171 and 849 individuals of this pest was collected in the system without and with strips, respectively. Adults of S. violascens were collected during the whole period in the system with strips without reaching high numbers. This shows that S. violascens are always present in systems with higher even though adults of environmental diversity, this species is controlled by biological factors in such areas. The use of strips of native vegetation within Eucalyptus plantations can reduce the number of adults of S. violascens.

Index terms: Lepidoptera Pests, Eucalyptus, Native Vegetation.

[1817] ARTHROPODS, THINNING AND INNOVATIVE HARVEST DESIGNS: ECOSYSTEM MANAGEMENT AND BOREAL BIODIVERSITY

W. J. A. Volney¹, J. R. Spence², & D. W. Langor¹; ¹ Natural Resources Canada, Canadian Forest Service, 5320-122^m Street, Edmonton, Alberta, Canada T6H 385, ² Dept. of Biological Sciences, Univ. of Alberta, CW405A Biological Sciences Bldg., Edmonton, Alberta, Canada T6G 2E9

We report impacts of forest cutting on boreal arthropod biodiversity based on two largescale field experiments located in northern Alberta, Canada. The first experiment (c. 340 ha with 4 replicates), located 1000 km N of Edmonton, was designed to compare several approaches to thinning as potential mitigation strategies for a persistent outbreak of spruce budworm. The harvest treatments, applied in 1997-98, reduced standing volumes by 25 or 50% in 3 patterns: linear strip, feathered edged strip or uniform shelterwood cuts. Responses in these thinnings were compared to those in untreated controls and standard, operational clearcuts. In addition to evaluating the impacts of these treatments on defoliation, we also collected data on impacts of these treatments on vegetation, moths, carabid beetles and saproxylic insects. Results to date suggest that reductions of stand volume have not reduced budworm populations in residual stands but spruce beetle populations temporarily increased in residual stumps. Immediate post treatment effects in the other biota assessed were associated with the degree of disturbance. The second experiment (c. 1000 ha), located c. 600 km NW of Edmonton was designed to explicitly study the trade-offs between biodiversity, more traditional measures of forestry performance, and other indicators of ecosystem function. The harvest treatments, applied in 1998-99 in a replicated experiment across for cover-types (conifer and deciduous dominated and two mixedwood types), left 10, 20, 50 and 70% of the volume as standing green trees selected compartments. Through explicit comparisons with experimental green trees selected compartments. burns, we are assessing the extent to which leaving green-tree residuals in a range of volumes delivers biodiversity outcomes similar to those resulting from natural disturbance. We have collected pre-treatment and response data about carabid and staphylinid beetles, spiders, parasitoids, moths and butterflies and saproxylic beetles, in addition to numerous data about plant biodiversity and community response. Initial results show that boreal insect communities are largely similar across cover-types within a northern mixedwood forest and that harvest can have large immediate impacts on aspects of arthropod community structure. The value of such large-scale experiments lies in simultaneous measurement of many variables in single study areas so that trade-offs between biodiversity and more traditional measures can be clearly assessed.

Index terms: forest harvest, fire, ecosystem management, residual structure, thinning, beetles, moths, spiders

[1818] EFFECTS OF A MULTI-YEAR GYPSY MOTH ERADICATION PROGRAM ON DIVERSITY OF NONTARGET FOREST CANOPY ARTHROPODS AND THEIR BIRD PREDATORS IN THE OZARK MOUNTAINS

F. M. Stephen¹, **M.P. Lih¹**, **G.W. Wallis¹**, **L.R. Nagy²**, **& K.G. Smith²**, ¹Dept. of Entomology, Univ. of Arkansas, Fayetteville AR 72701, USA, E-mail fstephen@comp.uark.edu; ²Dept. of Biological Sciences, Univ. of Arkansas, Fayetteville AR 72701. USA.

Through inadvertent transport of egg cases on a recreational vehicle, gypsy moth Lymantria dispar (L.) (Lepidoptera: Lymantriidae) recently colonized oak forests in the Ozark Mountains of Arkansas, USA. The introduction was undetected for approximately eight years. Upon discovery, an extremely rapidly reproducing population with egg mass numbers estimated to be several thousand per ha was found. In order to eradicate the infestation two aerial applications of *Bacillus thuringiensis* var. *kurstaki* were made approximately a week apart, on 10,100 ha in 1994 and on 7,150 ha in 1995. We hypothesized that the reduction in Lepidoptera larvae in the sprayed areas would potentially reduce the overall breeding success of the caterpillar-eating birds, and in particular the Hooded Warbler. Our objectives were to examine effects of eradication on (1) abundance and biomass of nontarget forest canopy arthropods; (2) structure of the breeding bird community; and (3) abundance and reproductive success of the Hooded Warbler (Wilsonia citrina), a Neotropical migratory bird that nests in the Ozarks and that utilizes caterpillars during the breeding season. Sampling of oak foliage in tree canopies in control and spray plots was conducted to estimate abundance and biomass of nontarget forest canopy arthropods in 1994, 1995 and 1996. Coincident with arthropod sampling, bird censusing at fixed-radius plots was conducted along transects in all spray and control plots to assess abundance and diversity of the bird community. The eradication sprays, in separate plots in spring of 1994 and 1995, dramatically reduced lepidopteran larval populations for four to six weeks post treatment. Lepidopteran populations remained low during the same time period one year post treatment, but appeared to be recovering by year two. The effect of spraying on the Neotropical migratory birds was evident in only a few species that were specialists on lepidopteran larvae, suggesting that Neotropical migratory birds may be adapted to fluctuations in prey availability on their breeding grounds. Index terms: Lymantria dispar, Bacillus thuringiensis, Neotropical migratory birds

[1819] INSECTS AND BOREAL FOREST MANAGEMENT

J. Niemelä Dept. of Ecology and Systematics, P.O. Box 17, FIN-00014 University of Helsinki, Finland, e-mail: jari.niemela@helsinki.fi.

Intensive forestry adversely affects biodiversity on various scales in the boreal forest, Especially in Fennoscandia, forests have lost much of their natural heterogeneity due to removal of coarse woody debris and large deciduous trees. As a consequence, many forest species are now threatened. At the scale of forest stands three types of responses to logging can be distinguished: (1) species of open habitat increase, (2) forest generalists remain largely unaffected, and (3) old-growth specialists suffer. On larger scales, forestry has homogenized landscapes. For instance, comparisons across the Finnish-Russian border show that many insects species common in the less impacted Russian forests are suffering in the intensively used Finnish forests. Adverse effects of forestry on biodiversity have prompted public criticism which has lead to a rapid development of harvesting methods, usually based on the 'natural disturbance imitation' hypothesis, intended to enhance the maintenance of biodiversity while harvesting timber. How well these methods achieve their ambitious goal is currently being investigated. A field experiment using plots of 1 ha to examine both ecological and economical-technical effects and feasibility of various 'alternative' forest harvesting techniques was started in 1995. Invertebrates and vascular plants were used as bioindicators. Results show that traditional clear-cutting has more profound ecological effects than harvesting aiming at uneven-aged forest structure or harvesting creating small openings (0.1-0.15 ha). However, costs of harvesting (time used) was higher for the uneven-aged method than for others. These results can be used to improve forest harvesting methods so that they better take biodiversity into consideration. Key words: Carabidae, biodiversity, forestry

[1821] LITTER ANT COMMUNITY IN SUBTROPICAL ARAUCARIA AND COASTAL ESCARPMENT FORESTS IN SOUTHERN BRAZIL

J. Ketterl^{1,2}, W. Engels^{1,2} & M. Verhaagh^{1,3}, ¹LPB, PUCRS, 90619-900 Porto Alegre, RS, Brazil; ²Zool. Inst., Uni. Tübingen, Auf der Morgenstelle 28, 72076 Tübingen, Germany, B-mail jochen.ketterl@student.uni-tuebingen.de; ³Staatliches Museum für Naturkunde, Erbprinzenstr. 13, 76133 Karlsruhe, Germany.

Within the Atlantic rain forest (Mata Atlântica), the montane Araucaria rain forest of Southern Brazil may be regarded as the most endangered ecosystem. After the massive forest clearance in the past decades, only a few percent of the former area are still covered with primary forest. Little is known on the flora and fauna of this unique type of tropical forest dominated by a coniferan tree, the so-called Brazilian pine Araucaria angustifolia. We studied the litter ant fauna in a fragmented Araucaria forest and a nearby coastal escarpment forest, comprising only deciduous trees, in a forest reserve of 4,500 ha located on the Serra Geral in Rio Grande do Sul. Different sampling techniques were applied, in particular Winkler extraction by which more than 80% of all ant species were obtained. The total of over 100 recorded taxa included species of the subfamilies Dolichoderinae, Ecitoninae, Formicinae, Myrmicinae, Ponerinae and Pseudomyrmecinae. The ant diversity in the litter stratum of the Araucaria forest was a little lower than that of the coastal forest with deciduous trees only and, in the Araucaria forest, most taxa were less abundant, except one eudominant Hypoponera species, representing nearly 50% of the total Winkler catch. The sample included many rare species and numerous yet unidentified and perhaps undescribed taxa. According to extrapolations, about 20% more species can be expected to occur at the sites. The results are discussed under biogeographical and environmental aspects

Index terms: litter ants, Winkler extraction, Atlantic rain forest, Araucaria angustifolia

[1820] CHANGE IN BUTTERFLY COMMUNITY WITH SECONDARY SUCCESSION OF TEMPERATE DECIDUOUS FOREST

T. Inoue, Forestry and Forest Products Research Institute - P. O. Box 16, Tsukuba Norin Kenkyu Danchi-nai, Ibaraki 305-8687, Japan, E-mail taisei@ffpri.affrc.go.jp

Transect counts of butterflies were made in the north of Ibaraki Prefecture, central Japan from April to October in 1998 and 1999. I compared butterfly communities observed in eight and eleven research sites in 1998 and 1999, respectively. Research sites were composed of grassland (1 site), cutover immediately after clear-cutting (1 site), very young (2 sites; 6-9 years old), young (2 sites; 16-21 years old) and old (2 sites; 47-51 years old) secondary forests and old-growth natural forests (3 sites; 124-175 years old). A total of 2367 individuals belonging to 73 species and that of 3285 individuals belonging to 79 species were observed during the season (14 counts) of 1998 and 1999, respectively. Species richness of butterflies was the highest in the grassland, the next highest in the cutover and very young (less than 10 years old) secondary forests, and the lowest in young (16-21 years old) and old (47-51 years old) secondary forests. Species richness in one oldgrowth natural forest that contains many gaps was relatively high (near to very young secondary forests), but those in the others that contain almost no gaps were very low. The habitat preference of each butterfly species observed was decided from the literature. Species that prefer primitive grassland were observed only in the grassland research site. Species that prefer primitive forest were very few in the grassland, cutover and very young secondary forests. The percentages of species that prefer primitive forest increased, as the forest grow older and were the highest in old secondary and old-growth natural forests. Index terms: butterfly diversity, old-growth forest, secondary forest, grassland.

[1822] ANTS AS INDICATORS OF ENVIRONMENTAL CHANGE IN LOWLAND FORESTS OF THE ALTO RIO JURUÁ, ACRE, BRAZIL

R.B.Francini¹ & A.V.L.Freitas², Museu de História Natural, FAFIS, Universidade Católica de Santos, Rua Euclides da Cunha, 247, 11065-902, Santos, SP, Brazil, E-Mail francini@unisantos.com.br, ² Museu de História Natural, Instituto de Biologia, UNICAMP, CP 6109, Campinas, SP, 13083-970, Brazil, E-mail: baku@atribuna.com.br. Financial support: CIFOR, BSP

Among conservation biologists, there has been considerable recent interest in the identification of good indicators of the state of ecological systems, that can be readily incorporated into land monitoring and assessment programs. The ants are good candidates for use as indicators, since they are diverse and dominant in biomass and, have fundamental importance in ecosystem function. Along the upper Juruá River, south of Marechal Taumaturgo, AC, 130 hours of field work in 1999 with 8 series of standardized sardine baits (80 samples from 8 places) gave 70 morphospecies of ants. The species accumulation curves for the eight places showed some stabilization, but the combined curve for the 80 samples did not reach an asymptote. The richest sites (up to 25 species) were in the uplands with the poorest (6 species) were the seasonally flooded areas of Foz Analysis included similarity matrices using the Morisita index and the do Breu. clustering. The poorest places were secondary environments and igapós (where part of the ant assemblage is eliminated during the rainy periods), and the richest places were the forests with low levels of disturbance. A contingency table between the similarity of the places and their linear distance indicated a high significantly difference. Therefore, other factors, natural and/or anthropic should explain this difference. These results show that ants can be a excellent group of organisms to environmental monitoring, but with limited use for non-specialist people (local populations), due to difficulty in separating species without the aid of special equipment (local people recognize only 21 "kinds" of ants) and special training. Nevertheless, the recognition of a locally rich soil fauna (with many species) using fixed baits (for example sardine) could be a good basis for environmental monitoring by trained biologists. The abundance of some larger predator species (large Ponerinae and ground-swarming ants) could also be interpreted as indicative of better preserved areas, but medium to long term monitoring on the part of a team of specialists would be necessary to support a proposal of use of those organisms as indicators. Observations of these two categories of ants in a hunter's log book could help in future comparisons.

Index terms: anthropic impact, bio-indicators, ant assemblages.

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[1823] INTRODUCTION AND RELEASE OF RHYSSINES TO CONTROL SIREX NOCTILIO IN BRAZIL

E.T. Iede¹, S.R.C. Penteado¹, S. Murphy², D. Haugen³ & W. Reis Filho⁴, ¹Embrapa Florestas, Caixa Postal 319, CEP 83411-000, Colombo, PR, BR, iedeet@cnpf.embrapa.br; susete@cnpf.embrapa.br; ²CABI – Bioscience, Silwood Park, Buckhurst Road, Ascot, Berkshire SL5 7TA United Kingdom, s.murphy@cabi.org; ³USDA-Forest Service, Saint Paul, Minnesota, USA, hauge017@tc.umn.edu; ⁴Epagri, Caixa postal 319, CEP 83411-000, Colombo-PR-BR, wilson@cnpf.embrapa.br

An integrated pest management program of Sirex noctilio in Brazil was initiated after the detection of S. noctilio in 1988. The program is based on monitoring, improved silvicultural management and in the introduction of the parasitic nematode, *Deladenus* The program is being complemented by the introduction of Megarhyssa siricidicola. nortoni and Rhyssa persuasoria (Hym.: Ichneumonidae), both imported from Tasmania, Australia. Importations were made in 1996 and 1997, through a cooperative project of Embrapa Forestry, the International Institute of Biological Control (CABI-Bioscience) and the USDA Forest Service. In the 1996 shipments, 77 M. nortoni arrived alive in Brazil. They were kept under quarantine in chambers with controlled humidity and temperature, where 1.8m long, 0.25cm diameter Pinus taeda billets with S. noctilio larvae were offered to them. Billets were collected by the end of August, about 45-60 days before the parasitoids arrived and kept in a cold chamber at 12C, to synchronize the life cycle of S. noctilio with that of the parasitoids. In 1997, only 9 females and 4 males of M. norteni and 9 females of R. persuasoria were imported. The first generation of M. norioni emerged in 1997 and resulted in 88 females and 45 males, of which 18 mated females were released in the field. The second generation of M. nortoni yielded 218 males and 101 females, of which 136 males and 97 females where released in the field. In 1999, only 50 males and 31 females emerged. The 1998 generation of *R. persuasoria* yielded 18 males and 19 females, of which 2 males and 10 females were released in the field. In 1999, 40 females and 20 males emerged. At the end of 1999, the establishment of these species at the release areas was not confirmed.

Index terms: Biological control, Pinus spp., Rhyssa persuasoria, Megarhyssa nortoni

[1825] ADVANTAGES AND LIMITATIONS IN THE USE OF PATHOGENS AS BIOCIDES FOR CONTROL OF FOREST PESTS

J.L. Madden ^{1,2} & **V.Patel**², ¹School of Agricultural Science, University of Tasmania & ² CRC Sustainable Forest Production, Hobart, Tasmania, Australia. E-mail:< johnL.madden@bigpond.com>.

Entomopathogens together with parasitoids and predators are major biological components of the 'natural control' of insects. However their individual effectiveness is unpredictable. Some potentially useful pathogens of specific insect pests have been grown successfully and demonstrated effectiveness in dosage mortality assessment under laboratory and field situations. Some have been propagated economically, formulated, packaged and applied to limit pest damage. In this sense they can be described as biocides for they replace the use of an insecticide. Emphasis on this type of use has been intensified due to both public and agency response to environmental and health concerns and problems of resistance. Today the quest for new insecticides continues because they, when used responsibly, are economical and possess important practical advantages. The positives include availability, ease in transport, handling, application and rapid cessation of pest damage. In use they are predictable in their effect and versatile as individual compounds may be used against a range of forest, agricultural and stored product pests. Thus biocides must ideally satisfy two criteria. They must share in the above advantages and be utilized in those environments that favour a better realization of their potential for economic control. These requirements will be addressed with respect to an evaluation of the potential use of spore formulations of strains of the entomopathogenic fungi, Beauveria and Metarhizium in the control of chrysomelid eucalypt defoliators. Though high rates of field infection and mortality (>90 percent) were achieved, the approach was subject to severe limitations. First the durations of the most susceptible stages, the egg and first two larval instars, were relatively short and there must be suitable prevailing weather conditions for application. Then the effectiveness of oil- spore sprays was restricted to direct contact with target stages. Later stages, though infected, continued to feed and failed to provide a significant reduction in defoliation status. However the results suggest that pathogens do have a role to play in more environmentally predictable and frequently monitored locales such as nurseries and small farm plantations. Preferably future research in this field should concentrate on enhancing those key characteristics and properties of pathogens and selecting the appropriateness of each pest situation to provide a biocide as a worthy alternative to an insecticide.

[1824] DETECTION AND CONTROL OF THE GUM TREE WEEVIL GONIPTERUS SCUTELLATUS IN CHILE (COLEOPTERA: CURCULIONIDAE)

<u>M. A. Beéche Cisternas¹, S. Rothmann T.², ¹ Servicio Agrícola y Ganadero / Defensa Agrícola – Av. Bulnes Nº 140, Santiago – Chile; ² Servicio Agrícola y Ganadero / Laboratorios Agrícolas – Av. Bulnes Nº 140, Complejo Lo Aguirre, Santiago – Chile</u>

The gum tree weevil, Gonipterus scutellatus, is one of the most important defolianting pests, in whose respect Eucalyptus globulus and E. viminalis, both cultivated for commercial purposes in Chile for the production of wood pulp - are among its most susceptible hosts. The larvae and adult of this pest are feeding from the eucalyptus foliage and may cause a significant reduction to the trees growth, including deformation of their crown and an increased susceptibility to the attack of other pests. This insect, of Australian origin, is currently present in most of the countries where eucalyptus is cultivated both in commercial and non-commercial form. In Chile, the first detection of *G. scutellatus* was performed by SAG inspectors during February 1998 in the locality Termas de Jahuel (V Region, Province of Los Andes); this resulted in the need to know the pest dissemination in the country, to determine the presence of natural enemies and to implement control actions which could reduce the potential damages in eucalyptus commercial plantations. Following the phytosanitary prospections, it could be determined that G. scutellatus is present in Chile only in the Provinces of Los Andes and San Felipe (V Region) and that no important natural enemies of the pest exist. As a result, the need was defined of introducing into the country the oothec parasitoid Anaphes nitens (Hymenoptera: Mymaridae). This biological control program was undertaken in order to supply the implementation of quarantine control actions coupled to chemical air focal controls, intended to reduce the possibility of disseminating the eucalyptus weevil in non-infested areas of the country. Thus, during October 1998 the collection of A. nitens took place in different localities of South Africa (Cape Town and Natal Provinces) where 3,232 G. scutellatus parasitized oothecs were collected and transported to Chile, being submitted to post-entry quarantine followed by their release in infested areas. The post-entry quarantine was carried out in the SAG / Lo Aguirre Laboratories and Quarantine Stations (Metropolitan Region, Chile) inside bio-climatic chambers, using for the quarantine and breeding of the parasitoid oothecs of the eucalyptus weevil collected in Chile and/or produced in the laboratory. Release of A. nitens took place in 6 localities of he Provinces of Los Andes and San Felipe, including a total of 5,715 adults. The subsequent field evaluations have demonstrated that A. nitens was successfully established in Chile and it reaches to day oothecs parasitism percentages ranging between 94 and 98% in the localities where they were released.

[1826] THE MORPHOLOGY OF THE IMMATURE STAGE OF *PHORACANTHA RECURVA* (COLEOPTERA: CERAMBYCIDAE) AND A KEY TO LARVAE OF THE SPECIES OF *PHORACANTHA* IN URUGUAY

M. Bianchi¹, E. Morelli² & A. Sínchez³, ^{1,3}Facultad de Agronomía. Departamento Forestal. Avenida Garzón 780. Montevideo Uruguay. C.P 11900 e-mail phoracantha @ yahoo. com, ². Facultad de Ciencias. Sección Entomología.Iguá 4225. Montevideo. Uruguay. C.P 11400; e-mail emorelli@ fcien.edu.uy.

During the last ten years species of the Eucalytus genus have been widely planted in Uruguay with industrial purposes. As a consequence of this, some insects pest have been detected with eventually could cause serious economic damage. Phoracantha semipunctata was detected in 1932 and Phoracantha recurva has been recently found in 1998 which have been accidently introduced. Larvae of these beetles bore trough the bark and mine along the cambium of stressed trees, usually killing its host. P. semipunctata and P. recurva larvae were reared in the laboratory on its natural host (on Eucalytus globulus ssp. globulus logs).Neonate larvae were manually transferred to logs which were kept in a controlled environment chamber (25°C and photoperiod 12 hs.). Mature larvae and pupae were removed from these logs to make its description. Diagnosis of the larvae was based on Duffy (1960), Costa, Vanin & Casani-Chen (1988) and Stehr (1991). Key to larvae of the species of Phoracantha in Uruguy: Temples with broad ferruginous cuneiform band behind the antennal bases. Supraocelar area with 7 setae, 3 of them in a straight towards at each median lobe - P. semipunctata. Temples without the broad ferruginous cuneiform band. Supraocelar area with 5 fine setae in a well - defined region. Abdominal tergite X with less abundant chaetotaxy and a pair of long setae in the border of each median lobe - P. recurva

[1827] USE OF CRISOPIDAE ON BIOLOGICAL CONTROL OF TROPICAL FOREST INSECT

S. de Freitas

ABSTRACT NOT RECEIVED

[1829] POTENTIAL USE OF ASOPINAE STINKBUG BUG PREDATORS IN BRAZIL

J. C. ZANUNCIO¹ & J. B. TORRES¹, ¹DBA-Universidade Federal de Viçosa 36571-000 Viçosa, MG, Brasil. E-mail: zanuncio@mail.ufv.br; ²DEPA-Fitossanidade, Universidade Federal Rural de Peranambuco, 52171-900 Recife, PE, Brasil. E-mail: jorge@nelore.npde.ufrpe.br

Pentatomid Asopinae have been reported as potential biocontrol agents mainly against defoliator insects in natural occurrences in several crops in Brazil. Species of the genus Podisus have been more frequently found in several agroecossystems than any other related species. For this reason control programs with such predatory species against caterpillars have been developed by eucalyptus forest companies in Brazil and several measures are been used aiming to maintain these natural enemies in agricultural and forest ecosystems. Among these measures the following ones can be highlighted in Brazil. i) quantitative mass production programs of stink bugs have been continually improved with better alternative preys and rearing facilities aiming to increase efficiency and cost-effective commercial production and field delivery. Advances in rearing with artificial diets are also been obtained; ii) a second aspect refers to the use of these predators as part of IPM programs which is critical in order to reduce insecticide application. Researches in laboratory and field conditions have been showing compatibility of some insecticides with releases of stink bug in the field; iii) predator-prey relationships are been studied in laboratory and in field cages particularly with Noctuidae caterpillars in soybean, cotton, tomato and cabbage crops. Number and frequency of releases of predatory bugs have shown better results when unfed nymphs are released in the evening and continuous releases of adults for long periods at the same place are not recommended due to the impact of egg parasitoids. Finally, a better understanding of ecology and evaluation methods for these predators would contribute to enhance their use in biological control programs and to evaluate their relative importance in natural ecossystems. In addition its is necessary to have more clear systematic studies and to revise the nomenclature of these insects in order to improve joint researches between laboratories and the possibilities to publish results of researches with Asopinae .

Index terms: predatory bugs, biological control, mass production, mass releases

0 [1839] PLATYPUS SULCATUS: A RATIONAL APPROACH TO ITS CONTROL IN POPULUS SPP. IN ARGENTINA

G. Mareggiani¹, A. Etiennot², <u>R. Giménez</u>³ & G. García⁴, Proyecto UBACyT, TG16. ^{1 y 4} Cátedra de Zoología Agrícola, Facultad de Agronomía, Univ. de Buenos Aires. Av. San Martín 4453, (1417), Buenos Aires, Argentina. E-mail: mareggiani@pinos.com.^{2 y 3} Cátedra de Terapéutica Vegetal, idem¹. E-mail: rgimenez@agro.uba.ar

Platypus sulcatus Chapuis (Col. Platypodidae), "ambrosia beetle", is a pest, which causes great losses on the final timber production of poplar trees (*Populus spp.*), becoming a serious danger for the regional economy in the Delta of Paraná River (Argentina). The current way to control this pest has a very high cost, not only from an economic point of view, but also due to their environmental impact. This damage is particularly important in an area ecologically sensitive as Delta of Paraná River, due to its proximity to the urban centers and sailing courses that serve as source of fish production. A better knowledge of the biological characteristics and population dynamics of P. sulcatus will be useful to evaluate management alternatives which will minimize the economic incidence on the final timber production. These studies have been carried out during two years, with traps put in the holes previously produced by the beetle. Sampling areas were selected taking into account the number of fallen trees and of holes with sap flow and larval sawdust. Every week traps were monitored to assess the date of adult sawdust and maximum adults emergence, differentiating males and females. It has been established that approximately a month before of maximum adult emergence, there was a great amount of adult sawdust in the traps. After that, in the latest days of November (the end of spring in the southern hemisphere), maximum adult emergence occurred. These results were related to climatic parameters of the area. The results here discussed together with those from the two years will be integrated to obtain a basis for the forecast of P. sulcatus, which will be useful to determine more exactly the moment for chemical control, in order to avoid indiscriminate insecticide applications.

Index terms: ambrosia beetle, wood borer, poplar

[1828] INTEGRATION OF REMOTE SENSING TECHNOLOGIES INTO INTEGRATED PEST MANAGEMENT PROGRAM FOR SIREX NOC TILIO IN BRAZIL

<u>А. Кпарр</u>

ABSTRACT NOT RECEIVED

[1831] STRATEGIES TO MANAGE TERMITES IN EUCALYPTUS PLANTATIONS IN BRAZIL

C.F. Wilcken¹, Dept. Plant Production - FCA / UNESP - Campus of Botucatu - P.O. box 237 - 18603-970, Botucatu - SP - Brazil. E-mail: cwilcken@fca.unesp.br.

The termites have great importance to forest ecosystems, as much decomposition agents as pests. The termite pests can affect root system of eucalyptus young plants or destroying the heartwood of trees. Syntermes spp. and Cornitermes spp are species that attack young plants and Coptotermes testaceus attacks the tree trunk. Plant mortality caused by young plant termites vary of 10 - 70 %. The control strategy is the chemical barrier in soil, around root system of plants. Today, the control can be made with fipronil (phenilpyrazol), applying the insecticide in the seedling before planting. New products are in test, mainly pyrethroids and neonicotinoids. Nevertheless, it is necessary reduce the treated area, because the termite attack in the field occurs in spots, due to aggregate distribution. Monitoring systems to termite infestations have been studied, using cardboard traps distributed in soil. Early results indicated that is possible to develop sampling techniques economically feasible and avoid unnecessary insecticide applications. Index terms: Forest pest, damage, control, monitoring

[1833] THE UNITED STATES RESPONSE TO TWO RECENT INTRODUCTIONS: ANOPLOPHORA GLABRIPENNIS (CERAMBYCIDAE) AND TOMICUS PINIPERDA (SCOLYTIDAE)

R. A. Hnack & T. M. Poland, US Dept. Agriculture, Forest Service, North Central Research Station, 1407 S. Harrison Rd., East Lansing, MI 48823, USA; E-mail: rhaack @fs.fed.us

Two recently introduced tree-feeding insects in the US include the Asian cerambycid Anoplophora glabripennis and the Eurasian scolytid Tomicus piniperda. Both insects likely arrived in the US on infested solid wood packing material (e.g., crating, pallets, or dunnage) associated with international cargo. Established populations of A. glabripennis were first discovered in New York City in 1996 and then in Chicago in 1998. All infestations have been in urban areas. Because of the limited number and size of infestations, the US Department of Agriculture (USDA) is attempting to eradicate this insect by cutting and chipping all trees with evidence of attack, i.e., exit holes or oviposition pits. All infested areas are under quarantine. As of January 2000, more than 4000 infested trees have been cut in New York and more than 1000 in Chicago. Maples (Acer spp.) are the most commonly infested trees, but elms (Ulmus spp.) and horsechesnut (Aesculus hippocastanum) are also readily attacked. USDA and university entomologists have begun several research programs in the US and China that are aimed at A. glabripennis life history, dispersal, chemical ecology, chemical control, entomopathogens, biological control, host range, trapping, and acoustic detection of larvae in wood. Established populations of T. piniperda, the pine shoot beetle, were first discovered in Ohio in 1992, and within one month it was found in 5 additional US states. As of January, 2000, T. piniperda is known to occur in 271 counties in 11 US states and in 33 counties in 2 Canadian provinces. Because T. piniperda populations were already so widespread when discovered in 1992, the USDA made no effort to eradicate this beetle. Nevertheless, since 1992, the USDA has imposed a federal quarantine on the movement of pine Christmas trees, ornamental nursery trees, and logs from infested to uninfested areas in the US. The quarantine requires that pine material be treated or pass inspection before being moved. In addition, a "National Compliance Management Program" was developed for Christmas-tree and nursery managers, which allows easier movement of pine trees if managers follow approved cultural and chemical controls . Since 1992, several state, biology, behavior, and control. This paper will discuss the US experience with A. glabripennis and T. piniperda, including quarantine issues and research programs. Index terms: exotic insect, eradication, quarantine

[1832] CERTIFICATION OF EXPORTED CHILEAN FOREST PRODUCTS. ADVANCES IN THE MANAGEMENT OF ENTOMOLOGICAL RISKS

D. Lanfranco, H. Peredo & Sandra Ide, Inst. de Silvicultura, Univ. Austral de Chile, Casilia 567, Valdivia, CHILE, E-mail certisan@uach.cl.

Chile is a country that largely exports primary forest products such as logs, lumber or chips. Currently around 40 foreign countries import these products which must be qualified in terms of sanitary requirements. These forest products (78%) come from radiata pine plantations, (9%) from eucalyptus plantations and (13%) from native forests. Considering the dependence on external markets, Chile has been diversifying markets and products, ensuring the high quality of them and fulfiling international sanitary/environmental regulations. Between 1999-2001 a group of forest pathologists and entomologists are studying the sanitary risks in all the levels of the productive process, including the storing and shipping procedures. This presentation focuses on the advances of entomological risks. The general research objective is to develop guidelines, techniques and procedures for the international sanitary certification of primary forest products: (1) To define the key biological aspects of the insect-tree interactions, (2) Select management and control criteria at each step of the productive, transformative and exportation process, (3) Create a plan of technological transference during the development of the project and(4) Establish sanitary certification protocols. Preliminary results indicate that the highest risks are during the process of harvest, wood manufacture, storage in the sawmills, and pre-embark storage in ports. Several forest management and silvicultural practices avoid, as proactive measures, the incidence of some defoliators, bark beetles or wood borers. However the thinning, pruning and harvesting in the forest along with the manufacture of primary products in sawmills, attract mainly bark beetles. The same problem occurs during storage time in ports. Several bark beetles species (native or introduced) can damage the logs causing holes and galeries or perhaps introducing blue stain fungi spores with the concomitant wood biodeterioration. Complementary research is centralized in basic biological and population dynamic indicators of bark beetles and their possible fungal associates. A brief review of risk levels in steps of the productive flow is presented, including a list of the main hosts per exported tree species and their significance. Some final comments identify future trends in forest health and productivity, primary Chilean products, new markets for enhancing international trade, pesticides in final shipments with environmentally inocuous chemicals, minimizing risks of infection and infestation in all phases of the productive process, and ensuring the compliance with all international sanitary standards.

Index terms: Chile, sanitary certification, primary forest products, international export standards

[1834] AN IPM APPROACH TO PREVENT THE ACCIDENTAL IMPORTATION OF SUBCORTICAL INSECTS FROM CHILE TO THE UNITED STATES

B. White, P. Montes, D. Lanfraco & R. I. Gara.

ABSTRACT NOT RECEIVED

[1835] DIFFERENTIAL COLONIZATION POTENTIAL AMONG WOOD-BORING BEETLES LEADS TO HIGH PROPORTIONS OF INBREEDING SPECIES ON TROPICAL ISLANDS

B. H. Jordal¹, R. A. Beaver² & L. R. Kirkendall¹, ¹Department of Zoology, University of Bergen, allegt. 41, N-5007 Bergen, Norway, E-mail: bjarte.jordal@zoo.uib.no; ²161/2 Mu 5, Soi Wat Pranon, T. Donkaew, A. Maerim, Chiangmai, 50180, Thailand.

Parthenogenesis and regular close inbreeding are important characteristics of colonizing plant and animals. Inbreeding in wood-boring species in the weevil families Scolytinae and Platypodidae is most frequent in tropical latitudes, especially on small islands. In order to study the relationship between colonization success, island attributes and mating system in these beetles, we analysed the relative proportions of inbreeders and outbreeders for 45 Old World tropical islands plus two adjacent mainland sites, and scored islands for size, distance from nearest source population, and maximum altitude. We applied stepwise regression to isolate the best predictor(s) among the three variables. The numbers of woodborer species decreased with decreasing island size, as expected. Elevation, on the other hand, did not contribute much to explain species numbers, neither did the degree of isolation. Numbers of outbreeding species decreased more rapidly with island size than did those of inbreeders (had significantly steeper slopes). Comparing species with similar ecology (ambrosia beetles) showed that this difference was due to differential success in colonization, rather than differences in resource utilization or sampling biases. This conclusion was further supported by analyses of data from eight small isolated islands, which suggested that outbreeding species have a higher degree of endemism and that inbreeding species are generally more widespread. A wide distribution might indicate high colonization potential. Recently established small populations necessarily go through a period of severe inbreeding, which should affect outbreeding species much more than inbreeding ones. In addition, non-genetic ecological and behavioural ('Allee') effects are also expected to reduce the the success of outbreeding colonists much more than that of inbreeders: compared with inbreeders, inbred lineages of outbreeders are expected to have slower growth rates, have greater difficulties with mate-location, and be vulnerable to random extinction over a longer period. Hence, it is no surprise that inbreeders are indeed more common on isolated tropical islands.

Index terms: island biogeography, Allee effect, inbreeding, Platypodidae, Scolytinae

[1836] RECORDS OF CONIFER APHIDS FROM ARGENTINA (HOMOPTERA, APHIDIDAE)

M. A. Delfino¹ & A. Binazzi², ¹ Cat. de Entomologia, Univ. Nac. de Córdoba, Av. Velez Sarsfield 299, 5000-Córdoba, Argentina, E-mail Erro! Indicador não definido. 2. Istituto Sperimentale per la Zoologia Agraria, Sezione di Entomologia Forestale, Via Lanciola 12A, 50125 Firenze, Italy, E-mail abinazzi@dada.it.

Planted forests of exotic Coniferae are present in many areas of Argentina. During the twentieth century many European and American species of *Pinus* were introduced into various parts of this country. Most of the damages caused to trees by aphids seem to result directly from their feeding, either by removing of sap or wounding of tissues, or at least in some cases by the toxic effect of saliva. Economic damage to some Coniferae by sporadic outbreaks of aphids has been observed in Argentina. Most of the aphid species living on either native or exotic Coniferae in Argentina belong to Cinara (Lachninae), a very large genus resulting from a highly successful adaptative radiation on Coniferae of the families Pinaceae and Cupressaceae. All Cinara species live without host alternation on the twigs, shoots or needles, branches, trunks and, sometimes, roots of their host conifers living holocyclic and/or anholocyclic. The following species were identified from Argentina: Cinara acutirostris, C. maghrebica, C. maritimae, C. pinivora on Pinus, C. costata on Picea, C. fresai, C. juniperi, and C. tujafilina on species of Cupressaceae. Also the genus Eulachnus, with long-bodied, narrow individuals living on needles of pines, was found in Argentina with only two species, E. rileyi and E. tauricus; the former is widespread all over the world being the most polyphagous entity of this genus, the latter is originally linked to various Mediterranean pines (mainly black pines); only a few species of this genus are strictly monophagous, i.e., some European ones; individuals of *Eulachnus* are often cryptic when feeding, but very active when disturbed. In the South of Argentina also Elatobium abietinum (Aphidinae) was collected on the needles of Picea spp.; spring colonies on this host plant cause discoloration and loss of old needles, sometimes involving serious defoliation. C. acutirostris, C. juniperi and C. pinivora are mentioned for the first time in South America. It seems likely that C. acutirostris was introduced into Argentina from Europe where it lives commonly on *Pinus nigra* and *P. pinea* while *C. pinivora* comes from North America where it feeds on pines of subsections Australes and Contortae (eastern USA and Canada). Some of the mentioned conifer aphid species are attended regularly by ants, i.e., C. acutirostris and C. maritimae. On the other hand, a few of them, i.e., C. acutirostris, C. fresai and E. rileyi, produce, with their outbreaks, a large amount of honeydew leading to much developing of sooty mould fungi. Index terms: Aphids, Coniferae, Argentina

[1837] THE EXOTIC FOREST PEST INFORMATION SYSTEM FOR NORTH AMERICA

J. E. Macías-Sámano, El Colegio de la Frontera Sur, ECOSUR, Carret. Antiguo Aeropuerto Km 2.5, 39700 Tapachula, Chiapas, México, E-mail: jmacias@tapecosur.edu.mx

This system (EFPISNA) is a joint project of the member organizations of the Insect and Diseases Study Group of the North American Forestry Commission, FAO. These organizations are the Canadian Forest Service, the Canadian Food Inspection Agency, Secretaría del Medio Ambiente, Recursos Naturales y Pesca (SEMARNAP) Mexico, the USDA Forest Service, and the USDA Animal and Plant Health Inspection Service. The web site (www.exoticpests.org) is being provided and maintained by the NSF Center for Integrated Pest Management at North Carolina State University. Other cooperating universities and research centers are Michigan State University, El Colegio de la Frontera Sur, and Universidad Autonoma Chapingo. The objective of this effort is to identify exotic insects, mites and pathogens with potential to cause significant damage to North American forest resources. The database contains background information for each identified pest and is intended to serve as a resource for regulatory and forest protection agencies in North America. Each pest in the database is assumed to be able to maintain a population in North America, and to cause either economic or environmental damage following introduction. To categorize the risk posed by each pest, an evaluation sheet is provided, which ranks pest risk using these three criteria. Although emphasis in the pest risk assessment model developed for this project is on potential establishment and impact, information pathways for introduction and means of dispersal is provided in the "Pest Fact Sheet". It is anticipated that this information will prove useful for the assessment and management of introduced pests, wood products and other commodities from offshore sources. Experts from around the world prepare records for EFPISNA. Each pest record will contain full authorship information, and will be peer reviewed before being added to the database. Information may be submitted to the EFPISNA in English, French, or Spanish. An Evaluation Worksheet and a Pest Fact Sheet are required for each evaluated spanish. An Evaluation worksheet and a rest Part oner are required for each evaluated pest at the time of submission. A data entry program for entering and storing database records has been developed for EFPISNA. We highly encourage prospective authors to download and use the program, which may be obtained by retrieving it from our web site. Currently this program is only available in an English language version, but we expect to have French and Spanish versions soon. Authors are encouraged to submit suitable hard copy or digital photographs or drawings to accompany submitted test. Space has been reserved for up to four graphics per data sheet, representing the organism's appearances, a distribution map, life cycle, and photos of damage.

[1838] AN OVERVIEW OF BIOTECHNOLOGICAL APPROACHES TO BIOLOGICAL AND BIORATIONAL CONTROL OF FOREST INSECT PESTS

A. Retnakaran¹, Q.-L. Feng¹, B. M. Arif¹ and S.R. Palli^{1,2}, 'Great Lakes Forestry Centre, Canadian Forest Service, P.O. Box 490, Sault Ste. Marie, Ontario, Canada, P6A 5M7; ²Rohm and Haas Research Laboratories, 727 Norristown Road, Spring House, Pennsylvania, 19477, USA; E-mail: aretnak@nrcan.gc.ca

The earliest recorded use of a chemical, sulfur, for insect control appears in the writings of Homer before 1000 BC. The use of inorganics as first generation pesticides was replaced with powerful organo-chlorines led by DDT as their second generation replacements. The adverse environmental effects of many of these broad-spectrum insecticides was dramatically brought to light in the "Silent Spring" (Rachel Carson 1962) and this spawned the advent of Biorationals under the banner of third generation pesticides (Carol Williams 1967). Since then numerous specialized pest control agents such as benzoyl ureas, hormone analogs, avermeetins, azadirachtin, chloronicotinyls, arylpyrroles etc have been introduced. Concomitantly, traditional biological control based on parasite and predator release was being augmented with microbial control. Biological control which is generally perceived as environmentally benign has its best success story with B.t. The advent of Biotechnology has opened a new area where tailor made pesticides that are target specific can be designed. A panoramic outline of the genesis of pest management from the past to the present will be presented.

Index terms: Organochlorines, Benzoyl ureas, Hormone analogs, Avermectins, Azadirachtin, Chloronicotinyls, arylpyrroles, B.t.

[1839] PREDATORS AND PARASITOIDS FOR CONTROLLING INSECT PESTS OF FORESTS

<u>J.-C. Grégoire</u>¹ & M. Kenis², ¹Laboratoire de Biologie animale et cellulaire, CP160/12, Université Libre de Bruxelles, 50 av. FD Roosevelt, B-1050, Bruxelles Belgium, E-mail jegregoi@ulb.ac.be; ²CABI Bioscience Centre Switzerland, 1, Rue des Grillons, 2800 Delemont, Switzerland, E-mail m.kenis@cabi-bioscience.ch.

Biological control methods using parasitoids and predators can be divided into three categories: the augmentation of local or exotic natural enemies by inoculative or inundative releases at critical times, the conservation of local natural enemies by modification of management practices favoring the natural enemies in the target area, and the importation of exotic natural enemies for permanent establishment, a strategy often referred to as classical biological control. The use of parasitoids and predators in augmentative biological control programmes against forest pests is hampered by several constraints, among which the high costs related to mass production and application to large areas. Nevertheless, augmentative releases would be particularly suitable in urban landscapes. The conservation of natural enemies, e.g. through modifications of cultural practices or selective insecticide timing, is still a rather neglected strategy in forest pest management. However, the increasing limitations in the use of chemicals and biopesticides in forest environment will undoubtedly favor conservation strategies. The conservation of natural enemies also shows much promises in agroforestry (i.e. the use of forest trees in agricultural systems), particularly in developing countries. Until now, most biological control programmes in forestry focused on the introduction and establishment of exotic natural enemies into new areas to control an invasive pest. There are numerous spectacular successes worldwide showing unbeatable cost/benefit ratios. Although, in most cases, the motivation was purely, or mainly, economic, classical biological control is also increasingly used to protect biodiversity, as shown in St Helena where the coccinellid Hyperaspis pantherina, predator of the scale insect Orthezia insignis, saved the endemic gunwood, Commidendium robustum from extinction. Although classical biological control has been recently criticized for its possible side effects on non-target organisms, it still represents the safest and most efficient management method against invasive pests. The long life span, size and complexity of forest ecosystems provide favourable ground for both naturally occurring and man-manipulated biological control. However, they also complicate assessment of the impact of native or introduced parasitoids and predators, and implementation of biocontrol programmes. This review attempts to draw a link between cases studies of relationships between native forest pests and native natural enemies and the effective or potential use of these predators and parasitoids in biological control programmes

Index terms: biological control, parasitoids, predators

[1840] THE ROLE OF *BACILLUS THURINGIENSIS* IN FOREST PEST MANAGEMENT: ITS CURRENT STATUS AND FUTURE PROSPECTS

J. A. Elek & N. Beveridge¹, ¹Forestry Tasmania, GPO Box 207 and Cooperative Research Centre for Sustainable Production Forestry, GPO Box 251-12, Hobart, Tasmania, Australia 7001, Email: Jane.Elek@forestrytas.com.au.

It is almost 100 years since a bacillus was isolated from a silkworm which was later named Bacillus thuringiensis Berlinger (Bt). The first commercial insecticide was developed to control the flour moth in the 1930s. Its mode of action and different strains mean that Bt can target specific groups of insect pests with minimal effect on natural enemies and the environment. However, it was not until the 1980s, when there was growing resistance by both insects and environmentally-aware people to the large-scale use of broad-spectrum insecticides, that it became cost effective to use the new, more expensive, biological insecticide. In 1980, insecticides based on the strain, Bacillus thuringiensis var. kurstaki (Btk), that specifically targets lepidoptera, were sprayed on 20% of the area managed for invasion of the gypsy moth (Lymantria dispar) in USA. By 1999 this had reached 79% (81,651 ha) of the total area treated for gypsy moth. In Canada in 1980, Btk-based insecticides were used on only 4% of the area treated for spruce budworm (Choristoneura fumiferana) but by 1995 this had increased to 100% (139,618 ha). Achieving this widespread use of Bt-based insecticides has not been easy. They not only target specific insect groups, but also require many other specific biological and physical parameters for successful control. This achievement is the result of considerable research into their mode of action and optimum requirements which lead to developing effective formulations and methods of application for Btk-insecticides. There is still similar work to be done on other strains and insect pests. We have been testing B. t. var. tenebrionis (Btt) for its activity against the chrysomelids Chrysophtharta bimaculata and C. agricola, defoliators of eucalypts. The Btt insecticide caused higher mortality and suppression of feeding of younger instars that was not proportional to body size, peaking at 4 d after treatment, and prolonged development time by several days. Its activity was also affected by the host Eucalyptus but not the chrysomelid species. It had no effect on the two major coleopteran predators. The future use of Bt-inssecticides will be affected by adoption of new technology. For example, in 1999 a virus and pheromone lure were used on about 20% of the area managed for gypsy moth in USA. However, a wide range of agricultural crops now have been engineered to incorporate several Bt genes, and the Btt gene has been engineered into eucalypts in Australian laboratories. Thus, Bt should continue to have an important role in managing forest insect pests, both as insecticides and perhaps as Btengineered tree crops.

Index terms: Bt, biological control, Chrysophtharta bimaculata, Chrysomelidae

[1841] TEBUFENOZIDE: AN EFFECTIVE AND SELECTIVE CONTROL AGENT FOR CATERPILLAR PESTS IN FORESTRY

G. R. Carlson¹, S. Dodo² & J. A. Nakano³, ¹Rohm and Haas Research Laboratories, 727 Norristown Rd, Spring House, PA 19477-0904, USA, E-mail rsagrc@rohmhaas.com; ²Rohm and Haas Quimica Ltda Fazenda Experimental, Caixa Postal 66, Paulínia SP, Brazil, E-mail: shizuo_dodo@rohmhaas.com; ³Av. Prof. Mário Werneck, 2.027 apt 1002, Bairro Burits, Belo Horizonte MG, Brazil, E-mail: Jose-akira-nakano@rohmhaas.com.

Insecticides for use in forestry must be effective, target selective and environmentally benign. Tebufenozide possesses all three attributes. It has been used successfully to control many of the key lepidopterous pests of forests in North America (*Choristoneura fumiferana*, *Lymantria dispar*), South America (*Thyrinteina arnobia*, *Rhyacionia buoliana*) and Europe (*Lymantria monacha*, *Thaumetopea pytiocampa*). Most of the beneficial attributes of tebufenozide result directly from its novel "ecdysonoid" mode of action. This presentation will briefly describe the mode of action and general biological properties of tebufenozide, and will summarize results of some recent lab and/or field tests.

Index terms: tebufenozide, Thyrinteina arnobia, Rhyacionia buoliana

[1842] BIORATIONAL AGENTS – MECHANISM AND IMPORTANCE IN INTEGRATED PEST MANAGEMENT (IPM) AND INSECTICIDE RESISTANCE MANAGEMENT (IRM) PROGRAMS

L. Ishanya & A. R. Horowitz, Dept. of Entomology, Agricultural Research Organization, The Voicani Center, Bet Dagan 50250, Israel, Fax: +972-3-968 3835, E-mail: vpisha@netvision.net.il,

In recent years, insect control by broad-spectrum insecticides has come under assault and scrutiny because of their undesirable effects on human health and the environment. Furthermore the rapidly developing resistance to conventional insecticides provides the impetus to study new alternatives and more ecologically acceptable methods as part of IPM and IRM programs. One of these approaches is the development of novel compounds affecting developmental processes in insects, such as chitin synthesis inhibitors, juvenile hormone mimics, and ecdysone agonists. In addition extensive efforts have been made to develop compounds acting selectively on some groups of insects by inhibiting or enhancing biochemical sites such as respiration (diafenthiuron), the nicotinyl acetyl choline receptors (imidacloprid and acetamiprid), and salivary glands of sucking pests (pymetrozine). Among the most recent novel insecticides with selective properties are the novaluron, thiamethoxam and spinosad. Novaluron (Rimon) is a novel benzoylphenyl urea that acts by both ingestion and contact. As such it is a powerful suppressor of lepidopteran larvae such as Spodoptera littoralis and Helicoverpa armigera (by ingestion) and of whiteflics such as *Bemisia tabaci* and *Trialeurodes vaporatiorum* (by contact). Thiamethoxam (Actara) is a novel neonicotinoid acts specifically on aphids and whiteflies and spinosad (Tracer) acts on diversity of insect species and is considered an important agent for controlling the western flower thrips. The above compounds will be discussed in relation to their modes of action and their importance in IPM and IRM programs in various agricultural systems.

Key words: Selective insecticides, benzoylphenyl ureas, juvenile hormone mimics, ecdysone agonists, biocontrol agents.

[1843] GENETIC ENGINEERING OF GENES THAT CONFERS INSECT RESISTANCE TO TREES

L. Jouanin, Biologie cellulaire, INRA 78026 Versailles Cedex, FRANCE, Email: jouanin@versailles.inra.fr

Trees are the target of many different phytophogous insects. Genetic engineering offers new possibilities of introducing insect resistance into trees. Several strategies have been considered to obtain such plants using genes which have demonstrated previously their interests in annual crops. The introduced genes are mainly genes of bacterial origin such as the *Bacillus thuringiensis* delta-endotoxins or genes of plant origin such as proteinase inhibitors or lectins. Poplar is often used as a model tree to demonstrate the interest of the strategy but insecticidal genes have also been expressed in many other trees including conifers. A review of the obtained results and of the pespectives will be presented. Index terms : Transgenic trees, entomotoxic proteins, poplar, conifer. [1845] BIOLOGICAL CONTROL OF FOREST PESTS USING INSECT SPECIFIC VIRUSES

S. R. Palli^{1,2}, T. R. Ladd¹, Q. L. Feng¹, W. Tomkins¹, M. Primavera¹, S. S. Sohi¹, B. M. Arif¹ & A. Retnakaran¹, ¹Great Lakes Forestry Centre, Canadian Forest Service, P. O. Box 490, 1219 Queen Street East, Sault Ste. Marie, Ontario, Canada, P6A 5M7; ²Rohm and Haas Research Laboratories, 727 Norristown Rd. Spring House, PA 19477, USA. Email: RAHSUB@ROHMHAAS.com.

Insect specific viruses especially baculoviruses are being developed as environmentally friendly alternatives to chemical insecticides. Virus control of insect pests is attractive because it is lasting, highly selective and effective. However, to compete against chemical insecticides, they have to be fast acting and cheaper to produce. The advent of recombinant DNA technology has made it possible to make these viruses fast acting by inserting genes from different sources. We have engineered several genes such as *Choristoneura* hormone receptor 3 (CHR7, an ecdysone induced transcription factor), *Choristoneura* hormone receptor 75 (CHR75, an ecdysone induced transcription factor), *Choristoneura* hormone receptor 75 (CHR75, an ecdysone induced transcription factor), *Choristoneura* normone receptor 75 (CHR75, an ecdysone induced transcription factor), *Choristoneura* nulticapsid nucleopolyhedrovirus (CfMNPV). All the genes were expressed under the control of CfMNPV polyhedrin promoter. The recombinant viruses were plaque purified, amplified and used in bioassays to determine LD50, ST50 and FT50 values for 4th instar C. *fumiferana* larvae. All the recombinant virus expressing CHR3 in sense orientation is the best recombinant virus we have produced so far. All three, LD50, ST50 and FT50 values for this virus were significantly better than the values for the wild-type or egt'viruses.

Index terms: baculovirus, *Choristoneura fumiferana*, ecdysone, juvenile hormone esterase, AaiT

[1844] INSECT PATHOGENIC FUNGI AS RESOURCE OF GENES FOR INSECT PEST CONTROL

St. R. Leger

ABSTRACT NOT RECEIVED

[1846] MODEL ORGANISM GENETICS AND GENOMICS: TOOLS FOR TARGET DEVELOPMENT IN PEST CONTROL

<u>S. Thibault & J. Margolis</u>, Exclixis, Inc. 260 Littlefield Ave. South San Francisco, CA USA, E-mail thibault@exelixis.com;

The pharmaceutical and agricultural industries are moving increasingly toward target based screening as their primary discovery engine for novel bioactive small molecules. Screening, of course, requires new targets and confidence that altering the activity of these targets in vivo will have the desired outcome, be it curing a disease or controlling a crop pest. Exelixis utilizes the power of genetic, genomic, and informatic technologies to rapidly identify and validate novel targets by using modulation of gene activity as a surrogate for chemical inhibition or activation of protein function. Transposon technology is one of the foundations of Exelixis' technology platform, providing a rapid method to deliver transgenes and modify the genome of both laboratory models and pest species. The power of *Drosophila* and *C. elegans* genetics makes them a fascile system for insecticide target discovery. Ideal targets are essential for viability, selective and specific to pest species, dosage sensitive, and lead to rapid knockdown when disrupted. Genes that kill an organism when knocked out or overexpressed represent first-stage validated targets for pesticide development. Historically, P element screens have tagged approximately 10% of letter al loci in *Drosophila*. Efforts are ongoing at Exclisits to saturate the number of transposon-tagged genes in *Drosophila* using P. Screens underway with second generation transposons may uncover a complementary set of loci. Exelixis is also committed to develop representative non-drosophilid insects and plant pathogenic nematodes as additional model genetic systems. Increasingly reverse genetic tools such as EST projects, large insert genomic libraries and RNA-mediated gene interference are enabling genetic entry points in species that lack a history of classical genetic analysis. Development of biotechnology tools used in target discovery for Lepidoptera, Coleoptera, and nematodes will be discussed.

[1847] A NEW VIRAL PRODUCT "INF-LD" USED IN THE CONTROL OF POPULATIONS DENSITY OF LYMANTRIA DISPAR AND EUPROCTIS CHRYSORRHOEA

M. Ciuhrii¹, G. Mihalache², T. Manole¹, P. Cosconea¹, C. Ciornei³, I. Voicescu, M. Iamandei¹, ¹Research Institute for Plant Protection-Bucharest, Bd. Ion Ionescu de la Brad, 8, sect. 1, Bucharest; Romania; ²Research Institute for Forestry-Bucharest; ³Department of Plant Protection-Bacau: Department of Plant Protection-Pitesti, Romania.

On the Romanian territory, every year many surfaces with forests and orchards could be infested with Lymantria dispar and Euproctis chrysorrhoea which are both damaging of deciduous forests. We choose any specific parts of forest suitable for producing the infection of epizootics. Only the infected larvae were collected after peculiar symptoms of NPV. In the laboratory the larvae were selected once again and after that the viruses were isolated, purified and are conditioning as follows:

Formulation	powder
Colour	white-yellow
Humidity(U%)	5-6%
Biological activity	80-94% host mortality
Nucleocapsid concentration	72 x 1011
SPVC concentration(inclusions)	5.6 x 10 🗆
The polyvirions presence(q2; q3)	60%
The alien microflora concentration	2×10^{2}
PH	7.0- 7.2
Resistance to light	60 hours
Homogeneity(in water)	60 s
Adherence	85-90 %
The period of storage	5 years
The dosage at ha	20 g

The viral product is advisable for treatments at the egg stage before the larvae are hatching strongly connected with eggs density. When the laying eggs density were at 1,3-1,8 per tree the treatment was made with hand-made sprayers in the belts with 5-m width. The distance between belts was of 400 m. In the cases when laying eggs density was smaller the distance between belts are corresponding widest at 600-800 m. In 1999 on the Romania territory 22,000 ha were treated and the effects were good, the population of L. dispar weren't in increasing. In the same year the effect of "Inf-Ld" effectiveness appear in the treatments against E. chrysorrhoea.

Index terms: Lymantria dispar, Euproctis chrysorrhoea, viral product, biological control, NPV.

[1848] PRELIMINARY STUDIES ON THE APPLICATION OF STEINERNEMATID NEMATODES AGAINST OVERWINTERING LARVAE OF PINE PROCESSIONARY CATERPILLAR, THAUMETOPOEA PITYOCAMPA DEN. ET SCHIFF. (LEPIDOPTERA: THAUMETOPOEIDAE)

O. Triggiani & <u>E. Tarasco</u>, Di.Bi.C.AF.A. - Dipartimento di Biologia e Chimica Agro-Forestale ed Ambientale, Università di Bari, via Amendola 165/A 70126 Bari Italia Email: eustachio.tarasco@agr.uniba.it.

Pine processionary caterpillar *Thaumetopoea pityocampa* (Lepidoptera: Thaumetopoeidae) is a very dangerous lepidopterous spread in the mediterranean area. A preliminary survey was conducted with 4 different strains of Steinernematid entomopathogenic mematodes in the nests of pine processionary caterpillars in a *Pinus silvestris* reafforestation (Gravina in Puglia - 550 m a.s.l.) of Apulia Region (Southern Italy). Three different strains of *Steinernema feltiae* (2 indigenous, from Apulia Region pine woods, and 1 from Germany) and 1.8. *kraussei* strain from Northern Italy were used; 300.000 Infective Juveniles (JJs) in a gel suspension were injected in the nests on January and February. The percentage of larval mortality was evaluated at 10 day intervals during 2 months. The results of this preliminary experiment pointed out:

- the ability of Steinernematid nematodes to control the processionary caterpillars;

- the persistence in the nests of IJs for more than 20 days from treatment;

the possibility of nematodes to complete their life cycle in the larvae of T. pityocampa;
no negative effects were observed on Prhyse caudata (Diptera: Tachinidae), the most important natural antagonist of T. pityocampa larvae.

Index terms: Steinernema, entomopathogenic nematodes, microbial control

[1849] OCCURRENCE OF HYMENOPTERA PARASITOIDS IN LARVAE OF PHORACANTHA SEMIPUNCTATA (COLEOPTERA: CERAMBYCIDAE)

G. T. Ribeiro & J. C. Zanuncio, Dept^a. de Biologia Animal, Univ. Fed. Viçosa, 36571-000, Viçosa, MG, Brasil, E-mail zanuncio@mail.ufv.br.

The importance of wood boring insects specially those of the Coeloptera order has been increasing in Brazil because wood from reforested areas in this country are been used for many products besides sawlog for export. Species of Cerambycidae are very important because most of them are wood borrers of tree species. *Phoracantha semipunctata* (Colcoptera: Cerambycidae) is one of the most important species of this group in the world because it damages Eucalyptus. This pest was recorded in the States of Rio Grande do Sul in Eucalyptus grandis, especially in recently cut and wood stored at small sawmills; in São Paulo in Eucalyptus citriodora; in Espírito Santo in a hybrid of Eucalyptus urophylla and E. grandis; in Bahia in Eucalyptus pellita, Eucalyptus cloeziana, Eucalyptus camaldulensis, E. urophylla and in a hybrid of E urophylla and E. grandis; in Minas Gerais in the area of Savannah in Eucalyptus spp. Tunneling in the subcortical region where its larvae feed during its development represents the damage by this insect. During the last instar larvae of this pest drill into the log where it prepares a pupal chamber. P. semipunctata can attack standing logs with bark in the field and also stored at the mill. Attacks by this pest represent an important problem because perforations in Eucalyptus wood make them unfeasible for export. Damage by this pest include the death of plants and wood depreciation. The incidence of P. semipunctata was registered in areas of E. urophylla in the northeast of Bahia where a high number of Eucalyptus trees were attacked after a fire. Many empty pupae of parasitoids were observed in larvae of P. semipuncinia. Alive pupae of this parasitoid were observed in alive pupae of this pest. These pupae were maintained in laboratory for emergence of the parasitoids which were sent to specialists for identification. They were identified as Liobracon sp. and Leluthia cf. Monitoring of wood piles in the Northeast of Bahia showed that about 50.0% of the pupae of P. semipunctata were killed by parasitoids, probably of the genus Leluthia. Another search in Eucalyptus logs after five months of cutting showed that approximately 45.5% of pupae of P. semipuctata were dead with the presence of empty cocoons of parasitoids, which was probably also of the genus Leluthia.

Key words: Phoracantha; parasitoids; biological control.

[1850] INFLUENCE OF NATURAL ENEMIES ON THE POPULATIONS OF TWO STOLAINI SPECIES (COLEOPTERA: CHRYSOMELIDAE: CASSIDINAE) IN A BRAZILIAN TROPICAL FOREST

<u>F.N. Sá</u>l & J. Vasconcellos-Neto^t, ¹ Universidade Estadual de Campinas - Inst. Biologia -Depto. Zoologia. Campinas, SP, Brasil, 13083-970. E-mail: fnsa@obelix.unicamp.br.

Natural enemies of Chrysomelidae are represented by organisms of many different taxa that can cause heavy impact on them. In this work, we followed populations of *Stolus* chalybea and S. areolata for two years, looking for natural enemies and investigating their influence on mortality of those Cassidinae populations. For the three studied species, we observed highest mortality rates during egg phase (87.5%, 66.98% and 65.65% for S. areolata, S. chalybea and A. phaeopoda respectively) provided by hymenopteran parasitoids, predation and infection by fungi. We obtained eight parasitoid species accounting for S. chalybea eggs (with total parasitism rate of 51.93%) and two accounting for S. areolata (with total parasitism rate of 28.57%). Larvae were harmed by predators like spiders and Pentatomidae hemiterans and by two Tachinidae species parasitizing them. Tachinidae parasitism rates was of 46.15% for S. areolata and 19.39% for S. chalybea. Larvae in earlier stages showed highier mortality than more mature larvae of the same species. We obtained the parasite nematode Hexamermis sp. (Memithidae) in adults of S. chalybea and we also observed some acari on their elytrum, but we could not be sure if they were acting as parasites or comensals. Adults of this Cassidinae species were also sometimes observed attached to spider webs. A one-year census on Bidens segetum and Mikania cordifolia, host plants of Stolas chalybea and S. areolata respectively, revealed, by significant positve correlations, that the abundance and richness of potential predators was synchronous with the abundance of the eggs and larvae of the beetles, sometimes showing a lag period in response. Ants, spiders and heteropterans were the most frequent predators found on host plants. We believe that this result may suggest the influence of the populations of invertebrate predators which forage on Cassidinae host plants their populations.

[1851] OVERVIEW OF MECHANISMS OF RESISTANCE IN TREES TO INSECTS

S. Larsson, Dept. of Entomology, Swedish University of Agricultural Sciences, Box 7044, SE-750 07 Uppsala, Sweden, E-mail Stig.Larsson@entom.slu.se

Plant resistance to insects has been defined as the "relative amount of heritable qualities possessed by the plant which influence the ultimate degree of damage done by the insect" (Painter 1951). Although other definitions of resistance are favored by some researchers, this plant-centered definition is most often cited in the literature and will be used in my talk. Painter's definition focuses on plant damage. A resistant plant can be less damaged than another, more susceptible, plant by 1) being less attractive to insects, 2) causing higher insect mortality, or 3) being more tolerant to the same amount of damage. Most often, published data on tree resistance to forest insects refer to the second category. In cases where tree resistance is thought to contribute to insect population dynamics it is highly relevant to investigate intraspecific variation in insect performance, such as mortality. It is important, however, to recognize that such data refer to responses at the level of the individual. Whether populations also respond depends on the strength of the effect, in relation to other population processes. It is also important to recognize that performance data may say more about a specific tree/insect interaction than about the tree's resistance in general. Insects from different feeding guilds often perform differently on dissimilar tree phenotypes because members of different guilds respond to different key traits in the plant (nutrients, secondary metabolites, physical characteristics, phenology). In my talk I will discuss the complexity of the resistance concept. I will emphasize the importance of clarifying whether the context in which resistance is used is tree- or insectoriented.

Index terms: Individual performance, population dynamics, feeding guild

[1852] MECHANISMS OF RESISTANCE IN TREES TO DEFOLIATORS

K. M. Clancy, USDA Forest Service Research, Rocky Mountain Research Station, 2500 S. Pine Knoll Dr., Flagstaff, AZ 86001-6381 USA E-mail: kclancy@fs.fed.us.

I will discuss 10 mechanisms known to be important in resistance of trees to insect defoliators, with appropriate examples from the literature and my own work with the western spruce budworm (*Choristoneura occidentalis*) and Douglas-fir (*Psuedotsuga menziesii*). The mechanisms I will emphasize are: 1) Phenological asynchrony between host trees and insect herbivores; 2) Host tree tolerance of defoliation, and the role of host tree vigor; 3) Host tree compensatory photosynthesis and growth in response to defoliation; 4) Toughness of leaves and needles; 5) Low nutritive quality of foliage; 6) Defensive compounds (or allelochemicals) in foliage; 7) Three-trophic-level interactions among the trees, their insect herbivores, and natural enemies of the herbivores (i.e., predators, parasites, pathogens); 8) Host tree microbial mutualists such as mycorrhizae and fungal endophytes; 9) Induced defenses in host trees; and 10) Induced susceptibility in host trees.

Index terms: phenology, tolerance, compensation, foliar chemistry, mutualists

[1853] MECHANISMS OF RESISTANCE IN TREES TO SHOOT INSECTS

R. L Alfaro¹, E. S. Tomlin², R. McIntosh³, J. Borden⁴ & J. King⁵, ¹Research Scientist, Pacific Forestry Centre, Victoria, BC. Canada; ²Research Scientist, Biology Dept., University of North Carolina, Greens borough, N.C., USA; ³Insect and Disease Specialist, Saskatchewan Environment; Prince Albert, Saskatchewan. Canada; ⁴Dept. Biological Sciences, Simon Fraser University. Burnaby, BC. Canada; ⁵Geneticist, BC Ministry of Forests, Victoria, BC. Canada.

This paper provides a summary of the resistance mechanisms to shoot insects that we have uncovered either by examination of the literature or by detailed work on the white pine weevil, *Pissodes strobi*, a shoot insect affecting spruce and pine in North America. The review indicates that conifers rely on a combination of defense mechanisms to fend off herbivores which feed on their shoots. These range from defense strategies in which the host provides improper nutrition to the attacker, for example by being in the wrong phenology state at the time of feeding, to constitutive defenses, such as resin canals and sclereids, to inducible defenses, which are activated in response to the attack. The latter include the manufacture and mobilization of defensive chemicals to the site of wounding, and the production of traumatic resin in conifers in response to insect and fungal attack...

[1854] MECHANISMS OF RESISTANCE TO WOOD BORERS

T. D. Paine, Dept. of Entomology, Univ. of California, Riverside, CA, USA 92521

Wood boring insects can include a wide taxonomic range including the Coleoptera, Lepidoptera, and Hymenoptera. In many groups, the larval stages feed in the inner bark and outer layers of xylem tissues of their host plants, and pupation may occur in cells constructed within the wood. The adult insects are entirely free-living. However, there are several groups of wood-boring beetles in which the adults excavate oviposition galleries in the wood of the host. As a broad generalization, many of the wood-borers colonize weakened, stressed, dead, or dying host plants. The insects are frequently part of a guild of secondarily invading scavengers of host material weakened by environmental factors, disease, or other insect activity. The resistance mechanisms (induced and preformed defenses that are under some living control) thought to be important against phloem feeders and other primary colonizers may become critical factors if the woodborers colonize relatively healthy trees. However, the resistance mechanisms against phloem feeders not critical factors if the insects are colonizing dead and dying trees. The physical factors that are associated with the bark or wood (e.g., lignin or moisture) can remain and may affect the survival of wood-borer larvae. In Australia, Eucalyptus resistance to infection and invasion has been associated with induced production of a phenolic resin. However, there may be differences in tree colonization patterns of woodborers in Australia compared to exotic environments in North America, South America, Africa, and in the Mediterranean basin where colonization of water stressed trees appears In California, Eucalyptus resistance to Phoracantha to be critical. semipunctata colonization appears to be independent of the induced response, but rather is a function of a physical factor. If the water content of the outer bark is greater than 55%, then the larvae are virtually incapable of penetrating that barrier. Induced reactions are present, but appear not to be a key factor because of the temporal lag in response. Index terms: Host resistance, Eucalyptus, Phoracantha semipunctata,

[1855] MECHANISMS OF RESISTANCE IN TREES TO BARK BEETLES

<u>F. Lieutier</u>, Laboratoire de Biologie des Ligneux. Univ. d'Orléans. B.P. 6759. F-45067 ORLEANS CEDEX 2. France. E-mail : francois.lieutier@univ-orleans.fr.

As in most phytophagous insects, the living host plays an essential role in the population dynamics of bark beetles. It is not surprising, in these conditions, that taking the host effect into consideration in the development of bark beetle research has lead, since the beginning of the 70ies, to a considerable amount of knowledge in bark beetle biology. Two basic resistance mechanisms have been recognized in conifers of which the relative importance depends essentially on the beetle behavior. The classical model of tree-bark beetle relationships is based on the involvement of a third partner, a moderately phytopathogenic fungus, which needs to be mass inoculated (that is above a certain threshold of density) to the tree by the beetles to weaken host resistance and kill the tree. Based on this model, different beetle strategies have been proposed to explain the between species variations in these relations and the beetle behaviors. The physical, histological and chemical phenomena involved have been intensively studied. A presentation of these results is given. However, when trying to understand the mechanisms in details, it appears that numerous aspects of conifer resistance to bark beetles are still unknown. The exact role of the associated fungi in beetle population establishment and in tree death is unclear, although it is the basis of the classical model. The role of the beetle itself is also not really understood and may have been under-estimated. How the tree defense reaction works when the threshold level of attack density is going to be reached and how this threshold is overcome have almost never been investigated. Tree resistance to beetle-fungus attacks has been mainly studied in the phloem although the beetle both at the phloem and the sapwood levels often inoculates the fungus. Sapwood resistance may have an essential role in containing fungus development and consequently in beetle establishment How environmental factors interfere in the beetle-fungus-tree relationships is a very complex and difficult topic which has been approached, except in few cases, only relatively recently. The effects of the resistance mechanisms on the aggressors are still poorly understood. The reasons for these lacks are analysed and suggestions for research development are presented. Although various tracks are suggested, they all correspond to a re-focusing of the approaches on the insect aspects and on experimental situations close to the threshold of attack density. Finally, the topics the most susceptible to give practical applications in the field of tree resistance and in the present context are presented Index terms : Conifer, review, research prospect

[1856] MECHANISMS OF RESISTANCE IN TREES TO GALL-FORMING INSECTS

G. Wilson Fernandes, ML Faria, TG Cornelissen, MM Espirito Santo, D Negreiros, FMC Castro. ¹Ecologia Evolutiva de Herbívoros Tropicais, DBG/Universidade Federal de Minas Gerais, CP 486, 30161-970 Belo Horizonte, MG Brazil, Email gwilson@icb.ufmg.br

Plants posses a wide spectrum of traits that generally affects the colonization and success of gall-forming herbivores. These include plant secondary chemistry and physical barriers, behavior (e.g., phenology), and genetics. We have studied the relationships between two species of wild congeneric dioecious shrubs of the genus *Baccharis* which are highly species-rich on gall-forming insects in southeastern Brazil. Approximately 40 new species of galling insects are known to attack these two host plant species in the area. We report on a two year field experiment in which 160 plants (80 males and 80 females) were equally divided into four treatments to evaluate the influence of plant quality on galling abundance, richness, and performance. The treatments were plant fertilization (NPK), irrigation, irrigation and fertilization, stress, and control. Plant Sex had no effect on the gall community. Irrigation and fertilization were found to negatively influence all the parameters evaluated, while stress had a negative effect on them. Galls were mostly common on control plants. Plant module senescence also negatively influence gall success, a parameter not generally studied in galling insect studies. Furthermore, plant diminishing galling success. [1857] THE BIOCHEMICAL MECHANISM FOR THE RESISTANCE OF RED MAPLE TREES TO FOREST TENT CATERPILLAR FEEDING

<u>B. V. Helson¹</u>, M. M. Abou-Zaid¹, J.T. Arnason² & C. Nozzolillo², ¹Canadian Forest Service, Natural Resources Canada, P. O. Box 490, Sault Ste Marie, ON P6A 5M7, CANADA, E-mail bhelson@nrcan.gc.ca; ²Ottawa-Carleton Institute of Biology, University of Ottawa, Ottawa, ON K1N 6N5, CANADA.

We have demonstrated experimentally that forest tent caterpillar (FTC) larvae do not feed on red maple leaves but will feed readily on sugar maple leaves. An ethanolic extract of red maple leaves applied to aspen leaf disks also deterred the feeding of larvae which suggested that the mechanism is biochemical in nature. Fractions of the red maple extract containing the highest concentrations of phenolic compounds were most deterrent. The red maple extract and phenolic fractions were consistently more deterrent than the comparable extract and fractions of sugar maple. These results suggested that phenolic compounds present in red maple could be involved in the resistance of red maple to feeding by FTC larvae. The major phenolic compounds in red maple and sugar maple were isolated and identified. Six of the the compounds present in red maple leaves were available and obtained commercially. When these compounds were assayed in choice leaf-disk tests at 283 µg/cm², methyl gallate and gallic acid significantly deterred the feeding of FTC larvae while the other 4 compounds which were flavonol glycosides did not. These findings indicated that only certain phenolic compounds in red maple are involved in the mechanism for resistance. In order to determine which specific compounds could be responsible, 10 more phenolic compounds from red maple leaves were extracted and purified in large enough quantities to test their antifeedant effects on forest tent caterpillar larvae. Five more gallate compounds including ethyl m-digallate, ethyl gallate, 1-galloylrhamnose, 1-galloyl-glucose and m-digallate also exhibited significant antifeedant activity. Gallates may be responsible for protecting red maple from feeding by FTC. Ethyl digallate in particular could be a major factor because it is the most common gallate compound in red maple leaves. It has not been detected in sugar maple which FTC larvae cat readily. Furthermore, ethyl digallate is also abundant in silver maple leaves which are also not eaten by FTC larvae.

Index terms: Malacosoma disstria, antifeedant, ethyl m-digallate, phenolics, gallates, sugar maple

[1858] OVERVIEW OF TREE RESISTANCE DEPLOYMENT APPROACHES

D. J. Robison, Department of Forestry, North Carolina State University, 3118 Jordan Hall, Box 8008, Raleigh, NC 27695-8008 USA, E-mail: dan_robison@ncsu.edu

The intensification of forest plantation systems is tightly coupled with tree genetic improvement and the deployment of increasingly limited genetic diversity. This presents substantial challenges with respect to pest management in these systems. In natural forests and traditional low-intensity plantations there are large amounts of genetic diversity among individual trees, whereas in more intensive systems the buffering or resiliency of the trees against pest depravations can be compromised. This buffering is due to large ranges in the variation and apparency of phenotypic host plant resistance characters, and their ability to limit pest population expansion and restrict pest biotype evolution. In intensive systems relatively few genetic families or specifics clones are deployed. These, by design, exhibit limited phenotypic variation and are cultured with weed management and fertilization. Together these can create perennial systems that are prone to large damaging pest populations. Simultaneously, the intensity of management and use of genetically improved planting stock represents an investment that must be secured and is likely to have a lower economic injury threshold than more traditional forest systems. Deploying these systems over large areas in an ecologically simplistic manner will lead to instability. What is required for ecological and production stability/sustainability is ecological complexity imposed through the careful screening and deployment of genotypes. Perennial clonal systems in nature contain a diversity of genotypes and can be very stable and productive over very long periods of time. Such systems can provide clues for forestry deployment, as does genetic interaction modeling between crops and pests. Selecting specific genotypes for temporal and spatial deployment on the basis of productivity and pest management is a new management tool in forestry that requires substantial development. The current level of understanding and theoretical basis for this development is discussed in this paper.

Index terms: clonal forestry, host plant resistance, planting designs, landscape diversity

[1859] DEPLOYMENT OF TREE RESISTANCE TO INSECTS IN SHORT-ROTATION BIOMASS PLANTATIONS

J. D. McMillin¹, D. R. Coyle², R. B. Hall³ & E. R. Hart^{3,4}, ¹USDA Forest Service, Forest Health Management, Rapid City, SD 57702, USA, E-mail jmcmilli/r2_blackhills@fs.fed.us; ²USDA Forest Service, SRI, New Ellenton, SC 29072, USA; ³Dept. of Forestry, Iowa State Univ., Ames, IA 50011, USA; ⁴Dept. of Entomology, Iowa State Univ., Ames, IA 50011, USA.

Insect herbivores have potential to cause economic impact on short rotation biomass plantations. Host plant resistance is a fundamental component of integrated pest management (IPM) to control insect herbivores in short rotation woody crop production. Operational biomass plantations currently are using a limited number of clones that probably exhibit modest host plant resistance to insects and may be promoting insect adaptation to resistance. Further complicating the development of deployment strategies for host plant resistance is the fact that different insect species prefer different clones; a seemingly resistant clone to one insect is susceptible to a complex of other insects. However, based on a review of the literature, examples of host plant resistance to forest insects include antibiosis, antixenosis, and tolerance. Approaches to incorporating host plant resistance into short rotation woody crop systems include tree breeding, genetic engineering, clonal deployment, and IPM development. Iowa State University and other researchers have investigated chemical and physical attributes that may affect the susceptibility of some select Populus clones and potential resistant traits of other clones. Recent evidence suggests that the ratio of long-chain fatty alcohols and a quinone compound in hybrid Populus influences Chrysomela scripta adult and larval feeding preference and performance. There have been several recent attempts to use genetic engineering to insert resistance genes, including Bacillus thuringiensis and protease inhibitor genes, into Populus clones. However, environmental and societal concerns may affect the operational status of these genetically engineered clones. Deployment strategies of host plant resistance include creating monoclonal stands, mosaics of monoclonal blocks that contain varying resistance traits, mosaics of clonal rows, and single tree and small groups of trees. Each of these planting strategies has benefits and costs in terms of maximizing plantation efficiency and minimizing pest damage. Future strategies using IPM for the control of insect pests of short rotation Populus systems will include a combination of host plant resistance, genetic engineering, biorational sprays, planting design strategies, and biological control. The use of all these strategies will help to maintain and conserve host plant resistance and genetically improved clones for longer-term use. Research needed to reach this integrated approach includes further identification of host plant resistance, large-scale testing of different deployment schemes, and further examination of the impact that natural enemies have on Populus insect pests. Index terms: Chrysomela scripta, clonal forestry, host plant resistance, Populus

[1860] HORTICULTURAL STRATEGIES FOR DEPLOYMENT OF TREE RESISTANCE TO INSECTS

D. A. Herms. Dept. Eutomology, The Ohio State Univ., Ohio Agric. Res. Dev. Cen., 1680 Madison Ave., Wooster, OH 44691 USA, email: herms.2@osu.edu.

Historically, insect resistance has received little consideration in the selection, use, and management of trees in urban forests and ornamental landscapes. Deployment of pest resistant has been constrained by a lack of long-term research. Furthermore, few studies have addressed the role of cultural practices in IPM programs. Plant defense theory offers potential in both arenas. Biogeography theory predicts that patterns of resistance will correspond with historical selection pressures exerted by key pests. For example, we found that native North American birches are highly resistant to bronze birch borer, with which they share an evolutionary history. Conversely, the exotic species that are planted almost exclusively are highly susceptible: Fertilization is frequently touted as an important component of IPM programs for ornamental plants. However, theory predicts that fertilization will decrease the resistance to trees growing on highly disturbed, infertile soils characteristic of many urban sites. Experimental data from our work and the literature is consistent with these predictions, and will be reviewed.

Index terms: plant defense theory, growth-differentiation balance, cultural management, IPM

[1861] RESISTANCE OF YOUNG AND MATURE BALSAM FIR TREES TO SPRUCE BUDWORM AS AFFECTED BY STAND THINNING : SHORT AND LONG TERM EFFECTS

É. Bauce, M. Charest & R. Bérubé, Département des Sciences du Bois et de la Forêt, Faculté de Foresterie et de Géomatique, Université Laval, Ste-Foy, Québec, G1K 7P4 CANADA, E-mail eric.bauce@sbf.ulaval.ca.

The impact of stand thinning on the resistance of young and mature balsam fir, Abies balsamea, trees to spruce budworm, Choristoneura fumiferana, the most important insect pest of the North American boreal forest, has been monitored and estimated for 8 years. Both field and laboratory experiments were conducted to reveal the ecophysiological processes involved at host tree and insect levels after the sylvicultural intervention. The density of young stands was reduced from 15000 stems/ha to 2500 stems/ha while the density of mature stand was reduced by removing 25% of the stand basal area. Both young and mature thinned stands suffered heavier defoliation by the insect one year after the treatment. In young stand the increased defoliation (24%) was related to high insect survival due to a reduction in foliar polyphenolics. In mature stands increase in defoliation (+45%) was related to high insect food consumption rate due to a reduction in foliar monoterpenes. These results were supported by laboratory rearing experiments. Because trees were more defoliated and did not produced much foliage one year after stand thinning, the amount of residual foliage after insect defoliation, an index of host tree resistance, was 75% and 38% lower in mature and young thinned stand respectively compared with control stands. These results indicate that stand thinning should be avoided during spruce budworm outbreaks. However, such negative impacts of stand thinning diminished gradually over time. In fact, two years after the treatments there was an increase in foliage production that exceeded the increase in defoliation in thinned stands. Moreover, five years after the thinning treatment, mature trees had 6 times more residual foliage after insect defoliation than control trees, Even after eight years, mature trees in thinned stand had 48% more residual foliage than control trees, indicating that thinning had a lasting effect in reducing host vulnerability to further attacks by the insect. Similarly, three years after the thinning treatment, young trees had 6 times more residual foliage than control trees. Even after five years, they maintained 104% more residual foliage than control trees. Our results suggest that stand thinning could be an efficient tool to reduce balsam fir tree vulnerability to spruce budworm as long as thinning is conducted few year prior to budworm outbreak so that treated trees can pass through their short period of high vulnerability before budworm's attack.

Index terms : Choristoneura fumiferana, vulnerability, polyphenolics, terpenes

[1862] POSSIBILITIES TO UTILIZE TREE RESISTANCE TO INSECTS IN FOREST PEST MANAGEMENT IN CENTRAL AND WESTERN EUROPE

C.M.Heidger (1) and F.Lieutier (2), (1) Hochschule Zittau/Goerlitz (FH) Univ.of applied Sciences, Dept.of Ecology and Environmental Protection, P.O.Box 261, D-02755 Zittau, Germany. (2) Univ. Orléans, Laboratoire de Biologie des Ligneux, B.P. 6759, F.-45067 Orléans Cedex, France.

The most relevant forest trees in Central and Western Europe are Norway spruce (Picea abies), Scots pine (Pinus sylvestris), maritime pine (Pinus pinaster), beech (Fagus sylvatica) and oak (Quercus petraeae, Q. robur). They are attacked by several pests among which the most agressive belong to the bark beetles, weevils and Lepidoptera and, to a lesser extend, aphids and scale insects. Trees have developed resistance mechanisms against all of these insects and the existence of more or less long periods without damage proves, that these natural mechanisms are efficient most of the time. In Central an Western Europe several investigations in this field have been undertaken for the above insects, revealing different kinds of mechanisms, which range from avoiding the pest to the induced systemic defence. These mechanisms depend on the damage location in the host and the feeding behaviour of the pest (defoliator, sap-sucking, phloem feeders,...). However, very few attempts have been made for a practical use of these mechanisms in forest pest management. Two main possibilities can be considered: tree breeding for genetic resistance by taking into account resistance criteria in genetic improvement programs, or enhancement of the defence mechanisms and resistance level of the trees by silvicultural practices. The paper presents all these aspects through examples of research on Central and Western European forest pests, while insisting on the possibilities open to utilize natural resistance in forest pest management for each of them. Index terms: resistance breeding, genetic selection, silvicultural methods.

[1863] DEPLOYMENT OF TREE RESISTANCE TO PESTS IN ASIA

N. Kamata, Lab. of Ecology, Fac. of Sciences, Kanazawa Univ., Kakuma, Kanazawa, Ishikawa 920-1192, Japan, E-mail: kamatan@kenroku.kanazawa-u.ac.jp

In NE Asia, many trials to deploy tree resistance to pests have been done. In China, selection had been the main method of tree breeding until the early 1980s. Later, breeding by crossing became popular for trees belonging to the genus Pinus, Salix, and Larix. In China, the influence of Lysenkoism prevented the progress of tree breeding by 1960s. The main purpose of tree breeding in China has been to breed fast growing trees to recover vegetation. Because such fast growing trees tend to be infested by pests, many plantations of popular and willows are susceptible to insect attack. Amongst them the Asian longhorn beetle, Anoplophora glabripennis, is the most serious pest, which sometimes kills trees. Projects to breed beetle-resistant tress have started. In S Korea, a forest rehabilitation program started after the Korean War. Many native pine trees have been planted but damaged badly by the pine needle gall midge, *Theodiplosis japonicus*. Recently, the salicylic acid concentration in the pine needle has been proved to be the important determinant of resistance against T. japonicus: Needles of susceptible species had a low concentration of salicylic acid under the phenolic compound-free conditions while needles of resistant species against this insect contained a higher concentration of salicylic acid. The Korean Forest Research Institute first tried to select the resistant strain but failed. Effective production of insect-resistant pines can be obtained through hybrids by crossing between susceptible and resistant species by increasing internal salicylic acid contents of the needles. In Japan, selection for larch and poplar resistant against hares and voles has been successful. Selection for Cryptomeria japonica resistant against Sugi bark borer, Senanotus japonicus, and against Cryptomeria bark midge, Reeseliella odai, has been carried out. The pine wilt disease caused by pine wood nematode, Bursaphelenchus xylophilus, is the most harmful pest in the NE Asian countries. There is a relationship between species-level susceptibility and phylogenic classification: pine species belonging to the subsection Australes are the most resistant, followed by the subsection Contortae. Pines belonging to the subsections Ponderosae and Oocarpae are susceptible. The subsection Sylvestres contains both resistant and susceptible species. After inoculation of PWN, the nematodes increased in number and spread rapidly in the susceptible pine trees, but not in the resistant trees. Responses of resistant pine species, wound periderm formation and occlusion of cortical resin canal, trapped the nematode within damaged tissue. The insensitivity of xylem parenchyma to the PWN also acts as a defensive factor of resistant pine species. In Japan, the national project to select resistant pine trees started in 1978, which was successful for P. densiflora. However, because P. thunbergii, which is an important species to protect seashore, is much more susceptible to PWN than P. densiflora and proved to be difficult to select resistant trees, the international hybridization project of P. thumbergii x P. massoniana was started in 1983 by introducing 20 liters/year of P. massoniana pollen from China.

[1864] USING RESISTANCE IN TROPICAL PLANTATIONS

<u>J.R. Cobbinah¹</u> & M.R. Wagner², ¹Forestry Research Institute of Ghana, UST Box 63, Kumasi, Ghana. ²School of Forestry, Northern Arizona University, P. O. Box 15018, Flagstaff, AZ 86011-5018, U.S.A.

The major factor limiting the establishment of indigenous species plantations in subsaharan Africa is insect pests. Earlier efforts at establishing commercial plantations of valuable timber species such as Iroko, Obeche, Mansonia, Mahoganies, Emire, Aucounnea have all been hampered by insect pests that in many cases had not been previously encountered in the natural forest. Even small trial plots and nursery blocks of these species have not been spared. Whiles chemical control has shown promise in the control of major pests of Mansonia, Emire, Afrormosia and Obeche, this strategy has proved ineffective against pests limiting the establishment of Iroko, Mahoganies and Ceiba. However, from both economic and environmental stand points chemical control appears not to be a feasible option in commercial plantation in this region. While the humid tropical forest is highly diverse and contains wide array of organisms at different tropic levels including potential natural enemies of the major insect pests, very low natural enemy fauna have been encountered in the commercial monocultural plantations. Results of recent studies on Iroko and Mahoganies however, indicate that there is considerable variability in susceptibility within and among provenances and progenies of forest tree species to pests and that tree resistance would be the centrepiece of IPM for major pests of forest plantations in Africa in the future. In Iroko as much as 12-fold differences in attack rates have been recorded on resistant and susceptible individuals. Selection of lines with reduced susceptibilities or high recuperative ability followed by clonal multiplication of these individuals have resulted in genetic gain of about 35%. Present findings suggest that success in plantation establishment would depend largely on the deployment of genetic resistance in IPM programmes.

[1865] INHERITANCE PATTERN OF RESISTANCE TRAITS IN HYBRID WILLOWS: EFFECTS ON HERBIVORES AND PATHOGENS

I. Hiältén, Department of Animal Ecology, Swedish University of Agricultural Sciences, S-901 83 Umeå, Sweden. E-mail joakim.hjalten@szooek.slu.se.

It is generally accepted that hybridization has been important for plant evolution. However, in recent years there has also been and increased interest for the role of hybridization in plant-animal interaction. Herbivore response to hybrid plants depends on both inheritance patterns of resistance traits and the response of specific herbivores to these characters. For insect herbivore plant phenolics plays and important role for food plant selection, acting both as attractants for specialist herbivores and as repellents for generalists. The aim with this study was to determine the inheritance pattern of plant phenolics in hybrid willows and the response of specific herbivores (galling sawflies) and parasitic fungi Melampsora sp. to these changes. To control the plant material used and minimize the influence of environmental variation F1 hybrids and parental species were produced by hand-pollination of willows in the field. In addition, the plants were potted and kept in an experimental field under controlled conditions. Three willow species were used, Salix caprea were crossed with both S. repens and S. phylicifolia. These species hybridize naturally. The inheritance patterns of plant phenolics can best be described as additive, that is hybrid plants had intermediate concentrations of phenolics compared to the parental species. However, the response of herbivores and Melampsora rust did not follow the same pattern. The densities of galling sawflies on hybrid plants were generally similar to the densities on the most susceptible parent. By contrast, hybridization resulted in a breakdown in the resistant of F1 hybrids to Melampsora rust. However, a reconstitution of resistance occurred in backcrosses, suggesting an additive inheritance of resistance traits. Potential mechanism for the response of herbivores and Melampsora rust to hybrid plant is discussed.

Index terms: Willows, hybrids, resistance, galling sawflies, melampsora rust

[1866] ENVIRONMENTAL EFFECTS ON RESISTANCE OF YOUNG SPRUCE TO INSECTS AND FUNGI

D. Wainhouse, Entomology Dept. Forest Research, Alice Holt Lodge, Wrecclesham, Farnham, Surrey, GU10 4LH, UK. E-mail d.wainhouse@forestry.gov.uk.

When the supply of mineral nutrients is limiting, application of fertilizer usually increases tree growth. This 'carbon-demanding' response to fertilisation can reduce resources allocated to carbon-based defences as predicted by resource-availability models of plant defence. Such effects on the expression of quantitative defences have been commonly observed in trees although their influence on herbivores has been less commonly measured. Experiments are briefly described in which young plants of Sitka spruce were grown under two light and nitrogen regimes to determine effects on growth, quantitative defences (resin and polyphenols) and nutritional status (sugars and nitrogen) of both above and below ground parts of the tree. Concentrations of resin, polyphenols and carbohydrates were higher in low nitrogen treatments as predicted by resource- availability models of defence and the changes were similar in all parts of the trees including tissues formed prior to experimental treatments. However, these changes did not appear to be the result of a direct trade-off with growth but reflected treatment-induced variation in the root/shoot ratio. Production of quantitative secondary chemicals may, therefore, be part of an integrated response of the trees to environmental stress. Bioassays with Elatobium abietinum, Gilpinia hercyniae and the facultatively pathogenic fungus Phacidium coniferarum however, showed changes in the concentration of carbon-based secondary chemicals alone were of only limited value in predicting susceptibility of spruce to insect and fungal attack.

Index terms: Spruce, growth, quantitative defence, RSR

[1867] ECOLOGY AND MANAGEMENT OF DEFOLIATING PESTS OF CONIFERS IN NORTHERN BRITAIN

<u>A. D. Watt</u>¹, B. J. Hicks¹, H. F. Evans² & S. E. Hartley¹, ¹Centre for Ecology and Hydrology, Banchory Research Station, Hill of Brathens, Glassel, Banchory AB31 4BY, Scotland, United Kingdom E-mail adw@cch.ac.uk; ²Forest Research, Alice Holt Lodge, Wrecclesham, Farnham, Surrey GU10 4LH, United Kingdom.

The main forest trees in the UK are North American conifers, Sitka spruce and lodgepole pine. Both tree species have been attacked by a range of native insects and outbreaks of one of these, pine beauty moth (*Panolis flammea*), has occurred regularly on lodgepole pine since 1977, while remaining an innocuous insect on Scots pine. Over approximately the same period, another insect pest, the winter moth (*Operophtera brumata*), has emerged as a pest of Sitka spruce and heather. This paper will summarise recent research carried out on these insect pests, particularly recent work on the impact of fungal pathogens on pine beauty moth and the evolution of host-specific races in both species. Index terms: pine beauty moth, winter moth, fungal pathogens, host-specific races. [1869] NEW BACILLUS THURINGIENSIS PRODUCTS AND THE FUTURE OF BACILLUS THURINGIENSIS PRODUCTS IN THE NEW MILLENNIUM

R. A. Fusco, Valent BioSciences Corporation, HC 63, Box 56, Mifflintown, PA 17059, USA, E-mail: robert.fusco@valent.com.

During the past 30 years, much technological advancement has been made in the development of microbial pesticides for use in forest insect control programs. Advances in fermentation technology, formulations, and application technology have been significant and have made *Bacillus thuringiensis subsp. Kurstaki* the preferred pesticide for controlling North American lepidopteran forest pest insects. These advancements include the fermentation of higher potency Btk formulations, increased formulation stability (both physical and biological), enhanced persistence of Btk preparations on target foliage, enhancement of activity in Btk preparations to specific pests, transconjugants, and genetic engineering technologies including bioencapsulation and Bt transgenic forest plantations. Methods to achieve aerial application objectives include temperature-driven simulation models of insect and plant development for predicting optimal spray lines, Differential Global Positioning Systems (DGPS) for aircraft guidance, Aircraft Integrated Meteorological Measurement System (AIMS) and the use of ELISA based Accurate Deposit Assessment Methodology (ADAM) kits. Microbial pest control in forestry with Btk and other microbials will be an exciting commercial challenge in the new millennium. Some of the current and future issues regarding the use of microbial pesticides will be presented.

Index terms: Bacillus thuringiensis subsp. Kurstaki, microbial control, technological advancements, Accurate Deposit Assessment Methology.

[1868] OUTBREAKS OF FOREST DEFOLIATING INSECTS AND FOREST DAMAGE IN JAPAN

N. Kamata, Lab. of Ecology, Fac. of Sciences, Kanazawa Univ., Kakuma, Kanazawa, Ishikawa 920-1192, Japan, E-mail: kamatan@kenroku.kanazawa-u.ac.jp

In Japan, various kinds of forest-defoliating insects sometimes reach the outbreak level and cause serious defoliation. Defoliated trees sometimes die after severe defoliation. In 1984, there was an episode killing more than $10,000 \text{ m}^3$ of beech trees after the *Syntypistis punctatella* outbreak in 1982. The mortality was more than 50%. The percentage of *Cryptomera japonica* that had died from the heavy defoliation by *Calliteara argentata* ranged from 6.5 to 58.2%. However, the tree mortality caused by insect defoliation is low because the climate in Japan is moist. Evergreen conifers sometimes die from insect defoliation but deciduous broad leaved trees seldom die. Amongst the forest-defoliating insects in Japan, *Dendrolimus spectabilis* has been studied the most intensively, because many pine trees died from pine wilt disease caused by the pine wood nematode, which has been proved to be the main cause of pine motality in 1970. Until then, defoliation caused by *D. speciabilis* was supposed to be one of the greatest causes weakening pine trees to induce secondary beetles attacks. Outbreaks of *D. speciabilis* frequently occurred from 1950s to the early 70s. Chemical and biotic insecticides were deployed to control this insect during these periods. The outbreaks of *D. spectabilis* have decreased in recent years according with the maturation of vast areas of pine stands planted after World War II. On the contrary, insect defoliation in larch plantation has become more frequent with stand maturation. Ptycholomoides acriferana, Spilonota eremitana, Cryptoblabes loxiella, Coleophora obducta, and larch sawflies, Pachynematus itoi and Pristiphora erichsoni are the main outbreak species. Especially, outbreaks of a larch sawfly, Pristiphora erichsoni, have been prevalent. It is specific that outbreak of P. erichsoni continues 4-6 years in the same stands. No density-dependent mortality factors seemed to be effective in this system. Host plant deterioration and/or outbreak of rodents that is driven by masting are the main factors to terminate the outbreak. In natural fir forests and larch plantations, *Lymantria fumida* periodically reaches the outbreak level and defoliates trees completely. A chemical insecticide (BHC) and biotic insecticide (mixture of NPV and CPV) were sprayed against this insect outbreak in the 1960s. In the 60s and 70s, many trial virus applications against outbreaks of forest-defoliating insects were done in Japan under the leadership of FFPRI, which included; D. spectabilis, D. superaus, Euproctis subflava, L. dispar, L funida, and Hyphantria cunea. Because silviculture in Japan declined rapidly with economic development, insecticide application against forest defoliators was no longer cost-efficient and was stopped in mid-1970s. The research budget and interests of forest entomologists shifted to pine will disease caused by pine wood nematode and many wood boring insects that spoiled wood quality. In spite of such circumstances, intensive population studies on *L. dispar*, *D. superans*, and *S. punctatella* have been continued. Outbreaks of these defoliators have occurred periodically and were terminated by insect diseases that operated in a density-dependent fashion. NPV and *Entomophaga maimaiga* are effective for *L. dispar*, CPV and NPV for *D. superans*, Cordyceps militaris for S. punctatella.

Index terms: Dendrolimus spectabilis, Syntypistis punctatella, insect disease, control

[1870] MASS REARING OF THE NATIVE ENDOPARASITOID CHOUIOIA CUNEA (HYMENOPTERA: EULOPHIDAE) AND ITS SUCCESSFUL USE FOR CONTROL OF THE INTRODUCED FALL WEBWORM IN CHINA

<u>Y. Zhong-ai</u>, Research Institute of Forest Ecology, Environment and Protection, Chinese Academy of Forestry, Beijing, 100091, P.R. China.

The introduced fall webworm, Hyphantria cunea, became an important pest in China, causing serious damage. Because of the severity of this damage, the native biotic agents attacking this introduced pest in China were investigated. One of them, a native endoparasitoid, Chouioia cunea Yang (Hymenoptera: Eulophidae: Tetrastichinae), is new to science. This parasitoid was found to cause considerable mortality of H. cunea pupae in some areas. The host range of this new species was investigated to find a practical substitute host for mass rearing of C. cunea. This mass-rearing technique is described along with the successful release of this parasitoid into new areas, three provinces and in the city of Tianjing. Parasitism by C. cunea in the areas it was released was usually over Srews Soft. These successful release of native parasitoids in the country of introduction more frequently than was previously assumed, and classical biological control (the introduction of natural enemies of the introduced pest from the country of origin) may not always be needed.

Index terms: Hyphantria cunea, Chouioia cunea, biological control, mass rearing, release, parasitic wasp

[1871] DEVELOPMENT OF INTEGRATED MANAGEMENT OF DEFOLIATING INSECTS IN CANADA

I.S. Otvos¹, V. Nealis¹, & K. van Frankenhuyzen², ¹Natural Resources Canada, Canadian Forest Service – Victoria, 506 West Burnside Road, Victoria, B.C. V8Z 1M5 Canada, E-mail: iotvos@pfc.forestry.ca, ²Natural Resources Canada, Canadian Forest Service, Great Lakes Forestry Centre, P.O. Box 490, 1219 Queen Street East, Sault Ste. Marie, ON, P6A 5M7, Canada.

Forests in Canada cover about 453 million hectares, approximately 45% of the total landmass of the country; of this 244 million hectares is productive forest. The forests of Canada are the most important natural resource in the country; they contribute more to the economy of the country than all the other natural resource sectors combined. The protection of this valuable natural resource is of great economic importance. The development of forest insect pest control in Canada is reviewed, from the early days of organic chemical insecticides, to the development of microbial insecticides and the more recent concept of integrated management of insect pests. Broad-spectrum chemicals have been replaced by the more selective microbial insecticide for defoliators. The shift from chemical insecticides to the extensive use of Bacillus thuringiensis was gradual. Classical biological control was, and still is, used against pests of foreign origin introduced into Canada without their natural enemies. Inspection and eradication are used to prevent or delay establishment of exotic pests. There has been a shift towards more intensive forest management, this change being reflected in methods of control - attempts are made to manage insect pest problems before drastic measures are required to control them. This change is also noticeable in the way insect problems are addressed. It is recognized that insect damage and its impacts should be minimized in an ecologically sound and environmentally friendly manner. Insects are managed instead of being suppressed, and whenever possible an integrated approach is taken. In the future, attempts will be made to prevent insect outbreaks or mitigate the long-term impacts of insect disturbance on the forest. The approach will be more ecologically based and comprehensive by integrating pest dynamics, forest use, socioeconomics and environmental considerations. The control agents used to manage forest insects will likely have narrow activity ranges requirement likely to be demanded by the environmentalists and general public. This will increase the pressure to develop novel control agents (such as genetically engineered microbes or introducing insect pathogens into host trees). However, some of these novel approaches may not gain general acceptance due to public opposition. It is inevitable that some effective and safe direct control measures may have to be used on a short-term basis when insect damage is unacceptable.

Index terms: biological control, defoliators, integrated pest management

[1872] GROWTH LOSSES AND ECONOMIC CONSEQUENCES OF PINE SAWFLY DEFOLIATION

P. Lvytikäinen-Saarenmaa¹ & E. Tomppo², ¹Finnish Forest Research Inst., Rovaniemi Research Station, P.O. Box 16, FIN-96301 Rovaniemi, FINLAND, E-mail paivi.Jyytikainen-saarenmaa@metla.fi; ²Finnish Forest Research Inst., National Forest Survey, Unioninkatu 40 A, FIN-00170 Helsinki, FINLAND.

The European pine sawfly (Neodiprion sertifer) and the large pine sawfly (Diprion pini) are common forest pests in northern coniferous forests, reaching occasionally outbreak levels and defoliating wide areas of Scots pine (Pinus sylvestris) stands of all ages. Defoliated area during the latest outbreak of D. pini in 1998-99 was approximately 500 000 ha. N. sertifer is an early-season defoliator that feeds on old needles only, whereas D. pini is a late-season defoliator that feeds on new and old needles. Defoliation reduces tree growth and timber yield, but these aspects have been considered quite often less important than tree mortality. Economically significant reductions in increment occur even after a single defoliation period, and even when densities remain below those required to call upon a secondary attack by scolytid bark beetles. Defoliation by N. sertifer seldom kills trees, whereas the number of killed trees is much higher after damage by D. pini. Tree mortality after outbreak period of N. sertifer has been recorded to be approximately 4 %, and after outbreak of D. pini approximately 30 % of the total tree number in defoliated stands. However, mortality can be much higher in young stands. Volume growth can be decreased by 33 % and 85 % after moderate, and by 40 % and 99 % after heavy defoliation by N. sertifer and D. pini, respectively. Increment losses are two or three-fold higher after defoliation of D. pini compared to N. sertifer. The economic value of growth losses is possible to estimate on the basis of the proportion of tree species in a stand, structure and age of a stand, average annual increment, intensity of pine sawfly defoliation, and a value of timber. In Finland the estimated average economic value of growth losses and killed trees might reach up to 45 USD/ha for N. sertifer, and 310 USD/ha for D. pini, after a single-year outbreak. The recovery period of Scots pine after insect defoliation is partly unknown, but volume growth will re-establish at least within 10-15 years. These estimates of economical losses indicate a dramatically higher impact of pine sawflies than those revealed by the earlier few studies in Europe.

Index terms: Neodiprion sertifer, Diprion pini, Pinus sylvestris, annual increment, timber yield

[1873] MANAGEMENT VS. MITIGATION OF DAMAGE: CAN WE DO BETTER IN THE 21ST CENTURY?

<u>E. A. Cameron</u>¹, Dept. of Entomology, Penn State Univ., 501 A.S.I. Bldg., University Park, PA 16802-3508, USA E-mail: acameron@psu.edu.

'Forest pest management,' especially in North America, frequently occurs in response to short term public pressure to mitigate nuisance or perceived damage. Practices and procedures that would reduce adverse impacts over the longer term too frequently have not received the emphasis they deserve. Often we still do not understand the steps that can or might be undertaken to improve management over the lifetime of a forest. These gaps in knowledge must drive research efforts to improve management of defoliators, and to integrate economic, ecologic, aesthetic, and other values. Vast forested areas require different practices than those which are suitable for smaller, intensively-managed, areas of high value - a fact which must be borne in mind as manipulative management decisions are made. The use of chemical insecticides has diminished in recent years, in large part as a result of environmental concerns as well as of cost. Biologically-based insecticides are also costly to use, and are coming under increasing criticism as agents of environmental disruption especially with reference to their effects on non-target organisms. Biological controls, in particular with respect to exotic species, have had both successes and failures. They, too, are under increasing criticism from vocal groups that seem to desire preservation of existing fauna even at the expense of reasoned arguments for introduction of additional exotic species. Sound silvicultural practices too often have not received the support and priority that they deserve. Sustainable management, coupled with intensive public education, must be the touchstone for evolution of 21st century forest practices if forest managers are to regain the confidence and support of the general public and of public agencies. Examples such as the gypsy moth, Lymantria dispar (Lepidoptera: Lymantriidae), spruce budworms (Choristoneura spp. (Lepidoptera: Tortricidae), sawflies (Hymenoptera: Tenthredinoidea) on various coniferous and Tenthredinoidea) on various coniferous and hardwood hosts, and leafrollers and leaftiers (Lepidoptera: Tortricidae), especially on oaks (Quercus spp.), will be among those referenced as illustrative of past and possible future practices.

Index terms: Lymantria dispar, Choristoneura spp., Tenthredinoidea, silvicultural practices

[1874] IMPACT OF TIMBER HARVESTING ON INSECT HERBIVORE POPULATIONS OF *QUERCUS* IN A NORTH AMERICAN TEMPERATE DECIDUOUS FOREST

R. J. Marquis¹ & J. T. Lill¹, ¹Dept. of Biology, Univ. Missouri-St. Louis, 8001 Natural Bridge Rd., St. Louis, MO 63121-4499 EUA, E-mail robert_marquis@umsl.edu.

Tree harvesting may have significant effects on the abundance of forest organisms over and above the local effects of tree removal. The nature of such possible landscape-scale effects on insect herbivores are not well known. We have been documenting the landscape effects of timber harvest on the abundance of insect herbivores both pre- and post-harvest on two deciduous tree species (Quercus alba and Q. velutina) of a deciduous forest of the Ozark plateau of the central United States (Missouri). This study is part of larger multi-collaborator project called the Missouri Ozark Forest Ecosystem Project (MOFEP) run by the Missouri Department of Conservation. Replicate forest sites (3 each per treatment, approximately 240 ha) underwent one of three harvesting treatments in 1996: control or no harvest, even-age management or approximately 10% of stands clearcut, and unevenage management or thinning of the forest. Insects were sampled without removal both on saplings and the canopy of adult trees. Effects of timber harvest are described for three years pre-harvest and three years post-harvest. Insect abundance declined 30-70% across all treatments following harvesting compared to pretreatment levels. As in the pretreatment years, insect abundance was higher on understory plants of Q. alba on north- and east-facing slopes than on south- and west-facing slopes. Also, insect abundance was generally higher on Q. alba than on Q. velutina in both the canopy and understory (except for the first census following leaf flush), higher in the understory than in the canopy, and higher late in the season on Q. alba than early, but lower on Q. veluting later in the season than earlier. Treatment effects appeared in both the understory and canopy in the first year following cutting (1997). Treatment effects were relatively weak in the understory (occurring in only 1/4 censuses each for both species), with cutting increasing the number of insects compared to controls for both Q. alba and Q. velutina when such effects did occur. In contrast, cutting reduced the number of insects encountered in the canopy compared to control sites in both 1997 and 1998, and then finally increased the number of insects at the end of 1999. Links to changes in insectivorous bird abundance as also affected by timber harvesting will be discussed. Index terms: forest management, insect communities, landscape effects.

[1875] CONNECTION BETWEEN THE FLORA AND LEPIDOPTERA FAUNA OF AMERICAN NORTHWEST FORESTS

T. D. Schowalter, Dept. of Entomology, Oregon State Univ., Corvallis, OR 97331-2907, USA, E-mail schowalt@bcc.orst.edu.

Canopy arthropods are a poorly known component of forest ecosystems but represent the vast majority of species, some of which are capable of dramatically altering forest structure and function. Their small size, short life spans and high reproductive rates make Nevertheless. them highly sensitive to environmental gradients in time and space. relatively few studies have addressed factors affecting patterns of species abundance or community organization in forest canopies. Studies of canopy communities in the Pacific Northwestern U.S. demonstrate effects of crown position, tree species, forest age, and latitudinal or climate gradients on arthropod species abundances and community structure. Relatively few taxa show significant variation with crown height, despite the 40 m depth of foliated crowns. However, most taxa show significant variation in occurrence or abundance among tree species. Folivores, predators and detritivores generally are most abundant in older or undisturbed canopies, whereas sap-sucking species are most abundant in younger canopies. Economically important folivores (such as the western spruce budworm, Choristoneura occidentalis) and sap-suckers (such as the Cooley spruce gall adelgid, Adelges cooleyi) are most abundant in homogeneous canopies of the dominant tree species, compared to more heterogeneous canopies. Similarly, species and functional groups also vary in their representation across latitudinal or precipitation gradients in this region. Species within each functional group vary in their responses across these environmental gradients, indicating an important role of biodiversity in buffering the ecosystem from changes in ecological functions during environmental changes Index terms: Choristoneura occidentalis, Adelges cooleyi, forest, disturbance, precipitation

[1876] COMPARISON OF THE MACROLEPIDOPTERAN ASSEMBLAGES OF SALIX NIGRA AND ACER NEGUNDO: A STORY OF CATERPILLARS, PLANTS, PARASITOIDS, AND PREDATORS

P. Barbosa¹ & A. Caldas¹, ¹Dept. of Entomology, Univ. of Maryland, Plant Sciences Bldg., College Park, MD, 20742, USA, E-mail pb5@umail.umd.edu and Bldg., ac182@umail.umd.edu

Larval free-feeding macrolepidoptera of two riparian trees Salix nigra (black willow) and Acer negundo (box elder) were sampled and sorted by species and abundance. Data collected established that the majority of species in the assemblages in each tree species occurred at low abundance in each of the 5 years when larvae were sampled. On both trees, assemblages were dominated numerically by relatively few species, a pattern that has been observed for insect assemblages on plants in managed and unmanaged habitats. Absolute sampling of two macrolepidopteran assemblages on box elder and black willow was undertaken by fogging the canopy. Collections of larval Lepidoptera demonstrated that assemblages are numerically dominated by few species, i.e., scarce species constitute a large proportion of our samples. Specifically, the proportion of singleton species in these temperate habitat assemblages parallels that observed in fogging studies in tropical habitats. The similarity index calculated for the species in the two assemblages was relatively low. The latter results were compared to those obtained from absolute sampling (achieved by fogging). The patterns were the same regardless of the sampling approach. Patterns of larval parasitism among species in the macrolepidopteran assemblages also were examined.. Total parasitism of larvae on box elder was significantly higher than that of larvae on black willow. Comparisons of parasitism levels among lepidopteran families showed that in five of seven families larval parasitism on box elder was significantly higher than on black willow. For species whose larvae were found on both tree species, total parasitism was significantly higher when the larvae were on box elder than when larvae of the same species were on black willow. In comparisons of species found on both tree species, larvae in three of seven families suffered significantly higher levels of parasitism when on box elder than when on black willow. The roles of the functional/numerical responses of parasitoids, common and numerically dominant parasitoid species, and plant volatiles are considered as causal mechanisms underlying differential parasitism but are not supported by the data. Age based differential predation by birds on one of the more common macrolepidoptera species also has been observed. Behavioral observations further suggest that the ability of prey larvae to differentiate among predators and other herbivores in the habitat may serve as the basis for other examples of differential predation.

Index terms: Differential parasitism, box elder, black willow, insect assemblages scarce species.

MACROLEPIDOPTERA OF EASTERN NORTH AMERICAN [1877] DECIDUOUS FORESTS: ASSOCIATIONS WITH HOST TREES AND PARASITOIDS IN THE CENTRAL APPALACHIAN MOUNTAINS

. Strazanac & L. Butler. West Virginia University, Division of Plant and Soil Sciences, P. O. Box 6108, Morgantown, West Virginia, 26505, USA.

The macrolepidoptera associated with the eastern North American deciduous forests are an abundant and diverse group. A large portion of the more than 5,000 species (USDA 1985) of the described Lepidoptera from this region are probably associated with the Appalachian Mountains and their adjacent foothills. The foliage macrolepidopteran fauna of Appalachian deciduous forests is in large part documented. For many species, the details of their distribution, host preferences, and especially, their parasitoid relationships are not well known. Two recent studies on oak-dominated sites illustrate how limited our knowledge is of the parasitoid-host relationships. Butler (1993) reared 46 species of macrolepidopteran larvae, producing 136 primary parasitoid-host associations. Of these, 115 were not previously reported. An on going project with an extensive rearing effort of catempillars from selected hardwood trees produced 60 tachinid parasitoid associations not previously reported. In terms of the diversity of caterpillars attacked, Tachinidae can be equally effective parasitoids as Braconidae and Ichneumonidae in forest canopy environments.

Index terms: Tachinidae, Braconidae, Ichneumonidae, canopy, hardwoods

[1878] RICHNESS AND ABUNDANCE OF CATERPILLARS ON CONGENERIC PLANTS IN CERRADO AREAS OF THE DISTRITO FEDERAL

I. R. Diniz¹ & H. C. Morais², ¹ Departamento de Zoologia, ² Departamento de Ecologia, Universidade de Brasília, 70910 900, Brasília, DF, Brazil. E-mail: ivone@rudah.com.br.* Patial funding from CNPq Proc. nº 5010225/92; PIBIC/CNPq/UnB.

The richness and abundance of Lepidoptera larvae on the same host plants is compared between areas with similar vegetation (cerrado sensu stricto): Fazenda Água Limpa (FAL), Botanical Garden of Brasília (JBB) and the National Park of Brasília (PNB). The FAL and JBB study areas are 6 km apart and both are cerca 30 km from PNB. Host plants examined were Byrsonima coccolobifolia, B. verbascifoliu (Malpighiaceae), Erythroxylum deciduum, E. suberosum, E. tortuosum (Erythroxylaceae). These species are deciduous, woody shrubs, dropping their leaves at the end of the dry season and are common in the cerrado. The inventories of caterpillars were conducted within 1 ha areas and, weekly, 15 plants from each species, measuring between 0.50 and 2.50 m of height, were examined in each area. The exophytic, folivorous caterpillars were collected and separated according to morphospecies. The data were obtained between March and August of 1994, including the peak for caterpillar abundance (May-July). In general, 20% of the 4394 plants examined presented caterpillars and the richness per plant species varied between seven and 24. The variation in caterpillar richness among plant species is not related to host plant density, nor with other easily recognizable characteristics such as leaf pilosity or plant size. The proportion of plants with caterpillars, here used as an indicator of caterpillar abundance, was greater at JBB (26%) and lower at PNB (14%). For Erythroxylum spp., caterpillar abundance and the number of caterpillar species presented a positive relationship in the three areas: E tortuosum > E. deciduum > E. suberosum. This relationship between abundance and richness was completely broken for Byrsonima spp.: B. coccolobifolia (FAL = 15% and 10 spp.; JBB = 38% and 15; PNB = 16% and 23), B. verbascifolia (18% and 13; 38% and 21; 12% and 20). Two lepidopteran species (Cerconota achatina and Gonioterma exquisita - Elachistidae) are dominant on Byrsonima spp., but their frequency of occurrence varies between locales ($\chi^2 = 24.897$; p < 0.001). Erythroxylum spp. also present two dominant caterpillar species, however, with lower frequencies, which do not vary between locales. Variation in the abundance and richness of caterpillars occurs between species of Erythroxylum, whereas on Byrsonima spp. the variation occurs predominantly between locales and is related to the population variations of the dominant caterpillar species on those plants. Index terms: Elachistidae, Cerconota achatina, Gonioterma exquisita

[1879] IMPACT OF FOREST UTILIZATION ON THE ASSEMBLAGE OF LONGICORN BEETLES (COLEOPTERA: CERAMBYCIDAE) IN THE WARM-TEMPERATE FORESTS OF JAPAN

K. Maeto¹, S. Sato¹ & H. Miyata², ¹Shikoku Res. Ctr., Forestry & For. Prod. Res. Inst., 915 Asakura-Nishimachi 2, Kochi 780-8077, JAPAN, E-mail maeto@ffpri-skk.affrc.go.jp; ²Kochi Pref. Forest Tech. Ctr., 80 Ouhira, Tosayamada, Kochi Pref. 782-0078, JAPAN.

Insect diversity has been seriously affected by the reduction of temperate natural forests, due to coppicing, shifting cultivation, logging and monocultural planting, but only a little is known what insect groups or guilds depend on natural forests and thus suffer greatly from the forest utilization. Shimanto River Basin of southwest Japan was largely covered with natural or semi-natural forests dominated by evergreen broad-leaved and coniferous trees, although the traditional practice of shifting cultivation and coppicing had started several thousand years ago. In recent several decades, however, they have been rapidly cleared and mainly converted to coniferous plantations or young secondary forests. It is estimated that near-primary forests remained account for less than 0.3 % of total woodland area in the district. In order to understand the impact of such forest utilization on insect diversity, we have established 14 study plots of near-primary natural forests, naturally regenerated secondary forests (30-60 year-old) and coniferous plantations (ca. 30 year-old) in the Shimanto River Basin area. Here we report the influence of forest alterations on the assemblage of longicorn beetles (Coleoptera: Cerambycidae and Disteniidae). The beetles were sampled by the use of white and yellow collision traps attached with flower fragrance chemical (benzyl acetate) and ethanol as attractants in 1998 -1999. The assemblages were compared among plots in the correlation coefficient (tau) of species ranking and coordinated by the multi-dimensional scaling (MDS). Total number of species (general species richness) was not different among three forest types (natural forest, secondary forest and plantation). Even in coniferous plantations, the vegetation of undergrowth and naturally regenerated patches will be rich enough to keep many species of longicorn beetles. But species composition was conspicuously different among them. It is noteworthy that natural forests were characterized by the richness of the subfamily Lepturinae, especially of the genus Pidonia. The larvae of Pidonia inhabit thick bark of partly decayed or fallen trees of angiosperm. They are less host-specific and feed on various tree species, which are regenerated in secondary forests, but they require old-age trees with thick bark and humid forest floor. Our findings support the view that insects specific to natural forests strongly depend on the large and complex structure of aged forests, as well as on the taxonomic diversity of vegetation. Monitoring and management of old forest remnants and neighboring secondary forests for the conservation of biodiversity will be also discussed.

Index terms: Pidonia, biodiversity, human impact, forestry, kairomone trap

[1880] ARCHAEOLOGICAL GROUND BEETLE ASSEMBLAGES AND RECENT FOREST FAUNA IN FLANDERS: WHAT HAVE WE LOST DURING MEDIEVAL FOREST DEGRADATION AND FRAGMENTATION?

K. Desender ¹& A. Ervynck², ¹ Dept. Entomology, RBINSc, Vautierstr. 29, B-1000 Brussels, Belgium, E-mail: kdesender@kbinirsnb.be; ² Inst. Archaeological Heritage Flemish Community, Doornveld 1 box 30, B-1731 Zellik, Belgium.

In 1988, the Provincial Archaeological Museum of south-east Flanders excavated a stone well of Roman type at Velzeke (Eastern Flanders, Belgium), at the edge of a Roman site that flourished from the first to the third century AD (Van der Plaetsen, pers. comm.). The lower 3,5 m of the well's filling consisted of a deposition of organic debris that was subdivided in 11 sampling units and sieved on 0,5 mm meshes. The residues proved to be rich in zoological remains, i.e. bone, mollusc shells and the chitinous remains of insects. From the latter group, only the carabid remains were used in order to attempt a reconstruction of the former landscape around the well. Radiocarbon dating situated the existence of this fauna around 500 AD and covering a time span of more or less 150 years (Van Strydonck, pers. comm.). From each subunit, the remains of at least 100 carabids could be identified, yielding a total sample of more than 1100 ground beetles, belonging to 58 species. Most of the subunit samples (especially subunit 2 - 9) yielded a detailed carabid faunal assemblage for a woodland habitat, dominated by stenotopic and eurytopic woodland species, implying that woodland surrounded the well at that time. Extensive data on the recent carabid beetle fauna occurring in woods of Flanders were compared to the archaeological dataset of the post-Roman forest. Integration of these data reveals that during medieval forest degradation an fragmentation, most woods must have been impoverished to a high extent with respect to their stenotopic woodland beetle fauna. Typical woodland beetles show a reduced dispersal power (constant brachyptery) and appear to be powerful indicators for larger ancient woods.

Index terms: Carabidae, diversity, historical ecology, ancient woods.

[1881] SIREX NOCTILIO IN SOUTH AMERICA: DISTRIBUTION, MONITORING AND CONTROL

E.T. Iede¹, P. Klasmer² & S.R.C. Penteado¹, ¹Embrapa Florestas, Caixa Postal 319, CEP 83411-000, Colombo, Paraná, Brasil. iedeet@cnpf.embrapa.br; susete@cnpf.embrapa.br; ² Inta, Campo Forestal Gral. San Martín, C.C. 268430, El Bolsón, Pcia. de Rio Negro, Argentina. vklasmer@bariloche.inta.gov.ar.

Sirex noctilio is being monitored and/or controlled in approximately 3.9 million hectares Pinus spp. in South America's Southern Cone of which 2 million ha are in Brazil, 1.5 million ha in Chile, 0.3 million ha in Argentina, 0.1 million ha in Uruguay and 0.05 million ha in Paraguay. The woodwasp is a secondary pest in its origin region, but became a main pest of Pinus spp. in the countries where it was introduced. In South America, it was first registered in P. taeda and P. elliottii stands at the Department of Cerro Largo in Uruguay, in 1980. The insect dispersed rapidly to the existing 35,000 ha of the country. In 1993, it was first detected in the Argentinian Patagonian Andes threatening stands of little economic significance, but of strategic ecological importance. In 1985, it was detected in P. taeda stands at the Province of Entre Rios and dispersed to Corrientes (1993), Jujuy (1994), Misiones (1995) and Cordoba Provinces (1995). In Brazil, the pest was introduced in Rio Grande do Sul (1988), Santa Catarina (1989) and Paraná (1996), and attacks currently around 300,000 ha, most of it of P. taeda. Monitoring and early detection are among the main prevention measures adopted in all countries, including Chile and Paraguay where the pest is not present. Monitoring is made with trap-trees, trees that are stressed with herbicides to become attractive to the pest. In Chile, the program is complemented by a quarantine control of solid wood packing material.

In the countries where *S. noctilio* is present, control measures are similar, but enforced with different intensity. In general, forest management practices, specially thinning of overstocked stands, were intensified and natural enemies introduced. Large applications of the *Deladenus siricidicola* were made. This nematode sterilizes females and after inoculation is dispersed through the wasp eggs. Nematode inoculation is done since 1988 in Uruguay, 1989 in Brazil and 1995 in Argentina. *Ibalia leucospoides* (Hym.: Ibaliidae), a parasitode of the woodwasp eggs was accidentally introduced together with the pest and is present in the whole pest dispersion area. It has an average parasitism of 23% (ranging 4-45%) and a high capacity of establishment. In Brazil and at the Argentinian Patagonian Andes, *Megarhyssa nortoni* and *Rhyssa persuasoria* (Hym.: Ichneumonidae), ectoparasitodes of the woodwasp mature larvae are being introduced to complete the biological control program.

Index terms: woodwasp, pine plantation, trap trees, natural enemies

[1882] RISK TO SOUTH AMERICAN RADIATA PINE RESOURCES BY THE PINE SHOOT MOTH, RHYACIONIA BUOLIANA

D. Lanfranco¹, P. Klasmer², E. Botto³ & S. Ide¹, ¹Inst. de Silvicultura, Univ. Austral de Chile, Casilla 567, Valdivia, CHILE, E-mail dlanfran@uach.cl; ²INTA (E.E.A.Bariloche), CC 268430, El Bolsón-Rio Negro, ARGENTINA. ³IMYZA-CNIA-INTA, Castelar (1712), Buenos Aires, ARGENTINA.

The european pine shoot moth populations are distributed in the South American countries of Argentina, Uruguay and Chile. The most susceptible hosts are Pinus radiata, P. ponderosa, P.contorta var. latifolia and P. taeda that are extensively established. Rhyacionia buoliana (Rb), is a univoltine tortricid that attacks fresh buds and shoots, causing serious injury to the stem if the leader shoot is attacked. The impact of this pest has been monitored by following indicators such as pest density, host-pest relationships and damage, the productive objectives of the stands, and levels of pest control and pest dynamics in the light of quite diverse site conditions in Chile. Several historical data will be presented. Silvicultural, biological, chemical and pest management measures have been adopted, but each plantation represents an unique case study with variable indicators. Most of the control actions are mechanical and chemical during the first 2 or 3 years of plantation growth and later there is effective biological control with an univoltine specific internal parasitoid, Orgilus obscurator (Oo) that has been introduced into these countries. Levels of parasitism by Oo, increase with time, specially in temperate plantations areas. Parasitism rates are between 0% to 84% in Chile and 0% to 65% in southern Argentina. Few studies have been conducted about O.o behaviour: survival rates, sex proportion, fecundity, basic genetics and incidence of wildflowers. An endemic chilean egg parasitoid Trichogramma nerudai was recently and experimentally introduced to southern Argentina, as an inundative strategy. Native natural enemies in Chile (birds, spiders and insects parasitoids or predators) also enhance Rb population control. Between them, Coccygomimus fuscipes, an ichneumonflies, is commonly detected, also in Argentina. Carduelis barbata, a passerine bird, also plays a predator role principally during their reproductive periods. An unstudied but interesting spider complex may have some significance. Meanwhile, satisfactory levels of recovery in damaged trees with one or at most two stem defects are observed. This is evident in trees with several levels of crooks and not good in forked or multiforked trees. No long term studies have been conducted in the countries with Rb, nevertheless forest health and sustainability of the forest resources are commonly invoked in forestry meetings and papers. Chile and Argentina are still establishing pine plantations mainly with susceptible species to this pest. And Rb is still a serious pest in both countries.

Index terms: pine insect pests, pest management, Argentina, Chile

[1883] MANAGEMENT OF THE WHITE PINE WEEVIL IN NORTH AMERICA

Rene L Alfaro, Pacific Forestry Centre, Canadian Forest Service, Victoria, BC V8Z 1M5

The white pine weevil, Pissodes strobi Peck, is an indigenous insect of North America, and can be found in most regions of Canada and the United States. In British Columbia this insect has become a serious pest of reforestation, causing severe damage to young stands of Sitka spruce, Engelmann spruce, white spruce, and their hybrids. An Integrated Pest Management System has been proposed for *P. strobi*. This system relies on restoring ecosystem balance by reducing the conditions that lead to outbreak development. The system recommends tactics that diminish heat accumulation in the stand by encouraging growth of suitable non-host conifers as well as deciduous species such as aspen or alder. These trees render the stand cooler and shadier, reduce food supply, and probably create conditions which enhance natural enemy populations. Reduction of damage by increasing plantation density is also recommended. Central to IPM is the continuous monitoring of weevil populations and forecasting of weevil impacts on forest productivity. This can be accomplished through a computerized decision support system, which helps to evaluate the need for, and the possible benefits of a given tactic. A salient feature of the IPM system for P. strobi is the combination of tactics involving silviculture and host genetic resistance. Host genetic resistance could be utilized to allow increased reforestation with spruce species in ecosystems prone to infestation. In low hazard areas, silviculture-driven tactics such as mixed-species planting and increased planting density may be sufficient to produce a successful spruce crop. In high hazard areas, the silvicultural prescription should include the use of resistant stock. However, the deployment of resistant genotypes should take into consideration the need for avoiding the risk of insect selection leading to biotypes capable of overcoming the resistance mechanisms. For this, a component of susceptible stock should be planted along with the resistant material.

[1885] REFORESTATION PEST PROBLEMS IN TROPICAL AMERICA

<u>J. E. Macías-Sámano</u>, El Colegio de la Frontera Sur, ECOSUR, Carret. Antiguo Aeropuerto km 2.5, 39700 Tapachula, Chiapas, México, E-mail: jmacias@tapecosur.edu.mx

The concept of reforestation in America's tropics has changed, very especially because of our environmental concerns and the goal of sustaintability. Until now, reforestation was the equivalent of plantations, and dealt with very few, mostly exotic species. To great extent, major world timber companies established this pattern. Provoking an immense interest in the study of entomofauna associated with species growing in plantations, such as pines, eucalyptus, teak, mahogany and gmelina, among others. Therefore there is some information about them. However, the very nature of the tropics call for managing diversity of native species and the potential timber trees - those more likely to be adapted to local environments and those that would follow sustaintability goals- are many and poorly known. Consequently the study of the entomofauna associated to these potential timber species is in its infancy. There are very few efforts in Central and South America that try to document, in a synthetic way, the pest for these species. Published information is in small numbers and to be qualitative and anecdotal. This is partially due to the large number of potential timber species available at any particular location. An International effort is needed to develop this information that is of basic nature to establish any reforestation effort.

[1884] CHALLENGES TO PEST MANAGEMENT IN SOUTHEAST ASIS

E. Lapis.

ABSTRACT NOT RECEIVED

[1886] ARTHROPODS AS BIOINDICATORS IN AN AREA UNDER REFORESTATION IN SÃO PAULO STATE, BRAZIL

<u>M. P. Pais</u>¹ & E. M. Varanda², Depto de Biologia, FFCLRP, Univ. de São Paulo, Av. Bandeirantes 3900, CEP 14040-901, Ribeirão Preto, SP, Brasil. ¹E-mail paism@usp.br; ²E-mail emvarand@ffclrp.usp.br.

Due to the high level of devastation to which ecosystems components in the Atlantic Forest have been submitted, several reforestation methods have been employed both by the public and private sectors. Among these methods, the most relevant are those concerning the successional status of plant species, such as heterogeneous reforestation. However, information lacks on methodologies that promote the faster recovery of the diversity of the flora, fauna and their interactions. An indicator that has been employed in several studies concerning the successional recovery of a forest is the insect or arthropod diversity and community structure. Arthropods are useful environmental indicators because of their small size, their continuous presence and sensitiveness to narrow environmental changes. In October 1999, we began monitoring the arthropod community in a 16.6-ha area that had been reforested December 1998 on the Ribeirão Preto campus at São Paulo University. We have collected arthropods associated with the three most abundant pioneering and climactic plants in the area every four months. Our study aims at documenting the major changes on the arthropod community structure in the first stages of reforestation and gathering information to contrast with other information referring to reforestation employing only pioneering plants. Our results have indicated a high species richness: on 240 plants, we found 223 morphospecies of insects and 16 morphospecies of spiders. In total, 3,308 organisms were collected. Guilds are distributed as follows: 42.4% of the organisms are herbivores, 15.9% are predators, 1.7% are parasitoids, 3.5% are detritivores, 32.7% are ants (retained as a distinct guild because of their various feeding activities), 2.2% are seed-eaters, wood-eaters, fungus-eaters or "tourists" and 1.6% were not assigned to guilds due to identification difficulties. Because predators, parasitoids and detritivores are abundant in more stable communities, we expect that their occurrence will increase in the next collections. The results indicate that the reforestation methodology employed promotes a high faunal recovery from the first steps following planting. (FAPESP)

Index terms: semideciduous mesophyllous forest, faunistic analysis, faunal monitoring

[1887] USE OF STRIPS OF NATIVE VEGETATION WITHIN EUCALYPTUS PLANTATIONS AS A STRATEGY TO REDUCE LEPIDOTERA PEST POPULATIONS

J.C. Zanuncio¹, **T.V. Zanuncio¹**, **J.M.M. Pereira¹**, **A.C. Oliveira² & G.D. Freitas²**, ¹ Dep. de Biologia Animal, Univ. Federal de Viçosa. 36.571-000 Viçosa, MG, Brasil. E-mail: zanucio@medufybr, ²Mannesmann Florestal Ltda. Curvelo, Minas Gerais, Brasil.

Eucalyptus plantations are used in Brazil as a source of wood for pulp and paper and as well as to produce charcoal for metallurgy. The Eucalyptus plantations face serious problems with pests such as leaf cutting ants and lepidopterous defoliators. For this reason faunistic analyses were made aiming to evaluate the effect of "cerrado" (Brazilian savannah) native vegetation on Lepidoptera associated with Eucalyptus cloeziana plantations of the Maanesmann Florestal Ltda in Minas Gerais, Brazil, which has been proposed as a strategy for reducing pests of Eucalyptus because islands and/or strips of native vegetation can be reservoirs of natural enemies of defoliator pests. The objective was to test the hypothesis that native vegetation as strips inside Eucalyptus clossiana plantation could reduce populations of defoliator Lepidoptera. The insects were collected during one night with light traps in five sampling sites for each system of Eucalyptus cultivation (i.e. with and without strips of "cerrado") every 15 days during six months. The first trap was located 100 meters within the native vegetation reserve, the second at the border of this reserve within the Eucalyptus; the third 250 meters into the plantation, the fourth at 500 meters (which placed it in the native vegetation strip, or between two blocks of Eucalyptus in the plantation without strips) and the fifth at 750 meters into the Eucalyptus plantation. Lepidoptera were removed from light traps, sorted and counted. A total of 5,511 individuals of 459 species and 16,021 individuals of 300 species of Lepidoptera were collected in areas with and without strips of "cerrado". In the first system, a higher number of species was collected within the strips of "cerrado" vegetation, the four most frequent species accounted for ± 20% of the individuals collected; nine species were constant (present in 50% to 100% of the samples) among the 23 most important ones, four of these were accessory (present in 25 to 50% of the samples) and ten accidental (present in 0 to 25% of the samples). Diversity was higher in the intersection of the habitats and smaller within the eucalypt plantation. In the system without strips of native vegetation, a higher number of species was collected in the native vegetation; the intersection between native vegetation and eucalypt plantation was similar in species composition with a smaller number of species within the eucalypt plantation. The three most frequent species in this habitat accounted for \pm 31% of the individuals collected; nine species were constant, nine were accessory and eight were accidental. The diversity indexes were higher in the plantation with them than in the plantation without "cerrado" strips. Additional sampling is required to evaluate populations of natural enemies in the native vegetation and the role of strips in spreading these natural enemy populations throughout the Eucalyptus plantation. Lower population levels of defoliator Lepidoptera within *Eucalyptus* plantations with strips of native vegetation shows that the strategy of Mannesmann Florestal Ltda using such strips can be recommended to aiming to reduce problems with Lepidoptera pests of in Eucalyptus in Brazil.

[1888] INSECT RESISTANCE IN EUCALYPTUS GLOBULUS TO ACUTE AND CHRONIC INSECT DAMAGE IN AUSTRALIA

R.B. Floyd¹ & M. Matsuki², ¹ CSIRO Entomology & Cooperative Research Centre for Sustainable Production Forestry, GPO Box 1700, Canberra, ACT 2601, Australia. E-mail: Rob.Floyd@ento.csiro.au² CSIRO Entomology, GPO Box 1700, Canberra, ACT 2601, Australia. E-mail: Marnoru.Matsuki@ento.csiro.au

Eucalyptus globulus occurs naturally in SE Australia and widely planted in plantations in SE and SW Australia. Previous studies showed large inter-population variation in resistance to insect herbivores. In this study, we examined relationships between growth of E. globulus and acute and chronic damage caused by insects. We defined acute damage as intense damage caused by Christmas beetles (Anoplognathus spp. Scarabaeidae: Coleoptera) occurring in two days to two week each summer and chronic damage as less intense damage by other insect species occurring over three months or longer. Seedlings from 18 populations of E. globulus were planted in a field trial, and we measured growth and insect damage for five years. There was large inter- and intra-population variation in insect damage. All but one of the 185 plants suffered acute damage by Anoplognathus spp., and up to 90% of a plant was affected in any one year. Populations of *E. globulus* from Tasmania and the Bass Strait islands, which have previously shown resistance to autumn gum moth (Mnesampela privata Geometridae: Lepidoptera) and leaf blister sawfly (Phylacteophaga froggatti: Pergidae: Hymenoptera) tended to show cross-resistance to Anoplognathus spp. Individual plants and populations that tended to suffer severe acute or chronic damage in one year tended to suffer acute or chronic damage, respectively, in the following year. Populations suffered up to 50% reduction in mean annual growth rates due to insect damage. Reduction in growth was greater in populations with inherently fast growing plants than those with inherently slow growing plants. Insect pest management implications of these observations will be discussed. Index terms: Anoplognatius spp., Scarabaeidae, between-provenance variation, defoliation.

[1889] THE CHALLENGES OF SOIL-DWELLING SCARABS AS PESTS OF EUCALYPTS

J. N. Matthiessen, CSIRO Entomology & Cooperative Research Centre for Sustainable Production Forestry, Private Bag PO, Wembley, WA 6014, Australia. E-mail: iohnm@ccmar.csiro.au.

Several soil-dwelling scarabs are highly destructive pests of the early establishment phase of eucalypt plantations in various parts of southern Australia. Most are native 'spring beetle' species of the diverse genera Heteronyx and Liparetrus, with the accidentally introduced African black beetle, Heteronychus arator, a major pest in higher-rainfall areas of south-western Australia. A critical characteristic of these pests is that they often cause the death of seedlings, which are highly vulnerable because of their small size. This necessitates re-planting. Damage takes the form of defoliation by adult 'spring beetles' severe root pruning by *Heteronyx elongatus*, and severing of stems by adult African black beetle. Challenges in dealing with such pests include: difficulties in scouting for risk assessment and management intervention because of subterranean habit or sporadic mass invasion from adjacent habitat; the potential for catastrophic damage to occur rapidly (in minutes); assessing cryptic subterranean root and stem damage as seedlings may appear healthy but succumb to physical stresses some time after damage has occurred; in the case of African black beetle, very low damaging population densities and complexities of seasonal changes in activity; patchy distribution within a plantation; cultural incompatibilities between silviculture and pest management; and environmental factors that exacerbate risk of damage. These constraints typically render reactive interventionist control strategies risky. They also work strongly against the development or application of biological approaches to control, with their general limitation of slow effect and better applicability to reducing eruptive pests below economic thresholds. Prophylactic management techniques offer the most appropriate option particularly for those scarab species that dwell in the habitat prior to planting it with eucalypts (African black beetle and *Heteronyx elongatus*). These techniques are currently insecticidal but are erratic in effect. Improvements should be possible with better targetting, and with the support of cultural modifications, subject to economic constraints. Invasive 'spring beetles' appear not amenable to prophylactic techniques and present a potentially intractable challenge. Index terms: African black beetle, Heteronychus arator, Heteronyx, Liparetrus, spring

[1890] BIOLOGICAL CONTROL OF COLEOPTERAN PESTS OF EUCALYPTUS IN CALIFORNIA

J. G. Millar¹, **L. M. Hanks² & T. D. Paine¹**, ¹Dept. of Entomology, Univ. of California, Riverside CA 92521, USA, ²Dept. of Entomology, Univ. of Illinois, Urbana IL 61801, USA.

Eucalyptus spp. were introduced into California more than 100 years ago, and are now widely distributed throughout the southern and central parts of the state. Eucalyptus trees are valued because of their fast growth rates, their tolerance of drought and poor soils, and until recently, their lack of any significant insect pests; no native insects have expanded their host ranges to include Eucalyptus to any significant extent. However, around 1980, the first serious pest of Eucalyptus, the Eucalyptus longhorned borer Phoracantha semipunctata, was introduced into the state, followed by a congeneric species, Phoracantha recurva, in 1995. These two beetle species attack stressed trees, particularly those that are drought stressed during California's long hot summers. Trees are killed in a few weeks by the destruction of the cambium layers by the developing larvae. A biological control program initiated in the early 1990's, using the egg parasitoid Avetianella longoi and several braconid parasites of the larvae, has helped to reduce tree mortality. However, during the course of this project, it became obvious that the two borer species have subtly different biologies and life histories; since its introduction four years ago, *P. recurva* has largely replaced *P. semipunctata* in southern California. Possible reasons for this rapid replacement of one species by another in a shared habitat will be discussed. In addition to these two wood-boring insects, two serious defoliating pests also have been introduced into California within the last decade. The first, the Eucalyptus snout beetle Gonipterus scutellatus, has a considerable history as a pest of Eucalyptus in other regions of the world. In California, populations of this beetle initially increased rapidly, before being brought under control by importation and release of the egg parasitoid Anaphes nitens. The parasitoid has spread with the beetle as it expanded its range, and no further control efforts have been required for several years. More recently, a Eucalyptus tortoise beetle, Trachymela sloanci, was first found in California in 1997. This beetle has caused extensive defoliation of some Eucalyptus species in southern California, and damage has been exacerbated by the introduction of another pest, the red gum lerp psyllid, Glycaspis brimblecombei. Efforts to introduce and establish an egg parasitoid, Enoggera reticulata, for control of T. sloanei are ongoing. This paper will present an overview of the biological control efforts for each of these beetle species Index terms: Phoracantha semipunctata, Phoracantha recurva, Avetianella longoi, Gonipterus scutellatus, Trachymela sloanei

beetles

[1891] DIFFERENTIAL PARASITISM BY AN EGG PARASITOID, AVETIANELLA LONGOI, OF TWO PHORACANTHA SPP. ATTACKING EUCALYPTUS

T. D. Paine¹, K. Luhring¹, J. G. Millar¹ & L. M. Hanks², ¹Dept. of Entomology, Univ. of California, Riverside CA 92521, USA; ²Dept. of Entomology, Univ. of Illinois, Urbana IL 61801, USA

The cerambycid beetle Phoracantha recurva appears to be replacing a well-established congener, P. semipunctata, from their shared ecological niche (stressed Eucalyptus trees and fallen branches) in southwestern California. The proportion of P. recurva in the mixed population increased rapidly from 0.1% in 1995, the first year this species was detected, to 4.7% the following year, and 74% in 1997. Eggs of the P. semipunctata are the typical host of the encyrtid egg parasitoid Avetianella longoi. A field study indicated that egg masses of the two beetle species were located at equal rates by the parasitoid, but that A. longoi oviposited preferentially in P. semipunctata eggs. In no-choice laboratory bioassays, the parasitoid oviposition rate was similar between the two host species when the host eggs were 0.5 d old, but higher in *P. semipunctata* eggs when host eggs were \geq 1.5 d old. Survival of the parasitoids was significantly lower in P. recurva eggs of all age classes than in P. semipunctata eggs. In choice experiments, female parasitoid oviposition rate was significantly higher in P. semipunctata eggs regardless of host egg age. In both experiments, some P. recurva embryos survived the parasitoid attack and emerged as neonate larvae, whereas P. semipunctata embryos never successfully developed in parasitized eggs. These results were corroborated by the results of additional laboratory studies which tested strains of A. longoi reared on eggs of either P. semipunctata (S--strain wasps) or P. recurva (R-strain wasps) for multiple generations. Female parasitoids of both strains preferred to oviposit in P. semipunctata eggs, and survival rates were much higher in P. semipunctata eggs than in P. recurva eggs, for both 0.5 and 2.5 day old host eggs. Preference for and survival of progeny of R--strain or S--strain females on P. semipunctata eggs was not significantly different. A substantial fraction of P. recurva eggs survived parasitism and produced neonate larvae, whereas no P. semipunctata eggs survived parasitism. A larger percentage of *P. recurva* eggs produced neither a parasitioid nor a neonate larva than parasitized *P. semipunctata* eggs. Although *P. recurva* eggs were smaller in diameter and weight than *P. semipunctata* eggs, eggs of both species were large enough to support the development of several parasitoids, so it is unlikely that inadequate nutrition was a contributing factor to survival in eggs of either host species. Cumulatively, these results suggest that eggs of both species contain adequate nutrition for developing parasitoids, but that ovipositing A. longoi females and their developing progeny frequently are not able to manipulate P. recurva egg development.

Index terms: Phoracantha semipunctata, Phoracantha recurva, Avetianella longoi

[1992] BIOLOGICAL CONTROL OF INSECT PESTS OF EUCALYPTUS IN FRANCE.

J.C. Malausa., I.N.R.A. Centre de Recherches d'Antibes, Entomologie et Lutte biologique, 1382 route de Biot, 06560 Valbonne, France, E-mail: malausa@antibes.inra.fr.

Three specific insect pests of eucalyptus have been accidentally introduced from Australia into the mediterranean region. These species have reached France in the last decades : the curculionid *Gonipterus scutellatus* Gyllenhall in 1978, the psyllid *Ctenarytaina eucalypti* (Maskell) in 1979 and the cerambycid *Phoracantha semipunctata* (Fabricius) in 1984.

After a brief history of their geographical dispersal and bionomics, their present status and economic importance in France is reported. P. semipunctata is not reported as a severe pest and seems to be naturally limited by cool winter conditions. The two other species appeared to present a serious risk, particularly for ornamental trees and a classical biological control strategy have been developed successfully to control them. G. scutellatus is now very well controlled by the South-African oophagous parasitoid Anaphes nitens (Girault), first introduced on western Liguria coast in Italy. C. eucalypti reappeared in 1994 on ornamental eucalyptus of the mediterranean French Riviera and also in Brittany in western France. This pest developed heavy populations, causing important economic damage in thes two very different climates. After attempting to establish without success two species of coccinellid, Australian Encyrtidae Psyllaephagus pilosus Noyes was released in the two regions in 1997. Results were spectacular and control of the pest was effective in the first year of the releases. The parasitoids spread repidly over a very long distance and is now present all along the Mediterranean and Atlantic coasts of France. Control of psyllid populations is very effective since this time certainly due to the high mobility and host detection ability of P. pilosus. It is always a concern that introductions of other pests of eucalyptus from Australia may occur in France like in other countries.

Index terms: Ctenarytaina eucalypti, Psyllaephagus pilosus, Phoracantha semipunctata, Gonipterus scutellatus [1893] TRENDS IN INSECT PEST PROBLEMS OF LOCALLY EXOTIC EUCALYPT PLANTATIONS: THE EXAMPLE OF TASMANIAN BLUE GUM IN WESTERN AUSTRALIA

A. D. Loch, CSIRO Entomology and Cooperative Research Centre for Sustainable Production Forestry, c/- Department of Conservation and Land Management, Brain St, Manjimup, WA 6258, Australia, E-mail: a.loch@ccmar.csiro.au.

Tasmanian blue gum, Eucalyptus globulus globulus, is one of the world's most popular eucalypt planiation species because it has excellent pulpwood properties, grows rapidly leading to short rotations, and can grow in a variety of soil types. The species is native to south-eastern Australia (Tasmania and Victoria), but is now grown widely throughout the world in climates with cool winters. Most of the world's two million ha of E. g. globulus plantations have been established where the species is exotic. Even in Australia, most plantations occur outside the species' native range, where it could be termed a locally exotic species. This is the case in south-western Australia where 160,000 ha of E. g. globulus plantations are grown widely under a Mediterranean type climate, with current planting rates reaching 40,000 ha per year. The rapid rise of the *E. g. globulus* plantation industry in south-western Australia has seen a corresponding increase in insect pest problems, with the industry facing a suite of establishment pests that attack trees as small seedlings through to serious defoliators of established trees. The development of these problems is not unexpected given that native eucalypt forests, from which many of these pests have originated, dominate the regional landscape. Also, most pests are exotic species from eastern Australia that prefer E. g. globulus as a host. Given that this plantation system is not unique, with eucalypt species being increasingly grown worldwide, the potential entomological implications for growing eucalypt species in both locally exotic and exotic situations need to be appreciated. This presentation will provide a current perspective on the insect pest problems of this dynamic plantation system and highlight historical and potential future trends in such problems. Possible reasons for insect species becoming pests of this plantation system will be evaluated, with particular reference made to the differences between native and exotic insect pests.

Index terms: Eucalyptus globulus globulus, plantations, hardwood forestry, exotic pests, native pests

[1894] ASSOCIATIONS OF INSECTS AND PATHOGENS RESULTING IN DISEASE AND DAMAGE TO PLANTATION GROWN *EUCALYPTUS* IN THE TROPICS AND SOUTHERN HEMISPHERE

M. Wingfield¹, J. Roux¹, P. Govender^{1,2} & B. D. Wingfield^{1,3}, Tree Pathology Cooperative Programme (TPCP), Forestry and Agricultural Biotechnology Inst. (FABI), Univ. of Pretoria, Pretoria, 0002, Republic of S. Africa; Dept. of Zoology & Entomology, Univ. of Pretoria, Pretoria, 0002, Republic of S. Africa; Dept. of Genetics, Univ. of Pretoria, Pretoria, 0002, Republic of S. Africa

The tremendous growth and success of plantation-grown *Eucalyptus* in the trepics and southern hemisphere, can partially be attributed to the fact that these trees have been separated from the pests and diseases that affect them where they are native. Diseases and insect pests are, however, gradually causing increasing damage to these trees. Interesting interactions between pests and pathogens have also emerged as threats to *Eucalyptus* in plantations. Various opportunistic pathogens such as species of *Botryosphaeria* and *Cryptosporiopsis eucalypti* cause serious disease on trees damaged by *Helopeltis* spp (Hemiptera: Miridae). *Ceratocystis fimbriata* that causes the recently discovered Ceratocystis wilt disease of *Eucalyptus* in Africa and South America is also likely to have insect vectors. The relationship between insects and fungal pathogens of *Eucalyptus* has largely been ignored in the past. Our belief is that an enhanced knowledge of these insects and the fungi with which they interact will form an integral component of efforts to reduce the damage associated with them.

Key words: Eucalyptus, Botryosphaeria, Helopeltis, Ceratocystis fimbriata

[1895] MONITORING OF LEAF CUTTING ANTS IN REFORESTED AREAS IN BRAZIL

J. C. Zanuncio¹, R. Zanetti², A. C. Oliveira³ & G. D. Freitas³, ¹Dept^a. de Biologia Animal, Univ. Fed. Viçosa, 36571-000, Viçosa, MG, Brasil, E-mail zanuncio@mail.ufv.br; ²Dept^a. de Entomologia, Univ. Fed. Lavras, C. Postal 37, 37200-000, Lavras, MG, Brasil, E-mail zanetti@ufla.br. ³Mannesmann Florestal, Rua Voluntários da Pátria, 81, C. Postal 152, 35790-000, Curvelo, MG, Brasil.

Since1990, Brazilian forest companies have started monitoring programs for leaf cutting ant populations of the genera Atta and Acromyrmex in reforested areas aiming to increase the efficiency and to reduce control costs of these pests besides the amount of insecticide used. Populations of these insects can be sampled with several methodologies including random parcels of a fixed size, based on areas of high level of infestation or with transects. The first consists of parcels of 720 to 1800 square meters where all ant colonies are counted, measure and divided by class of size. In the second method most severe areas of defoliation are identified, where the number and size of ant colonies and of damaged trees are counted and the level of defoliation is estimated. In the transect method imaginary lines of similar length as the plantation block with a width of one to three lines of plants are marked where all ant colonies are counted. Data obtained are processed and the number and size of ant colonies are determined to estimate the necessity of new evaluations, immediate control and of the best control method to be used. Sampling intensity usually varies from 1 to 3% of the area. Because no comparative studies about the accuracy of each methodology exist it is difficult to affirm which is the best one for Brazilian conditions but all of them are producing important information for integrated management of leaf cutting ants. Such methods are allowing reduction of about 30 to 40% of the area receiving leaf cutting ant control compared to companies that are not monitoring and control these pests every six months. A well known monitoring system was developed by Mannesmann Florestal which allowed a reduction of about 88.6% in the number of persons working with leaf cutting ant control and an increase in 64,1% in operational results of such control with an economy of about US\$ 1.200.000,00 in 1992 and of more than US\$ 900.000/ano since 1998. Leaf cutting ants monitoring also allows to analyse interactions between ant populations and the forest and to plan actions for integrated management of this pest. Data of the monitoring system of Mannesmann has also developed growth models for several forest species as function of density of anthills. This made possible to estimate levels of economic damage for this pest besides important information for leaf cutting ant management in forest plantations including the effect of the age of the plant and of the surrounding native vegetation on ant populations, among others.

Index terms: Sampling, Atta, Acromyrmex, forestation

[1896] THE SPATIAL AND TEMPORAL IMPACT OF ENDEMIC NATURAL ENEMIES ON THE MORTALITY OF CHRYSOMELID BEETLES IN EUCALYPT PLANTATIONS

<u>G. R. Allen</u>^{1, 2} & V. S. Patel², ¹ School of Agricultural Science, Univ. of Tasmania, GPO Box 252-54, Hobart, Tasmania, 7001 Australia, E-mail Geoff.Allen@utas.edu.au; ² CRC for Sustainable Production Forestry, GPO Box 252-12, Hobart, Tasmania, 7001 Australia.

The eucalyptus leaf beetle Chrysophtharta agricola has been identified as a major threat to plantations of Eucalyptus nitens in Tasmania. We set up a replicated natural enemy exclusion experiment, across 3 yr old plantations separated by at least 20 km, to examine the impact of natural enemies on the survival of C. agricola in the field. Beetle mortality was assessed at egg, larval and pupal stages using uncaged and 'entire' tree caged treatments. After assessment of egg mortality, six selected branches on all experimental trees were loaded with clutches of first instar beetle larvae (ca. 30 larvae per clutch). Overall mortality and spatial variability in mortality both within and between trees was regularly monitored until emergence of adult beetles. Pupal mortality was assessed using litter cages, dug prior to commencement of the experiment, under each tree. To identify the parasitoid complex and the host stages attacked clutches of 'sentinel' or trap larvae exposed for the duration of each instar were seeded on further treees within the plantation. At least three primary parasitoids (two tachinids and one braconid) and one hyperparasitoid were present in the parasitoid guild which showed temporal separation in their timing of attack. Overall mortality in uncaged treatments exceeded 99 % across all plantations and was spatially variable both within and between trees. Variability in uncaged treatment survival was greater within trees than between trees with spider predation having a large impact on intra-tree larval survival. Within a plantation average mortality of uncaged larvae was up to 10 fold greater than for controls with the majority of loss in control cages occurring within the first few days of larval establishment. Natural enemies were concluded to have a significant impact on populations of C. agricola. Since the majority of larval damage is done in the fourth or final larval instar, yet control decisions are made in earlier instars, beetle monitoring protocols that account for spatial variability and the temporal patterns of both natural enemy attack and parasitoid induced mortality may need to be devised. Landscape approaches to the management of leaf beetles and their natural enemies should also be considered.

Index terms: Chrysophtharta agricola, parasitoids, tachinids, Chrysomelidae, forest insects

[1897] PEST INSECT IN EUCALYPTUS FOREST PLANTATION ON TABASCO STATE, MEXICO

I.Izquierdo, F.C. Gilli & J.L.Soberano, Desarrollo Forestal S.A. de C.V. Calle Sindicato de Agricultura, 701. Colonia López Mateos. 86040 Villahermosa, Tabasco, México. Phone (+5293)14-3672, 14-2654. E-mail: Erro! Indicador não definido. and forgivez@usumacinta.com.mx.

Through the last years the increasing demand for forest products has motivated the establishment of commercial forestry plantations over the world. This activity is in its early stage in Mexico, mainly in the tropical humid zone, where the state of Tabasco is located, using tropical fast growing species of Eucalyptus genus. The variety of crops found in the region and the different management practices allow the presence of problems like pest insects and diseases that could have an important negative economic impact. This paper shows a list of insects considered as a pest, which are affecting the growth rate of eucalyptus plantations. The data was obtained on a monitoring program from our initial plantation, which covers an area of 1,000 ha spread in different regions of the state, from 1994 through 1999. The field observation and collection of entomological material were carried out monthly through visual inspections and collecting methods. The pest insects were classified according to the development stage of the plantation and the economic importance of damage. From this field research we found that the most important pest insect species is the leaf beetle Metachroma inconstans, which causes severe perforations in the leaves, damaging the top of the plant, causing a growth delay, forking and the death of the plant. The leaf cutter ant Atta cephalotes and Acromymex sp cause strong defoliation on small plants, retarding the development or in severe repeated attacks, the death of plants. These species are considered the second pest in economic impact. The buprestid Psiloptera sp and the weevil Pantomorus albicans are secondary insect pests, causing scrapes in the stem promoting the drying of plants. At one-year-old plantations, the butterfly larvae attacks occur with slight or severe level of defoliation, causing the plant growth to delay. The most important species in this category is Sarsina violascens and others with lesser importance such as Notodonta sp, Eupseudosoma sp, Estigmene acraea and Automeris sp. The underground termite Coptotermes crassus is considered one of the most important pest insect attacking mature plantations with damage to the wood and root system. Other species of minor importance is the ambrosia beetle Xyleborus sp, several species of cerambycids and buprestid cause stem galleries, propitiating the entrance of pathogenic agents.

Index terms: Metachroma inconstans, Coptotermes crassus, Eucalyptus, Atta cephalotes, damage

[1898] BODY SIZE DISTRIBUTION OF CARABIDAE IN RELATION TO PRIMARY PRODUCTIVITY IN THE BOREAL FOREST OF NORTHERN SWEDEN

B. E. Aava, Dept. of Animal Ecology, Swedish Univ. Agri. Sci., S – 901 83, Umeå Sweden. e-mail: birgitta.aava@szooek.slu.se

Body size distributions at large scale have been shown to be positively skewed for most assemblages of animal taxa. A number of explanations have been put forward to explain this phenomenon. Among them are energetically related models. However, these models are primarily aimed at explaining the skew for mammalian assemblages, which are certainly dependent on energy for their growth. But, how general are these energetic models? Do they apply to other taxa (like arthropods? If energy is of any functional importance for size distributions of arthropods then we should expect to see differences in frequencies of sizes between sites varying in primary productivity. If energy availability has an effect on the size distribution it may be by setting a limit to how similar in size species within the same guild can be in a local community. This would lead to species being more similar in size where energy availability is good than where energy is limited. Also, species may on average be larger in more productive sites. I examined the effects of primary productivity on the distribution of body lengths of carabid beetles in seven 10 year old clear-cuts of boreal forest stands in the county of Västerbotten, Sweden. The hypothesis was that there would be fewer size classes of carabids in more productive sites and that these sites would contain more of larger sized species than less productive sites. Preliminary data suggest that there is no such relationship.

Key-words: Body size; Primary productivity; Arthropod; local scale

[1899] RESPONSES OF THE PINE PROCESSIONARY MOTH THAUMETOPOEA WILKINSONI TO EXTRACTS OF THE CHINABERRY TREE, MELIA AZEDARACH

E. M. Abou-Fakhr Hammad¹, J. A. Nasr¹ & N. M. Nemer¹, ¹Faculty of Agricultural & Food Sciences, American Univ. of Beirut, 850 3rd Ave. 18th Fl. New York, NY 10022-6297. E-mail: efat@aub.edu.lb.

Outbreaks of T. wilkinsoni were reported lately on Pinus halepensis Mill. and P. brutia Tenore in Lebanon. A comparative study was performed among aqueous extracts of M. azedarach and certain biorational insecticides: Azadirachtin (3%) and Bacillus thuringiensis var kurstaki formulations. Leaves or fruits of Melia were extracted in water at a ratio of 1:5 (w/v) for overnight. The leaf and fruit extracts were tested at 0, 12.5, 25, 50 and 100% concentrations with 3 methods of application: topical application on larvae, introducing larvae after treating pine needles, and topical application on larvae and needles simultaneously. Data on number of dead larvae after treatment were recorded daily. Results have shown that there were significant differences in % mortality among treatments against 1st larval instars. Extracts of *Melia* fruits (100%) and leaves (100%) have caused mortality of 50-96% compared to that of the control, 5.5%. Dipel[®] was comparable in its effect to these extracts at 48 h and above, whereas MVPII[®] was comparable in its effect at 96 h. For 2nd larval instars, there were significant interactions among treatment and method of application at 24, 48 and 96 h. The fruit extract (100%) topically applied have caused the highest mortality followed by MVPII® and fruit extract (100%) topically applied on needles and larvae. At 96 h, the fruit extract (50%) caused mortality of 94% and 78% when applied on needles and over larvae and needles. respectively. At 72 and 120 h, there were significant differences among treatments. The fruit extract (100%) and MVPII® have caused mortality of 94% and 89% respectively at 72 h, but 100% mortality was detected at 120 h. For 3rd larval instars, there were significant interactions among treatment and method of application at 24, 48, 72 and 96 h. The fruit extract (100%) topically applied over larvae was comparable in its effect to MVPII® applied over larvae and needles. At 120 and 144 h, the fruit extract (100%) caused a significant larval mortality of 85% and was comparable in its effect to Azatin®, MVPII[®], and Dipel[®]. Fruit extracts (50%) were comparable in their effect to fruit extracts (100%) only at 144 h. Data analyses have shown EC_{50} values for second instars of 44 mgeq/ml of fruit extract applied on needles and 32 mg-eq/ml of fruit extract applied on larvae and needles at 5 days after treatment. BC_{so} values of 52 and 132 mg-eq/ml of fruit and leaf extracts, respectively, applied on needles against 3rd instars at 6 days after treatment were determined. Thus, Melia extracts were found to be effective against larvae of the pest indicating a potential insecticidal activity.

Index terms: Botanicals, Biorational Insecticides, Pinus sp

[1900] MANAGEMENT OF REFORESTATION INSECTS: FIRST STEP OF SUSTAINABLE FORESTRY

R.I. Alfaro, Research Scientist, Pacific Forestry, Centre, 506-W Burnside Rd., Victoria, BC. Canada.

The white pine weevil, Pissodes strobi Peck, is an indigenous insect of North America, and can be found in most regions of Canada and the United States. In British Columbia (BC) this insect has become a serious pest of reforestation, causing severe damage to young stands of Sitka spruce, Picea sitchensis (Bong) Carr., Engelmann spruce, Picea engelmannii Parry, white spruce, Picea glauca (Moench) Voss, and their hybrids. Attacked trees take to several years to recover. In this process, branches from the uppermost whorl below the damaged terminal compete for dominance, and the tree remains for one or more years with multiple leaders. Depending on the number of internodes destroyed and the growth characteristics of the tree, a permanent stem defect could form at the point of injury. Losses in severely infested stands, due to reduced growth and defect, can be as high as 40% of the stand volume. This paper describes the conditions that make stands of spruce (Picea spp.) susceptible to attack by the white pine weevil in British Columbia and discusses a pest management system which combines silviculture tactics with host genetic resistance. The system relies on restoring ecosystem balance by reducing the conditions that lead to outbreak development. The system recommends tactics that diminish heat accumulation in the stand by encouraging growth of suitable non-host conifers as well as an overstory of deciduous species such as aspen or alder. These conditions render the stand cooler and shadier, reduce oviposition sites and food supply because trees produce short, thin leaders, and may create conditions which enhance natural enemy populations. Reduction of stem defects by sanitation thinning and by planting at close spacing is also recommended. Central to IPM is the continuous monitoring of weevil populations and forecasting of weevil impacts on forest productivity. This can be accomplished through a computerized decision support system, which helps to evaluate the need for, and the possible benefits of a given tactic.

[1901] ARTROPODS DIVERSITY IN SEABIRDS COLONIES: APPLIED TO PHALACROCORAX ARISTOTELIS OF ISLANDS CIES AND ONS (NW PENÍNSULA IBÉRICA)

A. J. Alonso¹ & J. Garrido¹, ¹Dept. de Ecologia y Biologia Animal, Univ. de Vigo, Lagoas-Marcosende 36200, Vigo, Spain, E-mail aiap@uvigo.es and jgarrido@uvigo.es.

In this paper we studied the composition, diversity and trophic relation to arthropods fauna in 19 nests of cormorant (*Phalacrocorax aristotelis*), collected in two sites in NW Spain (Cies and Ons Islands) during 1997. At first, we made a faunistic study where the presence of high number of mites, spiders, ticks, flies, beetles and fleas are constated. Several colonies have been studied in three different breeding phases, except the ectoparasite fauna, most of arthropod fauna prefer to nest in the feeding phase where the organic materia contribution and relativity humidity is higher, in all phases the saprofagous mites are the most abundant group. With the fauna data, we studied the trophic relationship between the different groups, a modelic diagram of energy has been elaborated. Of the 84 present families in the cormorant nests, a large proportion of arthropod families found occurs there occasionally, and penetrated of the circundant habitats, only some families of mites, saprofagous fly larvae and depredators beetles find suitable conditions to survive and develop their life cycle in the nests.

Index terms: bird nest, nest fauna, arthropods.

[1902] RELATIONSHIP BETWEEN TICKS AND SMALL WILD MAMMALS IN A DISTURBED ATLANTIC FOREST FRAGMENT IN ITAPEVI COUNTY, STATE OF SÃO PAULO, BRAZIL

D. M. Barros-Battesti¹, V. C. Onofrio¹, S. M. Simons¹, R. S. Paço¹, M. Miretzki², V. L. N. Bonoldi³ & N. H. Yoshinari³, ¹Lab. Parasitologia, Inst. Butantan, Ave. Vital Brazil, 1500, 05503-900, São Paulo, SP, BR, E-mail-dbattest@usp.br; ²Museu de Hist. Nat. Capão da Imbuia, Dept. Zoo., PMCPR, R. Benedito Conceição, 407, 82810-080, Curitiba, PR, BR, ³Dept. Clínica Médica, Fac. Med., Univ. São Paulo, Ave. Dr. Arnaldo, 455, 01246-903, São Paulo, SP, BR, *Supported by FAPESP.

From January to December 1999, ticks were studied in a fragment of Atlantic Forest in a residential condominium, in the city of Itapevi, State of São Paulo. We investigated the relationship between ticks and hosts, observing the ticks' monthly and seasonal relative density indices (TRDI) and infestation indices per host group. Mammals were captured in monthly trappings carried out for five consecutive days. A total of 163 small mammals were trapped. Of these, 39,3% were infested with 186 ticks. Rodents were infested only by immature ticks, identified as Ixodes didelphidis (N=12), I. loricatus (N=8) and Amblyomma aureolatum (N=13). In these hosts, the higher monthly TRDI was recorded in August, and the higher infestation index occurred in June (during the dry season). Immature Ixodes ticks were collected only on Oligoryzomys nigripes and Bolomys lasiurus, and immature ticks of A. aureolatum were collected on Euryzygomatomys spinosus and on B. lasiurus. The marsupials were infested by adult and immature ticks. The adult ticks were identified as I. didelphidis (N=48), I. loricatus (N=61) and A. aureolatum (N=1). I. didelphidis was collected during the whole year but I. loricatus was more collected during the rainy season than during the dry season. The immature ticks found on marsupials were identified as A. cajennense (N=41), I. loricatus (N=1), and Haemaphysalis juxtakochi (N=1). The higher monthly TRDI and infestation index on marsupials were recorded in October (rainy season), when the highest number of specimens of immature A. cajennense ticks were collected. The difference between the proportion of tick stages per host group, during both seasons, was significant according to Fisher test (P<0.05). An increase of the parasitism of Amblyomma on small wild mammals, when compared to previous studies in this area (where human cases of Lyme-like illness were recorded), was observed. These species of Ixodes and Amblyomma, as well as some small wild mammals, have been found naturally infected with unidentified spirochetes. As such, the increase of Amblyomma on these hosts can contribute to the increase of human infection risk, since both species bite people as well as domestic animals. Index terms: Ixodes - Amblyomma - tick/host infestation indices

[1903] FOREST SOIL CLASSIFICATION BASED ON COLLEMBOLA FAUNA

L. De Bruyu^{1,2}, W. Jacobs², F. Janssens², S. Thys², F. Hendrickx³, D. De Bakker⁴, K. Desender⁴, J.P. Maelfait^{1,3} & B. De Vos⁵, ¹ Inst. Nature Conservation, Kliniekstr. 25, 1070 Brussel, Belgium; ² Dept. Biology, Univ. Antwerpen, Groenenborgerlaan 171, 2020 Antwerpen, Belgium; ³ Lab. Ecclogy, Univ. Gent, K.L. Ledeganckstr. 35, 9000 Gent, Belgium; ⁴ Dept. Entomology, RBINSc, Vautierstr. 29, 1000 Brussel, Belgium; ⁵ Inst. Forestry and Game Management, AMINAL, Gaverstr. 4, 9500 Geraardsbergen, Belgium; E-mail: luc.de.bruyn@instnat.be.

It has been stated by several authors that the abundance, species diversity and life history characteristics of Collembola can serve as excellent ecological indicators of the state of the environment. Specific community characteristics may reveal properties of the habitat that would otherwise be difficult or even impossible to quantify by measuring physical factors or based on vegetation revelés. In the scope of a research project on the occurrence, diversity and bio-indicative value of terrestrial invertebrates, a multitude of arthropod taxa were sampled in 56 forest plot (40 woods) in Flanders (Belgium). The main aim was to classify the forest soils based on the sample animals or animal groups. Collembola were collected with a core sampler (\Box =5cm; depth=10cm) and extracted with a modified McFayden apparatus. In all, about 14 000 specime belonging to 41 species were collected. Collembola community composition, structure and functionality were related to forest soil characteristics (texture and chemistry), vegetation structure and composition, and geographical and landscape ecological setting (forest area, isolation, ...). In general, the Collembola communities fall apart along a soil texture gradient while there is a tendency that the species are grouped according to the main tree species. Index terms: ecological indicators, habitat afinities

[1904] THE EFFECT OF THE INTRODUCTION OF A PINUS CARIBAEA PLANTATION ON THE ANT'S POPULATIONS OF VENEZUELAN SAVANNAS

<u>I. Bulla¹</u>, W. Goytía² y R. Candia¹, ¹Instituto de Zoología Tropical, Fac. Ciencias, UCV, Apdo 47058, Caracas 1041-A, Venezuela, FAX= 605-2204, Email: Ibulla@strix.ciens.ucv.ve.; ⁽²⁾ IDECYT, Univ. Simón Rodríguez, Apdo 47925, Caracas 1041-A. This work was financed by the ISC Program of the European Commission, Project CT 94-0099 VE.

During the last 30 years large plantations of Pinus caribaea were introduced in Monagas State (Venezuela), replacing most of the original savanna vegetation by pine forests and abandoned fields. This change greatly affected the arthropod's fauna of this system. In this article we will analyze their effect on the ant's populations. Ants were sampled using pitfall traps in 7 sites; 1) S1, a Trachypogon plumosus natural savanna that will be used as a baseline; 2) S2, an "island" savanna of 5 ha, completely surrounded by tall (over 10 m) pines; 3) S3, an Axonopus canescens natural savanna (a second baseline); 4) P1, a stand of pines four years old, with remnants of savanna vegetation among the trees; 5) P2, a stand of pure pines 12 mts high, ready for harvest; 6) P3, an area recently harvested, almost bare, with logs and twigs over the ground; 7) P4, similar to P3 but 4 years old. Ten pitfall traps were located in each site and collected monthly. Here we report the results of August (peak rainfall) and November (beginning of drought). A total of 74 species of ants were collected. The most important genera were Pheidole (16 spp), Camponotus (8 spp) and Solenopsis (5 spp). There is little change in the composition of the community between the rainy season (60 spp) and the drought (64 spp), but there are important differences among the 7 sites. Maximum diversity was achieved in P4, the abandoned field 4 years old (35 spp). The natural savannas were poorer with 21-23 spp. The island savanna S2 showed slightly higher diversity. The recently harvested area P3 had a surprisingly high diversity, considering its lack of resources (very scarce vegetation and little cover), of 17 spp in August and 22 spp in November. This is a very rapidly changing system. There is a definite change in the composition of the community as we move from the natural savanna to the mature pine forest and the abandoned fields, with species that characterize each step of the process. P4, the 4 years old field shows signs of recovery of the original fauna, but it seems that many years will be required to complete the process. Index terms: diversity, ants, savannas, pine forest

[1905] WATER STRESS EFFECT ON WORKER CUTTING-ANTS OF ACROMYRMEX HISPIDUS ON THREE ORIGINS OF EUCALYPTUS GLOBULUS GLOBULUS

P. Caffarini¹; <u>A. Peliçano¹</u>; P. Carrizo² &J. Lemcoff¹, I Facultad de Agronomía, Univ. de Bs.As., Av. San Martín 4453 (1417), Cap.Fed., Argentina apelicano@mail.agro.uba.ar, 2 Facultad de Ciencias Agrarias y Forestales, Univ. La Plata, Calle 690 y 119 (1900), La Plata, Argentina

The present study evaluates behaviour changes on worker cutting-ants of Acromyrmex hispidus, because of water stress on its host, Eucalyptus globulus. The influence of three different origins of eucaliptus named Jeeralang, Moogara and Otways National Park on these changes was also tested. The experimental arena was an artificial ant nest kept at 24 +/- 2 C, 80 % of relative humidity, and 12:12 hours of light:darkness. Ants were offered one stem 15 cm long with leaves for each treatment and origin, that were randomly distributed along that arena. This was done six times in a consecutive way. Between those assays, ants were offered other hosts, to prevent them from being acostumed. To create stress conditions, gardening was raisingly restricted for four weeks in the nursery, before samples were taken. Total and eaten Iraf surface was measurdby means of a foliar area gauge. Results, as a percentage of eaten surface by origin and treatment was tested by means of Tukey non-aditivity teste. The test was not meaningful (P=0,455), and transformations were not necessary before performing stadistic analysis. Averages were compared by means of two-way ANOVA (treatment and origin)and Tukey. Eaten average surfaces were significaty differents 31,295 % for the stress treatment and 3,125% for the control (P+0,0004). On the hand eaten average surface by origin was not significantly different (P=0,12). It is known that plant host susceptibility is enhanced as a result of stress. This is a consequence of a different chemical compounds, as a decrease in monoterpens production , tanines and others sustances. However, those tests are performed by direct damage, this means for those insects who really eat the plant. Worker-cutting ants do not use it this way, but it is a substrate for the fungi they feed from, so another response can be expected.

Index terms: preference, eucaliptus, cutting ants

[1906] OCCURRENCE AND DAMAGES CAUSED FOR ONCIDERES SAGA (COLEOPTERA: CERAMBYCIDAE) IN ARBORIZATION

A. G. Carvalho¹, J. G. N. Wendt¹, J. M. Pinto², A. M. Lunz¹ & S. R. S. Ventura¹, ¹Depto. de Produtos Florestais, Univ. Fed. Rural do Rio de Janeiro, Seropédica, RJ 23851-970, Brasil; ²Depto. Fitotecnia, Univ. Fed. Rural do Rio de Janeiro. E-mail: acacio@ufrrj.br.

The species of the Leguminosae as the Acacia mangium, Albizzia lebbeck, Clitoria fairchildiana, Delonix regia, Cassia fistula, Cassia javanica, Samanea saman, Piptadenia rigida, Bauhinia forficata and Inga edulis. They are among the more used in the urban arborization of the state of Rio de Janeiro, even so to the these, several insects are associated, among these meet the coleopterans that occupy a prominence position in these forest essences in a general way. Inside of this context it is found the species Oncideres saga (Coleoptera, Cerambycidae), whose popular name is "sawyer", which has been causing damages in the crowns of the species used in the urban arborization in the state of Rio de Janeiro, once the O. saga is known as one of the species more poliphagous, and this coleopteran damages branches and trunks with a great diameter width. This work was accomplished in NUCLEP in the municipal district of Itaguaf, RJ, where were collected and measured all the cut branches, being measured the length of the base of the branch wholesale to the apex of the same, considering the bifurcation of larger extension and the diameter in the base of the branch, where was took place two readings in positions opposed for the obtaining of the medium diameter of the fallen damaged branches on the soil or arrested to the crowns of the trees. The arborization is composed by the following essences: C. fairchildiana, B. forficata, A. lebbeck and D. regia and the number of branches cut by the O. saga was of 2, 3, 111 and 8, respectively, being evaluated therefore a total of 124 branches. The length measures, in meters, for to C. fairchildiana, B. forficata, A. lebbeck and D. regia were of 3.81 ± 2.07 ; 2.76 ± 0.95 ; 2.86 ± 0.66 and 3.36 ± 0.66 0.78 respectively. The found medium diameters, in cm, were of $3,89 \pm 1,26$; $3,25 \pm 0.92$; $3,57 \pm 0.79$ and $3,82 \pm 0.77$ for C. fairchildiana, B. forficata, A. lebbeck and D. regia, respectively. It is ended that the damages provoked by O. saga cause serious damages to the crown and the shaft of the essences that compose the arborization of NUCLEP. A. lebbeck is the dominant essence in the arborization and the most susceptible to the sawyer. Index terms: Urban arborization, "Sawyer".

[1907] ANALYSIS OF THE DAMAGES CAUSED FOR ONCIDERES SAGA (COLEOPTERA: CERAMBYCIDAE) IN A FORESTRY REMNANT IN THE CAMPUS OF UFRRJ, BRASIL

<u>A. G. Carvalho¹</u>, A. M. Lunz¹, M. C. Machado¹ & S. R. S. Ventura¹, ¹Depto. Produtos Florestais, Univ. Fed. Rural do Rio de Janeiro, Seropédica, RJ 23851-970, Brasil. E-mail: acacio@ufrij.br.

The family Leguminosae counts inside with several species of the Campus of the Universidade Federal Rural do Rio de Janeiro, so much in planted areas as in regeneration, as Mimosa caesalpinaefolia, Inga edulis, Cassia grandis and Samanea saman. The main group of insects associated to these species is the order Coleoptera, where stands out the family Cerambycidae, whose habit of to yearn and to cut branches and even shafts for accomplishment of postures cause great damages to the crowns of the trees. The species Oncideres saga, well known as "sawyer", it is one of the ones that attack a great number of forest species. This work was accomplished in a forestry remnant in the Campus of UFRRJ, close to the Institute of Forests. The diameter of the cut branches was obtained through two readings in positions opposed in the area cut for obtaining of the medium diameter, and the length was measured of the base to the apex of the cut branch. The number of branches cut by O. saga was of 351, being three of M. caesalpinaefolia, five of I. edulis, eight of C. grandis and 335 of S. saman. The found medium diameters, in cm, were of $3,50 \pm 0,33$; $2,64 \pm 0,36$; $2,95 \pm 0,67$ and $3,43 \pm 0,82$ for M. caesalpinaefolia, I. edulis, C. grandis and S. saman, respectively. Already the medium lengths, in meters, for this sequence of species were of $3,87 \pm 2,03$; $1,62 \pm 0,74$; $1,68 \pm 0.98$ and $2,58 \pm 1,23$. It is ended that O. saga causes considerable damages in area with regeneration of native and exotic species, and that the species S. saman is the most susceptible to the attack of this insect.

Index terms: "Sawyer", Mimosa caesalpinaefolia, Inga edulis, Cassia grandis, Samanea saman.

[1908] SUPPRESSION OF SOUTHERN PINE BEETLE INFESTATIONS USING VERBENONE, AN ANTI-AGGREGATION PHEROMONE

S. R. Clarke¹, R. F. Billings², S. M. Salom³ & C. W. Berisford⁴, ¹Forest Health Protection, USDA Forest Service, 701 N. 1st St., Lufkin, TX 75901, USA, E-mail sclarke/r⁸_tx@fs.fed.us; ²Forest Pest Management, Texas Forest Service, P.O. Box 301, Lufkin, TX 75902-0310, USA; ³Dept. of Entomology, Virginia Tech, Blacksburg, VA 24061-0319, USA; ⁴Dept. of Entomology, Univ. of Georgia, Athens, GA 30602, USA.

The southern pine beetle (SPB), Dendroctonus frontalis, is a destructive forest insect pest of pines throughout the southeastern United States, Mexico, and Central America. Cut-and-remove or cut-and-leave treatments are effective in suppressing expanding infestations and reducing impacts, but new tactics are desired which limit the numbers of trees felled, particularly the uninfested trees. Operational methods for two such tactics using verbenone, an anti-aggregation pheromone produced by SPB, have been developed and successfully tested in the southeastern United States. The verbenone-only and verbenone-plus-felling treatments reduce or eliminate the need for tree-felling and thus are compatible with management objectives for sensitive or protected areas such as parks or wilderness. Verbenone pouches, the elution device, are tacked at ca. 4 m to trees either under attack or in a buffer strip around the expanding "spot head". Tables give the number of pouches required per tree and infestation, based on tree diameter and the number of currently-infested trees. A web-site providing training in the use of the two tactics is available for potential end-users. The U.S. Environmental Protection Agency recently registered verbenone, but treatments have not become operational to date. Refinement of the treatment methods continues, and current studies test new elution devices and lower pouch placement height. Trapping studies are also underway to identify other semiochemicals that may improve treatment efficacy when used in combination with verbenone. Trapping studies conducted in 1999 in Honduras suggest that verbenone tactics may also be effective in SPB spot suppression in that country. We plan to test the efficacy of verbenone treatments on SPB infestations throughout the range of the beetle. Index terms: Dendroctonus frontalis, semiochemicals, bark beetles.

[1909] MORPHOLOGICAL CHARACTERISTICS OF NESTS AND CONTROL OF ATTA SEXDENS RUBROPILOSA WITH GRANULATED BAITS IN A PLANTATION OF PINUS TAEDA, SAFAC, WANDA, MISIONES

<u>Q. R. de Coll</u>¹, W. Lange¹, R. A. Friedl¹ & T. M. C. Della Lucia², ¹ Email:odecoll@inta.gov.ar; ²tdlucia@mail.ufv.br

Leaf cutting ants limit agricultural and forest production. Leaf-cutter ants of genus Atta are distributed in the whole province of Misiones, and are pests is of great economic importance because of the damage they cause. They are measured to estimate the surface area and to apply the granulated baits for controlling the ants. The external morphological characteristics of the nests are thus important to determine the correct dose to apply. The main current problem is the correct mensuration of the earth mound. The aims of the present work are to determine the morphlogical characteristics of the nests and the most efficient dose of the granulated bait with sulfuramide in the control of Atta sexdens rubropilosa. Nests were marked in a 19,5 hectare plantation of Pinus taeda of deep red soil belonging to the SAFAC, S. A. company, in the town of Wanda, Misiones, Argentina The assay with granulated bait was carried out in December of 1997. In the plantation, 33 m wide strips were defined and the geographical coordinates of the nests were measured. Values of estimated surface area and volume of each nest were obtained from mathematical formulae, once their leght, width and height were determined. The calculated surfaces were those for the rectangle and the ellipse; the volume was that of a fustrum of right circular cone. The treatments with the sulfluramide bait (0,3 %) HBT 347 consisted of application of 6, 8, 10 y 12 g/m² calculated as a rectangle, a positive control with 10 g/m² of dodecachlor (0,45%) was also used, as well as a negative control, without bait application. The statistical design used was a completely randomized experiment with 6 treatments and 8 replications per treatment. The attractiveness of the granulated bait was evaluated by observations 24, 48 and 72 h after application. Inactive nests were checked after 15, 30, 60, 90 y 303 days. Six nests were selected for excavation after 153 days. Spatial distribution of the nests of A. s. rubropilosa in the pine forest were of contagious type, with 120 m² of nests per ha, with a maximum of 128 m² and a minimum of 9,7 m². The average density was 2,51 nests per ha. The nests of larger area and volume were found The average density was plantation. The nest of maximum area had $33,12 \text{ m}^2$ and that of minimum, $30,18 \text{ m}^2$, with a standard variation of 2,079 m². The volume average was 14,36 m^{3} (maximum 58.32 m³ and minimum, 4,43 m³). The analysis of the results showed that 6 and 8 g/m² were the most effective doses of sulfluramide bait. The number of inactive nests increased with time; 100% of them were inactive at the end of 303 days. On the other hand, 25 % of the nests treated with either 10 or 12 g/m² were still active at that time. Index terms: leaf-cutter ants, nets, control, sulfluramide, Pinus taeda.

[1910] FAUNA OF LEPIDOPTERA IN A TRANSECT OF NATIVE VEGETATION- *EUCALYPTUS* PLANTATION IN IPABA, MINAS GERAIS, BRAZIL

O.T. Dall'Oglio¹, <u>I.C. Zanuncio¹</u>, ¹ Dept. Biologia Animal, Univ. Federal de Viçosa, Viçosa, Minas Gerais, Brasil, 36.571-000, E-mail onice@insecta.ufv.br; zanuncio@mail.ufv.br.

Lepidoptera defoliators are important pests of Eucalyptus in Brazil because forest monocultures represent simplified ecosystems where herbivore insects can be more abundant and cause damage. The maintenance of understorey vegetation and the preservation of strips and remnants of native vegetation have been recommended as a strategy to increase environmental heterogeneity and consequently the diversity of species of insects in reforested areas. The objective of this research was to study the fauna of Lepidoptera in three situations: Eucalyptus, area of transition native vegetation/Eucalyptus and within a fragment of native vegetation in Ipaba, Minas Gerais, Brazil, from April 1997 to March 1998 with five light traps. The first and the second traps were installed in the Eucalyptus plantation at 400 and 200 meters of the transition native vegetation/Eucalyptus; the third in this transition; and the fourth and the fifth light traps inside the native vegetation, at 200 and 400 meters from the transition. Lepidoptera collected were divided in the following groups: i) group 1, primary pest (those species previously recorded in outbreak conditions in Eucalyptus plantations); ii) group 2, secondary pests (species that feed on Eucalyptus but not in outbreak conditions); iii) group 3, species without defined importance to Eucalyptus; and, iv) group 4, non identified species. A total of 20,606 individuals were collected, being 1,808 of group 1; 231 of group 2; 8,874 of group 3 and 9,693 of group 4. Out of 2,039 individuals of primary and secondary pests, 2.94% were only collected in the fragment of native vegetation; 18.69% in the transition native vegetation and Eucalyptus and 78.37% in the Eucalyptus plantation. The species without defined importance to Eucalyptus were collected in higher numbers within the Eucalyptus at 200m from the transition and in the transition with 38.40 and 31.61% of the individuals, respectively, while the group of non identified species presented higher number of individuals in the transition of Eucalyptus with the native vegetation with 37.88%. Pest species presented higher number of individuals per species in the Eucalyptus plantation than in the transition and in the native forest, while non-pest species presented similar number of individuals per species in all points. This shows that areas of native vegetation intermingled with *Eucalyptus* plantations can contribute to a larger diversity of species and to the reduction of the number of individuals of the Lepidoptera pests in these plantations.

Index terms: Insecta, Eucalyptus, pests, forest remnants

[1911] ARTHROPODS IN RELATION WITH ARAUCARIA ARAUCANA: AN APPROACH TO ITS BIODIVERSITY IN ARGENTINA

<u>G. Dapoto</u>, H. Giganti, M. Bondoni & M. Gentili, Depto. Biología Aplicada, Un. Nac. del Comahue, C.C. 85, 8303, Cinco Saltos (R.N.), Argentina. E-mail: gdapoto@uncoma.edu.ar

Araucaria araucana (Araucariaceae) is a native conifer from Argentina and Chile spread mainly over the Andes Mountains between 37°30' to 40° S and 900 to 1700 m o.s.l. approximately. This very old specie has a big economic, biological, social and also anthropological interest, since it was exploited with intensity until some years ago mainly for timber extraction and is in strong cultural relation with people of its spread area, specially the native. It makes different vegetative communities in Argentina. In association with Nothofagus spp:: forests with: N. obliqua, N. dombeyi and N. pumilio, placed with rainfall about 3500 mm/year and with N. antarctica and Lomatia hirsuita (Proteaceae) with less density in places with less rainfall and lower altitude. Going to the East humidity decreases, then it makes a transition with the patagonian steppe up to 250 mm/year approximately. It was studying arthropods in relation to the different associations formed by A. araucana as contribution for to know the biodiversity of this communities and then look for a sustainable development of this natural researches. The specie determined at moment: 6 Acarina in 3 families, 85 Coleoptera in 20 families, 64 Hemiptera in 2 families, 15 Homoptera in 5 families, 25 Hymenoptera in 8 families, 96 Lepidoptera in 16 families, 4 Orthoptera, 4 Diptera and specific reduced fauna of A. araucana (21 specie determined at moment that mean about 9 % of total collected) are reported in this paper.

Index terms: insects and mites, patagonian native forests, biotaxonomy.

[1913] CARABID BEETLES AS MODEL ORGANISMS IN POPULATION GENETIC STUDIES ON HIGHLY FRAGMENTED TEMPERATE FORESTS (FLANDERS, BELGIUM)

K. Desender¹, P. Verdyck¹, V. Versteirt¹ & J.-Y. Rasplus², ¹ Dept. Entomology, RBINSc, Vautierstr. 29, B-1000 Brussels, Belgium. E-mail: kdesender@kbinirsnb.be; ² Centre de Biologie et Gestion des Populations, INRA, Equipe Taxonomie et Ecologie,488, rue Croix de Lavit, F-34090 Montpellier.

Populations of many terrestrial arthropods nowadays only survive in small remnants of natural habitats. Forests in Flanders are well documented historically, but now cover less than 10% of the total surface only. Most of these forest are extremely fragmented, reduced in size and isolated. Within the context of a regional project, effects of habitat fragmentation, including historical ecology, are studied in a wide variety of forest habitat organisms. Ground beetles appear to be extremely useful model organisms in such studies. They are speciose, have a rather well known distribution both in time and space (Red data book available), are highly variable in habitat preference (stenotopic and more eurytopic species) and their dispersal power (-gene flow) is reflected in the development of hind wings and flight muscles (macropterous, brachypterous and wing polymorphic species). Population genetic results based on allozymes, studied by means of cellulose acetate electrophoresis in large samples of several forest ground beetles, invariably show a significant genetic differentiation between populations. Some of the brachypterous species show geographical isolation by distance (Mantel-tests). Highest F5T-values are obtained for rare and brachypterous species (Abax ovalis, A. parallelus and Carabus auronitens). C. auronitens, extremely rare in Flanders and limited to a few ancient forests only, shows a very high FsT value, indicating that a large proportion of its total genetic variation occurs between populations. In the near future, we will therefore also study this ground beetle by means of more powerful or completely neutral markers (microsatellites). Based on allozymes, the smallest value of genetic differentiation is found in Agonum assimile, a common and more mobile species from inundation and valley forests. Abax ater, another common forest carabid, suggests an unexpected negative relationship between genetic diversity and forest area (further study planned with microsatellites). Genetic erosion in small populations is indicated for some very rare and brachypterous carabids, which are known indicators for ancient forests. To conclude, some recommendations are given for regional nature conservation.

Index terms: Carabidae, gene flow, genetic differentiation/diversity, fragmentation.

[1912] BEETLES, SPIDERS AND FLIES AS BIO-INDICATORS IN FORESTS: A LARGE SCALE RESEARCH PROJECT IN FLANDERS (BELGIUM)

K. Desender¹, D. De Bakker¹, P. Grootaert¹, M. Pollet¹, L. De Bruyn², B. De Vos³ & J.-P. Maelfait², ¹ Dept. Entomology, RBINSC, Vautierstr. 29, B-1000 Brussels, Belgium, E-mail: kdesender@kbinirsnb.be; ² Inst. Nature Conservation, Kliniekstr. 25, B-1070 Brussels, Belgium; ³ Inst. Forestry and Game Management, AMINAL, Gaverstraat 4, B-9500 Geraardsbergen.

In 1997, a research project was started on the occurrence, diversity and bio-indicative value of terrestrial invertebrates in 56 forest stands distributed over 40 woods in the entire region of Flanders (Belgium). A complete year cycle of samples was therefore taken in these forests (mainly by means of continuous pitfall trapping for soil surface active invertebrates and the use of coloured pan traps for flying insects). The first part of the study (sampling and identification of about one month of samples for a multitude of invertebrate taxa) involved scientists from several universities [Ghent Univ. (RUG), Antwerp Univ. (RUCA) and Louvain Univ. (KUL)] and scientific institutions (region of Flanders: Institute for Forestry & Game Management and Institute of Nature Conservation; Royal Belgian Institute of Natural Sciences). In the current contribution, we report on the identification (complete year cycle) and ecological analyses of a limited number of animal taxa, i.e. ground beetles (Carabidae), spiders (Araneae) and flies (Empididae and Dolichopodidae). These arthropods are target model organisms because they are (1) well known for what concerns their taxonomy and biology, (2) speciose, (3) documented concerning their former and recent distribution in our region (Red data books), and (4) abundantly occurring in the sampled forests. Besides, a multitude of environmental variables have been quantified from each sampling forest plot. These include local forest soil characteristics (texture, detailed soil and forest floor chemistry), vegetation structure and composition, as well as geographical and landscape ecological setting (forest area, isolation, etc...). Identification of the complete year cycle from 56 forest plots (carabids and spiders) or 49 plots (flies), yields some 200.000 specimens belonging to more than 550 species. Multivariate analyses are based on habitat preference data for the most abundant species (41 ground beetles, 80 spiders, and 39 flies). Indirect and direct gradient analyses yield comparable results in each case. The most differentiated assemblages for spiders and flies primarily seem to react to soil texture and related characteristics. In carabids, on the other hand, an assemblage of large ancient forests is first distinguished from humid lowland forest communities, whereas in the second place mainly soil texture and site productivity seem to define observed assemblages. Index terms: Carabidae, Araneae, Empididae, Dolichopodidae, ecological indicators.

[1914] VARIATIONS IN THE SPECIES COMPOSITION OF CURCULIONOIDEA IN NATURAL AND PLANTED FORESTS OF CENTRAL SPAIN

L. Diodato¹, M. P. Gurrea Sanz² & A. Notario³, ¹Fac. Ciencias Forestales, Univ. Santiago del Estero, Avda Belgrano 1912, 4200-Santiago del Estero, Argentina; ² Dept. Biología, Fac. de Ciencias, Univ. Autónoma de Madrid, 28049, Madrid, Spain; ³ Dept. de Ing. Forestal. ETS Ing. Montes, Ciudad Universitaria, 28040, Madrid, Spain.

In the Central Mountains of Spain, afforestations have been carried out in the last fifty years, which has caused vegetation changes. Hence, it is currently possible to find plantations of *Pinus sylvestris* growing in natural areas that were originally covered with Quercus pyrenaica, thus resulting in landscapes where natural hardwood forests and softwood plantations are adjacent to one another. The purpose of this paper is to analyze and compare the fauna of Curculionoidea in the natural oak forests with that found in the pine plantations. Material resulting from periodic sampling procedures conducted in 1996, 1997 and 1998 in representative stands of both oak forests and pine plantations in various localities of the Sierra de Guadarrama, Madrid, Spain, has been studied. The samples were collected by using the "shaking" and "netting" methods on undergrowth plants and by "shaking" the tree canopies. Specimens belonging to 86 different species of Curculionoidea, representing the families Attelabidae, Brentidae, Curculionidae, Erirhinidae and Nemonychidae, were collected during the study. The cluster analysis conducted on the data revealed that the fauna associated with the undergrowth in both oak forests and pine plantations is the group most similar to each other, followed by the fauna from the oak canopies, while the one associated with the pine canopies constitutes a separate group. Where endemic species may be lost, it is important to consider this process, especially when land management and conservation are sought. Index terms: Coleoptera, Pinus sylvestris, Quercus pyrenaica, reforestations.

[1915] EFFECTS OF NON-NATIVE SPRUCE PLANTATION ON CARABID BEETLES

Z. Elek¹, <u>T. Magura¹</u> & B. Tóthmérész², ¹Dept. of Zoology, Kossuth L. Univ, P. O. Box 3, Debrecen, H-4010, Hungary, E-mail elekz@tigris.klte.hu and magura@tigris.klte.hu; ²Ecological Inst., Kossuth L. Univ., P. O. Box 71, Debrecen, H-4010, Hungary.

The impacts of non-native spruce plantation on carabid beetles were studied in the Bükk National Park in Hungary, Central Europe. Pitfall catches from recently established (5 years old), young (15 years after planting), middle-aged (30 years after planting), old spruce plantation (50 years after planting), and from a native submontane beech forest as a control stand were compared. Indicator species analysis (IndVal approach) shows that deciduous forest species decreased significantly in abundance in the plantations, and they appeared in high abundance only in the native beech forest. Furthermore, species characteristic of open habitat increased remarkably in abundance in the recently established plantation. Carabids were significantly more abundant and more species rich in the native forest than in the plantations, while these parameters were not significantly different among the plantations. Multiple regression between the abundance and species richness of carabids and twelve environmental measurements shows that pH of the soil, cover of the herbs and density of the carabids' prey have a significant effect in determining abundance and species richness. Our results proved that plantation of nonnative spruce species has detrimental effect on the composition of carabid communities and no regeneration can be observed during the growth of plantations even 50 years after the establishment. It emphasises the importance of an active nature management practice to facilitate the recolonization of the native species.

Index terms: carabid beetles, spruce plantation, species richness, indicator species, nature management.

[1917] WOOD LOSS IN EUCALYPTUS PLANTATIONS BY *COPTOTERMES* SP. (ISOPTERA:RHINO TERMITIDAE) IN GOIAS-BRAZIL

<u>P. M. Fernandes</u>¹; A.E.Fardin²; A. Forlin² & C. Czepak, ¹Universidade Federal de Goiás, Escola de Agronomia, c.p. 131, Cep. 74001-970, Goiânia -GO. Pmarta@terra.com.br²CODEMIN S/A, Niquelândia-GO.

Eucalyptus is the main forest species grown in Brazil with a planted area around five millions hectares. Trees attacked by termites at harvest are very common to be found however; economic losses due to termites have not been determined. This study was conducted in a eucalyptus plantation belonging to CODEMIN S/A, at Niquelândia, Goiás. The species of termites in association with eucalyptus were collected and identified. Index of plants attacked and the volume of wood per tree also was estimated. The estimates of the volume of wood lost by termite infestation were obtained from 10 trees in six sample dates: 16/04/97, 21/08/97, 28/11/97, 13/03/98, 03/09/98, and 27/11/98. The index of plants attacked by termites was determined in areas harvested in 1997, 1998 and 1999. In each patch, the evaluations of the number of trunks attacked were made about 60 days after cutting in one complete row and in each 20 rows. The main species of termites observed associate to euclyptus trees Coptotermes sp, Nasutitermes sp., Labiotermes sp., Heterotermes sp., Cornitermes sp. The genus Coptotermes was frequent found attacking central part of the trunk being the main responsible for this type of injury. The percentage of volume of wood loss by termite attack was variable among sampling dates. The highest loss was observed for Eucalyptus of species E. cytriodora and the lowest for E. urophylla with mean of 1,36%. The incidence of trunks attacked was low, ranging from 0.65 to 14.40% and a mean of 6,81%. These results allowed to conclude that mean of losses in volume of wood/ha due to attack of termites were very low and were below 0.1% in all patches evaluated.

Index terms: termites, eucalyptus, wood loss

[1916] NATURAL RESISTANCE OF TEN CUBAN FOREST SPECIES AGAINST TERMITE ATTACK

H. C. Escoto¹, N. T. Isasi-¹, J. M. Montalvo², ¹Dept. of Entomology, Forest Research Institute, 174 street no. 1723 e/ 17B and 17C. Siboney. Playa,. C. Havana, Cuba, E-mail iif@ip.etecsa.cu.

Wood samples of sapwood and hardwood of ten Cuban forest species were selected to study its natural resistance against Cryptotermes brevis (Isoptera: Kalotermitidae). Assays of alimentary selectivity and compulsory alimentation in laboratory conditions during 60 days were conducted. Species included in this work are: Cinnamomun parviflorum (White sweet potato); Laurocerasus occidentalis (Male Cuajani); Swietenia mahagoni (Cuban mahagoni); Sapium jamaicennsis. (Piniche); Colubrina arborescens (Guaguasi); Pithecellobium arboretum (Sabicu moruno); Quercus cubana (Oak); Pithecellobium obovale (Encinillo) and Zanthoxylum elephantiasis (Bayúa). The weight loss records were analyzed by the Newman-Keuls Test applied to a significance level of 5%. Results allow classifying the relative resistance of the sampled species that relating them with data from field studies will give a complete information of the resistance of these woods to termite attack.

Index terms: Cryptotermes brevis, durability, Cuban woods.

[1918] SCOLYTIDAE TRAPPINGS IN YOUNG LOBLOLLY PINE (PINUS TAEDA) STANDS

C. A. H. Flechtmann¹, D. C. Oliveira¹ & L. Cordeiro², ¹Dept. of Biology, FEIS/UNESP, Av. Brasil 56, 15385-000 Ilha Solteira/SP, Brazil, E-mail flechtma@bio.feis.unesp.br; ²Klabin do Paraná Papéis, Lagoa Fazenda Monte Alegre, 84279-000 Telêmaco Borba/PR, Brazil, E-mail leordeiro@klabinpr.com.br

Tropical (Pinus oocarpa and Pinus caribaea) and subtropical (Pinus taeda) pines comprise ca. 35% of the total reforested area in Brazil. Native Scolytidae beetles, the great majority of them originally found on hardwoods, are quickly adapting to these exotic pines. These insects are among the most important pests in temperate forests throughout the world, and they are quickly becoming important in Brazil, where they are growing in abundance and diversity. The results presented here originated from an experiment originally designed to monitor Scolytidae populations from implantation until harvest of a stand of pines, and to correlate/predict them through a time series analysis which includes factors as various as thinning, stand age, temperature, rainfall, humidity, delimbing, and stand density among others. The trap used was a vane flight intercept trap type baited with 95% ethanol, released at a rate of ca. 0.52 g/d at $21\Box C$, and deployed in a *Pinus taeda* and *P. taeda* \times *P. elliottii* hybrid stands, owned by Klabin do Paraná Papéis, and located in Telêmaco Borba, Paraná state, Brazil, The site (originally *P. taeda*) was harvested in November 1997 and planted in March 1998; stumps and abundant slash were present. Areas surrounding the experimental site were composed of woods (native vegetation), young loblolly pine and old loblolly pine (ranging from 13 to 22 yr old). Traps were placed in a 5 x 5 grid, spaced 100 m apart, on 11 June 1997, and beetles trapped were collected every 7 d. After 82 wk, in total 331,930 scolytid specimens (47 species) were trapped, the majority of them ambrosia beetles. The most abundant species were Xyleborus ferrugineus (90.8% specimens), Hypothenemus eruditus (8%), Xyleborinus linearicollis (0.7%) and Hypothenemus obscurus (0.3%). Results indicate that X. ferrugineus is developing in stumps and slash of larger diameter, while the remaining 3 species were developing in smaller diameter slash. "Border" traps (traps at the outer margin of the grid of 25 traps) caught significantly more specimens than "inner" traps for X. ferrugineus and H. eruditus, maybe due to a combination of competition among traps (border traps compete less with other traps than inner traps) and immigration of scolytids from nearby stands (there is a greater chance of those incoming beetles to meet a border trap than an inner trap). Traps closer to older stands (woods and old pine) caught significantly more individuals of the 4 species mentioned above than in traps closer to young loblolly pines. Index terms: ambrosia beetles, trap competition, scolytid migration, Xyleborus ferrugineus, Pinus taeda.

[1919] RESPONSE OF BRAZILIAN AMBROSIA BEETLES (COLEOPTERA, SCOLYTIDAE) TO KAIROMONES AND PHEROMONES

C. A. H. Flechtmann¹, V. L. S. Sagi¹ & L. Cordeiro², ¹Dept. of Biology, FEIS/UNESP, Av. Brasil 56, 15385-000 Ilha Solteira/SP, Brazil, E-mail flechtma@bio.feis.unesp.br; ²Klabin do Paraná Papéis, Lagoa Fazenda Monte Alegre, 84279-000 Telêmaco Borba/PR, Brazil, E-mail lcordeiro@klabinpr.com.br

Reforestation in Brazil is relatively new, as establishment for most of the plantations began in the mid 60's. For years pine plantations remained surprisingly free of pests, and to this date few insects constitute any regular, economically important pests. Yet, scolytid beetles, constituted mainly by xylomycetophagous ambrosia beetles, are growing in abundance and diversity in pine stands over the years, demanding constant monitoring. The main lure (if not the only one) used in traps to monitor these beetles in Brasil is the kairomone ethanol. However, it is well known that many species respond little or do not respond at all to this attractant. The objective of this experiment was to evaluate, for a Brazilian reforested stand, the attractiveness of scolytids to some semiochemicals widely used in temperate forests in North America and Europe. Multiple funnel traps (Lindgren7) were baited with the kairomones D-pinene and ethanol and the pheromones sulcatol (racemic) and (+)-sulcatol (retusol), plus a control (blank). Traps were deployed in a mature *P. taeda* stand (owned by Klabin do Paraná Papéis, and located in Telêmaco Borba, Paraná state) in 3 lines (5 traps/line); traps were 5 m apart within each line, and lines were spaced 20 m apart. Beetles trapped were collected every 7 d, at which time traps were randomized within each line to reduce positional effects. The experimental design was a randomized complete block design. In 11 wk of trapping, a total of 9,031 scolytid specimens were trapped, distributed in 35 species. The kairomone □-pinene proved unattractive to all scolytid beetles; however, it was highly attractive to an unidentified predatory Tenebrionidae. H. eruditus, H. obscurus (Cryphalini), X. gracilis, X. linearicollis, X. ferrugineus and X. retusus (Xyleborini) were significantly more trapped in ethanol-baited traps over other treatments. Despite the fact that it is assumed (however never proved) that there is no pheromone production in Xyleborini, X. adelographus and X. affinis were surprisingly clearly attracted to sulcatol- and retusol-baited traps over other semiochemicals; no X. adelographus specimens were trapped in ethanol-baited traps. Results show that monitoring can be improved with the use of lures other than ethanol, and that D-pinene could perhaps be used in pine stands as a way of concentrating scolytid natural enemies to a certain area.

Index terms: response to kairomones and pheromones, Xyleborus adelographus, Xyleborus affinis, Pinus taeda, Brazil.

[1920] DISTRIBUTION AND ABUNDANCE OF *MONOCHAMUS* SPECIES ON PINES IN ITALY

V. Francardi¹, F. Pennacchio¹, P.F. Roversi¹, A. <u>Binazzi</u> ¹& A. Leccese¹, ¹ Exper. Inst. of Agric. Zoology, Forest Entomology Section, via di Lanciola 12A, Cascine del Riccio, 50125 Firenze, I, E-mail isza@fi.flashnet.it, abinazzi@dada.it.

4 species of longhorn borers are present in Italy, Monochamus sutor (Linnaeus), M. sartor (Fabricius), M. saltuarius (Gebler) and M. galloprovincialis (Olivier), the last with two subspecies, M. g. galloprovincialis and M. g. pistor (Germar). M. sartor and M. saltuarius develop on Picea abies, Abies alba, Pinus sylvestris and P. nigra, M. sutor also on P. mugo while M. g. pistor lives on Pinus sylvestris and P. nigra; all these cerambycids are widespread in alpine and prealpine zones with continental climatic conditions. Moreover, M. g. galloprovincialis lives on P. pinaster, P. halepensis, P. pinea and P. sylvestris in Mediterranean regions. Attacks of this longhorn beetle are common also on exotic pine timber plantations (i.e., P. strobus, P. radiata and P. insignis). In the last years, the occurence in our country of hot-dry summers causing many fires especially in the N-W and, in the same time, an outbreak of the maritime pine bast scale Matsucoccus feytaudi Duc., have led to a progressive decline of pine stands in those areas causing an epidemic increasing of native populations of M. g. galloprovincialis. The possible implications for the pine stand health of the recent introduction in Europe (Portugal) of the pine wood nematode (PWN) Bursaphelenchus xylophilus (Steiner & Buhrer) which causes pine wilt diseases as well as the possibility that indigenous Monochamus can be its main vectors, lead the control of M. g. galloprovincialis populations to be attempted. Management practices aimed to the cerambycid population reduction have to be carried out mainly on the coastal zones where the climatic conditions are more favourable to the PWN possible development.

Index terms: longhorn beetles, vectors, phytopathogen nematodes

[1921] COMMUNITIES OF SOILS INSECTS ON FRENCH GUYANA INSELBERGS : A SYNCRONIC STUDY THROUGHT VEGETATION DYNAMICS

R. Garrouste^{1,2}, ¹Muséum National d'Histoire Naturelle (MNHN), Antenne de Guyane c/o IRD BP 165 F-97323 Cayenne cedex, French Guyana, E-mail : garroust@mnhn.fr; ²MNHN Laboratoire d'Ecologie, 4, avenue du Petit-Château F-91800 Brunoy, France.

Inselbergs are very common in French Guyana (FG), as well as rocky outcrops, and host a mosaic of vegetation types with floristic singularities ("savane roche"). On two average altitude granitic inselbergs in center of FG, (Le Mont Chauve and Savane Dashine) studied by a pluridisciplary team (faunistic and floristic surveys) specialy dropped by helicopter, communities of soil arthropods where studied with emphasis on insect community, as prelimary results (during the rainy season). Adaptation of a Berlese-Tullgren extraction method was used in the field, using a glasshouse-like device to insure light and dry. Vegetation dynamics is studied throught soils insects from several plots at different stages, from epiphytic bromeliad mats to forest, using ordination. Formicids are dominant, and sometimes soils termits, who plays certainly a important role in soils dynamics. Index terms : insect community, dynamics, ordination

[1922] RESIN-COLLECTING BEES (HYMENOPTERA, APIDAE) ON CLUSIA PALMICIDA (CLUSIACEAE) IN A RIPARIAN FOREST IN BRAZIL

S. J. Gonçalves-Alvim, T. C. Lana & B. D. Ranieri, Ecologia Evolutiva de Herbívoros Tropicais, DBG/UFMG, CP 486, Belo Horizonte, MG, 30161-970, Brazil, E-mail silmarv@icb.ufmg.br

Primary flower resources to bees, i.e. those that satisfy the basic needs such as feeding and reproduction, include pollen, nectar, oil, resin and gums. Although resin provides an essential resource for the reproduction of a large number of bees in tropical communities. there are few studies about resin-collecting bees on Clusia ssp. This system was studied with monthly collects made during a year (July /92 to June/93) in a riparian forest, in Alcântara (2⁰23'00"S and 44⁰25'00"N), State of Maranhão (Northeastern Brazil). An amount of 178 bees belonging to 5 genera and 9 species of Apidae were collected both in pistilate and staminate plants of Clusia palmicida (Clusiaceae). The most abundant species were Trigona fuscipennis, T. pallens, and T. fulviventris. The other species, Euglossa piliventris, Partamona sp., Eufriesea surinamensis, Eulaema cingulata, Euglossa sp. and Partamona pearsoni had less than seven specimens captured. Bee activity was checked from 0600 to 1800 h, and the highest bee activity occurred from 0600 to 1000 h. The smallest abundance of bees occurred from 1200 to 1500 hours, when the temperature was too high for bee activity. Along the year, bees were more frequent from February to June (rainy season) and the highest number of bees was obtained in the end of the rainy season and the beginning of the dry season (in July). The smallest abundance was in October. We also found a positive correlation between number of individuals and number of bees species along the year (Pearson's correlation index = 0.69, P < 0.05). The highest frequency of large bees, such as Eulaema, Eufriesea and Euglossa, was observed in the staminate flowers of C. palmicida that have a greater load of resin. Visits of larger bees on pistillate flowers were less frequent. In addition, the meliponine bees (smaller bees) were frequently observed on two flower sexes. As larger bees can transport larger loads of resin in their corbiculae and in some cases these bees prefer to visit bigger inflorescence than smaller ones, we argue that this behavior is advantageous energetically. Index terms: Meliponinae, Euglossinae, social bees, foraging behavior, flower resources, resin.

[1923] ARBOREAL ARTHROPOD COMMUNITY STRUCTURE ACROSS FOUR MILLION YEARS OF ECOSYSTEM DEVELOPMENT IN HAWAII

D. S. Gruner¹ & D. A. Polhemus², ¹Dept. of Zoology, Univ. of Hawai'i at Manoa, 2538 the Mall/Edmondson Hall, Honolulu, HI 96822, USA, E-mail: dgruner@hawaii.edu; ²Department of Entomology MRC 105, National Museum of Natural History, Smithsonian Institution, Wash., D.C. 20560, USA.

The Hawaiian archipelago forms a linear time series of replicated communities, with ages of volcanic origin varying over seven orders of magnitude. Important ecosystem attributes, such as parent substrate, climate and elevation, may be held constant at selected sites along the series. Previous studies along a montane mesic chronosequence (300 yrs.--4.1 million yrs.) have shown that rates of many ecosystem processes peak at sites of intermediate volcanic substrate age (20,000 yrs.—1.4 myrs). At these sites, the canopy is dominated by a single tree species, Metrosideros polymorpha (Myrtaceae) and arthropod lineages are largely conserved. These features make the islands an ideal natural laboratory to test the relative importance of ecological versus historical and evolutionary hypotheses of community organization. In 1997, we used pyrethrum canopy fogging to sample freeliving arthropods on 41 M. polymorpha trees at 4 sites on 3 islands. Total arthropod densities and biomass were highest at more productive, intermediate-aged sites. Foliar nitrogen concentrations were highly correlated with total arthropod density on individual trees. However, species richness of phytophagous true bugs (Heteroptera) and predatory carabid beetles (Coleoptera: Carabidae) increased as a function of geological age. Moreover, one of three indigenous tribes of Carabidae (Psydrini) was completely absent from, and presumably has not colonized, the oldest site. Although contemporary ecological processes appear to determine relative species abundances and biomass in local communities, regional species pools determine local richness and historical or phylogenetic accidents place constraints on composition.

Index terms: Hawaii, canopy arthropods, Carabidae, Heteroptera, pyrethrum fogging.

[1925] THE ASSOCIATED FAUNA COMPOSITION AT THE *EUPHALERUS* SP (HEMIPTERA:PSYLLIDAE), IN SEROPÉDICA, RJ, BRAZIL

M. Guaiará¹, A. G. de Carvalho¹, W. Santos² & A. Calcagno², UFRRJ – BR-465, Km 7. Seropédica, RJ, Brasil. CEP: 23.835. ¹ Depto. de Produtos Florestais, E-mail: guajara@ufrrj.br, ² DEnF/ CIMP, E-mail: cimp@ufrrj.br.

The associated fauna at the Euphalerus sp (Hemiptera:Psyllidae), that colonize the leguminous Clitoria fairchildiana ("sombreiro") was checked, althrough material collected in municipal district of Seropédica - RJ. The objective was to obtain incial data about the potential species natural controlers, that has been observed for the first time, as in the municipal district as in association with said vegetal host. To the propositions, were demarked four distinct environments in Seropédica and in each one of them was selected one tree of the C. fairchildiana. In each tree was collected 120 folioles, distributed uniformently to the four squareds and in three heights on the trees, to represent even better the crown. At laboratory, the folioles was put each one in Petri's board and so left by 15 days. The emerged insects were collected and deposited in glass flask, with alcohol at adys. The energed insects were conducted to identification. It was detected, complete, 161 70%, and after it has been conducted to identification. It was detected, complete, 161 specimens, that complied this distribution: Acarina – 66 individuals (40,99%); Hymenoptera - 59 individuals (36,65%); Aranae - 22 individuals (13,66%); Hymenoptera:Formicidae - 3 individuals(1,86%), Chrysopidae - 3 individuals (1,86%); Diptera - 3 individuals (1,86%); Coleoptera - 3 individuals (1,86%) and Thysanoptera - 2 individuals (1,24%). Although we haven't apllied an efficient methodology to quantify this information, it registered the adults number of Olla abdominalis (Coleoptera: Coccinellidae) that chased during the sampling. Some examples of this species already has been created at laboratory, fed with nymphs and adults of Euphalerus sp to potential predatory verification has been obtained two generation, below this condition. It is register the colonization by entomopathogenic fungi *Cladosporium* sp, that is in almost all folioles studied, mainly in attack advanced age of Euphalerus sp, when the folioles are dry on the floor.

Index terms: Clitoria fairchildiana, natural controlers, Olla abdominalis, entomopathogenic, Cladosporium

[1924] DISTRIBUTION OF *EUPHALERUS* SP (HEMIPTERA: PSYLLIDAE) IN STATE OF RIO DE JANEIRO, BRAZIL

<u>M. Guajará</u>¹, A. G. de Carvalho¹, B. Cerqueira² & J. C. da Conceição², UFRRJ – BR-465, Km 7. Seropédica, RJ, Brasil. CEP: 23.835. ¹ Depto. de Produtos Florestais, E-mail: guajara@ufrrj.br, ² DEnF/ CIMP, E-mail: cimp@ufrrj.br.

In order to check the dispersion and the distribution of Euphalerus sp on Rio de Janeiro, where the species was recently registered in association with Clitoria fairchidiana, were accepted two methodology: a) questionary, with pictures showing aspects of the occurrence of Euphalerus sp, directed to the development agent of 17 regions that form the state, for dispatch to the municipal district and b) visity municipal districts on Rio de Janeiro, annotating which one that the insect was occurring, with observation at infestion level found. Through to the first methodology only 7 municipal districts directed reply. The preliminary appointment showed the occurrence of Euphalerus sp on: Northwest Region I- Varre-Sai, Porciúncula, Natividade e Bom Jesus de Itabapoana; Northwest II: Itaperuna; North II: Conceição de Macabu; North III: Italva; Medium Paraíba I: Valença, Pinheiral, Piraí, Barra do Piraí e Rio das Flores; Medium Paraíba II: Volta Redonda, Barra Mansa e Rio Claro; Medium Paraíba III: Porto Real, Itatiaia, Resende e Quatis; Baía de Ilha Grande: Angra dos Reis, Parati e Mangaratiba; Metropolitan: Paracambi, Seropédica, Itaguaí, Japeri, Queimados, Nova Iguaçu, Duque de Caxias, Belford Roxo, São João de Meriti, Nilópolis, Rio de Janeiro, Niterói, São Gonçalo e Maricá; South Center I: Parafba do Sul, Levi Gasparian e Três Rios; South Center II: Vassouras, Paulo de Frontin, Mendes, Paty do Alferes e Miguel Pereira. The insect, that had the first register on March of 1999, haven't been found on the two last municipal districts when the appointment initiate, on December of the same year, but it has been found there on February of 2000. Taked place though than the trees recently attacked, as attacked was flowered, while the others, that was constantly striped haven't none indication of flower.

Index terms: Clitoria fairchildiana, development agents, municipal districts - RJ

[1926] PATTERNS OF SPECIES RICHNESS AND ABUNDANCE OF DEFOLIATOR LEPIDOPTERA ASSOCIATED WITH *EUCALYPTUS GRANDIS* IN BRAZIL AND HOW THEY RELATE TO PLANT AGE

<u>**R.N.C. Guedes¹**</u>, **J.C. Zanuncio¹**, **T.V. Zanuncio¹** & **R. A. Araújo¹**, ¹Dept. of Animal Biology, Federal Univ. of Viçosa, Viçosa, MG 36571-000, Brazil, E-mail: guedes@mail.ufv.br.

The present work documents patterns of species richness and abundance of defoliator Lepidoptera associated with an Eucalyptus grandis plantation, established in an area previously occupied by the Atlantic tropical forest in Brazil, and how they relate to plant age using data of a five-year survey. The higher number of species collected (1,385), the lack of dominant species, and the non-occurrence of any pest outbreaks during the survey may be due to the high plant diversity of the native forest reserves maintained in the area. There was no significant seasonal fluctuation of species richness, but there were seasonal fluctuations on species abundance with outbreak species prevailing in October, at the start of the rainy season. Species richness and abundance of defoliator Lepidoptera were positively correlated. There was an increase on both with plant aging. However, largest numbers of major outbreak species and minor eucalypt defoliators, which accounted for 14% of the insects collected, were observed in plants near mid-age (four to five years-old) of their cutting cycle (seven to ten years). This may be due to a higher amount of better quality plant leaves at mid-age or the decrease in silvicultural management practices at this period of Eucalyptus cutting cycle in Brazil. The abundance of the main outbreak species observed in the survey, Stenalcidia grosica (Geometridae), was adversely affected by plant age. Nonetheless such effect was weak (r = -0.21, p = 0.03) and we were not able to obtain further significant correlations between plant age and abundance of the other most frequent and constant species collected.

Index terms: Insect survey, Stenalcidia grosica, insect abundance, outbreak species, eucalypt defoliators.

[1927] CRYPTORHYNCHUS LAPATHI ATTACKING POPLARS IN TURKEY

N. Guler, Plant Protection Section, Poplar and Fast Growing Forest Tress Research Institute, P.K. 93, 41001, Izmit/ TURKEY, E-mail: kavak@turnet.net.tr

In Turkey, aproximately 5 million cubic meter of poplar wood is producued annually. More than a quarter of this total poplar wood production is obtained from plantations in the Marmara and Western Black Sea regions of Turkey where the damage caused by Cryptorhynchus lapathi L. (Coleoptera - Curculinidae) is observed. C. lapathi causes damage on stems of poplars in nurseries and in plantations. Although the adult of C.lapathi can not move very far away, the size and the number of infested plantation sites have increased because of the use of infested nursery stock. The most serious problem in preventing the extension of this insect is due to the diffuculty that the ordinary poplar growers face in diagnosing the infested poplar saplings to plant. The life cycle of C.lapathi was investigated on two of the poplar clones: P.x euramericana cv. "1-214" and "1-45/51" which are widely used in commercial plantations in Turkey. The insect lays its eggs on the stem barks and the larvae from eggs feed and then hibernate in bark tissues. As soon as the vegetation starts, the larvae also start feeding and boring galleries in bark and in wood. Majority of the galeries (approximacly 60 percent) penetrates obliquely into wood then continues parallel to tree axis being mostly upward. Some other galleries (approximately 35 %) continue obliquely towards to tree axis. Few galleries are bored perpendiculer to tree axis. No correlation was observed between the length of galleries bored by C.lapathi and the diameter of infested trees. Although some authors reported that the adults of C.lapathi may also hibernate, hibernation of an adult C.lapathi has never been observed by us, but only the larvae. The generation period of C.lapathi lasts for one year in the Marmara and Western Black Sea regions of Turkey. Chemical control of C.lapathi is required in poplar nurseries and plantations. In order to secure the effectiveness of chemical control, it should be applied before the larvae penetrate into wood. In the Marmara and the Western Black Sea regions of Turkey, mean temperature is 12 °C in midapril during which the larvae of C.lapathi are in the bark tissues at a proportion of 45 % and under the bark on the surface of wood at a propartion of 55 %. Whereas, in the early may, more than 20 % of larvae are in galleries bored in wood. Therefore, delay in chemical application results with an ineffective control of C.lapath. Poplar plantations growing on sites with high water table during vegetation period and coppiced plantations are observed to be more sensitive for C.lapathi infestation. The rate of infestation decreases by the enlargement of tree diameter. Application of efficient cultivation techniques and good site conditions reduce the rate of insect damage and its infestation. Index terms: Poplar cultivation , Cryptorhynchus lapathi L.

[1928] THE EXOTIC FOREST PEST INFORMATION SYSTEM FOR NORTH AMERICA

R. A. Haack¹ & J. G. O'Brien², ¹ US Dept. Agriculture, Forest Service, North Central Research Station, 1407 S. Harrison Rd., East Lansing, MI 48823, USA; E-mail: rhaack @fs.fed.us; ² US Dept. Agriculture, Forest Service, Forest Health Protection, 1992 Folwell Ave., St. Paul, MN 55108, USA; E-mail: jobrien @fs.fed.us

The Exotic Forest Pest Information System for North America is a project sponsored by the North American Forestry Commission, comprised of members from Canada, Mexico, and the United States. This Internet-accessible database identifies insects, mites and pathogens with potential to become established and cause damage to forest resources in any of the three North American countries. Emphasis is placed on organisms not yet present in North America. Each record in the database consists of a brief pest risk assessment and a pest information section. For each organism, the risk assessment section qualifies risk by probability of establishment, economic impact, and environmental impact. The pest information section provides details on host plants, geographic distribution, methods for detection and identification, means of spread, control measures, general biology, and a bibliography. It is anticipated that this information will prove useful in assessing and managing future pest organisms in both North America and worldwide. The web site and pest records will be available in English, French, and Spanish. The directors of the project are actively seeking authors to write new pest records for the database, as well as qualified people to review current and future records. A new record can be submitted in any of the three official languages: English, French, or Spanish. Once approved and edited in the language in which it was first submitted, each record will then be translated to the other two languages by project members. The original authors and their affiliations are listed for each record. For further information, or to participate in the development of this information system, visit the web site at: http://www.exoticforestpests.org

Index terms: database, exotic pest, quarantine pest, risk assessment

[1929] AZADIRACHTIN FROM THE NEEM TREE: AN EFFECTIVE NATURAL PRODUCT FOR FOREST INSECT PEST MANAGEMENT

B. Helson¹, D. Lyons¹, P. de Groot¹, D. Thompson¹, R. West², & K. Wanner³, ¹Canadian Forest Service, Natural Resources Canada, P. O. Box 490, Sault Ste Marie, ON P6A 5M7, CANADA, E-mail bhelson@nrcan.gc.ca; ²Box 515, Portugal Cove, NF, A0A 3K0, CANADA, ³Dow AgroSciences, 5501 Oberlin Dr., San Diego, California 92121 USA

In the laboratory, azadirachtin in a commercial EC formulation of neem seed extract was very active on 13 species of tree-defoliating, lepidopteran and sawfly (Hymenoptera) larvae. Open-feeding sawfly species were much more susceptible than lepidopteran species. In field trials, ground-based foliar applications of neem at 50 g azadirachtin/ha by motorized backpack mistblower or compressed air sprayer have proven effective against white pine weevil, pine false webworm and introduced pine sawfly on pines. Dosages of 100 g/ha gave acceptable protection from spruce budworm damage on spruce and fir. Ultra-low-volume, aerial applications of EC formulations at 50 g/ha were effective against balsam fir sawfly on balsam fir and pine false webworm on red pine. Neem seed extracts also possess systemic properties against forest defoliators and leafminers when inoculated into the trunks of trees. In field trials against pine false webworm, trunk inoculations of small red pine trees with undiluted EC formulations at 0.05g azadirachtin per tree before egg hatch provided excellent protection of both old and new foliage. Trunk inoculations of large, 25-30 cm dbh, 20-m tall, red pine at 0.02 and 0.05g azadirachtin per cm dbh also provided excellent protection. Dosages of 0.1-0.2 g/cm dbh in large white spruce were effective against spruce budworm larvae. A dosage of 0.1 g/cm dbh greatly reduced cedar leaf miner populations on white cedar. Systemic neem applications are also persistent. Treatment of 20-cm dbh white pine at 0.1 g/cm dbh resulted in high mortality of introduced pine sawfly larvae for at least 77 days. Injections for pine false webworm control can be made before winter at least 7 months before egg hatch the following spring. A novel device, the Systemic Tree Injection Tube has been developed to inject neem formulations into trees under pressure, quickly, easily and cheaply. Azadirachtin has proven to be an effective, versatile bioinsecticide in ground, aerial and systemic applications for the management of several forest pests, particularly sawfly species in high value plantations.

Index terms: Acantholyda erythrocephala, Diprion similis, Neodiprion abietis, Pissodes strobi, Choristoneura fumiferana

[1930] INTERACTIONS BETWEEN BEETLE ATTACK RATE AND PINE TREE DEFENSES PRODUCE POSITIVE DENSITY DEPENDENCE IN DENDROCTONUS FRONTALIS

<u>R.W. Hofstetter</u>¹, M.P. Ayres¹ & P.L Lorio², ¹Dept. of Biological Sciences, Dartmouth College, 202 Gilman Hall, Hanover, NH 03755, USA, E-mail rwh@dartmouth.edu; ²U.S.D.A Southern Research Station, 2500 Shreveport Hwy, Pineville, LA 71360, USA.

The southern pine beetle, Dendroctonus frontalis, is a significant agent of mortality for pines in Mexico and the Southeast United States. The flow of resin from pines is the primary defensive mechanism against *D. frontalis.* However, resin flow is impacted by abiotic conditions and time of year, and differ greatly among individuals. The interaction between the tree resin system and beetle attack behavior influence the population dynamics of D. frontalis. By experimentally altering the attack rates on trees with varying capacity for resin production, we were able to test the hypothesis that the interaction between attacking beetles and pine tree resin systems creates positive density-dependence (Allee effect) in bark beetle populations, which will tend to destabilize beetle population dynamics. As predicted, attack success was highest in trees with the lowest resin flow and the highest landing rate of beetles. There was a threshold of beetle attack rates (around 1.5 beetles/day/dm²) in our study in which resin flow declined and beetles successfully reproduced, and below which resin flow was maintained or even increased and beetles failed to reproduce. Factors that influence attack rates near the attack threshold would have strong effects on population growth rates. The interaction between beetle attack rates and tree resin production appears to produce positive density dependence which tend to destabilize population dynamics.

Index terms: Population dynamics, bark beetles, tree defenses, Allee effect

[1931] CHEMOTAXIS OF SOME SCOLYTIDS AND THEIR PREDATORS TO 4-ALLYLANISOLE AND ETHANOL IN CENTRAL OREGON PINE FORESTS

G. Joseph¹, <u>R. G. Kelsey²</u>, R. W. Peck² & C. G. Niwa², ¹Dept. of Forest Science, Oregon State Univ., Corvallis, OR 97331, USA., current address, Dept. of Crop Science, UAS, GKVK Campus, Bangalore 560065, INDIA; ²U.S. Forest Serv., PNW Research Station, 3200 Jefferson Way, Corvallis, OR 97331, USA, E-mail kelseyr@fsl.orst.edu.

Lindgren multiple funnel traps were set up in central Oregon pine forests to determine the response of scolytid bark beetles to 4-allylanisole (4AA) and ethanol. Traps were baited with three release rates of 4AA (0, 0.6, 4.3 mg/h) and two release rates of ethanol (4.5, 41.4 mg/h) in a 3 x 2 factorial design. All baits had a 1:1 mixture of \Box - and \Box -pinene with a release rate of 11.4 mg/h. Of the 13,396 scolytids caught, *Dendroctonus valens* made up 60%, *Hylurgops* spp. 18.5%, *Ips* spp. 16%, *Hylastes* spp. 1.8%, *Gnathotrichus retusus* 0.9%, and bark beetle predators another 2.8%. Increasing the release rate of ethanol in the absence of 4AA increased the number of most scolytid species caught by 1.5 to 3.7 times confirming its role as an attractant. Ips latidens, Temnochila chlorodia, and Clerid predators were exceptions and did not show a response to higher ethanol release rates. The release of 4AA at the lowest rate inhibited the response of most scolytids, with a significant reduction in G. retusus, Hylastes macer, and Hylurgops porosus when compared to traps without 4AA. The high release rate of 4AA further inhibited the response for most beetles compared to low 4AA. Seven species were significantly deterred by high 4AA including the latter three, and Hylastes longicollis, Hylastes nigrinus, Hylurgops reticulatus, and Ips latidens. Exceptions include Hylurgops subcostulatus which was attracted significantly to both low and high 4AA, and I. pini which was attracted to low and high 4AA, but only in combination with low ethanol. Dendroctonus valens was attracted significantly to the low 4AA, and unaffected by the high 4AA. The predators appeared to be less inhibited by 4AA than most bark beetles. Gnathotrichus retusus and Hylastes longicollis showed the most positive responses to ethanol and they were also strongly inhibited by high 4AA. Although 4AA can deter the response of some secondary bark beetles attracted to ethanol in combination with - and D-pinene, this inhibition could be weakened for certain species by increasing the release rate of ethanol. 4-Allyl- anisole may have some utility for managing the behavior of secondary bark beetles that are most sensitive to this compound.

Index terms: Methyl chavicol, bark beetles, primary attraction, host selection.

[1932] TERMITES (INSECTA: ISOPTERA) IN *EUCALYPTUS* SPP. PLANTATIONS OF THE FOREST EXPERIMENTAL STATION, UNIVERSITY OF SÃO PAULO, IN ANHEMBI, STATE OF SÃO PAULO, BRAZIL

L.K.Junqueira¹ & E. Berti-Filho², ¹ Depto. de Ciências Florestais ESALQ/USP. E-mail: lkjunque@carpa.ciagri.usp.br; ²Depto. de Entomologia, Fitopatologia e Zoologia Agrícola - ESALQ/USP, C.P. 9, 13418-900, Piracicaba, SP. Financial support: CAPES.

Termites are important pests of *Eucalyptus* plantations in Brazil, and considered a limiting factor for the implantation of commercial forests, because they attack from seedlings to adult trees. This research was carried out to determine the percentage of seedlings killed by the termites species and to survey the termite species occurring in two *Eucalyptus* plantations (area 1 - *E. saligna*, area 2 - *E. urophylla* x *E. grandis*) of the Forest Experimental Station of the University of São Paulo, in Anhembi, State of São Paulo, Brazil. A total of 9,198 seedlings were found attacked by the termites and 658 cardboard traps (Termitrap *), distributed in a 9.0 m x 10.0 m spacing, were used for a 3 week period. The results were as follows: Area 1 (*E. saligna*) - 11.08% of dead seedlings and 4,29% of cardboard with termites (*Embiratermes* sp., *Cornitermes* sp. and *Heterotermes tenuis*); Area 2 (*E. urophylla* x *E. grandis*) - 9.15% of dead seedlings and 2.09% of cardboard with termites (*Cornitermes cunulans*, *H. tenuis*, and specimens of the Subfamily Apicotermitinae). It is suggested that the cardboard traps do not show the same efficiency observed in the agricultural areas, because in forested areas there are roots, remainings of bark and wood which are more attractive to the termites. Index terms: eucalipts, termites, sampling, traps

[1933] ATTRACTION OF SCOLYTUS UNISPINOSUS BARK BEETLES TO WATER-STRESSED BRANCHES OF DOUGLAS-FIR CONTAINING ETHANOL

R. G. Kelsev¹ & G. Joseph², ¹U.S. Forest Serv., PNW Research Station, 3200 Jefferson Way, Corvallis, OR 97331, USA, E-mail kelseyr@fsl.orst.edu; ²Dept. of Forest Science, Oregon State Univ., Corvallis, OR 97331, USA., current address, Dept. of Crop Science, UAS, GKVK Campus, Bangalore 560065, INDIA.

Three similar-sized branches on each of seven Douglas-fir (Pseudotsugae menziesii) trees with a southern exposure were selected randomly to receive a water-stress, defoliation, or control treatment. Water-stressed branches were prepared by freezing them at the base with dry ice. Defoliated branches were also frozen with dry ice, but all secondary branches and needles were immediately removed to eliminate transpiration and minimize water loss. All water-stressed branches were attacked by Scolvtus unispinosus at 12 to 24 days after imposing treatments, resulting in a significantly higher density of gallery holes (107 m⁻²) than in the defoliated or control branches, which were not attacked. Needles and woody tissues from stressed branches, sampled after being attacked, contained significantly higher ethanol concentrations (2.91 to $15.26 \square mol g^{-1}$ fresh wt.) than tissue from defoliated or control branches (0.005 to 0.12 [mol g1 fresh wt.), which did not differ from each other. The water content in woody tissues and needles of stressed branches was 40.9 and 28.1% of the amount in control branches, respectively, when sampled for ethanol analysis. Woody tissues in defoliated branches remained moist, with 91.3% of the water in controls. Drying needles from water-stressed branches lost 18.3 to 33.7% of their total monoterpenes compared to needles on the controls. The mechanism for ethanol synthesis in water-stressed branches appears to be distinctly different from that of logs overwintering on the forest floor. Ethanol synthesis in stressed branches probably was initiated by cytoplasmic acidification as a result of damage to cellular membranes from drying and heating. Ethanol that accumulated in needles and woody tissues of stressed branches functioned as a primary host attractant for S. unispinosus at our Willamette Valley, Oregon, site.

Index terms: host selection, primary attraction, kairomones, ethanol, Scolytidae.

[1934] ARTIFICIAL REARING OF AN AMBROSIA BEETLE, *PLATYPUS QUERCIVORUS* (COLEOPTERA: PLATYPODIDAE) ON BOLTS OF A DECIDUOUS OAK, *QUERCUS SERRATA*

H. Kitajima, Dept. of Forest Biology, Forestry and Forest Products Res. Inst., Kukizaki, Inashiki, Ibaraki-Pref., 305-8687, Japan, E-mail kitajima@ffpri.affrc.go.jp

The ambrosia beetle Platypus quercivorus is a pest of oak and other broad-leaved trees and is a supposed vector of a pathogenic fungus causing mass mortality of oak trees in Japan. A method of inducing P. quercivorus adults to initiate reproduction in bolts (50 cm long, 6.7 to 12.0 cm long) of a deciduous oak, Quercus serrata, one of the host species of the beetle, was developed. Used individuals were new adults that had emerged from attacked trees of Q. mongolica. One soaked bolt immersed in water for 10 to 15 days under a condition of 25°C 16L8D and a unsoaked bolt stored at 5°C were put in three plastic boxes (41×70×35cm), and kept at the same condition. Fifteen adult males were released into each plastic box, then the number of holes bored by the males was counted daily for one week. A mean of 26±5(SE) % of the released males initiated holes on the soaked bolt, while no males attacked the unsoaked one. The rate increased to 78±3 % by placing the soaked bolt on wet bog moss spread on the bottom of the plastic cases. A single virgin female was introduced into the entrance of holes with living males to induce copulation. Copulation occurred at 55 and 83% of the tested holes on the 3rd and 4th day after the males initiated them. In cases where copulation did not occur, introduced females paid no attention to the holes or males rejected copulating with females. Therefore, the best time of introduction of the female was the 4th day after the male initiated a hole. After 30 days from introduction of females, one bolt with 11 holes each with a pair of adults was dissected and development of progeny was investigated. The 11 pairs had excavated galleries, and ten of them had a large number of eggs and 1st to 5th instar larvae in the galleries. These results indicate the possibility of rearing P. quercivorus under artificial conditions.

Index terms: soaked bolt, male induction, copulation, development of progeny.

Symposium and Poster Session

[1935] MAIN INSECT FOREST PESTS AFFECTING PINES IN THE PATAGONIA ARGENTINA

P. Klasmer¹, E.N. Botto², J.C. Corley³, J.M. Villacide³ & V.F. Arhex³, ¹ INTA, El Bolsón, (8430), Rio Negro, Argentina.; ²INTA, IMYZA, CNIA, (1712) Castelar, Buenos Aires, Argentina. ³INTA, S. C. de Bariloche, (8400), Rio Negro, Argentina.

Insect forest pests are the main adversities affecting pines production in the Patagonia region of Argentina. Among the different insects causing damage to pine plantations only two exotic pest are really relevant due to its economical impact, the siricid woodwasp Sirex noctilio (Hymenoptera: Siricidae) and the european pine shoot moth Rhyacionia buoliana. (Lepidoptera: Tortricidae). S. noctilio (SN) was accidentally introduced in the Patagonia in 1989 and detected in plantations in 1993. It is at present well established and spreading slowly in the area nearby San Carlos de Bariloche (province of Rio Negro). Bioecological studies started in 1993 revealed that the pest could have a one, a two or a three years generation as well as Ibalia leucospoides (Hymenoptera: Ibaliidae), a natural enemy of SN, introduced into the area simultaneously with the woodwasp. Although population levels of SN are not significantly high its sole presence and its potential to kill live trees became a real threat to the promoted forest production in the region. Therefore biological control strategies based on the use of the above mentioned I. leucospoides, the recently introduced nematode Deladenus siricidicola (Nematoda: Neotylenchidae) and the exotic entomophagous parasitoids Rhyssa sp. and Megarhyssa sp. (Hymenoptera: Ichneumonidae) has been started. The european pine shoot moth (EPSM) became a pest to the pines in the Patagonia in 1981. At present this insect is well established in the provinces of Chubut, Neuquen and Rio Negro. In this region EPSM has only one generation per year (univoltine pest). Despite population levels recorded for EPSM in the Patagonia are not as high as those observed in other countries (i.e., Chile), this pest accounted for the 20% to 30% damage assessed in most pine plantations surveyed. Fortunately EPSM is being naturally attacked by a set of entomophagous parasitoids acting on different life stages of the moth: *Trichogramma* sp. (Hymenoptera: Trichogrammatidae) on eggs, Orgilus obscurator (Hymenoptera: Ichneumonidae) on larvae and Coccigomymus fuscipes (Hymenoptera: Braconidae) on pupae. The role of these biological control agents as well as the performance of the introduced egg parasitoid Trichogramma nerudai, are being evaluated to be used in biocontrol strategies.

[1936] PERFORMANCE OF NEEDLE-FEEDING INSECTS ON SCOTS PINES EXPOSED TO DROUGHT AND NUTRIENT STRESS

M. Kyto, Finnish Forest Research Institute, Vantaa Research Centre, P.O.Box 18, FIN-01301 Vantaa, Finland, E-mail maarit.kyto@metla.fi.

11-year-old Scots pines growing on a forest site with limited nutrient availability were subjected to four different treatment combinations consisting of water deprivation/natural water availability and NP-fertilization/natural nutrient availability. Pine sawfly (*Diprion pini*) larvae and grey pine aphids (*Schizolachnus pinet*) were reared on the trees in two consecutive years to study the effects of host tree stress on their performance. The treatments clearly affected tree growth, the concentrations of nitrogen and annino acids in the needles, and the carbon-nutrient ratio. Effects on starch and sugar concentrations of the needles were less marked, and the resin acid concentration was unaffected by the treatments. Results from the insect rearing experiments (sawfly cocon size, diapause, and egg-production; aphid survival and reproduction rate) are presented and discussed. Index terms: *Diprion pini*, *Schizolachnus pineti*, *Pinus sylvestris*, resistance, defoliator [1937] CHEMICAL PROTECTION OF *EUCALYPTUS* SEEDLINGS FOR LEAF CUTTING ANT DAMAGE

D. Link. Centro de Ciencias Rurais-UFSM. Cidade Universitaria, Predio 42, Santa Maria, RS. 97105-900 Brasil.

The leaf cutting ants are the most important defoliators of the cultivated forest trees in Brazil. A search was made to evaluate the effects of chemical products against leaf cutting ant damage on *Eucalyptus* seedlings after field planting. The defoliation caused by the leaf cutting ant, *Acromyrmex crassispinus* can give rise to the seedling death. Seedlings were sprayed with 0.7, 1.05, 1.4 and 2.1g a.i. of Thiamethoxam; 1.4, 2.1, 2.8 and 3.5g a.i; of Imidacloprid; 0.7 and 3.3g a.i. of Acetamiprid; 0.7, 1.05 and 1.75g a.i. of Thiodicarb; 1.6 and 2.4g a.j. of Fipronil and water (check). Each treatment was sprayed on 1,000 seedlings before field planting. Two check treatments were used, one with *E. saligna* seedlings and another with *E. camaldulensis*. 1 20g1033 Each two or three days the experimental area was examinated and annotated the data of damaged seedlings and ant nests. Thiamethoxam, Imidacloprid and Acetamiprid shielded the seedling a month. The defoliation at check treatments changed of 4.7% in *E. saligna* at 13.5% in *E. camaldulensis*. Index trems: *Acromyrmex crassispinus*, cultivated forest, pesticides, losses

[1938] SPATIAL DISTRIBUTION OF NESTS OF THE LEAF CUTTING ANT ATTA SEXDENS RUBROPILOSA (HYMENOPTERA: FORMICIDAE) IN PLANTATIONS OF EUCALYPTUS UROPHYLLA IN BRAZIL

E. T. Lopes¹, <u>J. C. Zanuncio²</u>, L. Couto¹ & D. Pratissoli³, ¹ Dep. de Engenharia Florestal, Univ. Federal de Viçosa, 36.571-000 Viçosa, MG, BRAZIL. ² Dep. de Biologia Animal, Univ. Federal de Viçosa, 36.571-000 Viçosa, MG, BRAZIL. E-mail: zanuncio@mail.ufv.br. ³ Dep. de Fitossanidade, Univ. Federal do Espirito Santo, 29.500-000, Alegre, ES, BRAZIL.

Atta and Acromyrmex (Hymenoptera: Formicidae) leaf cutting ants are important pests in Brazil because they are adapted to the majority of ecosystems in this country specially to those disturbed by activities of human being. This research was developed in June and July 1998 in Montes Claros, State of Minas Gerais, Brazil in ten blocks of a 72 months old *Eucalyptus urophylla* plantation with 365.4 hectares. This region presents average altitude of 630 meters, Latitude of 16° 43' 32" South, Longitude of 43° 51' 52" West and tropical hot dry climate with temperatures between 25° and 40° in the summer. Mean rainfall is 1,000 mm concentrated mainly in November and December with an average relative humidity of 65.0%. All ant colonies of the leaf cutting ant Atta sexdens rubropilosa (Hymenoptera: Formicidae) were identified, mapped and their areas were measured considering the largest length and width of each ant colony besides their respective distance from the nearest border of each block of Eucalyptus. After this a fog equipment was used to find the number of ant holes per ant colony. All ant colonies of this leaf cutting ant were distributed in classes according to their location from the border of each block of *Eucalyptus*. A total of 222 ant colonies of *A. sexdens rubropilosa* was found with largest percentages of ant colonies, total area of ant colony and number of ant holes in the classes from 0.0 to 10.0 meters with respectively, 29.3%; 22.7% and 10.3% for each of these parameters. If a total of 20.0%; 40.0%; 60.0%; 80.0% and 100.0% of ant colonies of this leaf cutting is controlled in this area of Eucalyptus the total area controlled would be 64.00; 113.70; 179.70; 240.30 and 319.10 hectares, respectively, out of 365.40 hectares. The knowledge of the spatial distribution of ant colonies of A. sexdens rubropilosa in plantations of Eucalyptus could allow the control of this pest in strips inside their border thus reducing labour costs and amount of insecticides in the environment. Index terms: Atta sexdens rubropilosa, spatial distribution, monitoring, reforestation

[1939] APPLICATION OF A GEOGRAPHICAL INFORMATION SYSTEM TO THE STUDY OF SIREX NOCTILIO (IIYMENOPTERA-SIRICIDAE) IN CALAMUCHITA VALLEY, CÓRDOBA, ARGENTINA

A. Lopez¹; M. Demaestri; E. Zupan; G. Moretti; O. Barotto; J. Gonzáles & G. Balbi, Univ. Nac de Río Cuarto-R. N. 36 km 601-5800 Río Cuarto- Argentina. E-mail: alopez@ayv.unrc.edu.ar

Since 1996 work was carned out at the University of Rio Cuarto, Argentina, using a System of Geographical Information (SIG) to gather knowledge about presence, distribution and severity of damage made by the "Pine Borer Wasp" (Sirex noctilio F.)in Calamuchita Valley. This methodology has not been applied previously in this country. Its importance rest on the benefit of making possible the ordinately assembling of a great number of data for processing, modyfying, amplifying, and combining them at will. Feeding a data base with damage percentages obtained in several locations, insect outbreaks development and stabilization, and age of forested areas, would allow to analyze the yearly evolution of S. noctilio in the region with the aim to establish a strategy of management of the pest. The area of study consist of 36.200 forested hectareas with 31.125 of Pinus elliottii being the rest been planted with P. taeda and P. radiata. Seven operational areas were established according to the geographical location, planimetric surface (has.), age of trees over 10 years old, and management of the forest. To quantify the grade of outbreaks permanent transects were utilized. In each operational area three sample seasons were fixed up with at least two transects, of 200 trees long. These trees were distributed into two contiguous lines running through different landscapes (lowland, hillside, and hill). Monitoring data were used to feed the SIG made up of two different data base frames: spatial and thematic information. The graphical outcomes are analog maps made up by means visual analysis of fhotogramas, scale 1:50.000, digital processing of satellite image analysis LandSat TM 5 and generation of thematic maps. To digitalize the analog information the vectorial system ARC/INFO was applied. Database were created using the entity-relation model with Visual dBASE, 1995 software. The information is cartographically modelled with the ARCVIEW software, using the digital obervation provided by the "Atlas del Suelo INTA, 1995".

[1940]ANALYSIS OF THE DEGRADATION OF THE WOOD OF SIX FOREST SPECIES FOR SCOLYTIDAE (COLEOPTERA)

A. M. Lunz¹ & A. G. Carvalho¹, ¹Depto. Produtos Florestais, Univ. Fed. Rural do Rio de Janeiro, Seropédica, RJ 23851-970, Brasil. E-mail: amehl@zipmail.com.br

The field rehearsals are valid in the evaluation certain arboreal species when exposed to the action of degradation agents. Bodies of test of standardized dimensions were put outdoors so that, through periodic inspections, it was possible to observe the degradation of the wood. Among the degradation agents are the coleopterans of the family Scolytidae. that attack wounded and recently abated trees. The study was driven in the period of September 11, 1998 to April 2, 1999, in the campus of the Universidade Federal Rural do Rio de Janeiro, in a total of twelve collections. This work had as objective to verify the attraction degree of wood of six forest species when exposed to the atmosphere, using a methodology similar to the rehearsal of traditional field. The following species were chosen: Clitoria fairchildiana (sombreiro), Samanea saman, Gmelina arborea, Lophantera lactescens (lanterneira), Mimosa caesalpinaefolia (sabiá) and Eucalyptus citriodora. Ten bodies of test of each species were cut, measuring 1,20 m of length and with medium diameter of 17 cm. After the beginning of the exhibition, evaluations were weekly accomplished to register of the beginning of the attack of the insects. Samples of 10 cm of length were removed of each test body, biweekly, after having been verified that the attack had begun. One of the variables analyzed in the retired samples in the field was

(1941) DIVERSITY AND ABUNDANCE OF BEES IN AN ARAUCARIA FOREST OF RIO GRANDE DO SUL, BRAZIL

Birgit Harter Marques 1.2, 1 LPB, PUCRS, 90619-900 Porto Alegre, RS, Brazil, e-mail biggi@pucrs.br; ²Zool. Inst., Univ. of Tübingen, 72076 Tübingen, Germany.

The south Brazilian Araucaria forest is part of the Atlantic rain forest biom. This special type of forest is mainly found at higher altitudes. Originally it covered most of the upper mountain ranges from Minas Gerais and Rio de Janeiro to Rio Grande do Sul. Massive clearings during the past decades have left only small remnants of this ecosystem. In an Araucaria forest reserve of 4,500 ha located on the Serra Geral at 30° S comprising primary and secondary forest as well shrub and grassland areas, the effect of habitat fragmentation on the apifauna and the melittophilous flora was studied over a period of four years. Bees of nearly 200 species were recorded visiting flowers of also about 200 species of plants belonging to 53 families. Within the bee sample, the halictides represented the greatest α -diversity, followed by anthophorides, megachilides, and renides and colletides. Only 15 species of Apidae were recorded. Bee of about 1/3 of the species were observed on flowering plants in all the different habitats. Others occurred only in the forest or in the secondary vegetation. Foraging stingless bees were the most abundant flower visitors, especially in arboreus habitats. In the open grassland halictids were the dominating foragers. There was some correlation in species richness between the taxa of abundant bees and the families of mainly exploited plants. Within these melittophilous plants, asteracean shrubs were the most important nectar and pollen sources. There impact as pioneer elements in the succession of natural Araucaria forest regeneration and the role of a highly divers bee community in angiosperm pollination in this ecosystem is discussed. Index terms: Araucaria forest, bee diversity, melittophilous plants, ecosystem analysis.

[1942] USDA FOREST SERVICE FOREST HEALTH PROTECTION INTERNATIONAL PARTNERSHIPS AND ACTIVITIES

J. D. McMillin¹ & D. B. Twardus², ¹USDA Forest Service, Forest Health Management, Rapid City, SD 57702, USA, E-mail jmcmilli/r2_blackhills@fs.fed.us; ²USDA Forest Service, Forest Health Protection, Morgantown, WV 26505, USA.

The USDA Forest Service Forest Health Protection (FHP) provides assistance in the identification, monitoring, and management of insects and diseases on federal, state and private lands in the United States. Because of trade agreements, the ease of travel between countries, increased demands worldwide on forest resources, and the threat of exotic insects and diseases to native forests, FHP is also actively involved in the international arena. An International Activity Plan guides FHP international activities. Goals of the Plan and examples of FHP projects toward meeting these goals include: Goal 1. U.S. Forests are protected from exotic pests. Includes reviewing and supporting regulatory laws, policies, and programs. And, identifying and developing technologies to assist in protecting U.S. forests. This latter effort has included: cooperative port monitoring in the Russian Far East for Asian gypsy moth, investigating potential natural enemies of the common pine shoot beetle, and identifying semiochemicals for use in detection of Asian long-horned beetle. Goal 2. North American countries have strong forest pest management programs. This includes developing cooperative projects, sharing technical expertise, and enhancing working relationships. For example, aerial survey detection training has been provided to strengthen the Mexican pest management program. Goal 3. Biological control options are in place to protect forests from exotic pests. Objectives include increasing our knowledge of biological control techniques and where feasible developing and implementing biological control programs. A biological control program for hemlock wooly adelgid is currently underway in the eastern U.S. In addition, efforts to coordinate a biological control program for mealybug in the Peoples Republic of China is in progress. Goal 4. Forest health technology and expertise are shared worldwide. Technical assistance has been made available including the evaluation of remote sensing needs and capabilities of detecting Sirex in Brazil, providing assistance in aerial application for gypsy moth suppression in Bulgaria, and hosting visiting scientists for the purpose of sharing information and technology. These examples are only a few of the more than 65 projects in 20 countries that FHP has participated in over the last two years. FHP international activity partners include the participating countries, the UNFAO, USAID, USDA Forest Service International Programs and APHIS. USDA FS Forest Health Protection continues to explore opportunities for additional partnerships and activities worldwide.

Index terms: Forest health management, international forestry

the number of perforations done by the insects. A total of 1497 perforations were counted, being almost whole done by Scolytidae. The action of another families of wood-boring beetles was verified in the presence of perforations and typical galleries of Bostrichidae and Platypodidae, besides some postures, galleries and holes of emergency of Cerambycidae. The species C. fairchildiana were more attacked, with 731 perforations (48,83%), proceeded by S. saman, with 458 (30,59%); E. citriodora, with 179 (11,96%); M. caesalpinaefolia, with 84 (5,61%); L. lactescens, with 26 (1,74%), and Gmelina arborea, with just 19 perforations (1,27%). The percentage of perforation of the first two species was superior significantly to the others at level of 5% of probabilities. This presupposes physical and chemical properties especially adapted to the development of those agents degradadores in these two species, or still, they can liberate attractive chemical components to the insects in larger amount than the other wood, demanding larger attention to avoid an accentuated degradation when exposed in the field. Index terms: Test bodies, Perfurations, Cerambycidae, Bostrichidae, Platypodidae
[1943] IMPACTS OF DOUGLAS-FIR BEETLE ON FOREST OVERSTORY AND UNDERSTORY CONDITIONS OF THE GREATER YELLOWSTONE AREA

J. D. McMillin¹ & K. K. Allen¹, ¹USDA Forest Service, Forest Health Management, Rapid City, SD 57702, USA, E-mail jmcmilli/r2_blackhills@fs.fed.us.

Douglas-fir beetle (Dendroctonus pseudotsugae) infestations frequently result from disturbance events that create large volumes of weakened Douglas-fir (Pseudotsuga menziesii) trees. Although research has focused on determining the susceptibility of forest stands to Douglas-fir beetle and predicting the amount of tree mortality caused by Douglas-fir beetle infestations following disturbance events, there has been an inadequate amount of work on consequent changes in both the overstory and understory. In the early 1990's, populations of Douglas-fir beetle increased in fire-scorched trees and then infested undamaged neighboring stands on the Shoshone National Forest, Wyoming, U.S.A. In 1999, transect sampling (32 km) and 25 pairs of previously infested and uninfested plots were used to quantify changes in forest stand conditions and subsequent responses in the understory caused by Douglas-fir beetle infestations. Significant effects of the Douglas-fir beetle infestation included: 1) Basal area was reduced by 40 - 70 percent, average tree diameter decreased by 8 - 40 percent, and the Douglas-fir component of the overstory decreased by more than 15 percent. 2) Conifer seedling regeneration increased nearly four-fold in the infested plots and 90 percent of the regeneration was Douglas-fir. 3) The understory vegetation (forbs, grass, and shrubs) had a three-fold increase in the infested plots compared with uninfested plots. In addition, basal area of Douglas-fir killed by the Douglas-fir beetle was significantly correlated with initial Douglas-fir basal area and percent of Douglas-fir, but not tree diameter or trees per hectare. Significant inverse relationships were also found between post-infestation basal area and the abundance of forbs, grass, shrubs, and understory height. Douglas-fir beetle infestations are causing significant short-term impacts in both the overstory and understory and contributing to the mosaic in forest structure observed in the Shoshone National Forest.

Index terms: Bark beetles, Dendroctonus pseudotsugae, forest succession, insect impact

[1945] IMPACT OF DEFOLIATION BY COSTALIMAITA FERRUGINEA (COLEOPTERA: CHRYSOMELIDAE) IN EUCALYPTUS GRANDIS

J. E. P. Mendes¹, N. Anjos¹ & F. R. A. de Camargo², ¹Dept. of Animal Biology (Entomology), Universidade Federal de Viçosa, P. H. Rolfs Avenue, n/w. Zip code 36571-000, Viçosa - MG, Brazil. E-Mail: jmendes@alunos.ufv.br. ²Votorantim Celulose e Papel, Dept. Research Unity Jacaref, H. Gal. Euryale de Jesus Zerbine, Km 84, Zip Code 12300-000, Jacaref - SP, Brazil.

The objectives of this work was evaluate the population dynamics and the injuries caused by Costalimaita ferruginea, as well as the consequences of its attack on a young plantation of Eucalyptus grandis, in Pindamonhangaba, São Paulo State, Brazil. The worst focus technique was used throughout the period of study as the monitoring system of the C. ferruginea population dynamics at Votorantim Celulose e Papel. An experiment was carried out soon after the end of the outbreak, to evaluate the consequences of the attack, where three pest attack intensities were evaluated as well as a control. The experimental design used was in random blocks, with five repetitions. It was measured the diameters of the trunk at 20 cm and 1,30 m of the soil, the height and the survival of the trees at four time intervals after the attack. The wood volume was calculated and the relationships among the growths in diameter and height, were studied besides the distributions of frequencies of diameters and height. The obtained data were submitted the regression analysis and the models compared by the test of F (p≤0,05). The quality of the trees 12 months after the attack were also evaluated. Tukey's multiple range test (p≤0,05) was used to compare the quality of the trees and frequency distribution. The injuries happened from the apex to the base of the canopy and they increased with time. The impacts on the growth and production of the trees increased, proportionally, with the different intensities of attack of the pest and with time. Which ranged from 2,38 and 13,93%, for DA20; 2,63 and 13,47% for DAP; 1,35 and 10,34% for height and, 4,28 and 28,45% for the wood volume 24 months after the attack. The rate of trunk diameter growth (DA20/DAP), as well as the rates between height and diameters (H/DA20 and H/DAP) were only altered by the largest attack intensity. The frequency distributions were altered with the attack intensity, altering the dynamics of the plantation growth. The trees more intensely attacked were more tortuous and suffered alterations in the process of natural disbudding, and they also had an increase in mortality and decrease in the volumetric production. Therefore, Costalimaita ferruginea is a pest of great importance for young plantations of eucalypts. Index terms: forestry insects, leaf beetle, Integrated management, eucalypts, defoliation

[1944] NEW RECORDS OF COLEOPTERA AND HYMENOPTERA FROM ARAUCARIA ANGUSTIFOLIA TREES IN THE SOUTH OF BRAZIL

<u>R. Mecke^{1,2}</u>, W. Engels² & M. H. M. Galileo³, ¹Lab. Pesq. Biol., Pontificia Univ. Católica, P. O. Box 1429, Porto Alegre, RS, 90619-900, Brazil; ²Zoolog. Inst., Univ. Tübingen, Auf der Morgenstelle 28, 72076 Tübingen, Germany, E-mail roland.mecke@tonline.de; ³Mus. Ciênc. Nat., Fundação Zoobot., P. O. Box 1188, Porto Alegre, RS, 90001-970, Brazil.

During a reforestation research project looking for more efficient methods to restore the South-Brazilian araucarian forests, the insect fauna associated with the parana pine (Araucaria angustifolia) has been investigated. The study has been realized in the area of 'Centro de Pesquisas e Conservação da Natureza Pró-Mata" of the Pontifícia Universidade Católica do Rio Grande do Sul (Porto Alegre, RS, Brazil), located on the Serra Geral at S 29° 28', W 50° 10'. A special interest was given to the Coleoptera and Hymenoptera developing under the bark, in the wood or in the reproductive organs of A. angustifolia and also to the predators of these insects. To extract the insects from the plant material (wood, male and female cones) photoeclectors have been used. Additionally larvae, pupae and adults have been collected by hand. The collected phytophagous, entomophagous and parasitic insects belong to the families Alleculidae, Brentidae, Buprestidae, Cerambycidae, Cleridae, Curculionidae, Melandryidae, Nemonychidae, Oedemeridae, Ostomatidae, Platypodidae, Scolytidae, Silvanidae (Coleoptera), Braconidae, Ichneumonidae, Orussidae, Xiphydriidae (Hymenoptera). Altogether there have been found more than 20 new records of Coleoptera and Hymenoptera species for the parana pine, at least 3 of them being new species. For the first time a wood-boring sawfly species (Hymenoptera: Xiphydriidae) has been recorded developing in branches of araucaria trees. There could be reared a large series of this species which now gives the possibility to describe the intraspecific variation of a neotropical xiphydriid wasp. Furthermore the relationships between some wood-boring Coleoptera (Cerambycidae, Curculionidae, Scolytidae) and their natural antagonists (Brentidae, Cleridae, Ostomatidae, Braconidae, Ichneumonidae) have been analysed.

Index terms: forest entomology, reforestation, parana pine, biological control.

[1946] EFFICIENCY OF GRANULATED SYSTEMIC INSECTICIDES TO ELIMINATE THE *COPTOTERMES HAVILANDI* COLONIES ATTACKING ROOTS OF TREES

E. B. Menczes¹, L. O. Andrade¹, A. C. Bicalho¹, G. T. Araújo¹ & E. L. Aguiar-Menczes², ¹CIMP "CRG"/ UFRRJ, BR 465, km 7, Seropédica, RI 23890-000, Brazil, Email ebmen@zaz.com.br; ²Embrapa Agrobiologia, Caixa Postal 74505, Seropédica, RJ 23840-000, Brazil, E-mail menczes@cnpab.embrapa.br.

The subterranean termite Coptotermes havilandi is an exotic species and considerate the worse pest in urban, suburban and rural areas of Brazil. However, the real concentration is in the metropolis like São Paulo, Rio de Janeiro and Niterói. This pest are adapted to the residential buildings, commercial buildings, fabrics, etc. The occurrence of this pest has been found attacking root system of trees that are used as shade and/or ornamental plants in the streets, avenues, parking lots, and as fruit trees in the backyards of houses. This present research had as objective to verify the efficiency of four systemic insecticides used in the granulated formulation applied in the soil to control C. havilandi. The insecticides used were never indicated and registered to control the infestation of C. havilandi in any circumstances. Preliminary observations showed that the infestation of the roots of the majority of the trees, when isolated or not, is very frequent. In such case, four insecticides of the toxicological class I were chosen to analysis their efficacy as contact, stomach or fumigant products against this species. Aldicarb 150G, carbofuran 50G, termophos 50G and carbosulfan 50G were used in the dosages recommended to control the coffee pests by the manufacturers. Five different species of native trees and five exotic trees were chosen for treatment. The native trees were: cashew (Anacardium ocidentali); jobo plum (Spondia venulosa); pinecone (Rollinia mucosa); guava (Psidium guajava); and Clitoria faschildiana (shade tree). The exotic ones were: flamboyant (Delonix spp.); eucalyptus (Eucaliptus spp.); Casuarina spp.; mango (Mangifera indica); and avocado (Persia americana). Before the treatments, we used monitoring stakes for detecting the presence of the termites. Although we had suspected of the presence of the nests in the root system, the method used for inspection was not enough to detect them. The four insecticides used showed 100% of efficiency, destroying the colonies completely in a short time. However, aldicarb 150G showed to be more efficient than the others in relation to the its time of action. It killed C. havilandi in 24 hours after the application, while the others had their action delayed (48 hours). However, there was no significant difference among the treatments.

Index terms: subterranean termite, chemical control

[1947] PRELIMINARY INVENTORY OF ARBOREAL INSECTS IN SANTA MARIA, RS, BRAZIL

A. B. B. Morais, Depto. de Biologia, CCNE, Universidade Federal de Santa Maria, 97105-900, Santa Maria, RS, Brasil e-mail: amorais@ccne.ufsm.br

Santa Maria city is localized in the transition zone between Brazilian Meridional Plain and Central Depression, in the state of Rio Grande do Sul. The subtropical forest, originally covering the highest localities, is now fragmented and differentialy modified by human settlement. The present study aims to obtain a preliminary inventory of arboreal insects and evaluate them as bioindicators of ambiental disturbance. Three field places were visited from March 1998 to February 1999: Cidade dos Meninos, Perau Velho and São Marcos. Insects were collected by use of a beating umbrella and conserved in 70° alcohol. From 5805 insects collected, 2074 in 15 Orders (35.73%) were from CM, 1940 in 12 Orders (33.42%) were from PV, and 1791 in 15 Orders were from SM. CM is the place with the greatest vegetation coverture from the three field places while SM is the smallest and more disturbed what could have influenced on the less frequency of insects collected in the later. Four Orders summed 78.59% of all insects: the O. Lepidoptera was the most abundant (1641 individuals, mostly larvae -28.27%), followed by O. Coleoptera (1166 individuals - 20.09%), O. Hymenoptera (997 individuals, mostly ants - 17.17%), and O. Heteroptera (758 individuals - 13.06%). By place, in CM O. Lepidoptera was the most abundant, followed by O. Hymenoptera, O. Coleoptera and O. Heteroptera; in PV O. Lepidoptera was the most abundant, followed by O. Coleoptera, O. Heteroptera, and O. Hymenoptera; and in SM O. Coleoptera was the most abundant, followed by O. Lepidoptera, O. Hymenoptera, and O. Heteroptera. O. Psocoptera had higher frequency (n=162) in SM than in CM (n=95) and PV (n=49). In conclusion, it seems that insects could have a good potential to be used as disturbance bioindicators.

Index terms: Lepidoptera; Coleoptera; Hymenoptera; Heteroptera; bioindicators.

[1949] CONSUMPTION AND UTILIZATION OF THREE SPECIES OF EUCALYPTUS BY THYRINTEINA ARNOBIA (LEPIDOPTERA: GEOMETRIDAE)

A.L.T. Oltati¹ & <u>C.F. Wilcken¹</u>, ¹Dept. Plant Production, FCA/UNESP, Campus of Botucatu, P.O. Box 237, Botucatu, SP, 18603-970, Brazil, E-mail: aottati@fca.unesp.br

Food intake and utilization indices are indicators of an insect's alimentary behavior and some of its relationships with respective host plants. Thyrinteina arnobia is considered one of the most important Eucalyptus pests in Brazil. This experiment was conducted considering the economic importance of this defoliator and the need of alternative means of its control (other than the chemical). The main objective was to compare the above mentioned indices in insects fed with three Eucalyptus species (E. camaldulensis, E. dunnii and E. urophylla), for two consecutive generations. Leaves used in the experiment were collected at the FCA/UNESP (Botucatu, São Paulo state) campus and the studies were cariied out at the Entomology Laboratory of the Plant Production Department (FCA/UNESP). under a temperature of 25 \pm 1^o C, relative humidity of 70 \pm 5% and photophase of 13 hours. The experimental design was a completeley randomized design, with 3 treatments and 100 replications. Data were submitted to analysis of variance and means separated by Tukey test. Results showed that the relative consumption rate (RCR), the efficiency of conversion of ingested food (ECI) and digested food (ECD) were not influenced by the three host plant species. The relative growth rate (RGR), relative metabolic rate (RMR) and approximate digestibility (AD) were lowest for the caterpillars fed with *E. urophylla* in the first generation. For the second generation, RCR, RGR, RMR and AD were highest for the caterpiliars fed with *E. camaldulensis* and *E. urophylla*, ECI was similar for the three host plants and ECD was higher under E. dunnii. We also verified that the performance of T. amobia in the second generation under E. dunnii was worser than when compared to the first generation insects; caterpillars fed with E. camaldulensis kept the same performance while insects fed with E. urophylla had in improve in its performance, when compared to their first generation. Index terms: Forest pest, integrated management pest, eucalypt

[1948] EFFICIENCY OF DIFFERENT INSECTICIDES IN CONTROL OF NURSERY FLY SCYTHROPOCHROA SP. (DIPTERA: SCIARIDAE) IN EUCALYPTUS SEEDLINGS

C. Orlato¹, C. F. Wilcken¹, C. C. Ortiz² & J. C. Augusti², 1Dept. of Crop Production, FCA / UNESP – Campus of Botucatu, P. O. Box 237, Botucatu, SP, 18603-970, BR, Email cwilcken@fca.unesp.br; 2Bahia Sul Celulose S.A., Rod. BR 101, Km 880, Teixeira de Freitas, BA, 45995-000, BR.

The flies of family Sciaridae have been occurred since 1990 on many of Brazilian eucalyptus nurseries. Scythropochroa sp. larvae causes damages to the root system of seedlings obtained by vegetative propagation, causing plant mortality. The larvae take 5 mm long in the last instar and it develops in the substratum of the seedlings. This work was carried out at the Bahia Sul Celulose S.A. eucalyptus nursery, in Mucuri - BA -Brazil. Into one of the greenhouses were settled two pest control experiments using manual drench in the substratum as the way of products application: just with one application (test 1) and with two applications (test 2). The insecticides treatments were: Vectobac AS (Bacillus thuringiensis var. israelensis) in the dosages of 280 and 560 ml c. p. /1001 of water (treatments 1 and 2); Trigard 750 PM (Cyromazin) in the dosages of 15 and 30 g of c. p. / 100 l of water (treatments 3 and 4); Decis 25 CE (Deltamethrin) in the dosages of 20 and 40 ml c. p. / 100 l of water (treatments 5 and 6) and the check (treatment 7). Both experiments were carried out in the 10^{th} day after stalking, but one day before (9^{th} (ay) the attack was previously evaluated. In the test 2, the plots of each treatment with insecticide received the second application, at 7 days after the beginning of the test, using the same first application dosages. Both experiments were evaluated in each 3 days, taking out in random 10 stalks per each tray and verifying the larvae number and its level of damage in each stake. The statistical delineation used for each experiment was randomized, with 7 treatments and 10 repetitions. The obtained results were submitted to the analysis of variance and the averages compared by Tukey's test to the level of 5% of probability. In the test 1, the treatments that were pointed out through rooting period were Vectobac AS 560 ml / 100 l (T2) and Decis 25 CE 40 ml / 100 l (T6), exhibiting respectively at the final control evaluation 77,9 % and 62,3 % of efficiency. In the test 2 pointed out Vectobac AS (T2) and Decis 25 CE (T6) again, reaching 100% of control in the evaluations after 9 and 12 days (T6) and 12 and 15 days (T2), of the beginning of the test. In the final evaluation (28 days into greenhouse) was detected the importance of the second application, showing how efficient are the biological insecticide BTi (E = 97,2 %) and deltamethrin (E = 95.5 %).

Index terms: nursery fly, forest nursery, greenhouse, chemical control, biological control.

[1950] MONITORING OF LEPIDOPTERA DEFOLIATORS OF *EUCALYPTUS* IN NIQUELÂNDIA, STATE OF GOIÁS, BRAZIL

J. M. M. Pereira, T. V. Zanuncio, J. C. Zanuncio, & M. A. Guimarães, Dep. de Biologia Animal, Univ. Federal de Viçosa, 36.571-000, Viçosa, MG, BRASIL. E-mail: zanuncio@mail.ufv.br.

Population fluctuation of Lepidoptera primary and secondary pests of *Eucalyptus* was studied in Niquelândia, State of Goiás, Brazil from May 1991 to April 1996. Every fifteen days Lepidoptera species were collected with light traps powered by twelve volt batteries. Ten primary pest species with 3,846.90 individuals and 13 secondary pests with 137.85 individuals per light trap were collected. Most abundant pest species were: primary pests - *Thyrinteina arnobia* (Geometridae), *Sarsina violascens* (Lymantriidae), *Psorocampa denticulata* (Notodontidae); secondary pest species - *Idalus admirabilis* (Arctiidae) and Citheronia marion (Saturniidae); with 2,021.18; 842.27; 421.24; 44.16 and 28.92 individuals per light trap, respectivelly. Highest numbers of individuals of primary pest species were registered from May to June while secondary pest species should be done during this period which can be made with different methods such as cloths under *Eucalyptus* lpants, light traps or counting the number of caterpillars per branch of those trees. Population of pest species can be detected with these methods allowing a better control of them with less damage to *Eucalyptus* trees.

Index terms: Eucalyptus, Lepidoptera defoliators, monitoring

[1951] MANAGEMENT OF HEADWATER FOREST STREAMS: ISSUES OF INSECT DIVERSITY AND BIOMASS PRODUCTION FOR VERTEBRATE PREDATORS

R. A. Progar & <u>A. R. Moldenke</u>, Dept. of Entomology, Cordley Hall 2046, Oregon State Univ, Corvallis, OR, USA 97331 E-mail: progarr@bcc.orst.edu.

The riparian areas encompassing headwater streams comprise over fifty percent of federally managed land in the Pacific Northwest. Forest management practices and their consequences (for example, compaction or disturbance) are likely to have direct effects on the abundance and diversity of arthropods in these sensitive habitats, and indirect effects through the foodweb on vertebrates of concern. We examined the effect of stream flow (perennial vs. dry-season temporary), and canopy presence on the pre-harvest insect fauna collected from emergence traps in headwater streams at three sites in the conifer forests of western Oregon. Density and biomass of aquatic insects were higher in temporary streams in the spring, but higher in perennial streams during the summer. Taxon richness was continuously higher in perennial streams. The abundance of Chironomidae exceeded all other taxa during the spring, but was largely replaced by Mycetophilidae as the most abundant taxon during the summer, especially in temporary streams. Trichoptera and Ephemeroptera emerged in higher numbers from perennial than from temporary streams. These results are consistent with our hypothesis that the absence of vertebrate predators (fish and giant salamanders) allows the density of arthropods in temporary streams to flourish, serving as: (1) a potential source of colonization for perennial streams and (2) an important role in the terrestrial food web as an abundant food source for insectivorous We also examined the effect of canopy presence vs. clearcut on the insect vertebrates. fauna. Headwater streams flowing through clearcut uplands support higher densities, biomass and richness than forested streams. The proliferation of aquatic insects in headwater streams flowing through clearcuts is presumably due to the increased primary production from increased insolation, and higher diversity of allochthonous detritus. Pitfall sampling on transects perpendicularly across these streams clearly indicated that diversity and abundance are significantly greater at the immediate creek edge and 1-3 meters away within the riparian vegetation zone; all species characteristic of the upland forest floor occurred within the riparian zone as well.

Index terms: riparian management, emergence trapping, temporary stream, aquatic insects

[1952] VERTICAL DISTRIBUTION OF CLOUD FOREST PRONOPHILINAE BUTTERFLIES IN MONTE ZERPA, CORDILLERA DE MERIDA, VENEZUELA

T. W. Pyrcz¹, <u>J. Woitusiak</u>¹, ¹Zoological Museum, Inst. of Zoology, Jagiellonian Univ., R. Ingardena 6, 30-060 Kraków, Poland. E-mail: wojt@zuk.iz.uj.edu.pl

A method of sampling along elevational transects has been used to study vertical distribution of Pronophilinae butterflies (Nymphalidae, Satyrinae) on southern slopes of the Serrania de La Culata in Central part of the Cordillera de Merida, Venezuela, known as Monte Zerpa. Ranges of vertical distribution have been estimated for 20 species on the basis of 1100 records obtained from a series of collection sites set every 25 m from 2250 up to 3050 m. The ranges of only two species, Steromia bega and Erethris porphyria were as wide as the width of the entire cloud forest zone. The ranges of all the other were about 400 m on average. When superimposed on an altitude scale, ranges of Pronophilini revealed a characteristic pattern with the lover pool of species distributed within the zone of 2250-2750 m and the upper pool in the zone of 2500-3050 m. The highest biodiversity was found at middle elevation where ranges of the two pools overlap. Parapatric distribution was found for three pairs of closely related species, where Lymanopoda obsoleta, Pedaliodes montagna and Corades chelonis occured at lower elevations, whilst Lymanopoda dietzi, Pedaliodes ferratilis and Corades pax were replacing them at higher elevations. Possible factors which may play a possible role in the process of vertical range formation and maintainance of parapatric distribution in Pronophilini butterflies are discussed.

Index terms: Andes, altitudinal zones, cloud forest, butterflies, parapatry.

[1953] DEVELOPMENT OF *PSILOPTERA* SP. (COLEOPTERA: BUPRESTIDAE) IN STUMPS OF *PINUS CARIBAEA*, IN THE NORTHEAST REGION OF THE STATE OF BAHIA, BRAZIL

G. T. Ribeiro & J. C. Zanuncio, Dept^e. de Biologia Animal, Univ. Fed. Viçosa, 36571-000, Viçosa, MG, Brasil, E-mail zanuncio@mail.ufv.br.

Psiloptera sp. has been constantly damaging Eucalyptus seedlings of several species in many places of Brazil. Feeding of this insect occurs on the bark, on lateral branches and also on stems of young plants thus reducing their normal growth. Females of Psiloptera usually lay their eggs on the upper extremity of Eucalyptus stumps. After the incubation period larvae of this pest hatch and migrate to the roots or to deeper parts of the stumps. After emergence from the stumps adults of this pest prefer to attack young plants of Eucalyptus. Stumps of *Pinus* trees are preferred by *P. semipunctata* for egg laying and larval development in the northeast area of Bahia where constant attacks and damage by this pest on recently planted seedlings have been recorded. Occurrence of this beetle is, most of the time, associated to areas where Pinus trees were cut. Monitoring in areas with different types of vegetation near to areas with plants attacked or to places where Pinus trees were cut confirmed the presence of pupae and larvae of Psiloptera in stumps of this plant. Recently planted areas showed that the number of beetles increased near areas planted with Pinus. This indicates that plantations with Eucalyptus in areas previously planted with *Pinus* or close to plantations of this tree group are more likely to be attacked by *Psiloptera*. It is suggested that researches should be done aiming to quantify the number of stumps with larvae and the number of larvae of Psiloptera per stump before the use of land for planting. This could identify the occurrence and potential damage by Psiloptera in the area. These studies and others about the biological cycle of this insect can lead to development of better control methods of this pest in the field.

Words key: Wood borer of Eucalyptus and Pinus stumps; Psiloptera; larval development.

[1954] OCCURRENCE OF *PSILOPTERA* SP. (COLEOPTERA: BUPRESTIDAE) DAMAGING PLANTS OF *EUCALYPTUS* SPP., IN THE NORTHEAST REGION OF BAHIA, BRAZIL

G. T. Ribeiro & J. C. Zanuncio, Dept^e. de Biologia Animal, Univ. Fed. Viçosa, 36571-000, Viçosa, MG, Brasil, E-mail zanuncio@mail.ufv.br.

Successive attacks by the beetle Psiloptera sp. has been recorded in the last years in plantations of Eucalyptus in the northeast region of the State of Bahia, Brazil mainly in recently planted seedlings. Adults of this species feeds on bark, on lateral branches and also on young stems of Eucalyptus seedlings causing losses of the apical meristem and thus avoiding the normal development of the plant. Due to the severity of damage, which are not in many cases well evaluated companies with similar problem are adopting hand picking of this insect as a control strategy. During 1998 a total of 592.94 beetles/ha were collected in an area of 1012 hectares. This number was much higher than that of 1999 with 211.0 beetles/ha in an area of 1620 hectares. Such difference between 1998 and 1999 could be related to a higher rainfall during this last year. This could have represented a shorter period after planting for the bug to attack Eucalyptus seedlings. A faster development of seedlings in the field could also reduce the action of the beetles and to decrease damage to plants besides difficulting its location. During hand picking a total of 4.21% of the *Eucalyptus* blocks showed more than 1,000 beetles/ha being 1,215/ha the largest number of beetles collected per hectare; 14.74% of these blocks showed between 500 and 1000 beetles/ha; 42.26% of them had between 100 and 500 beetles/ha; and the remaining 35.79% of the blocks had less than 100 beetles/ha. Hand picking seems to be the best and more viable strategy to control this pest. Besides reducing damage by this pest when they are occurring in the area it can, also reduce risks of future outbreaks due to a sharp reduction of adults of this pest in the area and thus reducing population in the subsequent years. Even though hand picking presents satisfactory results it demands an intense labor activity which can turn it non-viable for large areas.

Words key: Psiloptera; damages in Eucalyptus, Control.

[1955] DESCRIPTION OF LARVAL TUNNELS AND PUPAL CHAMBERS OF CALYDON SUBMETALLICUM IN ROBLE PELLIN OF PATAGONIA, ARGENTINA

S. Rizzuto¹, ¹Cátedra de Zoología Forestal, Facultad de Ingeniería. Univ. Nac. de la Patagonia, Sede Esquel, Sarmiento 849, 9200 Esquel, Chubut, Argentina. E-mail: pautasso@cybersnet.com.ar

Cerambycids are one of the main groups of forest insects because of the damage they cause to the wood. During their development they make tunnels and galleries in the host plant, reaching vital tissues. Nothofagus forests (Deciduous Forest District, Sub-Antarctic Domain) range from Neuquén to Tierra del Fuego, and several species have economic interest; N. antarctica (ñire) and N. pumilio (lenga) are widely distributed. In the north of the district there are N. procera (rault) and N. obliqua (roble pellín) forests; these species have very precious wood. N. dombeyi (coihue) is found in the more humid zones in a narrow fringe close to Chile, in Neuquén, Río Negro and Chubut. These species are used for buildings, furniture or sometimes in posts and as firewood. Although some species of Nothofagus in Patagonia are attacked by cerambycids, there are no inventories and the biology of this group is unknown. This study describes larval tunnels and pupal chambers of Calydon submetallicum in N. obliqua. Dead wood of roble pellín was collected in Trevelin city (42° 06' S, 71° 28' W). It was put into wire cages outdoors for twelve weeks. Imaginal emergence was recorded in summer. Pupal chamber construction in cerambycids is a complex behavior that requires many succesive steps before the larva moves into pupa. Galleries produced by C. submetallicum are subcortical and pupal chambers are internal, constituting part of the sapwood.

Index terms: Cerambycids, Nothofagus obliqua, wood boring insects, Patagonia.

[1957] APHIDS (HOMOPTERA: APHIDIDAE: LACHNINAE: CINARINI) ON PINUS SPP. AND CUPRESSUS SP. IN SOUTHERN BRAZIL

S. M. N. Lazzari & <u>R. C. Zonta de Carvalho</u>, Depto. de Zoologia, Universidade Federal do Paraná, Curitiba, PR, BR. E-mail lazzari@bio.ufpr.br

Recent aphid outbreaks have been registered on Coniferae in southern Brazil, causing significant losses to the forestry, lumbering, and paper mill industry. The Cinarina Cinara pinivora (Wilson) and Cinara atlantica (Wilson) have been collected on Pinus elliotti, P. taeda, and P. caribaea. C. pinivora was first recorded in 1994, feeding preferentially on thicker branches, during the cooler months of the year. It spread from Santa Catarina to Rio Grande do Sul, Paraná, and São Paulo. C. atlantica was first collected in 1998, especially at the branch tips and buds. It has been found year round, in the South Region, São Paulo, and Minas Gerais. These Cinara species differ in a number of ways including the shape of the siphuncular sclerite and sclerotinization of abdominal terga. Other Cinara species on Pinus have been cited for Brazil: Cinara piniformosana (Takahashi), which has not been found lately and Cinara maritimae (Dufour). On Cupressaceae, two specie have been collected: Cinara tujafilina (del Guercio) on Thuja sp. and Cinara cupressi (Buckton) on Cupressus sp. The later was first collected in 1999, in Paraná, and can be distinguished from C. ujafilina by the color of the femur and tibia, and number and distribution of the hairs on the base of the antennal segment VI. The Eulachnina Essigella californica (Essig) and Eulachnus rileyi (Williams) have been observed associated with Cinara colonies on Pinus spp. The Californian pine needle aphid, E. californica, was first recorded in early June 1999, on slash pine P. elliotti and on Mexican weeping pine P. patula, in Paraná. It is characterized by the 5-segmented antennae, tarsal claws with double tips, and lime green color in life. E. rileyi has 6-segmented antennae, normal claws, color varying from dark olive green to gray, with a dusting of bluish-gray wax. Alate and apterous viviparae and nymphs of both species can be found on branch tips feeding on the needles, and moving quite rapidly. The damages of these Cinara species, and probably of the other associated pine species, are more visible after a couple of years of infestation. Chlorosis and premature needle dropping, stunting and malformation of trees, and extensive growing of sooty mold on the honeydew produced by the aphids, have been observed. Another indirect damage of Cinara is caused by the great amount of aphids that stick on collecting panels staining the resin with a reddish pigment. This damage results in loss of commercial value and credibility. Cinara eggs have been collected, although sexual morphs have not been found until the moment. More studies on biology, distribution, host plant-aphid-natural enemies relationships and control strategies are needed.

Index terms: Aphid outbreak; pine aphids; Cinara spp.; Essigella californica; Eulachnus rileyi.

[1956] CONSERVE OR NOT TO CONSERVE FOREST FRAGMENTS: CASE STUDY USING BUTTERFLIES AT THE KENYA COAST

L. M. Rogo, International Centre of Insect Physiology and Ecology, P. O. Box 30772, Nairobi, Kenya. Email: Irogo@icipe.org.

Throughout the tropics, deforestation is destroying the forest resource base, leaving only fragments of forests. A case in point is the eastern coastal forest of Africa, which once stretched from northern Natal to southern Somali. In Kenya only a few large tracks of this forest remain, such as the Arabuko-Sokoke (4,000 hecters) and Shimba Hills (14,000 hecters) forests. More common are the very small fragments like the Muhaka (180 hecters) and Mrima (350 hecters) forests. Species richness, diversity and composition of butterflies in two Kenya coastal forest remnants of Muhaka and Mrima hill were investigated to demonstrate the importance that forest fragments play in maintaining biodiversity. Sixty-three species were recorded from each forest remnant from a total of 1329 individuals. Species accumulation curves for both forests did not reach an asymptote with the likelihood that additional sampling effort could yield more butterfly species. High species similarity was recorded between the forest interior and the surrounding matrix, primarily due to invasion of the forest interior clearings by the savanna species. Despite their small sizes, these forest remnants were found to maintain viable populations of true forest butterflies. However, the number of species was less than half of that recorded from Shimba hills and Arabuko-Sokoke, located in the same larger forest reserves of geographical area. Records from Muhaka forest show species unique to it, not found in the larger forest reserves, underscoring the importance of small remnants in the preservation of forest biodiversity. However, in the event that conservation priorities were to be set, conservation efforts should be directed to larger forest reserves since they maintain more biodiversity. The high species similarity between the forest remnants implied that if habitat corridors were created, gene flow between these remnants and other larger forest reserves, would be possible. This would reduce the isolation of true forest butterfly populations within the remnants and potential local extinction.

Index terms: Forest remnants, species richness, species diversity, species composition, conservation.

[1958] BIOLOGICAL DATA AND POPULATION ABUNDANCE OF THREE SPECIES OF CASSIDINAE (COLEOPTERA: CHRYSOMELIDAE) IN A TROPICAL FOREST AREA IN BRAZIL

F.N. Sá¹ & J. Vasconcellos-Neto¹, ¹Universidade Estadual de Campinas - Inst. Biologia -Depto. Zoologia. Campinas, SP, Brasil, 13083-970. E-mail: fnsa@obelix.unicamp.br.

Few information is available on the biology and phenology of Chrysomelidae, unless if they are of economic interest. In this work we have followed the populations of Stolas chalybea, S. areolata and Anacassis phaeopoda for two years in order to obtain basic biological data on them and to know their occurrence throughout the year. We collected the data in fortnightly visits at the studied site by censusing host plants of studied Cassidinae. During each census, we have recorded the group sizes and position of egg and larval clusters and adults on their host plants. We also recorded their numbers. In an attempt to recognize the factors that influence the abundance of Cassidinae, we correlated that with temperature and rainfall at the study area, with some plant size parameters and also considered the relative abundance of different pheno-phases of the host plants. We observed that after emerging from the eggs, larvae of the three studied species remained aggregated, although the size of the groups decreased as the larvae developed. Egg clusters and larvae of the two Stolas species were more frequently found on the underside of leaves of their host plants; nevertheless, mature larvae of S. areolata were only observed on the upper side of leaves. Adults of the three species were always isolated and both Stolas species were more frequently found on the upper side of leaves. S. chalybea and S. areolata seemed to have the same pattern of occurrence throughout the year: they became active with the end of the dry season, reproduced more intensely during the rainy season and reduced their activity around June, during the beginning of the period of lower temperature and rainfall. A. phaeopoda showed a similar pattern, but it could be observed at the field earlier than the other two species. The three species also showed a lower peak of egg laying at the end of diapause of adults, what can suggest that females overwinter fertilized already. Larvae could be observed approximately from november until April or May. This pattern of occurrence was very similar to the occurrence of leaves on their host plants. Significant positive correlations between Cassidinae numbers and temperature showed that this parameter can influence ovipositing and mating activities. The number of new branches on the host plant was the most common trait that was significantly related to Cassidinae presence. Other parameters like number of branches and number of leaves were also related to the abundance of Cassidinae.

[1959] SCOLYTIDAE AND ASSOCIATED INSECTS IN PONDEROSA PINE STANDS UNDER DIFFERENT STRUCTURAL CONDITIONS IN NORTHERN ARIZONA

G. Sanchez-Martinez¹ & M.R. Wagner¹, ¹School of Forestry, College of Ecosystem Science and Management, Northern Arizona University P. O. Box 15018, Flagstaff, AZ 86011-5018, USA, E-mail gs8@spruce.for.nau.edu

Bark beetle (Coleoptera: Scolytidae) outbreaks are commonly associated with unhealthy forest conditions. In general, overstocked stands are considered more susceptible than open grown stands. However, because epidemic levels represent extreme values, bark beetle outbreaks may indicate unhealthy forest condition mostly from just one perspective. Forest management today requires more understanding of ecosystem components and ecological processes. Different bark beetle species create a variety of structural conditions within a given forest which, according to our management objectives and forest values, may be classified as healthy or unhealthy. Thus, from an ecosystem-oriented approach, a forest with high bark beetle infestations can be as unhealthy as a similar forest, but with no infestations at all. The objective of this study was to explore the association between the structure of ponderosa pine (Pinus ponderosa Dougl. ex Lawson) forests of the Coconino Plateau in northern Arizona and the diversity of Scolytidae and other important bark inhabiting insects. Although many dense stands with unhealthy conditions occur in this area, no significant bark beetle outbreaks have occurred for several decades. Four stand conditions were evaluated: 1) Dense stands with no management during the past 20-30 years, 2) Thinned mature even-age stands with >30% of hasal area (BA) removed between 1987-94, 3) Thinned mature even age stands with >30% of BA area removed by thinning with a prescribed burn 3 to 4 years after thinning, and 4) Formerly dense stands with no management which had been burned by stand replacing wildfires with >90% of BA removed by fire. Bark beetles and associated insects were sampled with Lindgren funnel traps baited with attractants (1998-1999). Dendroctonus brevicomis was the only aggressive species found in this study. It was more abundant in thinned stands and barely present in unmanaged stands; however, population levels of this species seem to be insufficient to cause outbreaks. D. valens was present in low levels in all stand types as well as Ips pini. Wood borers (Coleoptera: Cerambycidae) were more abundant in unmanaged and thinned only stands. Sevaral insect predators were well represented in all stands. Our preliminary results indicate a low diversity of bark inhabiting insects and suggest either: lack of suitable hosts or high efficiency of natural enemies. The lack of bark beetle attacks on susceptible stands could mean tree stagnation, interruption of natural disturbances, and poor habitat diversity.

Index terms: Pinus ponderosa, forest health, bark beetles.

[1960] *CTENARYTAINA EUCALYPTI* (HEMIPTERA, PSYLLIDAE) HOST EVALUATION

<u>D. L. Q. Santana</u> & R. V. C. Higa, *Embrapa Flerestas*, Estrada da Ribeira, Kml11, Colombo, PR. E-mail francis.santana@bbs2.sul.com.br.

On its natural environment (Australia) Eucalyptus is a host of several insects from Psyllidae family. Ctenarytaina eucalypti has a large distilution and it is considered among then, the most harmful. The species was first observed in Brazil in 1988 in Eucalyptus dunnii in a nusery. Leaf and stem deformity, growth delay, apical bud death, accessory bud development and seedling lost have been recorded. In order to evaluated C. eucalypti host preferential 1534 seedlings of 20 Eucalyptus species were produced in plastic tube, placed next to each other and they were infested with the pest. Insects number per plant was count when seedlings were around 20 cm high. E. camaldulensis, E. nitens, E. dunnii, E. benthamii, E. cinerea and E. viminalis had 100% of seedlings infested by C. eucalypti, on the other hand, E. grandis, E. pilularis, E. maculata, E. saligna, E. pellita, E. tereticornis, E. citriodora, E. resinifera, E. robusta, E. deanei, E. urophylla, E. microcorys and an hybrid ("Cambiju") were not infested. It was found an average of 6, 5, 20, 12, 20 and 3 C. eucalypti nimphs on E. camaldulensis, E. nitens, E. dunnii, E. benthamii, E. cinerea e E. viminalis respectively. It was observed that glaucous leaves were more susceptible to the insect attack.

Index terms: Eucalyptus spp., eucalypts pests

[1961] INSECTS ASSOCIATED WITH SEEDS OF THREE NATIVE SPECIES OF BRAZILIAN ATLANTIC FOREST

D. L. O. Santana¹, A. C. S. Medeiros¹, C. S. Ribeiro-Costa² & A. F. Santos¹, ¹Embrapa Florestas, Estrada da Ribeira, Km 111, Colombo, Paraná, Brasil, E-mail francis.santana@bbs2.sul.com.br;²Departamento de Zoologia, Univ. Federal do Paraná, C. P. 19020, 81.531-990, Curitiba, Paraná, Brasil. E-mail stra@bio.ufpr.br.

A Brazilian Institution, Embrapa Florestas placed at Colombo (Paraná), created in 1999 an active seed bank for the species of native forests in order to provide seeds for uses such as refforestation programs, reclamation of degraded ecosystems, etc. Fruits of three brasilian native species (Enterolobium contotisiliquum, Bauhinia forficata and Cordia trichotoma) were collected from Capitão Leônidas Marques, Paraná State. In order to evaluate the quality of seeds for storage in the Embrapa seed bank, 100 fruits for each species were processed and the seeds dissected to examine damages. Relating to Enterolobium contotisiliquum (timbaúva) presented average of 3.7 seeds per fruit and 21.8 % of them were damaged by a bruchid beetle, Merobruchus bicoloripes. In this plant it was also observed specimens of an Hymenoptera parasitoid belonging to the subfamily Braconinae. The fruit of Bauhinia forficata (pata-de-vaca) showed average of 4.5 seeds per fruit and 31.3% of the total number of seeds consumed by the bruchid Gibbobruchus speculifer. 5.1% specimens of G.speculifer were parasitized by the Eulophidae, Horismenus missouriensis and Pteromalidae sp. The damage in seeds of Cordia trichotoma was variable depending on the lots. One sample of Rio Grande do Sul had 95% of seeds damaged by the bruchid Amblycerus profaupar. Specimens of an unidentified Hymenoptera were also observed parasiting larvae of this bruchid. Considering the diversity and abundance of the insects species observed on these seeds lots it is necessary to conduct a careful observation of the seeds of the quoted species of plants to prevent infestation in the seed bank.

Index terms: Merobruchus bicoloripes, Gibbobruchus speculifer, Horismenus missouriensis, Amblycerus profaupar, seed pests

[1962] INFLUENCE OF STRIPS OF NATIVE VEGETATION IN PLANTATIONS OF FUCALYPTUS CLOËZIANA ON POPULATION OF OXYDIA VESULIA

<u>G.P. Santos</u>¹, **T.V. Zanuncio²**, **J.C. Zanuncio² & R. Pinto²**, ¹EPAMIG/CTZM, Vila Gianetti, 47, C. Postal, 216, 36570-000 Viçosa-MG, Brasil, E-mail: germi@mail.ufv.br; ²Dept. de Biologia Animal, Univ. Federal de Viçosa, 36571-000 Viçosa-MG, Brasil, Email: zanuncio@mail.ufv.br.

Eucalyptus species are planted in the majority of reforested areas in Brazil. These species of the Myrtaceae family are being damaged by insects from native hosts including Lepidoptera such as Oxydia vesulia (Lep.: Geometridae). This species is a primary pest of Eucalyptus being responsible for significant damage to this plant in reforested areas of Brazil. Eucalyptus plantations are characterized by extensive and contiguous areas which offers abundance of food and shelter for harmful insects and creates conditions for more frequent and harmful outbreaks of Lepidoptera pests. The establishment and preservation of native remnants of vegetation have been proposed as a strategy for pest management because it can increase ecological diversity and, consequently, favors the development and reproduction of natural enemies. Such strategy has been used in regions of the Savannah in the State of Minas Gerais, Brazil, where 25 meters wide strips of Savannah linked to each other and to forest remnants are used every 500 meters of *Eucalyptus* plantation. Lepidoptera individuals were collected in two different situations representing a Eucalyptus plantation with strips of native vegetation and another one without such strips. Five light traps were used in each plantation at two meters height and turned on at 6:00 to 7:00 P.M. and turned off between 8:00 and 9:00 A.M. the following day. These traps were located as: number 1- inside an area of Savannah at 100 meters from its border; 2- in the transition between the Savannah and the Eucalyptus plantation; 3- inside the Eucalyptus plantation at 250 meters from the Savannah; 4 in the center of a Savannah strip at approximately 500 meters from the border of the Savannah or between two blocks of *Eucalyptus* in the system without strips; and 5- inside the *Eucalyptus* plantation at 750 meters from the Savannah border. A faunistic analysis was made using frequency, constancy and diversity indexes for O. vesulia. A total of 329 individuals of this pest were collected with higher abundance in the plantation without strips where 266 individuals were collected and only 63 individuals were collected in the other system. This species was constant in the system without strips and accessory in the one with strips with frequency of 1.15 and 1.66% in these two systems, respectively. A large number of individuals of O. vesulia were collected in both plantations from the second period of February. The plantation with strips showed higher number of individuals of this pest inside the Eucalyptus plantation at 250 meters from the border of the Savannah with 31 individuals while in the one without strips O. vesulia showed higher number of individuals in the point at 750 meters from the border of the Savannah.

Index terms: insect monitoring, defoliator Lepidoptera, native forest

PREDATION RV [1963] SEED **CTENOCOLUM** CROTONAE (COLEOPTERA:BRUCHIDAE) IN LONCHOCARPUS MUEHLBERGIANUS (LEGUMINOSAE)

L.T.Sari ¹, C.S.Ribeiro-Costa¹, A.C.S.Medeiros² & D.L.Q. Santana², ¹Dept. of Zoology, Univ. Fed. of Parana, P.O.Box 19020, 81531-990, Curitiba, Parana, Brazil, Email stra@bio.ufpr.br; 2 EMBRAPA Florestas, Estrada da Ribeira, Km 111, Colombo, Parana, Brazil, E-mail dalva@cnpf.embrapa.br.

Lonchocarpus muchlbergianus (rabo-de-bugio) is a Brazilian native tree recorded from Minas gerais, Mato Grosso do Sul until Rio Grande do Sul. The beautiful lilac flowers arising from October until January are the reason for their use as an ornamental tree. In order to evaluate the seed predation by insects, fruits were collected from two specimens of this plant placed at Tres Barras, Parana, Brazil. A sample of 500 g of fruits was selected and processed in laboratory resulting in 2353 seeds. Usually the fruits are composed by two seeds, rarely by three or four seeds. It was registered 77.39 % of healthy seeds, 10.24 % of shriveled and 12.36 % damaged by insects. A bruchid species, Ctenocclum crotonae, was detected in this material. The genus Ctenocolum is composed by eight species registered from South and Central America; C. crotonae is the only recorded from Brazil. Species of Lonchocarpus are common host plants of this genus. The host plants of C. crotonae are L. hondurensis, L. margaritensis, L. nitidus, L. pentaphyllus, L. rugosus and Piscidia carthagenensis. In fact, this is the first record of L. muehlbergianus as a host plant of C. crotonae. This species was registered from Mato Grosso and, in this paper, the geographical distribution is amplified including the Parana state. Other immatures of Tenebrionidae and Curculionidae were detected feeding the seed contents but theirs damages were indistinguishable; both groups represented a loss of 2.84 % of the total number of seeds. A parasitoid belonging to the family Eulophidae, Horismenus missouriensis, was observed inside seeds probably developing in larvae or pupae of the Coleoptera species. This Hymenoptera was already recorded parasitizing bruchid species, as Amblycerus submaculatus, A. hoffmanseggi and Gibbobruchus speculifer. As the hole left by the adult bruchid in the seed is larger than the hole of the parasitoid, it was possible to differentiate both species. The parasite emmerged from 4.63 % and C.crotonae from 4.88 % of the total number of seeds.

Index terms: beetle, biology, damage.

[1964] OCCURRENCE OF WOOD BORING BEETLES IN THE NATIONAL FOREST MÁRIO XAVIER, RJ, BRASIL

V. M. Schermack¹, <u>A. G. Carvalho¹</u>, A. M. Lunz¹, J. G. N. Wendt¹, J. M. Pinto² & S. R. S. Ventura¹, ¹Depto. Produtos Florestais, Univ. Fed. Rural do Rio de Janciro, Seropédica, RJ 23851-970, Brasil. E-mail: schermack@ufrrj.br; ²Depto. Fitotecnia, Univ. Fed. Rural do Rio de Janeiro.

For counting with a wide diversity of species, the order Coleoptera is associated to several alimentary habits among its representatives. Considering the economic importance, they stand out in this order the wood-boring species that caused damages to the forest species, making perforations and galleries that degrade and they serve as entrance for agents degradadores of the wood, as the mushrooms Ambrosia. The families Scolytidae and Platypodidae are common in alive, reviled or recently abated trees; the family Bostrichidae is seen in wood in drying process, and the family Cerambycidae lives in several wood types embracing alive trees, even deteriorated logs. Seeking to establish the incidence and the frequency of the families of Coleoptera above-mentioned in the area of the National Forest Mário Xavier, km 50, Seropédica, RJ, twelve impact window-traps were installed, model Carvalho-47, made with recyclable material and adapted starting from the model Marques-Pedrosa, to a height of 1,5 m of the soil. The collections are weekly being accomplished starting from July of 1999, with end forecast for July of 2001. Three types of snares were distributed by vegetation, in the following areas: native vegetation, mixed plantation, "sapucaia" and Eucalyptus spp. Until January of 2000, 30 collections were accomplished. Of the 4694 collected insects, 4447 (94,74%) belong to the family Scolytidae, 190 (4,05%) Cerambycidae, 53 (1,13%) Bostrichidae and 4 (0,09%) Platypodidae. For the different vegetation types, the area of mixed plantation indicated the largest incidence with 2373 (50,55%) collected individuals, proceeded by the native forest with 805 (17,15%), Eucalyptus spp, 743 (15,83%) and "sapucaia", 773 (16,47%).

Index terms: Scolytidae, Cerambycidae, Bostrichidae, Platypodidae, Window-traps.

[1965] WOOD BORING BEETLES IN PLANTATION OF SAPUCAIA, LECYTHIS PISONIS (LECYTHIDACEAE), IN THE NATIONAL FOREST MÁRIO XAVIER, SEROPÉDICA, RJ, BRASIL

V. M. Schermack¹, A. G. Carvalho¹, A. M. Lunz¹ & S. R. S. Ventura¹, ¹Depto. de Produtos Florestais, Univ. Fed. Rural do Rio de Janeiro, Seropédica RJ. 23851-970, Brasil. E-mail: schermack@ufrrj.br.

Seeking to establish the incidence and the frequency of the families of wood degrading beetles that happen in homogeneous plantations with native essences, three snares model Carvalho-47 were used, in a area of Lecythis pisonis (Lecythidaceae), in the National Forest Mário Xavier, Seropédica, RJ, in the period of July of 1999 to January of 2000. The snares were installed to a height of 1,30 m of the soil, being used as attractiveness the alcohol 96% that it was renewed weekly, after the collection of the insects. The samples, in a total of thirty, were taken to the laboratory of Forest Entomology of the Institute of Forests, Department of Forest Products (DPF) of UFRRJ, where the insects were quantified and identified the family level. The total of wood degrading beetles collected belonged to 773 individuals, and the frequency of the family Scolytidae corresponds to 725 individuals (93,79%), with a population pick in the month of August of 1999, frequently of 159 (20,57%); proceeded by the family Cerambycidae with 32 (4,14%) and family Bostrichidae with a 16 (2,07%), both reached population pick in the month of September of 1999 with 11 (1,47%) and 8 (1,03%), respectively. Doubled attention should be given to these families, once its species presents quite varied alimentary habits, feeding of medullas, phloems and xylems. It was ended that there is incidence of wood degrading bettes in sapucais, *Lecythis pisonis*, represented by the families Scolytidae, Cerambycidae and Bostrichidae, in decreasing degree of frequency, respectively. Index terms: Scolytidae, Cerambycidae, Bostrichidae, Window-traps.

[1966] NON-HOST SIGNALS INHIBITING FEEDING IN HYLOBIUS PINE WEEVILS: LABORATORY ASSAYS AND FIELD TESTS

F. Schlyter, E. Marling, P. Månsson & J. Löfqvist, Chemical Ecology, Plant Protection SLU. P.O. Box 44, SE-230 53 ALNARP. Science. http://www.vsv.slu.se/cec/ce.htm

Anti-feedants as a protection against herbivores have been described in many plants, wellknown is the 'neem' tree Azadiractica indica. In conifers, defense is quantitative, based on less toxic oleoresin compounds. In small, stressed conifers like the seedlings planted on clear-cuts in forestry, the quantitative defense is weak. These seedlings have been proected by insecticides like DDT and pyrethroids against the feeding by pine weevils Hylobius abietis (causing a 100 million US\$/year damage in Sweden), but use of insecticides will finally be banned in 2003. Our work follows two lines: 1) The screening of synthetically available anti-feedant compounds and related structures, mainly of plant origin. 2) The search for antifeedants in non-host plants. The development of laboratory bioassays has been a prerequisite for the project. Initially, Klepzig & Schlyter (1999) modified a twig technique of Salom *et al.* (1994). Later, to test small amounts of synthetics and extracts, we developed a micro feeding assay using TLC-plates. Presently, we are modifying an olfactometer to investigate the mode of action (taste/smell) of synthetics. For one active compound, carvone, a mainly olfactory mode of action is indicated. Field tests in 1997 and 1998 demonstrate that formulated carvone may protect seedlings for months. The long-term formulation of antifeedants, their mode of action, and finding of lower volatility compounds remain our goals. Index terms: Hylobius abietis, pine weevil, antifeedant, DDT.

[1967] ECOLOGY OF SCOLYTIDAE (COLEOPTERA) IN FORESTRY REMNANTS BELONGING TO CHAMPION Co. IN MOGI GUAÇU, SP, BRASIL

C. A. M. Silva¹ & A. G. Carvalho¹, ¹Depto. de Produtos Florestais, Univ. Fed. Rural do Rio de Janeiro, Seropédica, RJ 23851-970, Brasil. E-mail: carlmont@floresta.ufpr.br and acacio@ufrrj.br.

This work investigated the populations of bark and ambrosia beetles (Coleoptera: Scolytidae) in three belonging native forestry remnants belonging to the Agricultural Chamflora Ltda., in the municipal district of Mogi Guaçu, Itapira and Martinho Prado Júnior, state of São Paulo. In the period of January of 1998 to January of 1999 was studied the composition of the scolytids species, by means of biweekly collections in nine snares ethanol's model Carvalho-47, being obtained the fluctuation for each specie in the three native forest fragments of different sizes, forms and historical of disturbance. It was used the index faunistics: frequency, constancy, individual dominance of the species, richness, association among the species, similarity between communities and diversity. Thirty-eight species were collected, where four of them were not identified, only one was identified at the genus level. The 34 identified species are distributed in 12 genus and 5 tribes. Hypothenemus eruditus, Microcorthylus minimus, H. obscurus, Xyleborus retusus, Corthylus schaufussi and Premnobius cavipennis were the most abundant species. Six species were represented, each one, with just a specimen in the collections. H. eruditus was just aimed as constant and dominant in the three studied forest fragments. It was ended that there were differences in the composition of the species among the studied forest fragments, such differences suggest that the measure that the habitats suffers alterations, they happen changes in the density patterns and in the composition of the species, however the scolytids diversity was larger in the fragments with larger level of environmental interference. This suggests that some species of this family can be used as indicative of wide environmental changes and of long reach.

Index terms: Indicators, Bark beetles, Ambrosia beetles.

119691 USE OF ATTRACTANTS FOR SURVEYING DIPTERAN POPULATIONS IN A RAINFOREST AREA IN NORTHEASTERN BRAZIL

D. F. Silva¹, A E. Eiras² & S. D. Vasconcelos¹, ¹ Mestrado em Biologia Animal, Depto. de Zoologia, Universidade Federal de Pernambuco. Av. Prof. Moraes Rego, s/n, Recife-PE, 50670-420, BRAZIL. E-mail: simao@npd.ufpe.br.². Depto. de Biologia, Universidade Federal de Minas Gerais

Chemical communication is one of the most remarkable ways of information transmission among members of the Class Insecta. Despite the importance of chemical compounds in triggering specific behaviour such as aggregation, escape, oviposition and sexual attraction, there are few field studies which investigated the substances involved in insect attraction. In this study, a set of substances combined with CDC light traps were tested for the attraction and capture of Culicidae and Psychodidae adults in a remainder of rain forest in the State of Pernambuco, Northeastern Brazil. The following treatments were used: octenol (in an open glass vial); octenol with a single wick; octenol with double-folded wick; CO2 (released as commercial bread yeast); living bait (mouse), and deionized water (control). Four traps separated from each other for 100m were placed in the forest for 12 hours, from 5pm-5am, during which the temperature in the sampled area was about 30°C and the relative humidity around 84%. Four replicates were used, in separate days; each replicate being considered the capture of the four traps combined. From all the Phlebotominae collected, 56% were collected in the CO_2 traps, 19% with the octenol and 25% were caught in the control traps. From all the Culicidae collected, 65% were collected in the control traps, 20% in the bait trap and 15% in the octenol traps. The different proportions of adults of Culicidae and Phlebotominae captured suggest differential responses in germs of substances involved in their attraction and communication.

[1968] COMPOSITION OF SCOLYTIDAE (COLEOPTERA) IN THREE FOREST MACROHABITATS OF SEROPÉDICA, RJ, BRASIL

C. A. M. Silva¹, <u>A. G. Carvalho¹</u> & L. A. Pereira², ¹Depto. de Produtos Florestais, Univ. Fed. Rural do Rio de Janeiro, Seropédica, RJ 23851-970, Brasil. E-mail: acacio@ufrrj.br and carlmont@floresta.ufpr.br; 2Depto. de Ciências Ambientais, Univ. Fed. Rural do Rio de Janeiro.

This study compared the composition of bark and ambrosia beetles (Coleoptera: Scolytidae) in three different forest macrohabitats in the municipal district of Seropédica, RJ: Pinnus elliotti (Pe), Eucalyptus citriodora (Ec) and Secondary Forest (Ms). Those three areas frequently suffer the action of the fire. In each macrohabitat it was installed, to 40 cm of height of the soil, an impact snare, being used ethanol 96% as attractive. The collections were accomplished during the months of April of 1988 to January of 1989, totaling eleven samplings. With relationship to the preferences for macrohabitats of the two more abundant species, 60% of the Xyleborus hagedorni happened in on Pe, 32% in Ec and 8% in the Ms ones. Those preferences were shown significant for the Test X2 (P <0,05). X. affinis showed preferences in the occurrence of 52% of the total of its species in the Ms ones, remaining 26% in Ec and 22% in the Pc. Of the total of 8221 analyzed Scolytidae, 38% happened in the Pe, 33% in Ec and 29% in the Ms ones. Seven species were shown more abundant in on Pe: X. hagedorni, X. obliquus, X. ferrugineus, X. brasiliensis, Hypothenemus opacus, H. bolivianus and Coccotripes palmarum. Other six were more abundant in Ec: Premnobius cavipennis, Cryptocarenus hevea, C. seriatus, C. diadematus, X. spinulosos and H. obscurus and the two species X. affinis and H. eruditus were only shown more abundant in the Ms. Using the Index of Percentile Similarity in the comparisons among the three communities were obtained in decreasing order: Pe x Ec = 75,24%; Ec x Ms = 53,90% and Pe x Ms = 46,40%. The largest value obtained among the two researched vegetable monocultures suggests a habitat-specific tendency of most of the species of boring-beetles occurred in those three macrohabitats. The diversity of Scolytidae for macrohabitat, evaluated through Shannon Weaver Index (H', with log of base 10) it shows, in decreasing order: H'Ec = 0,77 (H'máx. = 1,18 and J' = H' / H'máx. =0,65); H'Ms = 0,65 (H'máx. = 1,14 and J' = 0,57); and H'Pe = 0,63 (H'máx. = 1,18 and J' = 0,53). There was not significancia (P>0,05) in the differences among the diversities through the Test t of Student, applied in the comparisons of the variances of the three researched macrohabitats.

Index terms: Diversity, Macrohabitat, Ambrosia beetles, Bark beetles.

[1970] A POPULATION SURVEY OF PHLEBOTOMINAE IN REMAINDERS OF RAINFOREST IN NORTHEASTERN BRAZIL

D. F. Silva & S. D. Vasconcelos, Mestrado em Biologia Animal, Depto. de Zoologia, Universidade Federal de Pernambuco. Av. Prof. Moraes Rego, s/n, Recife - PE, 50670-420, BRAZIL. E-mail: simao@npd.ufpe.br

Insects from the genus Lutzomyia (Diptera: Psychodidae) occur in the neotropical region and have great medical importance for they are vectors of leishmaniasis. Around 350 species of this genus are found in Brazil, from which around 30 have been registered in the State of Pernambuco, in the Northeast of Brazil. Apparently, few of these play a role in disease transmission, although the extent to which this is related to their abundance is still unclear. The objective of this study was to survey the Lutzomyia populations in areas of rainforest conservation in Pernambuco. Additionally, the influence of temperature and relative humidity on population fluctuations in a three month period was investigated. Two areas were sampled, Mata do Curado and Mata de Dois Irmãos, both characterised by high plant diversity and slight variations in altitude. Four traps separated from each other for 100m were placed in the forest for 12 hours, from 5pm-5am. The Lutzomyia adults collected were distributed as follows: 22% Lutzomyia choti, 14,6% Lutzomyia walkeri, 14,6% Lutzomyia anduzei, 14,6% Lutzomyia evandroi, 12,2% Lutzomyia sordelii, 9,8% Lutzomyia umbratilis and 12,2% Lutzomyia sp. From all the insects identified to the species level, none is referred to as a leishmaniasis vector.

[1971] SCOLYTIDAE ASSOCIATED EUCALYPTUS SPP. IN A FRAGMENT OF DECIDUAL SEASONAL FOREST

T.E.F. da Silva¹; <u>E.C.Costa</u>²; T.M.B. Vianna³; M.A.G.Costa², ¹ Rua Jorn. Maurício Sirotski Sobrinho, 85 – CEP 97020-040 – Santa Maria, RS – Brasil, e-mail: thomas.freitas.luz@zipmail.com.br.² Depto. de Defesa Fitossanitária, Centro de Ciências Rurais – Universidade Federal de Santa Maria, Campus Universitário, prédio 42, 1º andar, 3225 – CEP 97105-900 – Santa Maria – RS – Brasil – e-mail: eccosta@ccr.ufsm.br; ³ Depto. de Biologia. Ciências Naturais e Laxatas - Universidade Federal de Santa Maria.– Santa Maria, RS – Brasil - e-mail: a9670087@alunop.ufsm. br.

A survey of Scolytidae (Coleoptera) insect was carried out, in an area covered by *Eucalyptus* spp. in a fragment of Decidual Seasonal Forest in a District of Itaara, RS – Brazil. The traps settled at a certain point of 1,3 meters of soil were "Marques/Pedrosa" type. The quantitative and qualitative data was correlated with temperature, air relative humidity and precipitation. The populational evaluation was done using frequency, constance, abundance, dominance and diversity rate. The delimitations of communities was estimated by the quotient and similarity rate. The results revealed the existence in two communities of 37 species Scolytidaes's family belonging to 12 genus from 380 species coleted. *Corthylus antenarius, Microcorthylus minutissimus, Xyleborus gracilis* and Xyleborus paraguaiensis were the most frequent, abundant and dominant in both communities. The quotient of similarity were 0,75 and the similarity rate whe 53,9%. The diversity rate was the same to both communities. Genus Xyloborus presented a hight species number in the two communities. The fluctuation of population in a total collected of escolideos in Eucalyptus spp., showed a 99,95% correlation in the average of monthly minimum relative humidity.

Key words: population available; forest; insect

Symposium and Poster Session

[1973] UTILIZATION OF FLORAL RESOURCES BY MELIPONINEOS (APIDAE:MELIPONINI) IN A FOREST FRAGMENT, BELO HORIZONTE, MG, BRAZIL

S. M. Soares, <u>Y. Antonini</u> & R. P. Martins, Laboratório de Ecológia e Comportamento de Insetos, Departamento de Biologia Geral, ICB, UFMG, Cx Postal 486 CEP: 31140-390 Belo Horizonte, MG, Brazil E-mail: antonini@mono.icb.ufmg.br

The bees are flower visitors for excellence, and constitute the most important group of pollinators. The meliponini are the most efficient pollinating bees in the tropical region. To verify the diversity of meliponini in a forest fragment, the bees were searched on the plants with flowers once a week from July to December/1999, between 6:00 and 13:00. The bees were then collected with an entomological net. We collected 490 individuals distributed among 11 different species. Of these, 198 were T. spinipes, 173 Trigona fulviventris, 31 Tetragonisca angustula, 28 Paratrigona subnuda, 21 P. lineata, 21 Plebeia sp., 11 Melipona quadrifasciata, 5 Nannotrigona testacoicornis, 1 Paratrigona sp. and 1 Leurotrigona mulleri. Trigona spinipes was the most abundant and generalist, visiting 30% of the registered plants, however both species prefer to visit Malpighiaceae and Melastomataceae. Paratrigona species only Byrsonima sp. (Malpighiaceae) was visited by all 10 bee species. The other most visited plants were Hyptidendron sp. (Labiata), Cellis sp. (Ulmaceae), Thunbergia sp. (Acanthaceae), Aureliana velutina (Solanaceae). All bee species visited the Malpighiaceae and Acanthaceae and the majority of them visited Sterculiaceae, Fabaceae, Labiatae, Ulmaceae and Solanaceae. These data show that the different species of meliponini use the nectar and available pollen in a similar mode.

[1972] UNDERSTANDING THE INTRODUCTION AND SPREAD OF SIREX NOCTILIO IN THE SOUTHERN HEMISPHERE

B. Slippers', G. Hunter', T.A. Coutinho', B.D. Wingfield' & <u>M.J. Wingfield'</u>, Dept. of Microbiology & Plant Pathology, Forestry and Agricultural Biotechnology Inst. (FABI), Univ. of Pretoria, Pretoria, 0002, Republic of S. Africa, Dept. of Genetics, Univ. of Pretoria, Pretoria, 0002, Republic of S. Africa

Exotic pine species have been established with great success in plantations in the tropics and subtropics of the Southern Hemisphere. Part of this success can be attributed to the separation of these trees from their native pathogens and pests. These pests are, however, steadily being introduced and the introductions often lead to severe and damaging outbreaks. An example of one such a pest is Sirex noctilio. It is not considered a primary pest in the Northern Hemisphere, but has caused substantial losses to softwood plantations in Southern Hemisphere countries, where it has been introduced. Understanding the epidemiology and population dynamics of this insect is important in preventing further spread and in controlling the pest where it has already become established. In this study we report on the use of phenotypic and DNA-based studies of Amylostereum areolatum, the obligate fungal symbiont of S. noctilio, to determine the diversity and relationship of isolates from different countries in the Southern Hemisphere. Results show that the genetic diversity of isolates of A. areolatum from Southern Hemisphere wasps is small and uniform. This indicates that Sirex has spread between continents of the Southern Hemisphere after initial introduction at the beginning of the 20th century. Fungal isolates from South Africa and Brazil are the most closely related of all isolates, indicating a common origin of Sirex in these two countries. These techniques and data now enable us to monitor and characterise S. noctilio populations and to plan future biological control strategies.

Key words: Sirex, Amylostereum, Insect/fungal interactions

[1974] TROPHIC PATTERNS IN AN INSECT COMMUNITY OF PINE FOREST AND SAVANNA ECOSYSTEMS

M. El Souki¹, R. Candia[†] & L. Bulla¹, ¹Inst. de Zoología Tropical, Fac. de Ciencias, Univ. Central de Venezuela, Apdo. Postal 47058, Los Chaguaramos 1041-A, Caracas, Venezuela, melsouki@latinmail.com.

Besides traditional land use of Venezuelan savannas for agriculture and cattle, a recent impact on the natural savannas being increasingly employed during the last 30 years is the cultivation of timber species of *Pinus caribaea* and *Eucalyptus* sp. The area cultivated in the southeastern savannas covers today more than 5,000 km² and is currently expanding. Our research is about the impact assessment of pine forests on the native arthropod community of the savanna. The present study focuses on the most relevant temporal (seasonal and successional) changes occurring in the savanna insect community. The sampled plots representing natural savannas were three uncultivated plots: S1, Trachypogon sp. dominant; S2, Trachypogon sp dominant, but surrounded by mature pines (island); and S3, Axonopus sp. dominant. The cultivated plots were: P1, 4 year old pines; P2, 12 year old mature pines; B1, recently harvested pines, and B4, 4 year old field (last two are set-aside). Insects were captured using attraction yellow plates (6 per plot) and were divided into five trophic groups: herbivores, predators, parasitoids, saprophytes, and omnivores. The relation between species number and abundance from a total of 789 species and 6,927 individuals, respectively, was herbivores 277:3,435, predators 113:2,011, parasitoids 280:602, saprophytes 68:733, and omnivores 51:147. Herbivores, predators, and parasitoids showed their greatest richnesses in the pine plots and their lowest in B1; with slight variations, their richnesses in B4 are similar to those in the savannas. Saprophytes and omnivores showed few between-plot differences. Abundances of herbivores and parasitoids showed a preference for pines. Predator abundance in pines was similar to that in savannas, except in S3. Almost all trophic groups showed similar abundances between set-aside plots and savannas, except in S1. During the wet season, total, green, and green/dry rate biomasses, and vegetation cover showed a significant positive correlation with total insect, omnivore, herbivore and saprophyte richnesses and abundances, whereas vegetation evenness showed a significant positive correlation with both total insect and predator abundances. During the dry season, vegetation richness, evenness, and diversity showed a significant positive correlation with total insect, herbivore, predator and parasitoid richnesses and abundances. These results suggest that richness and abundance patterns are determined by the quantity of resources in the wet season, but by the variety (diversity) of vegetation resources in the dry season. The more important trophic group relationships found were between herbivore and parasitoid richnesses and abundances in both seasons. This work was financed by the ISC Programme of the European Commission, Project CT 94-0099 VE.

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[1975] DISTRIBUTION OF BARK AND WOOD-BORING INSECTS IN MARITIME PINE TREES INFECTED WITH BURSAPHELENCHUS XYLOPHILUS IN PORTUGAL

E. M. Sousa, P. M. Naves & L. P. Bonifácio, Dept. Prot. Florestal, EFN, Quinta do Marquês, 2780 Oeiras, Portugal. E-mail: dpf.efn@mail.telepac.pt

The Pine Wood Nematode Bursaphelenchus xylophilus (Nematoda; Aphelenchoididae) was found for the first time in Portugal and Europe in 1999, being confined to Setúbal peninsula, south of Tagus river. The biology and behaviour of the nematode and its insect vectors is not known in Europe, although some cerambycid and scolytid species that occur in this region are considered potential vectors. Maritime Pine (Pinus pinaster) trees infected with B. xylophylus were found to be quickly colonised by several bark and woodboring beetles and an intensive survey was conducted on 30 recently infected adult trees with an average 97,4 cm DBH, involving all trunk and branches debarking with capture of all insect development stages present. The results revealed a big under-bark insect diversity formed by scolytid (7 species), cerambycid (3), curculionid (1) and buprestid (1) beetle species. The scolytids were the most frequent group, particularly Orthotomicus erosus being present in the trunk and branches of all studied trees in high densities. Hylurgus ligniperda was found on 50% of the pines, while the other five scolytid species (Hylastes ater, H. linearis, H. attenuatus, Ips sexdentatus and Tomicus piniperda) were present in less than 33% of the pines. Regarding the cerambycid family, the three longhorn beetle species were common (more than 50% infested trees): Arhopalus syriacus larvae were present in all surveyed trees in high densities; Acanthocinus griseus was detected in 83% of the trees while larvae of Monochamus galloprovinciallis, the most probable nematode vector in Portugal, appeared in 50% of the pines. The only curculionid species, the pine weevil Pissodes castaneus was collected from 75% of the trees and the buprestid Chrysobothris chrysostigma in 33% of the pines. The within tree distribution revealed a spatial competitive exclusion pattern between the different species, with special emphasis to A. syriacus, H. ligniperda, H. ater, I. sexdentatus and T. piniperda in the lower sections of the trunk, while M. galloprovinciallis and P. castaneus were found mainly in the branches and in the upper part of the trunk. Regarding O. crosus and A. griseus no spatial distribution pattern was found, with this species present throughout all the trunk and branches

Index terms: Bursaphelenchus xylophilus, Pinus pinaster, bark and wood-boring beetles, Portugal

[1976] DEADWOOD IN COMMERCIAL FORESTS: A SOURCE OF INCREASED BIODIVERSITY AND OF OUTBREAKS OF PEST SPECIES?

W. Topp & R. Haeusler, Dep. of Zoology, Univ. of Cologne, D-50923 Koeln, Germany

This study examines the saproxylic insect fauna of a commercial mixed oak-beech forest situated in the Westerwald of Germany (50° 26'N / 07° 50'E, 325m above sea level) in which nature-oriented forestry has been practiced for the last 10 ten years. Using eclectors, insects were collected from the deadwood of oak and beech trees. Our studies concentrated on different types of decaying wood: 1. Deadwood, which has accumulated near the forest floor in the center of the forest in shady areas and which was different in respect to dimension (twigs, branches, logs) and phase of decomposition. 2. Living wood, which prior to sampling had been freshly cut and exposed either to sunny or shady areas for the length of one year. In total we collected insects from 8.5 m³ wood, equaling about 170 m². About 140,000 insects were found. The most dominant groups were dipterans (61,000 ind.) and coleopterans (25,000 ind.). Each "milieu type" of dead wood supported characteristic species. However, the fauna of decomposed logs was most diverse. In the shady area bark beetles but also predators of bark beetles were the most common coleopterans, so that there is no fear of mass occurrence of pest species in the center of the forest. Based on our data we recommend for this forest type an accumulation of 40 m² dead wood per ha, which is enough to supply the prerequisites for a diverse fauna and even for rare and endangered species, which live in shaded areas near the forest floor. In the area of study this amounts to about 5% of the amount of living wood. The actual numbers of the different beetles species were always higher in areas exposed to more sunlight compared to shaded areas. However, the abundance of individuals in the sunny areas outnumbered those of the shaded areas, but only when their development has taken place in branches with diameters > 7 cm. Remarkably high emergences were found for bark beetles (i.e. 850 ind./m² for Taphrorychus bicolor) from branches which have been exposed to strong sunlight. In a commercial forest in which nature-oriented forestry is practiced and an accumulation of dead wood will occur, the cultivation of graded forest edges is also recommended. This will reduce the amount of deadwood exposed to strong sunlight and thus minimize the outbreak of pest species.

This study was supported by Forstliche Versuchsanstalt Rheinland-Pfalz.

[1977] DEAD WOOD AND BEETLES: A CASE STUDY IN FLANDERS (BELGIUM)

V. Versteirt, K. Desender, G. Geudens & P. Grootaert, Dept. of Entomology, RBINSc., Vautierstraat 29, 1000 Brussel. E-mail: veerle.versteirt@kbinirsnb.be

There are only few data available on xylobiont beetles associated to dead wood in Flanders. In this contribution we present the first results from detailed samplings, performed in four forests in the surroundings of Brussels and Tongeren, within the framework of a study on terrestrial invertebrates in woodlands of the region of Flanders. Special attention was paid to sampling methodology. The following techniques were used on each sampling site: three pitfall traps, three white and three yellow pan traps, a large window trap, a dung baited trap and a tree eklektor, completely enveloping a large standing dead beech tree between 1.5m and 2m of height. Sampling was performed during a complete year cycle. On the whole, about 200 beetle species were obtained (some 8000 individuals), many of which are of high faunistic value. Preliminary analysis of the beetle diversity suggests lower values for a large and rather homogeneous forest. This pattern can also be explained by the presence of many additional species from surrounding open landscapes in smaller forests. The importance of dead wood for xylobiont arthropods is well known. Dying and dead trees provide essential habitats for a number of animals (like insects). In order to maintain this biodiversity it is important to consider the aspect of dead wood in managed forests. The quality of the species thereby seems more important than the observed number of species, because species richness not only is influenced by habitat quality but also, especially in small forests, by edge effects due to accidental immigration of species with a high dispersal power.

Index terms: woodland, beetle diversity, forest management.

[1978] LEPIDOPTEROUS ASSOCIATED TO TWO FOREST COMMUNITIES IN ITAÁRA, RS - BRAZIL

T.M.B. Viana¹; <u>E.C.Costa²</u>, ¹ Depto. de Biologia. Ciências Naturais e Exatas. Universidade Federal de Santa Maria.– Santa Maria, RS – Brasil - e-mail: a9670087@alunop.ufsm. br. ² Depto. de Defesa Fitossanitária, Centro de Ciências Rurais – Universidade Federal de Santa Maria, Campus Universitário, prédio 42, 1º andar, 3225 – CEP 97105-900 – Santa Maria – RS – Brasil – e-mail: eccosta@ccr.ufsm.br.

Aiming at analyzing the behavior of lepdopterous population in two communities, are constituited of planting field of Eucalyptus spp. with small plants in formation and another of a fragment of Decidual Seasonal Forest, weekly collections were made by using light trap. This work was develop in Itaára, RS - Brazil, from May 1997 to May 1998. In order to study the populations, lepidopterous fluctuations were analyzed, according, to the meteorological elements (temperature, air relative humidity, pluviometric precipitation) and faunal rates represented by frequency, constancy, abundance, dominance and diversity. In the communities delimitations were apply the quotient and similarity rate. Were collected 73 species of the large planting field of Eucalyptus spp., being 63,01% species of identified as infrequent and, in the fragment of Decidual Seasonal Forest 77 specieswere collected being 57,14% of them infrequent. The constant species, dominance and very abundance were: Sarcina violascens (Lymantriidae) found in the planting field of Eucalyptus spp. and Bronchelia puellaria (Geometridae) and Iscadia aperta (Noctuidae) in the fragment of Decidual Seasonal Forest. With relation of diversity rate to lepdopterous family, this higher in the fragment of Decidual Seasonal Forest, than in a large planting field of Eucalyptus spp. The quotient and percent of similarity changing with the studied ecossistem and with the species. In both forest communities the fluctuation of lepdopterous species influenced of the meteorological elements. Key words: light trap; forest; insect; faunal rates

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[1979] EVALUATION OF THIAMETHOXAM ON COSTALIMAITA FERRUGINEA (COLEOPTERA: CHRYSOMELIDAE) CONTROL IN EUCALYPTUS PLANTATIONS

C.F. Wilcken¹, N.S. Bezerra Jr.¹, E.B. Couto¹ & C. Orlato¹, Dept. Plant Production -FCA / UNESP - Campus of Botucatu - P.O. box 237 - 18603-970, Botucatu - SP. E-mail: cwilcken@fca.unesp.br

The eucalyptus yellow beetle Costalimaita ferruginea is one of the eucalyptus main pests in Brazil, occurring at October - December and limiting the plants growth up to 1 year old. Nowadays, there is a total absence of insecticides for forest use to control of this pest and the need to new products is pressing. This work was carried out to verify the insecticide thiamethoxam efficiency on C. ferruginea control in eucalyptus plantings. The experiment was installed in planting area of Eucalyptus hybrid, in Itapeva - SP - Brazil. The experimental design was in randomized blocks, with 5 treatments and 4 blocks, with 50 plants per plot. The treatments were: thiamethoxam (Actara) in dosages of 12.5; 25 and 50 g a_i./ha, deltamethrin (Decis 25 CE) in dosage of 5 ml of a.i. /ha and check. The number of insects / plant was evaluated at 1, 3 and 6 days after application, and the plant height at 10 and 55 days. The results indicated that thiamethoxam was efficient in C. ferruginea control in all tested dosages, being comparable to the control provided by deltamethrin. However, thiamethoxam control residual period was superior compared with deltamethrin, could imply in reduction in spraying quantity in eucalyptus plantings attacked by eucalyptus yellow beetle. It was not observed phytotoxicity symptom in treated plants. Index terms: Forest pest, chemical control, insecticide, eucalyptus yellow beetle

[1981] PRELIMINAR OBSERVATIONS OF CULICIDS (DIPTERA:CULICIDAE) ASSOCIATED TO PHYTOTELMATA IN A VERY HYMUD TROPICAL FOREST IN CHOCO-COLOMBIA

<u>M. Wolff¹</u>, S. Perez¹, J. Betancur², P. Duque¹, & C. Porter³, ¹ Dept. Biology, Univ. Of Antioquia, AA 1226. Medellín-Colombia, E-mail: Erro! Indicador não definido. ² Ins. Ciencias Naturales, Univ. Nacional of Colombia, AA 7495 Santafe de Bogotá Colombia; ³ Center for Disease Control and Prevention (CDC) 4770 Buford Highway Atlanta, Ga 30341-3724 USA.

The association between Diptera of the Culicidae family and phytotelmata in the department of Chocó (Colombia) was studied in the Ensenada de Utría National Park (bmh-T) in the understorey of mangrove swamps and heterogeneous forest. 18 species of phytotelmata were collected in seven families; Bromeliaceae, Maranthaceae, Heliconiaceae, Bignoniaceae, Rubiaceae, Palmae-Arecaceae and Caesalpinaceae. 1661 culicids were found in the above plants and were classified in the following genera: Wyeomyia, Culex, Anopheles, Trichoprosopon, Orthopodomyia, Toxorhynchites and Haemagogus. 10 new morphospecies belonging to the genus Wyeomyia and the subgenera Hystatomyia and Microculex were found as well as a new species report for Colombia, Anoedioporpa corrigani. The Principal Component Analysis (PCA) based on a presence - absence matrix showed two groups of plants that gather the hosts according to the species sheltered by them, and two groups of insects: the first one more generalist and the second a more selective group.

[1980] EVALUATION OF TWO TRAP CARDS TO MONITORING OF SCYTHROPOCHROA SP. (DIPTERA: SCIARIDAE) IN EUCALYPTUS SEEDLINGS NURSERY

C. F. Wilcken¹, C. Orlato¹, C. C. Ortiz² & J. C. Augusti², ¹Dept. of Crop Production, FCA / UNESP – Campus of Botucatu, P. O. Box 237, Botucatu, SP, 18603-970, BR, Email cwilcken@fca.unesp.br; ²Bahia Sul Celulose S.A., Rod. BR 101, Km 880, Teixeira de Freitas, BA, 45995-000, BR.

The nursery flies of the family Sciaridae (genera Bradysia, Sciara and Scythropochroa) have been causing damages in nurseries and greenhouses where is carrying out the vegetative multiplication of eucalyptus seedlings. The monitoring of flies infestations at greenhouses had origin in Europe and North America, where these insects are important pests in cultivation of ornamental plants. The monitoring was installed in 10 greenhouses at the eucalyptus nursery of Bahia Sul Celulose S.A., in Mucuri - BA - Brazil. Were tested two types of trap cards with useful area of 100 cm²: 1) acetate plates, recovering both sides with a mixture of engine oil + grease, on proportion of 50% each, 2) yellow stick cards (AgriSenseTM) especially developed to capture small insects. Were shared 6 cards for each greenhouse, been installed 5 cm high above stalks and 8.90 m distant among the cards. Evaluations were made in 7^{th} , 14^{th} , 21^{th} and 28^{th} days in the rooting period, counting the fly number per card and calculating the average for each greenhouse. Different dates concerning the 2 rooting cycles for each of 10 greenhouses were evaluated. The results showed that the best option to monitoring the Scythropochroa sp. population was the use of yellow stick cards. The high advantage of these traps, beyond the capture efficiency, was the durability of your glue, what allowed the fulfillment of 4 evaluations in the same card. The limit (accumulated) of good visualization to the counting of fly numbers was 200 adults per card. When this number was exceeded, the card was changed. The monitoring must be done during the whole year, suspending the activity only when were observed constant low infestations in every greenhouses, showing number below 10 flies per greenhouse in each weekly evaluation. The operational cost of both trap cards was also evaluated, been observed that the yellow stick card cost was much lower than acetate card, turning its utilization economically viable.

Index terms: Forest pest, nursery fly, greenhouse, rooting period, operational cost.

[1982] SPECIES MIXTURE OF BIRCH AND CONIFERS DECREASES DAMAGE BY A DIPTERAN MINER OF BIRCH STEMS

T. Ylioia¹ & T. Lapveteläinen², ¹Punkaharju Research Station, Finnish Forest Research Institute, Finlandiantie 18, FIN-58450 Punkaharju, Finland, E-mail tiina.ylioja@metla.fi; ²European Forest Institute, Torikatu 34, FIN-80100 Joensuu, Finland.

Females of *Phytobia betulae* (Diptera: Agromyzidae) lay eggs within the soft tissue of young shoots in the crowns of birch (*Betula pendula* and *Betula pubescens*). The larvae mine downward for several meters through the zone of differentiating xylem in the birch stems. The resulting tunnels become filled with brown parenchyma tissue, which reduces the aesthetic value of the light coloured birch wood and causes considerable expense to the forest products industry. There are presently no known ways to control Phytobia. We hypothesized that growing birch mixed with conifers would decrease *Phytobia* infestations by interfering with their ability to locate hosts. This hypothesis was tested by comparing infestation levels in stands of pure birch and stands that were a mix of birch and conifers (Picea abies and Pinus sylvestris). We sampled four birch stands (15 - 25 years of age) within each of six municipalities in southeastern Finland: one pure birch stand and three stands with about 20%, 60% and 80% of coniferous trees (altogether 24 stands). We established eight circular sample plots along systematic survey lines in each stand and counted the percentage of coniferous and birch trees. For one focal tree within each sample plot, we measured tree height, diameter, the number and length of branches, and canopy crown class (dominant, co-dominant, or intermediate). We also measured distances to the five nearest coniferous and birch trees (or ten birch trees in pure birch stands) and the canopy crown class and diameters of these neighboring trees. We collected two stem disks per sample tree. A disk from ground level was used to measure the age of the tree and a disk from 1.3 m height was used to count larval tunnels in five latest annual rings and measure the corresponding radial growth. There were fewer larval tunnels in birch trees in stands that included only about 20% of birch. The number of larval tunnels was almost the same in stands that included 60% of birch as the number of larval tunnels in pure birch stands. Fast growing trees in dominant canopy classes had the greatest number of larval tunnels. The stands with only 20% of birch trees contained more co-dominant and intermediate birch trees than the other stands. Silvicultural practices that favor mixed stands might limit birch infestations by Phytobia, but the proportion of coniferous trees must be high (at least 70%), which limits the total volume of birch that can be harvested. Index terms: Phytobia betulae, Diptera, Agromyzidae, Betula, species composition.

[1983] STEM BORING AND PUPATION OF A DIFFERAN MINER OF BIRCH STEMS

T. Ylioia, Punkaharju Research Station, Finnish Forest Research Institute, Finlandiantie 18, FIN-58450 Punkaharju, Finland, E-mail: tiina.ylioja@metla.fi.

Larvae of Phytobia betulae (Diptera: Agromyzidae) bore within the differentiating xylem tissue of birch trees (Betula pendula and Betula pubescens). Larvae (three instars) mine several meters within the stem, from the crown to the base of the tree. Larval tunnels are filled with brown parenchyma tissue that causes pronounced degradation of the birch wood used for furnishing. However, the biology of *Phytobia* is not well known and there are no known methods for control. In late summer, larvae exit the tree (through the bark at the base or in the roots) and pupate in the soil. In this study, we aimed to determine how fast larvae of Phytobia move through the differentiating xylem during the growing season and how much time the pupation takes. Every other day beginning on 10 June 1997, we examined randomly selected branches and small trees (up to 3 m high) from an open sunny birch stand to determine when the first eggs were laid. The first egg was found on 23 June 23. On 3 - 7 July, the first larval tunnels were 3 - 17 cm long. Beginning at this time, we conducted repeated sampling of 12 taller trees (11 - 16 m). On 9 July, tunnel lengths varied from 0.01 - 2.5 m. By 14 July, second instars had created tunnels that were 8 - 10 meters in length. The mining speed of Phytobia seems to be tremendous. Tunnels of the largest diameter (presumably created by the largest larvae) usually continued to the roots. In August, we carefully removed the outer bark from the base and the roots of young birch trees (158 trees) and collected the larvae found under the bark (22 larvae on 13 August from *Betula pendula*, and 34 larvae on August 15 from *Betula pubescens* and *B*. pendula). Each larva was placed within an individual vial containing a mixture of sand and peat. Nearly half (46%) burrowed into the soil within 10 hours (at room temperature) and began to pupate. Altogether 59% of the larvae pupated. Our study revealed no times during the life history when insecticide application is likely to be effective. Larvae are protected within their host trees while feeding and are only exposed for a few hours prior to burrowing into the soil for pupation. Potential control measures are further complicated by asynchrony in the timing of larval development and pupation.

Index terms: Phytobia betulae, Diptera, Agromyzidae, Betula, larval tunnel.

[1984] LEPIDOPTERAN COLLECTED IN AN *EUCALYPTUS* PLANTATION IN GOIÁS, BRAZIL, FROM MAY 1995 TO APRIL 1996 - EFFECT OF TEMPERATURE AND RAINFALL ON POPULATION DYNAMICS

<u>J. C. Zanuncio¹</u>, E. T. Lopes², T. V. Zanuncio¹ & J. F. Gonçalves¹, ¹ Dep. de Biologia Animal, Univ. Federal de Viçosa, 36.571-000 Viçosa, MG, BRAZIL. E-mail: zanuncio@mail.ufv.br; ² Dep. de Engenharia Florestai, Univ. Federal de Viçosa, 36.571-000, Viçosa, MG, BRAZIL.

Lepidopterans are considered in Brazil as an important group of *Eucalyptus* pests due to severe losses in wood production. Biweekly collections were made in the State of Goiás, Brazil aiming to study population dynamics and the effect of temperature and rainfall on Lepidoptera pests of *Eucalyptus*. Lepidopteran were collected with five light traps installed at two meters high with black light and powered by 12 volt batteries. These insects were divided in groups according to their importance as pests to *Eucalyptus*: group 1: 11 primary pests; group 2: 10 secondary pests; group 3: 64 species without defined importance to *Eucalyptus*; and group 4: non-identified species. Among the primary pests, *Thyrinteina arnobia* (Geometridae), *Eupseudosoma aberrans* (Arctiidae) and Sarsina violascens (Lymantridae) were the most frequent ones, the last two being constant and the first one accessory. *Idalus admirabilis* (Arctiidae) and *Eacles imperialis magnifica* (Saturniidae) were the most frequent secondary pests, the first being constant and the second accessory. Most of the Lepidoptera species were collected during the coldest and driest months, which shows that these conditions could favour the occurrence of Lepidoptera outbreaks. For this reason, population monitoring of these species should be intensified during these periods.

Index terms: Lepidopteran defoliators, Eucalyptus, insect monitoring

[1985] EFFECT OF FEEDING ON THREE EUCALYPTUS SPECIES ON THE DEVELOPMENT OF BRONTOCORIS TABIDUS (HET.: PENTATOMIDAE) FED WITH TENEBRIO MOLITOR (COL.: TENEBRIONIDAE)

J. C. Zanuncio¹, T. V. Zanuncio¹, R. N. C. Guedes¹ & F. S. Ramalho², ¹Dcp. de Biologia Animal, Univ. Federal de Viçosa, 36.571-000 Viçosa, MG, BRAZIL, E-mail: zanuncio©mail.ufv.br; ²Empresa Brasileira de Pesquisa Agropecu-ria – EMBRAPA, Caixa Postal 174. 58.107-720 - Campina Grande, PB, BRAZIL.

Brontocoris tabidus (Heteroptera: Pentatomidae) is an important predator of defoliating Lepidoptera in Brazil, which has been mass produced and released against defoliating caterpillars in Eucalyptus plantations. We aimed to improve the mass production of this predator by providing eucalypt seedlings, besides an alternative prey, for its development. The effect of three *Eucalyptus* species on the development of *B. tabidus* fed with Tenebrio molitor L. (Coleoptera: Tenebrionidae) pupae was studied at a temperature of 25.0 ± 2.5 °C; a relative humidity of 70.0 ± 10.0% and a photophase of 12:12 hours (light: dark). Pupae of T. molitor was provided in each of the following feeding treatments: treatment 1- Eucalyptus urophylla seedlings; treatment 2 - Eucalyptus camaldulensis seedlings; treatment 3 - Eucalyptus grandis seedlings; and treatment 4 - no seedling (only pupae of T. molitor). Duration of the nymphal phase of the predator was similar in all treatments with plant and prey. It was observed that adults developed from nymphs fed on T. molitor only had deformed wings and a small abdomen. B. tabidus fed during their nymphal and adult stages with prey together with Eucalyptus seedlings, had improved longevity, higher egg viability and a larger number of eggs and nymphs, than those insects fed only with prey. Therefore, it seems advisable to rear B. tabidus with prey and seedlings of one of the Eucalyptus species studied to improve the mass production of this predator for biological control of defoliating caterpillars of eucalypt plantations. Index terms: Plant feeding, predatory bug, alternative prey

[1986] KEY FACTORS AFFECTING POPULATIONS OF SCHIZOTETRANYCHUS NANJINGENSIS, APONYCHUS CORPUZAE AND ACULUS BAMBUSAE IN FUJIAN BAMBOO FORESTS DURING DIFFERENT SEASONS: AN ANALYSIS USING METHODS OF GREY SEQUENCE

Y. X. Zhang¹, J. Z. Lin¹, Z. Q. Zhang², M. G. Song³, J. Ji¹ & Q. Y. Liu⁴, ¹Institute of Plant Protection, Fujian Academy of Agricultural Sciences, Fuzhou, 350013 China, E-mail zyxlj@pub3.fz.fj.cn; ²Landcare Research, Private Bag 92170, Auckland, New Zealand; ³Nanping City Forest Protection Office, Nanping, Fujian, China; ⁴Laboratory of Forest Protection, Fujian Forestry Bureau, Fuzhou 350002, China.

The key factors affecting the population dynamics of mite pests on the moso bambooin Fujian, China. Schizotetranychus nanjingensis Ma & Yuan. In spring, temperature was an important factor influencing mite population growth in a big harvest year, but in a small harvest year predation was the key factor. In Summer, Relative humidity was most important to the population development of this species in a big harvest year, but in a small harvest year, predation was the key factor (except in 1996 when rainfall was the key factor). In Autumn, temperature was the key factor for mite population development in a big harvest year, but in a small harvest key factor was either rainfall or relative humidity. In Winter, temperature and predation were more important than other factors in a big harvest year, but relative humidity was the key factor in a small harvest year. Aponychus corpuzae Rimando. In Spring, The relative humidity was an important factor in a big harvest year, but in a small harvest year, predation was the key factor. In Summer, predation was the key factor in a big harvest year, but in a small harvest year, temperature was the most important factor. In Autumn, relative humidity was the key factor influencing its population in a big harvest year, but in small harvest year, rainfall was the most important factor. In Winter predation was the key factor in a big harvest year, but rainfall was the most important factor in a small harvest year. Aculus bambusae Kuang. In Spring, relative humidity was the key factor influencing its population in a big harvest year, but in a small harvest year, predation was the key factor. In Summer, predation was the key factor influencing its population in both big and small harvest years. In Autumn, relative humidity was the key factor in a small harvest year of 1996 and big harvest year of 1997, but predation was the key factor in the small harvest year of 1998. In Winter, rainfall was the key factor in a small harvest year, but predation was the key factor in a big harvest year.

Index terms: Pest mites, climatic factors, Typhlodromus bambusae, Grey Sequence.

[1987] OPHIOSTOMATOID FUNGI ASSOCIATED WITH THREE BARK BEETLES IN SOUTH AFRICA

X. D. Zhou¹, Z. W. de Beer², <u>M. J. Wingfield¹</u> & B. D. Wingfield¹, Dept. of Genetics, Forestry and Agricultural Biotechnology Inst. (FABI), Univ. of Pretoria, Pretoria, 0002, Republic of S. Africa; Dept. of Microbiology & Plant Pathology. Univ. of Pretoria, Pretoria, 0002, Republic of S. Africa

Ophiostomatoid fungi, for example, Ophiostoma, Ceratocystis and Ceratocystiopsis, are economically important because they cause blue stain in lumber and logs, thus reducing the value of export wood. These fungi are often associated with bark beetles (Coleoptera: Scolytidae). Three species of exotic bark beetles, Hylastes angustatus, Hylurgus ligniperda and Orthotomicus erosus occur on mature Pinus spp. in South Africa. Hylustes angustatus also damages pine seedlings during its maturation feeding stage. Despite extensive research on these three bark beetle species in South Africa, little is known about the fungi associated with them. The aim of this study was to determine the extent to which these three bark beetle scontribute to the blue stain problem, and to identify their fungal and 000 beetle galleries from trapping logs, infested stumps and root collars of Pinus patula and Felliottii trees in the eastern parts of South Africa, and about 600 fungal isolates were collected. Forty additional isolates were identified based on morphology, rDNA sequencing and mating studies. At least 12 different ophiostomatoid species have been found to be associated with these three bark beetles. The dominant fungal associates were *Leptographium serpens*, L. lundbergii, Ophiostoma ips, and Graphium sp. Ophiostoma galeiformis and L. procerum are reported here for the first time from South Africa.

[1989] BACTERIA ADVANCEMENTS AND RESEARCH NEEDS

[1988] NEMATONES RESEARCH NEEDS

<u>I. Glazer</u>

ABSTRACT NOT RECEIVED

[1990] VIRUSES

J. L. Flexner, Dupont Agricultural Products, Stine-Haskell Research Center, Newark, Delaware

Viruses have been isolated from more than a thousand species of insects from at least thirteen different insect orders. Entomopathogenic viruses from almost a dozen viral families have been isolated: Ascoviridae, Baculoviridae, Birnaviridae, Iridoviridae, Nodaviridae, Parvoviridae, Picornaviridae, Poxviridae, Reoviridae, Rhabdoviridae, and Tetraviridae. However, the number of currently registered viral insecticides is made up of a relatively small number of entomopathogenic viruses exclusively from the family Baculoviridae. All of these commercially available baculoviruses are targeted for lepidopteran hosts with the exception of one forestry product for sawfly control (Hymenoptera: Diprionidae). Most are very specific, infecting one or several slowly, sometimes taking 7 to 10 days to kill larger instars. All baculoviruses are extremely susceptible to degradation under UV light, making them ephemeral in direct sunlight when applied as insecticides without protective formulations. Recently, the nucleopolyhedroviruses such as AcMNPV have been genetically modified for an increased killing speed. The most promising of these genetically modified viruses encode and express insect-selective toxins and have resulted in an approximate 20 to 50% reduction in the killing time of their insect hosts. Several of these genetically modified baculoviruses have been field tested but none are currently being commercialized. The first viral insecticide was the single-nucleocapsid Nucleopolyhedrovirus of Helicoverpa (Heliothis) zea (HzSNPV) registered in 1971. This virus was developed by the USDA in the mid-1960s for control of Heliothines (e.g. Tobacco Budworm (Heliothis virescens), Corn earworm (H. zea), and Heliothis armigera) on cotton, row crops, fruits and vegetables and is still currently produced and marketed. By far the most successful viral insecticide used to date is the multinucleocapsid Nucleopolyhedrovirus of Anticarsia gemmatalis (AgMNPV) applied to over 1 million hectares annually for control of the velvetbean caterpillar, A. gemmatalis, in Brazil. This section will describe the commercial importance of baculovirus insecticides and the recent advances that have been made in formulation technology, mass production and genetic manipulation. Safety of genetically modified baculoviruses will also be discussed. In addition, this discussion will focus on areas of baculovirus research that have been neglected that could possibly advance the potential of this group for commercialization.

Index terms: biological control, microbial control, insect viruses, Baculoviruses, Nucleopolyhedroviruses

[1991] MICROBIAL CONTROL: DREAM OR REALITY FUNGI: ADVANCEMENTS AND SUCCESSES

J.C. Lord, Grain Marketing and Production Research Center, US Dept. of Agriculture, 1515 College Ave., Manhattan, KS 66502, USA, E-mail: lord@usgmrl.ksu.edu.

Commercial mycoinsecticides have been registered and used on all of the continents except Antarctica. Beauveria bassiana and Metarhizium anisopliae are prominent, but registered products exist for at least five other species. Successful use patterns involve selection of targets by biological and sociological factors. The systems in which mycoinsecticides are most successful include systems wherein there is a highly susceptible key target pest, systems of special concern for avoidance of synthetic toxins crops grown by cooperatives, and high value crops, especially in protected agriculture. Perhaps most importantly, mycoinsecticide can only succeed in those systems that allow delivery into contact with the target. Registrations do not ensure success. Market-driven products rarely succeed. Failures are often due to business plans built on large acreage, low value crops such as corn, cotton and soybeans. Technical staff sometimes fuels unrealistic expectations with optimistic predictions of performance. Unfortunately, there are past and future failures that are due to poor quality products and inadequate use rates. Advances in production, formulation, and storage are important factors in the successes. Production improvements are primarily engineering achievements. It is now practical to convert 10% of the weight of grain substrates into nearly pure conidia. Mixing and stability properties have been improved by the use of oil-based formulations. Optimization of water content of conidia and gas exchange in packaging has allowed storage of some commercial products for more than a year at moderate ambient temperatures for without significant loss of activity. Improvements in understanding and quantification of spore delivery have contributed to improved performance. Interestingly, selection of strains for virulence has contributed little to the success of mycoinsecticides, but selection for prodigious conidiation is an economic imperative. Five successful cases to be discussed are: M. anisopliae for control spittlebugs in sugarcane and pasture in Brazil, Verticillium lecanii for aphids, whiteflies and thrips in Europe, B. bassiana for coffee berry borer in Latin America, B. bassiana for control of miscellaneous pests in the United States and Mexico, and B. bassiana for control of Masson's pine caterpillar in the Peoples Republic of China.

Index terms: mycoinsecticide, microbial control, Beauveria bassiana, Metarhizium anisopliae, Verticillium lecanii

I. Federici

ABSTRACT NOT RECEIVED

[1992] MICROBIAL PESTICIDES: DREAM OR REALITY ENTOMOPATHOGENIC FUNGI VS. AGRICULTURAL PESTS

D. R. Sosa-Gómez, Embrapa Soja, Cx. P. 231, Londrina, PR, 86001-970, Brazil. Email sosa@cnpso.embrapa.br

Since 1888, when Krassilstchik based on the work of Metschnikoff produced Metarhizium anisopliae to control the sugar-beet weevil, there has been a dream to control pests with fungi. The microbial control foundation lays on the deep knowledge of the epizootiological aspects. Frequently, the epizootiological process has been simplified to the trilogy pathogen-host-environment. But in nature, an epizootic on a single host can be caused by an arrangement of different fungal genotypes infecting an array of different insect genotypes, feeding on a changing substrate in a changing environment. Far from a reality-based strategy, the traditional approach has been single strain application. Furthermore, the complexity of behavior and unstable nature of fungi have made them not easily produced on a massive level. Also due to the size of their genome, the complete knowledge (sequences and functions) of their genetic codes will take time to be accomplished. Therefore, many aspects should be understood before reaching the stage where fungi can be used as reliable control agents in a variety of agricultural systems. Mycopathogen epizootics occur in several agricultural and forest systems, but man has not been successful in reliably inducing epizootics. Nowadays there is incomplete knowledge about which are the biochemical and/or genetic determinants of the complex and multigenic fungal virulence. The interactions with different hosts make each case, a unique study. Although production methods have been improved in the last years, the relationship cost/benefit still is very high. Frequently, there is the need of several applications or the use of a high dosage approach to get adequate control. These facts limit mycoinsecticide use expensive commodities. Among the different aspects that need more research efforts, application technology appears to be the most neglected area. Not much progress has been made in this area to improve control. Soil inhabiting pests possibly demand more work than aerial or exposed pests, since the soil is a complex environment where homeostatic forces tend to diminish fungal impact. Additionally, in the soil several, organisms act in antagonistic ways, and a more elaborated inoculum delivering technology is required. Presently, Beauveria and Metarhizium species have been used in emerging and declining microbial control programs. However, the use of other entomopathogenic fungi might go a long way toward fulfilling the desired dream. Index terms: entomopathogenic fungi, biological control, microbial control

[1993] PERSPECTIVES AND LIMITATIONS ON THE COMMERCIAL DEVELOPMENT OF ENTOMOPATHOGENIC NEMATODES

S. Franceschini, Biochem s.r.l., Via Virgilio 1 Corbetta (MI), Italy,

The efficacy of entomopathogenic nematodes to control soil inhabiting insect pests has been extensively shown against many insect pests. However these biocontrol agents are currently used only on niche market mainly in cases where chemical has no effect. In order to reach an extensive commercial applications a number of tasks have to be addressed. Perspectives for the commercialization of these materials are very significant, mainly due to the high efficacy, exemption for registration and market requirements. The limitations to their further applications are on the other hand the consequence of erratic field results, particularly under unusual climatic conditions, also their relative high cost and lack of stability limit the use of these products. The development of new products that can solve these problems could significantly increase the use of EPN as biopesticides agents. Production costs have to be reduced significantly in order to increase the competitiveness of the EPN with chemical where there is an alternative. This can be accomplished by developing adequate fermentation processes for EPN mass production in which particular attention has to be paid to the establishment of efficient bacteria and nematode inoculum train for the preparation of seed fermenters. Increase of fermentation volumes, reduction of media ingredient expenses, reduction of fermentation time, increase of fermentation yields as well as recovery of the final product could be the key elements for the increase of EPN market share. Fermentation process has to be scaled up to an adequate volume to fulfill the market requirements. EPN are very delicate microorganisms not able to survive the handling stress of severe production processes resulting in organisms with poor field performance. In order to avoid these problems standard equipment has to be adapted for the production process. Formulation stability remains probably the main problem needed to overcome. Product shelf life has to be significantly improved in order to increase product storage at room temperature and avoid the development of contaminants. Good methods for quality control capable to discriminate the quality of single production batches as well as predict their field performance are also critical parameters to consider. EPN have the potential to take a significant portion of the market provided that the consumer expectations are fully met. Index terms: fermentation, formulation, shelf life.

[1994] GENETICS AS A MEAN TTO IMPROVE ETNS TOLERANCE TO ENVIRONMENTAL STRESS

I. Glazer

ABSTRACT NOT RECEIVED

[1995] GENETIC IMPROVEMENT OF ENTOMOPATHOGENIC NEMATODES

R. Gaugler, Department of Entomology, Blake Hall, Rutgers University, New Brunswick NJ 08901-8524, USA, E-mail Gaugler@rci.rutgers.edu.

Thirty years ago, the idea of using nematodes to control insects was a vague concept held by the handful of researchers working with these obscure insect parasites. Today nematodes are no longer a laboratory curiosity but have begun to be used in niche crops, including citrus, mushrooms, turfgrass, and home and garden.

Despite impressive strides in nematode use, further progress may require technological solutions to reduce the gap twixt nematodes and conventional insecticides in stability, reliability, cost, ease-of-use, and efficacy. Entomopathogenic nematodes are well suited for genetic manipulation due to their simplicity, transparency, ease of culture, short generation time, and small genome size, attributes that entomopathogenic nematodes share with the intensively studied nematode, Caenorhabditis elegans. Molecular insights generated with this closely related free-living nematode are now being applied to entomopathogenic species. This paper begins by summarizing the available classical and molecular genetic information relevant to entomopathogenic species. Efforts made at genetic manipulation including hybrid vigor, selective breeding, mutagenesis, and genetic engineering are discussed with emphasis on future prospects and remaining obstacles. Traits offering promise for modification and molecular tools required to accelerate efforts are identified. Case studies will focus on enhancing heat tolerance, desiccation tolerance (i.e., shelf-life), and the anti-immune response (i.e., enhanced efficacy) by overexpression of potentially useful genes. The use of interference RNA, a powerful new molecular tool developed to study gene regulation will be treated. This fast and simple procedure permits the disruption of gene expression and the creation of null mutants. The paper concludes by reviewing the potential that transgenic strains offer to enhance the broader study of entomopathogenic nematode biology. As one example, molecular markers expressing green fluorescence protein in posterior ganglia have been previously generated in heterorhabditid nematodes, but have been too indistinct to use for other than molecular purposes. New advances in expressing markers throughout the nematode cuticle coupled with the easy availability of fluorescent stereomicroscopy offers the ability to quickly screen large populations. The relevance of this advance to nematode field ecology will be discussed.

Index terms: mutagenesis, selection, genetic engineering.

[1996] USE OF PATHOGENIC NEMATODES AND THEIR SYMBIOTIC BACTERIA FOR THE CONTROL OF SLUG PEST

<u>R. A. France</u>, M. E. Gerding, S. Espinoza & E. Vivanco, INIA - Quilamapu, P.O. Box 426, Chillán, Chile.

Slugs are important pest over a wide range of climatic and agronomic conditions. Some agricultural practices, like mulching or reduced tillage favour slug reproduction up to levels capable to produce severe damage to monocots plants and make broadleaf cropping impracticable. Until now, slug control has been based in toxic baits, which are easily damaged by high humidity after application, and with active ingredients unfriendly to the environment. Biological control of slugs has been a complicated task mainly due to the presence of few natural enemies. However, the discovery of Phasmarabditis hermaphroditu, a parasitic nematode of slugs and snails, in the UK in 1988, provided a new alternative to slug control. This nematode has been found also in Chile (1996), following a fortuitous slug sampling. The nematode is an effective parasite, which enter into the slug either through the shell cavity or respiratory pore. Like entomopathogenic nematodes, P. hermaphrodita releases symbiotic bacteria that are pathogenic to slugs. These bacteria are responsible for producing a marked swelling of the mantle, inducing feeding inhibition and body disintegration. Moreover, the bacteria associated with the Chilean nematode also produces mouth and reproductive system prolapsing. The main differences between both isolates are in their symbiotic bacteria. The UK nematode was found to be associated with ninc bacterial isolates, however, only one was the most effective in killing slugs (Pseudomonas fluorescens) while another specie was capable to support nematode reproduction (Moraxella osloensis). On the other hand, the Chilean isolate has only two associated bacteria (P. fluorescens and Serratia fonticola), both of them capable to kill slugs and support nematode reproduction. Also, each one of the individual bacteria or their by-products when used as toxic bait for slugs' control produced similar symptoms to the ones observed with the nematode-bacteria combination. Also, it was observed that the field applications of the nematode not only killed the slug pest from the treated soils but also had a positive effect in the following crop. The UK P. hermaphrodita is currently commercialised by Microbio in Europe, but only as a garden biopesticide. Price is the main restriction for their use in farmland. Efforts should be made in order to find a more effective nematode-bacteria combination with improves nematode rearing efficiency and better storage capabilities. The potential of using the isolated symbiotic bacteria or their metabolites, either for slug control or source of novel products should be explored.

Index terms: Deroceras reticulatum, Phasmarhabditis hermaphrodita, parasitic nematcdes, slugs, biological control.

[1997] BIOPESTICIDES BASED ON ENTOMOPATHOGENIC NEMATODES: DREAM OR REALITY?

B. Fridlender, Biotech M.A.H. Headquarters Brurim M.P. Shikmim 79837 Israel, Email: tolof@hazera.com

The capabilities of insect and other parasitic nematodes to serve as biocontrol agents have been know for a long time. However, despite their effectiveness, the application of these very interesting biopesticides has remained limited to certain niches markets. Parasitic nematodes, as most biocontrol agents, are living organisms that have very specific requirements in order to remain healthy and retain their capabilities to effectively reach their target host pest. Nematodes activity, in contrast to other more simpler biocontrol agents, are based in a complex living system formed by the nematode and its symbiotic bacteria. The complexity of this biological system as well as the lack of full understanding of the physiological interaction of these components with their target pests, have probably been one of the most significant limiting factors in the extensive use of these biopesticides. The importance of the symbiotic bacteria and the main role played by them in the control of insects and other pests has been recognized only in the last couple of years. Nematodes probably act mainly as vectors of these bacteria with the capability to deliver their lethal load into the right place of the target pest. It could be that they also play another role in this complicated control system, however, it is still not fully clear how this is done. It is the complexity of the system what has made so difficult the mass production of these biopesticides at a costeffective price. The main limitations of available products are their short shelf life and lack of state of the art formulations. However, the efficacy demonstrated for the different strains of nematodes available and their wide spectrum of activity against many different pests fully justifies development efforts needed to obtain better and more readily available products. The development of future products should have a much less conventional approach and it should take into consideration the great deal of knowledge becoming available from the different genomic programs. New information being derived from the understanding of the function of the nematodes as well as their symbiotic bacterial genetic composition could be very significant for production and stability purposes. Nematodes capable to persist in wider ranges of environmental conditions associated with bacteria with increased pathological capabilities are just a couple of examples of characteristics that can improve the existing products. There is hope that the dream will be converted in reality. The use of the vast amount of functional genetic information arising from around the world could make the difference.

[1998] BACULOVIRUS PRODUCTION IN VITRO - RECENT DEVELOPMENTS

S. Reid & S. Weiss, Dept. Chem. Engin., Univ. of QLD., Brisbane, Q, 4072, Australia

In Australia, due to resistance by *Heliothis* larvae to nearly all available chemical sprays, an *in vivo* produced baculovirus product, Genastar[®], is finding a ready market on a range of crops. Recently we have demonstrated the ability to produce a Helicoverpa armigera singly enveloped nucleopolyhedrovirus (HaSNPV) in vitro using a Helicoverpa zea cell line which shows comparable activity to Gemstar in the field (Chakraborty et al., 1999). Currently a fed - batch process is being developed at pilot scale using a low cost medium (LCM) to further demonstrate the commercial potential of the HaSNPV fermentation product. Fed - batch studies have shown the potential to produce up to 1.2 g/L of B-Galactosidase using the Spodoptern frugiperda, SI9, cell line and a recombinant Autographa californica nuclear polyhedrosis virus, (Chan et al., 1998). It should be possible therefore to eventually produce 1.2 g/L of the HaSNPV virus (each virus particle is composed primarily of 0.5 picograms of polyhedral protein). At such yields, at the current application rates of 5 x 10¹¹ HaSNPV particles/Ha, a good buisness plan can be established for this product. While the development of LCM (less than \$4/L) and process models (Power et al., 1994), for insect cell/baculovirus systems are at an advanced stage, the stability of HaSNPV isolates over at least 10 passages (required to scale the process to the necessary 5-10,000 L scale) in culture, is proving problematic. This talk will review the status of our process research into the development of a baculovirus fermentation product.

Index terms: *Helicoverpa armigera*, nucleopolyhedrovirus, NPV, fermentation Chakraborty, S., Monsour, C., Teakle, R.T., and Reid, S., (1999). J.Inv.Path. 73, 199-205.

Chan, L.C.L., Greenfield, P.F., and Reid, S. (1998), Biotech. Bioeng., 59,178-188. Power, J.F., Reid, S., Radford, K.M., Greenfield, P.F. and Nielsen, L.K. (1994), Biotech.Bioeng., 44, 710-719.

[1999] POTENTIAL IN AUSTRALIA FOR A HELICOVERPA BACULOVIRUS

D.A.H. Murray, R.J. Lloyd & J. Boddington, Department of Primary Industries Po Box 102 Toowoomba Q 4350 Australia.

Helicoverpa armigera is a scourge for producers of fibre, grain, fodder and food crops in Australia, costing an estimated A\$225M annually in chemical control and lost production. Reliance on conventional synthetic insecticides has turned a full circle. More than 20 years ago a Helicoverpa nucleopolyhedrovirus (NPV) made a foray into the Australian insecticide market. Eventhough it had many of the attributes of a successful biopesticide, it did not compete in the market place with the new synthetic pyrethroids and carbamates. Insecticide resistance to these insecticide groups has changed the outlook as control of H. armigera is unreliable using conventional chemistry. There are also increasing pressures to adopt sustainable insect pest management approaches that embrace a responsible attitude towards the environment and the community. In late 1998, a Helicoverpa NPV, under the trade name Gemstar® was registered in Australia for Helicoverpa spp. control on grain sorghum and chickpea, Registration on cotton was approved in January 2000. The imported product costs about A\$60/L and is used at rates from 100 to 500 niL/ha. There has been an amazing uptake of Gemstar in the marketplace as pest managers recognise the potential contribution of this product. Limited use on a suite of other crops is allowed under permit. The adoption of Gemstar has been accompanied by a growing acceptance that total pest control is not achievable nor necessary in many of today's crops. Conservation of natural enemies is fundamental to this approach. Gemstar has delivered the goods, but it should not be used like any other insecticide. Education and understanding how Gemstar works are crucial, as are application and timing. Much of the current effort with Gematar is to improve its performance and broaden the The addition of milk powder has repeatedly improved field registration suite. performance of Gemstar. Various other additives have been evaluated, but none of these were equivalent to milk powders. Increasing persistence of NPV through the use of UV protectants has not been delivered, and in some crops multiple low rates are viewed more favourably than a single high rate application. Ultra low volume application has demonstrated its potential for cost effective Helicoverpa management in grain sorghum. An in vitro NPV was equivalent to Gemstar in initial field trials. The future for Helicoverpa NPV in Australia is very promising. It has cemented a niche in the marketplace, and this will invariably expand as users fully understand its capabilities. A locally produced in vitro product will also strengthen its share in a competitive insecticide market. An exciting time is dawning as finally some successful IPM programs are being developed. Just as before, the threat lies in new chemistry that provides a 'simple, quick fix' solution.

Index terms: Helicoverpa armigera, nucleopolyhedrovirus, NPV, in vitro

[2000] POTENTIAL FOR FUNGAL BIOPESTICIDES IN TROPICAL AGRICULTURE: THE AUSTRALIAN EXPERIENCE

R.J.Milner, CSIRO Entomology, GPO Box 1700, Canberra, ACT 2601, Australia.

Research in Australia on entomopathogenic fungi over the past decade has concentrated on the genus Metarhizium. This fungus is easily isolated from soil and there are now about 1000 isolates preserved in the CSIRO Insect Pathogen Culture Collection. This fungus is genetically very diverse with some isolates being specific for certain targets and others with a wide host range. For example, isolates from acridids recently named M. anisopliae var. acridum are only known from acridid grasshoppers in nature while isolates identified as M. anisopliae var. anisopliae often attack a wide range of hosts in the laboratory, though their host range in nature is unknown. Isolates also vary in their response to temperature with *M. anisopliae* var. acridum growing well at temperatures up to 3° C and poorly below 15 °C, while some isolates of *M. flavoviride* var. *flavoviride* grow well at 10 °C but poorly over 30 °C. These factors need to be taken into account when selecting an isolate to develop as a biopesticide. At least 2 commercial companies are producing strains of Metarhizium as biopesticides in Australia. However only one product, BioGreen for use against redheaded pasture cockchafer, *Adoryphorus couloni*, produced by Bio-Care Technology Pty. Ltd. is registered at present. A second product, BioCane, for use against sugarcane scarab larvae is expected to be registered soon. This product is effective against Australia's most severe sugarcane pest, the greyback canegrub, Dermolepida albohirtum, and applied as conidia soon after planting. The conidia are produced by solid substrate fermentation on sterile broken rice and used directly as a natural granule. In 1999, some 9 tonnes of product were used in commercial trials under experimental use permit. Also nearing registration is Green GuardTM, an oil formulation of M. anisopliae var. acridum (isolate FI-985) for control of locusts and grasshoppers. This has also been extensively field trialed under an experimental use permit and a dose of 1×10^{12} conidia/ha has proved effective over a range of weather conditions for control of Australia's worst locust pest, Chortoicetes terminifera. The expected cost of this dose is comparable with chemical pesticides and given current concerns about chemical residues in Australia and the expansion of organic farming, it is likely to be widely used for preventative control of locusts. Other potential targets include termites, crickets, flies and various soil insects. *Metarhizium* seems to be poised to become a major biopesticide in Australia over the next few years. Index terms: *Metarhizium*; locusts; sugarcane scarabs; biopesteides; *Adoryphorus*

couloni, Chortoicetes terminifera, Dermolepida albohirtum.

[2001] IS SOLID STATE FERMENTATION THE BEST OPTION TO PRODUCE FUNGAL BIOPESTICIDES?

<u>S. Reid¹</u>, D.A. Mitchell² & A.Mordocco¹, ¹Dept. Chem. Engin., Univ. of QLD., Brisbane, Q, 4072, Australia; ²Depto de Solos, UFPR, Rua dos Funcionários 1540, Juvevê, Curitiba 80035-050, Paraná, Brazil, E-mail mitchell@agrarias.ufpr.br

Entomopathogenic fungi have been studied widely for use as biological control agents against many Australian pests. Conidia can be produced directly by solid state fermentation (SSF), or alternately, submerged liquid fermentation (SLF) can be used to produce mycelia that are then placed in trays to induce sporulation (diphasic production). A model organism, Metarhizium anisopliae, was chosen for this study. Conidia of M. A model organism, incluming an inspirate, was closed to us study, comma or main anisopliae were initially produced in jars using parboiled rice as a substrate. Studies showed the organism to be sensitive to agitation, with an optimal conidia yield of 2.57×10^9 conidia g⁻¹ rice obtained without agitation. When hand agitation (days 4-14) was incorporated a small decrease in yield to 1.97×10^9 conidia g⁻¹ rice was produced. This yield decreased even further to 1.09×10^9 conidia g⁻¹ rice with 5 min agitation, day 4-14 at 7 rpm, and 9.14 x 108 conidia g-1 rice with 15 min agitation, day 4-14 at 7 rpm. In fact, any form of agitation was detrimental to conidia production. This presents a problem for large-scale production of this organism as agitation would be required at large-scale to encourage oxygen transfer and to promote heat removal, homogeneity and the uniform distribution of water added to the substrate during the fermentation. Based on the decrease in conidia yields in an agitated system, even if the agitation was infrequent, it was decided that SSF would be problematic at large scale, and therefore an alternative production technique was sought. Another feasible technique for the production of conidia was to use SLF to produce biomass and then produce conidia using SSF. This two-step production method is referred to as a diphasic process. The process decided upon was one in which no additional substrate was added during the SSF step when the vegetative biomass was the introduction of the state of mycological peptone and 10 g L¹ of yeast extract, giving a biomass yield of 20.90 g dry biomass L⁴. Conidia production by the biomass harvested from the SLF occurred only 48 h after placement on an agar plate surface with a yield coefficient of 1.4 x 1010 conidia g' dry biomass. The efficiency of the conversion process from biomass to conidia was low for this process at approximately 17% w/w but with further work this may be improved. Bioassays showed that the biological activity of the conidia produced by the SSF method and the diphasic method were equivalent

Index terms: Metarhizium anisopliae, Solid State Fermentation.

[2002] FUNDAMENTAL ISSUES THAT LIMIT SCALE UP OF FUNGAL BIOPESTICIDES USING SOLID STATE FERMENTATION PROCESSES

<u>D. A. Mitchell¹, O. F. von Meien², A. Maccari Jr¹ & N. Krieger³, ¹Depto de Solos,</u> UFPR, Rua dos Funcionários 1540, Juvevê, Curitiba 80035-050, Paraná, Brazil, Email mitchell@agrarias.ufpr.br; ²Depto de Engenharia Química, UFPR, Cx. P. 19011, 81531-970 Curitiba, Paraná, Brazil; ³Depto de Química, UFPR, Cx. P. 19081, 81531-990 Curitiba, Paraná, Brazil.

Fungal biopesticides have potential for use against many insect pests, however, their production at large scale can be problematic, especially when spores are the active agent. The production of these spores usually must be done in solid-state fermentation (SSF), because the fungi involved typically do not sporulate well in liquid culture, and even if they do, fungal spores produced in submerged liquid culture are usually more sensitive, less stable and less virulent than the aerial spores produced in the environment provided by SSF. However, despite the superiority of SSF, it has a major limitation: little is known about how to design and operate bioreactors for large scale SSF processes. As a result, relatively few fungal biopesticides requiring SSF technology have been successfully commercialized. Most commercial processes operate on relatively small scales, involving production in multiple trays or bags. However, it is difficult to use this production technology in batches of greater than a tonne of substrate because such processes are very labor intensive and therefore expensive at these scales. This presentation will explore the challenges in the development of large scale SSF bioreactors and current research being undertaken tomeet these challenges. It will show that several bioreactor designs can be used for SSF processes, but that even with the most efficient designs there is always a problem: due to the poor heat and mass transfer characteristics of solid beds, it is very difficult to maintain the bed temperature and the oxygen and water levels at values optimal for growth of the fungus. It is especially difficult to remove the waste metabolic heat generated by the fungus during growth at a rate sufficient to prevent the temperature of the substrate bed from increasing to values which are deleterious to growth and sporulation. Furthermore, large temperature gradients can occur within the bed. These can be prevented by agitating the solid substrate, but this usually decreases spore yields even further because it damages reproductive hyphae. Without presenting mathematical details, the presentation will show how mathematical models of fungal growth and the heat and mass transfer processes within the bioreactor are essential tools guiding how SSF bioreactors should be designed and operated. The establishment of rational model-based strategies for the design and operation of large scale SSF bioreactors will have significant benefits for the production of fungal bionesticides

Index terms: bioreactor design, process scale-up, transport phenomena, mathematical models

[2003] CURRENT STATUS ON MICROBIAL CONTROL OF TERMITES IN AUSTRALIA

R.J.Milner, J.A. Staples and M. Lenz, CSIRO Entomology, GPO Box 1700, Canberra, ACT 2601, Australia.

Subterranean termites are major urban pests in Australia. The most damaging species belong to the genus Coptotermes and form discrete nests in trees or in the ground. Termites can also cause problems in horticulture (Mastotermes darwiniensis). Current termite management measures are based on chemical controls, physical barriers and the imposition of the Australian building standard for termite management. Among the more novel methods for controlling active infestations in buildings are the use of bait systems and also nematodes of the genus Steinernema for Coptoternes spp. In 1983, Hänel and Watson showed that conidia of the hyphomycete fungus, Metarhizium anisopliae, could be applied to feeding sites of Nasutitermes exitiosus and the disease would transfer to the colony causing some adverse effects. However due to "unknown factors" the colonies often recovered and no epizootic developed. Over the past 10 years, we have been undertaking research to elucidate these "unknown factors" and hopefully develop a commercial microbial control product based on the conidia of M. anisopliae. An extensive survey was undertaken to assess the significance of Metarhizium as a natural mortality factor in Australian termite colonies. This survey resulted in over 100 isolates being obtained from termite contraits in was concluded that the fungus did not normally cause epizootics in termite colonies. Screening of the isolates resulted in the selection of FI-610 a strain with a wide host range which is highly pathogenic for all species of termites tested. This strain developed well under the temperature and humidity conditions normally found in termite nests but when introduced into a mound resulted in avoidance behaviour and the walling off of the applied conidia. It is now thought that these behavioural responses are the "unknown factors" of Hänel and Watson. Strategies for use of *Metarhizium* as a microbial control agent include killing the nest with a large dose of conidia blown directly into the centre of a nest, the use of the conidia as a prophylactic barrier by treatment of the surface of wood or of the soil, the use of a dust to eliminate termites from active galleries in damaged buildings and, recently, the possible use of conidia in baits. Problems and progress with baits will be discussed. We have an agreement with SGB Pty. Ltd. in Albury to commercialise Metarhizium for termite management in Australia.

Index terms: Metarhizium: termites: Steinernema, Coptotermes, Nasutitermes,

[2004] MICROBIAL CONTROL OF TERMITES IN BRAZIL

S.B. Alves¹, J.E.M. Almeida², P.J. Neves³ & A. Moino Jr.⁴¹ESALQ/USP, C.P.9,13418-900,Piracicaba/SP-Brazil.E-mail sebalves@carpa.ciagri.usp.br; ²CEIB, C.P.70, 13001-970,Campinas/SP-Brazil. jemalmeida@uol.com.br; ³UEL, C.P.6001,86051-970, Londrina/PR-Brazil.E-mail pmojneve@uel.br; ⁴UFLA,C.P.37,37200-000,Lavras/MG-Brazil. E-mail alcmoino@ufla.br

In Brazil termites are considered important agricultural and urban pests. Several crops, such as sugarcane, pastures, forests and citrus are frequently attacked by termites. In urban areas, these insects attack trees, buildings, furniture and even phone cables. To replace chemical control, studies were developed on microbial control (MC) of Heterotermes tenuis in sugarcane using baits ("Termitrap"), in which individuals are contaminated with control agents. These agents are later transmitted to other insects by contact or trophallaxis. The baits contained entomopathogenic fungi in association with chemical insecticides. Strains of Beauveria bassiana and Metarhizium anisopliae were selected for the control of H. tenuis in the laboratory and a higher than 90% inortality rate was observed. Also, B. bassiana associated with several insecticides caused similar mortality levels. The baits were also used for bioecological studies of H. tenuis in sugarcane to evaluate population level and foraging area. These studies showed that cultural practices in the sugarcane crop influence the termite populations, and that the use of 30 to 35 baits/ha is sufficient to monitor these populations. In field tests, the insecticide triflumuron, mixed or not with the entomopathogenic fungi, caused reduction of the termite population at 0.1, 0.15 and 0.2% concentrations. Similar results were obtained when the entomopathogenic fungi were used alone. Preliminary studies showed efficacious control of small and medium mound termite nests, Cornitermes cumulans with B. bassiana and M. anisopliae applied in an inundate strategy. However, this strategy was not very effective for the control of large nests. Further studies associating entomopathogenic fungi with im

[2005] MICROBIAL CONTROL OF TERMITES IN THE USA IN THE UNITED STATES

B.T. Forschler, Dept. of Entomology, Univ. of Georgia, Athens, GA 30602, USA

The potential for biological control using predators, parasites and pathogens has not been thoroughly investigated for termite control. Vertebrate and invertebrate predators have not been seriously considered because of a variety of biological constraints and the zero tolerance action thresholds used in termite control (Grace 1997. Agri. Entomol. 14:281-189). Insect parasitic nematodes have been investigated but were found to repel termites from the point of application rather than effect serious termite population reductions (Mix 1986. Pest Control 53:48-54; Epsky & Capinera 1988. J. Econ. Entomol. 81:21-30). Bacterial pathogens have been screened but effects on termites in laboratory bioassay were not promising (Grace and Ewart 1996. L. Appl. Microbiol. 23:183-186). No viral pathogens have been examined. Biological control of subterranean termites in the United States has been directed toward survey and laboratory bioassay of entomopathogenic fungi (Lai et al. 1982, J. Invertebr. Path. 39:1-5; Zoberi and Grace 1990. Mycologia 82:289; Jones et al. 1996. Environ. Entomol. 25:481-487). Intuitively, Rhinotermitidid termites have co-evolved with and therefore should have defenses against fungal epizootics. Experimentally it has been shown that termites have physical and social barriers to fungal infection (Boucias et al. 1996. Pflanzenschutz-Nachr. Bayer 49:103-145; Rosengaus et al. 1998. J. Chem. Ecol. 24:1697-1706). Our research has indicated that several isolates of three species of fungi are repellent in the spore or conidial stage while they are non-repellent in the blastospore or mycelial stages and they were ineffective in reducing reproductive potential (Forschler & Jelks 1998, Proc. Nat. Conf. Urban Entomol. pp. 102) It would appear that fungi are best suited for application to infested structural lumber as a repellent (Forschler 1998. Proc. 6th Siconbiol. pp. 100-105) rather than a subterranean termite population management tool. The greatest potential for a biological control agent probably lies with the little studied entomopathogenic viruses. Theoretically, a latent virus could be disseminated in a termite population via social contact before it expresses its lethal effects. Therefore, large-scale population impacts are possible and by knowing the stress factor that would 'turn on' a latent virus one could plan or predict the timing of termite population reductions. Screening termite populations for viral pathogens should yield candidates for intensive bioassay.

Index terms: biological control, subterranean termites, Rhinotermitidae, fungi, viridaeloprid at low concentrations resulted in a 4X reduction of the amount of conidia used, and in control levels greater than 80% for large *C. cumulans* nests. Microbial control of *Nasutitermes sp.* using *B. bassiuna* was also effective when the fungus was applied inside the nests. Despite the advances of MC in Brazil, studies are needed to evaluate its effectiveness and define strategies for its use in wide scale. It is important to continue studies with new insecticides in association with entomopathogens and the investigation of possible factors that affect the MC in the field, especially the action of antagonistic microorganisms in the soil. Index terms: *Heterotermes tenuis, Cornitermes cumulans*, entomopathogens

[2006] INTRODUCTION OF A PROTOZOAN FOR CONTROL OF IMPORTED FIRE ANTS IN THE USA

David H. Oi & <u>David F. Williams</u>, U.S. Dept. of Agriculture, Agricultural Research Service, Center for Medical, Agricultural & Veterinary Entomology, P.O. Box 14565, Gainesville, FL, 32604, USA, E-mail doi@gainesville.usda.ufl.edu.

Protozoan infections in fire ants have been reported infrequently since the 1970's. Thelohania solenopsae was the first protozoan (microsporidia) to be observed in fire ants, specifically the red imported fire ant, Solenopsis invicta, by Buren in 1973. Extensive studies in the mid-1990's by Briano et al., of T. solenopsae infections in the black imported fire ant, S. richteri, have established the potential of this protozoan as a biological control agent for fire ants. In 1996, T. solenopsae was discovered in Florida, USA from S. invicta by Williams et al. Imported fire ant Icolonies have been infected with T. solenopsae collected from Florida via the introduction of infected brood. Artificial inoculations of laboratory colonies have resulted in infected queens with reduced queen weights and oviposition rates. This has resulted in significantly less brood (88%) and lower queen survivorship than in uninfected colonies. To examine the potential host range of the Florida collected T. solenopsae, infected fire ant brood was introduced into laboratory colonies of seven species of ants. Infections were detected only in S. richteri colonies obtained from Argentina. Examinations of field collected colonies of 7 non-S. invicta ant species were also negative for T. solenopsae infection. Field inoculations were initiated in Florida in 1997, and 4 of 5 inoculated colonies became infected. Infections were detected in non-inoculated fire ant nests on subsequent sample dates suggesting that infections had spread. By 1999, infections have been detected in over 85% of the colonies sampled at this study site, and reductions in fire ant populations of over 60% also have been observed. Additional introductions were made in ten states to document the potential impact of T. solenopsae on imported fire ants in different geographic areas of the southern USA. Infections have been detected in seven of these states. Field infections in the USA have been predominately found in polygynous fire ant populations. The first field infections in the monogynous form of S. invicta have been detected among these introductions. T. solenopsae has been detected in 93% of the males and 75% of the females alates initiating nuptial flights. It is possible that infected reproductives will fail to establish new colonies, thus impeding the spread and continual reinfestations by fire ants.

Index terms: Solenopsis invicta, Formicidae, Microsporidia, biological control

[2007] MICROBIAL CONTROL OF ANTS WITH FUNGI

<u>I.L. Stimme</u>, Dept. of Entomology and Nematology, Univ.of Florida, Natural Area Drive, P.O. Box 110620, Gainesville, FL 32611-0602, USA, E-mail jls@gnv.ifas.ufl.edu.

Entomopathogenic fungi can infect and kill a wide variety of arthropod species but their role in the dynamics of social insect populations and communities is not well defined. The discovery in 1985 of a naturally occurring strain of the white muscardine fungus, Beauveria bassiana, in populations of Solenopsis invicta in Mato Grosso, Brazil spawned interest in the possibilities of using fungi as biological control agents for ants. Field studies in Brazil confirmed that B. bassiana has natural epizootics in fire ant populations in Mato Grosso and suggested that this microbial agent is an important factor in the regulation of abundance and distribution of fire ants in South America. Isolate 447 of Beauveria bassiana was selected as a candidate for evaluation as a microbial pesticide against ant species. Studies were conducted to evaluate the efficacy of the fungal strain for a variety of ant species including: (1) Red Imported Fire Ant, Solenopsis invicta; (2) Carpenter Ant, Camponotus floridanus; (3) Pharaoh Ant, Monomorium pharaonis; (4) Crazy Ant, Paratrechina longicornis and (5) Ghost Ant, Tapinoma melanocephalum. A bait formulation of the fungus was tested in comparison with three chemical pesticide products. Results showed that the fungal bait was significantly efficacious for all ant species tested and that performance of fungal bait was equal to or superior to chemical bait products for most of the ant species. These results indicate that a non-toxic biological control for social insects is not only possible but also feasible. The fungal strain was tested for eight other ant species and was found to be very pathogenic. However, the efficacy of fungal formulations appears to be dependent upon ant foraging and recruitment behaviors as is also the case with chemical bait products. The 447 strain is being developed as commercial products for ant control by SafeScience, Inc. and this strain also has potential for control of termites.

Index terms: Beauveria bassiana, fungal infection, ants, microbial control

[2008] CHALLENGES FACING MICROBIAL CONTROL OF SOIL-DWELLING PESTS

T. A. Jackson, AgResearch, PO Box 60, Lincoln, New Zealand. Email: jacksout@agresearch.cri.nz.

Soil dwelling insects are hosts to a wide variety of pathogens and the soil, being rich in microbes, should be an ideal environment in which to practise microbial control of insect pests. Difficulty arises in implementation of microbial control as the soil is a highly complex, competitive environment, placement of microbes in the correct position in the soil profile is difficult and survival of applied microbes is by no means assured. In addition, soil dwelling pests appear to show a high level of resistance to many pathogens and microbial toxins. In spite of these difficulties, some significant successes in control of soil dwelling pests have been achieved. Most have involved a microbe that is highly specific for the particular target species which also has the ability to persist in the soil, either through the inherent stability of the organism or from recycling through the host population. This specificity of micro-organisms for soil dwelling pests poses some problems in developing and managing microbial control systems. Pest outbreaks can be sporadic and mixed-species pest populations can be damaging to a particular crop. Specificity precludes use of microbial control agents as broad-spectrum controls, but does have the advantage of limiting non-target effects. Correct identification of the pest species and a thorough search for pathogens should be the first stages of any programme. Several of the successful microbial control programmes of soil insects are based on unique, specific micro-organisms and undoubtedly many more useful microbes await discovery. Microbial strains should be selected for both pathogenicity and environmental persistence. While strain selection is the essential first step in microbial control of soil dwelling pests, it must be followed by development of efficient production systems and delivery systems backed by quality control measures to ensure application of a standardised, high quality product. Although particular microbes may vary in their production and survival characteristics, there is an opportunity for application of generic systems for formulation and delivery to speed progress in microbial control development. To bring these factors together in a package remains a major challenge for the broad-scale implementation of microbial control for soil dwelling pests.

Index terms; micro-organism, specificity, pathogenicity, environmental persistance

[2009] BEHAVIORAL RESPONSE OF SOIL ARTHROPODS TO FUNGAL PATHOGENS

<u>M. G. Villani¹</u>, L. L. Allee² & R. I. Brandenburg³, ¹ Dept of Entomology, NYSAES, Cornell University, Geneva NY 14456, USA, email: mgv1@nysaes.cornell.edu; ²Dept of Entomology, NYSAES, Cornell University, Geneva NY 14456, USA, email: lla1@cornell.edu ³Dept. of Entomology, North Carolina State University, Raleigh, NC 27695, USA, email: rick_brandenburg@ncsu.edu

The Japanese beetle, Popillia japonica Newman, and the tawny mole cricket, Scapteriscus vicinus Scudder, are important soil dwelling pests of turfgrass in eastern United States. Inundative field applications of fungal pathogens Metarhizium. anisopliae and Beauveria bassiana have given inconsistent results against these two soil pest species. Changes in Japanese beetle grub feeding site selection on sod roots, movement patterns, and survival in Metarhizium. anicopliae inoculated soil were examined in greenhouse studies and through the use of radiographic analysis in the laboratory. Our studies indicate that the application of mycelial particles in soil affected the behavior of Japanese beetles larvae. Japanese beetle grubs avoided soil that contained high concentrations of pathogen for up to 20 days after application..Further studies have shown that a simple formulation of M. anisopliae sporulating on rice also elicits avoidance in Japanese beetle. Similarly, M. anisopliae grown on rice or a commercial preparation of Beauveria bassiana. incorporated into the upper level of the soil profile in a microcosm alters the highly stereotypic tunneling of the tawny mole cricket, with an accompanying deterioration of tunnels in the conidia-iucorporated soil. Preliminary field studies with liquid formulations of B. bassiana indicate that reverse rate responses often occur with higher rates providing less control. This may be the result of avoidance behavior associated with higher rates. This behavior would allow the mole crickets to avoid the fungal pathogen until it becomes inactive and then resume tunneling, causing increased damage. The avoidance response seen in laboratory experiments may be evidence of an evolutionary adaptation to avoid infected insects and areas of soil with high concentrations of conidia. While avoidance entomopathogenic fungi in the soil may seem to thwart efforts to directly control arthropod pests with pathogens, more in depth study of the parameters of this behavior may provide new control strategies.

Index terms: scarab, grub, soil insects, movement, behavior, Beauveria, Metarhizium.

Symposium and Poster Session

[2010] DISEASE/HOST MODELS FOR SOIL-DWELLING PES7S

N.D. Barlow¹, T.A. Jackson¹ & H.C.J. Godfray², ¹AgResearch, PO Box 60, Lincoln, New Zealand, E-mail barlown@agresearch.cri.nz, ²NERC Centre for Population Biology, Silwood Park, Ascot, Bcrks, UK

The usual approach to modelling insect/pathogen interactions is the 'classic' Anderson/May model, which divides the host population into categories according to their disease status and uses differential equations to represent changes in densities of the categories. These models have provided the foundation for most theory to date and helped to develop insights into the dynamics of host/pathogen systems. For example, long-lived, highly pathogenic infectious stages can cause cycles in forest insects, and non-infectious pathogen reservoirs can regulate hosts at low density. More complex versions of the models have been successfully applied to a number of specific case studies. Here we discuss two new models. One is a development of the Anderson/May model, applied for the first time to a soil insect/disease system and including not only a pathogen reservoir but also competition between pathogenic and non-pathogenic bacterial strains. The other represents an alternative approach, using discrete models analogous to those commonly applied to parasitoid/host and predator/prey systems. Such models are simple and easily fitted to typical insect and disease sampling data. The models are applied to two case studies, the New Zealand grass grub/Serralia spp. and the European chafer/Bacillus popiliae system. For grass grab, they show that naturally occurring bacteria contribute to but are not solely responsible for regulation of numbers, suppressing populations by around 17% on average, at a prevalence of 12%. If this is raised to 40% by augmentative biological control, grub populations are suppressed by 67%. Improvements in biological control may be achieved by enhancing saprophytic ability of the bacteria rather than virulence. For European chafer in New York State, existing *B. popilline* has little effect on grub density; however, a single inundative addition of bacteria can give a 50% reduction in the year of application. If biocide use is sustained then, as for grass grub, the impact of successive increases in disease prevalence is non-linear. In this case there is little effect up to prevalences of about 60%, then chafer densities drop rapidly with higher levels of sustained disease.

Index terms: Costelytra zealandica, Serratia spp., bacteria, disease, model

[2011] THE DEVELOPMENT OF *METARHIZIUM*-BASED BIOPESTICIDES FOR USE AGAINST SUGARECANE WHITEGRUBS IN AUSTRALIA

R.J.Milner¹ & <u>P.R.Samson²</u>, ¹CSIRO Entomology, GPO Box 1700, Carberra, ACT 2601, Australia and ² BSES, PMB 57, Mackay Mail Centre, Qld. 4741, Australia.

The most serious insect pests of sugarcane in Australia are the larvae of scarabaeid beetles, known as sugarcane whitegrubs. There are 19 species which can cause economic damage by feeding on the roots and thus reducing the yield of sugar harvested and the ability of the crop to ratoon. The beetles normally fly in October/December, with the complete lifecycle taking 1 to 3 years depending on the species and the latitude. Pathogens are important as natural control agents in some areas and one of the most significant of these are various strains of the hyphomycte areas and one of the most significant of disc of the disc and one of the most significant of disc of the disc of t Dermolepida albohitrtum, in the North Queensland tropics and M. flavoviride var. flavoviride and Beauveria bassiana being dominant in the Rhopaea grubs of temperate northern New South Wales. Two isolates of Metarhizium FI-1045 from greyback canegrub and FI-147 from negatoria canegrub, Lepidiota negatoria, have been selected for commercialisation as biopesticides. FI-1045, with the trade-name BioCane is being manufactured by BioCare Technology Pty. Ltd. at Somersby, New South Wales, is most advanced with registration expected by the middle of 2000. In 1999 some 9 tonnes of a rice-based granular product with conidia as the active ingredient was used in commercial trials against greyback canegrub mostly in the Burdekin region of Queensland. The material is applied at the rate of 33 kg $(6.6 \times 10^{13}$ conidia/ha) before fill-in of the planting furrow and provides 50-60% control in the first season. The conidia can persist in the soil for at least 2-3 years and it is expected that a single application will provide protection for several years. FI-1045 also shows promise for control of two other species, southern one-year canbegrub, Antitrogus consanguineus and picticollis, Lepidiota picticollis. The other isolate, FI-147, is ineffective against greyback canegrub, but very effective against negatoria and French's canegrub, L. frenchii. Field trials are currently underway with a combination of FI-1045 and FI-147 in the hope of controlling mixed infestations. Initially it is expected that these biopesticides will be used where chemical control measures are ineffective or undesirable, however they have the advantage of recycling in the canegrubs and thus the inoculum building up in the ratoon crops. It is hoped that this advantage will outweigh the problem that control can be too slow to prevent damage in the year of application. Metarhizium.

Index terms: sugarcane; whitegrubs; scarab beetles; Metarhizium, Beauveria;Dermolepida albohirtum; Lepidiota; Rhopaea; Antitrogus.

Symposium and Poster Session

[2012] AN INTEGRATED APPROACH TO MANAGE THE ANDEAN POTATO WEEVIL, PREMNOTRYPES SPP. (CURCULIONIDAE)

A. Lagnnoui, J. Alcazar & F. Cisneros, International Potato Center, Apartado 1558 - Lima 12 - Peru.

The potato production in the Andean area is essential for food security of the inhabitants of the Andes, particularly those in rural areas. Unfortunately, many pests (insects, pathogens, nematodes and weeds) are known to affect potato production in this region, causing severe losses. In the Andes, the most damaging potato pests are the Andean potato weevils, most in the genus *Premnotrypes* and often referred to as the Andean potato weevil complex. Despite the heavy use of insecticide in that region, the weevils are still causing severe losses to the potato crop. The Andean potato weevil is an endemic pest in the Andean countries that causes considerable losses. Over the years, CIP scientists developed an integrated management strategy based on locally produced entomopathogenic fungus, *Beauveria brogniarii*, to control weevil larvae. This naturally occurring insect killing fungus is now used in Peru, Colombia, and Bolivia to control the most serious insect pest of potato in highland areas. It is most prevalent among small, resource-poor farm families. The fungus has been found to be effective against larvae, pupae, and adult weevils. Use of the fungus is low-cost, effective and particularly attractive to poor farmers, relieving them of the high costs and undesirable effects of toxic insecticides.

[2014] PATHOGENS OF TARO BEETLES AND THEIR POTENTIAL USE IN PEST MANAGEMENT IN THE SW PACIFIC

R. Masamdu¹, N. Simbiken¹, I. Alloali³¹², W. Theunis³ & <u>T.A. Jackson⁴</u>. ¹EU/SPC Taro Beetle Project, PO Box 1639, Lae, Papua New Guinea. Email: SPC spetaro@datec.com.pg; ²EU/SPC Taro Beetle Project, PO Box 912, Honiara, Solomon Islands: ³PO Box 226, Zamboanga City 7000, Philippines; ⁴AgResearch, PO Box 60, Lincoln, New Zealand.

Seven species of taro beetles in the genera Papuana and Eucopidocaulus (Coleoptera: Scarabaeidae) are important soil dwelling pests of taro Colocasia esculenta and other cultivated aroids Xanthosoma sagittifolia, Alocassia, Cyrtosperma and Amorphophallus species in six countries in the South Pacific.; Papua New Guinea, Solomon Islands, Vanuatu, Fiji, Kiribati and New Caledonia. Surveys of pest populations in Papua New Guinea have shown that taro beetles are naturally infected by an entomopox virus, bacteria (Paenibacillus popilliae and Serratia marcescens), fungi (Metarhizium anisopliae and Cordyceps sp.), protozoans (Nosema sp., Vavraia sp. and a neogregarine) and nematode (Steinernema sp.). In addition, Papuana spp. are susceptible to Oryctes virus isolated from the rhinoceros beetle, Oryctes rhinoceros. Several pathogens have been tested as microbial control agents for taro beetle in the laboratory and field. Both larvae and adults of Papuana uninodis were susceptible to entomopathogenic nematodes (Steinernema glaseri, S. feltiae, S. carpocapsae and Heterorhabditis zealandica) in the laboratory, but field results were inconclusive and nematodes could not be recovered from the soil three months after application. Paenibacillus popilliae type A1 was found to be highly pathogenic to P. uninodis in the laboratory and infected larva were found in the field one year from application on Kiribati. A highly virulent strain of Metarhizium anisopliae was selected in the laboratory and has been tested in the field producing infections over a prolonged period. Adult beetles artificially infected with *Oryctes* virus have been released into the field and the virus has been shown to persist in the beetle population at one of the release sites. The ability of pathogens to persist, spread and reduce taro beetle populations and damage to taro will be discussed in relation to beetle biology and the potential of microbial control for taro beetle evaluated. Index terms: Papuana, Eucopidocaulus, Colocasia, microbial control

[2013] PATHOGENS FOR CONTROL OF NORTH AMERICAN SCARABS

M. G. Klein, USDA, Agricultural Research Service, 1680 Madison Ave., Wooster OH 44691, USA, E-mail klein.10@osu.edu

Scarab larvae and beetles are serious pests of turf, nursery, flower, and food crops throughout most of N. America, and are of increasing quarantine concerns. Introduced species such as the Japanese beetle, Popillia japonica, oriental beetle, Exomala orientalis, and European chafer, Rhizotrogus majalis, are of primary concern in the northeast and midwest, while native June beetles, Phyllophaga spp. and masked chafers, Cyclocephala, spp., predominate elsewhere. Even though microorganisms play a major role in the natural suppression of scarabs, no pathogens are commercially available against adult beetles, and few are available for larval control. This situation will probably change little in the next few years. Viruses are an important component of scarab control in some parts of the world, but are almost non existent in N. America. Several genera of protozoa, Adelina, Pseudomonocystis, and Ovavesicula for example, play an important role in natural suppression of scarabs, and are among the few agents infecting adult beetles, but they are unavailable for control programs. Infections from another protozoan, Nosema spp., are found much less frequently in N. America than Europe and Australia/New Zealand. Milky disease bacteria were the first microorganisms registered in the U.S., but their use has been severely limited by a lack of commercial products, the natural distribution of the bacteria, and the slow and erratic performance of products in the field. Recently, the genus of these bacteria has been changed from Bacillus to Paenibacillus, and the characteristic formation of parasporal bodies to separate species was shown to be unreliable. In addition, concerns have been raised about the release of a vancomycin resistant organism (P. popilliae in N. America) into the environment. Entomopathogenic nematodes, particularly those in the genus Heterorhabditis, are available for use against scarab larvae. The extent of their use in the future will depend on the availability of high quality products and dependable delivery systems to end users. The generalist insect killing fungi, Metarhizium and Beauveria spp. have a potential for increased use against scarab pests. Strains of these fungi with high scarab activity have been identified. Field tests using Japanese beetle traps, modified to facilitate auto-dissemination of the fungus by adults to larval populations, have been highly successful in the Azores and N. America. This delivery method offers hope for using fungal pathogens in areas that are otherwise difficult to treat.

Index words: Scarabaeidae, milky disease, nematodes, Paenibacillus popilliae

[2015] MANIPULATION OF SPRAY PARAMETERS TO IMPROVE EFFICACY OF MYCOINSECTICIDES AGAINST INSECT PESTS OF FIELD CROPS

<u>S. P. Wraight¹</u>, M. E. Ramos¹ & C. A. Bradley², ¹USDA, ARS, U. S. Plant, Soil, and Nutrition Laboratory, Tower Road, Ithaca, NY 14853 USA, E-mail spw4@cornell.edu; ²Mycotech Corp., 2500 Continental Dr., Butte, MT 50702-4109, USA, E-mail cbradley@mycotech.com

Most entomopathogenic fungi establish infections by direct penetration of the host's exterior body wall. The infectious units must therefore be applied directly onto the target insect or onto substrata in the host habitat where inoculation can be effected indirectly during locomotion or feeding. This mode of dose acquisition puts these agents at a marked disadvantage compared to many synthetic chemical insecticides whose vapor activity or capacity for systemic or translaminar movement obviates the need for precisely targeted spray applications. This paper reviews and compares results of field studies designed to evaluate the effects of various spray application methods on the field efficacy of Beauveria basssiana against Bemisia argentifolii (silverleaf whitefly) infesting cucurbits and Leptinotarsa decemlineata (Colorado potato beetle) infesting potatoes. In whitefly trials, efficacy of B. bassiana applications from a hydraulic sprayer configured to spray straight downward from 20 cm above the crop canopy was significantly improved by lowering nozzles to within a few cm of the crop canopy, orienting them downward at a 45° angle, and increasing hydraulic spray pressure over the range of 3.5 to 28.1 kg/cm². Compared to overhead sprays, efficacy of applications against early-instar potato beetle larvae was increased by mounting nozzles on lateral drop tubes and directing them upward at a 45° angle. These configurations effectively targeted the abaxial leaf surfaces, where young insects were feeding in a microenvironment shielded from sporicidal solar radiation and with greater than ambient relative humidity. Unexpectedly, however, use of the drop-nozzle configuration to spray third-instar potato beetle larvae had little effect on efficacy. Parallel greenhouse studies suggested that secondary acquisition of conidia by potato beetle larvae feeding on contaminated foliage was limited and that direct inoculation of larvae with a high dose of conidia was necessary to achieve control. This work indicates considerable potential for improving efficacy of foliar applications of B. bassiana through manipulation of various spray parameters and underscores the importance of precise targeting of mycoinsecticide sprays. Index terms: Entomopathogenic fungi, Beauveria bassiana, Bemisia argentifolii, Leptinotarsa decemlinenta, application technology, microbial control

[2016] DEVELOPMENT OF MYCOPESTICIDES FORMULATIONS AND APPLICATION TECHNIOUES

Alves¹ & R. P. Bateman², ¹Brazilian Agriculture Research Corporation -EMBRAPA Cerrados, Caixa Postal 08223, CEP 73301-970, Planaltina, DF, Brazil, E-Mail: ralves@cpac.embrapa.br; ²CABI Bioscience, Silwood Park, Buckhurst Road, Ascot, Berks, SL5 7TA, U.K.

A successful spraying technique needs to achieve the target; to be used on correct time under favorable environmental conditions; to be applied with the most appropriate equipment and volume application rate; with an effective formulation of the active ingredient and sprayed in the droplet size range to achieve that particular target. There is a great interdependance between the application technique and the pesticide formulation to achieve a successful insect pest control. Mycoinsecticide formulation refers to the resultant composition when an entomopathogenic fungus is mixed with other ingredients. The ingredients should contribute to the viability, stability, virulence, and efficacy of the microbial control agent and the acceptance of the product by the user. Successful results were obtained using oil-based fungal formulations against insect pests showed the potential of some oils for use as carrier to overcome or to decrease the effects of adverse conditions. Experimental results also showed that adjuvants can enhance the fungal infectivity and improve the mycoinsecticide application. The process of an effective mycopesticide application is consisted of some steps: mixing (some products are applied directly as formulated); atomisation; transport; collection; deposit formation; interaction with pest; and biological action. If all of the previous steps have been successfully completed, and if a sufficient dose has been delivered to the pest properly and in an active state, the desired result will likely to happen. This is the goal of an effective mycopesticide application and can be achieved only if all of the previous steps have been successfully completed. It is also necessary to increase the knowledge on pesticide application techniques within the farming, governmental and commercial sectors of all countries.

Index terms: emulsifiable adjuvant oil, controlled droplet application, Metarhizium spp.

[2017] FUTURE TRENDS IN CODLING MOTH CONTROL IN INTEGRATED PARTICULAR **EMPHASIS** PRODUCTION ON FRUIT WITH GRANULOVIRUS

E. Dickler, Federal Biological Research Center for Agriculture and Forestry, Institute for Plant Protection in Fruit Crops, Dossenheim, Germany

Opening statements in this presentation will discribe a wide spectrum of non chemical methods currently in use or in development for the control of codling moth. Presentations given by the speakers will deal with specific microbial control agents. The codling moth, Cydia pomonella, is a key pest in pome fruits and walnuts. In the Upper Rhine Valley of Germany, where this pest is bivoltine, it was for several decades the limiting factor in integrated control programmes, requiring 3-4 treatments each season with organophosphorus insecticides. This was more than half of all insecticide applications used in this area. In western Europe in the mid 80s, azinphosmethyl and other OPs were replaced by insect growth regulators (IGRs) which are less hazardous to the orchard ecosystem. They became of central importance in IFPprogrammes. However, in the early 90s, resistance to diflubenzuron, triflumuron, fenoxycarb etc. due to over-use and over-dosing of these chemical products was reported by several authors from the South Tyrol region of Italy, south eastern France, south west Germany and other central European fruit growing areas. In addition nowadays, organo-phosphorous insecticides, due to their acute human toxicity, have received worldwide criticism. Furthermore, the majority of these products are "existing active subtances", for which no ecotoxicity data are available. Manufacturing firms are not interested in supplying this information for re-registration. For these reasons, new strategies for codling moth control are needed, and around the globe, programmes were started to develop systems based mainly on the use of non-chemical products and techniques for sustainable fruit production. The objective of my presentation at this meeting is to describe the environmentally sound products, methods and techniques available nowadays for IFP programmes and possibilities for their intelligent combination with particular emphasis on granulovirus.

Components for integrated codling moth control

Selective, chemical insecticides

Pheromones: mating disruption, attract and kill

Eradication: SIR

Microbials, granulovirus, Bacillus thuringiensis,

Beneficials: pesticides, safe to beneficials, release of beneficials, e.g. Trichogramma, entomopathogenic nematodes

Cultural methods: hand fruit thinning, summer pruning, ground cover management

Monitoring: pheromone traps, corrugated paper bands, computer-based phenological modelling

Index terms: Cydia pomonella, integrated control strategies, granulovirus

Symposium and Poster Session

(2018) BIOCONTROL OF LEPIDOPTERAN PESTS OF APPLE AND PEAR WITH MICROBIAL AGENTS AND NEMATODES

J. V. Cross, Horticulture Research International, East Malling, Kent ME19 6BJ, UK.

Microbial pathogens and entomopathogenic nematodes are important components of the natural enemy complex in orchards and more effort needs to be devoted to fostering them and exploiting them as biocontrol agents in biologically-based IPM programmes. They can often be mass produced at low cost and applied as sprays and are potentially ideal biocontrol agents. Important general characteristics are their comparative environmental and human safety, compatibility with IPM programmes and reproductive capacity. They tend to be effective in a narrower range of environmental conditions than pesticides, but they can be improved by formulation, strain selection and genetic manipulation. They are often host- specific and thus, offer restricted marketing opportunities, which is a barrier to commercialisation. Baculoviruses are important pathogens of several lepidopteran pests but other viral pathogens have not been investigated in depth and are little known. The granuloviruses CpGV and AoGV have been researched extensively and are exploited as biocontrol agents. Commercial development has been limited by high costs, slow action, short persistence and specificity. Resistance to insecticides and the desire to reduce pesticides will lead to an increase in CpGV use. Future R&D approaches include genetic manipulation, formulation (to reduce UV sensitivity) and development of cheaper mass production techniques (possibly in vitro). A systematic search for other viruses is needed. The most important bacterial pathogen used as a biocontrol agent is Bacillus thuringiensis (B.t.). The HD-1 strain is widely used, but efficacy is moderate against lepidopteran orchard pests. Advances in biotechnology and genetic engineering provide opportunity for development of B.t. strains designed specifically to control orchard pests. Other approaches include the evaluation of new B.t. products developed for other markets world-wide and the bioassay of strains from B.t. collections. The main factor limiting the effectiveness of entomopathogenic fungi is the requirement for high humidities and moderate temperatures for spore germination and development. Pests which inhabit protected microenvironments should be targeted by improved formulation, the selection of low temperature-active strains, field evaluation and avoiding adverse effects of fungicides. The requirement for surface moisture for survival and movement of entomopathogenic nematodes means there are only limited prospects for using them as biocontrol agents for foliar pests. Pests overwintering in bark crevices close to the soil should be targeted.

Index terms: Cydia pomonella, Adoxophyes orana, Operophtera brumata

ENTOMOPATHOGENS FOR CONTROL OF USE OF [2019] LEPIDOPTERAN PESTS OF APPLE IN THE PACIFIC NORTHWEST OF THE UNITED STATES

L. A. Lacev, USDA-ARS-YARL, Wapato, WA 98951, USA

Control of insect pests of apple in North America has traditionally been accomplished using conventional chemical pesticides. Codling moth (CM), the primary pest insect of apple in the Pacific Northwest of the USA, has routinely been controlled with organophosphate insecticides. However, the use of conventional insecticides will be severely reduced in the near future due to implementation of the Food Quality Protection Act. Alternative interventions, such as the use of CM sex pheromone to disrupt mating (MD), will require low population densities of the moth in order to be effective. The use of microbial control agents could reduce CM population densities and complement MD while conserving beneficial insects. For the most part, microbial control of fruit tree pest insects has been underutilized. The combination of MD with the CM granulovirus (CpGV) and entomopathogenic nematodes (EPNs) offers promise for effective control of CM. The potential of CpGV for control of neonate larvae has been demonstrated by numerous researchers (Cross et al 1999), but the virus has not been routinely used in the USA. Overcoming problems associated with UV sensitivity will increase the attractiveness of CpGV to growers. The potential of EPNs for control of prepupal stages of CM has been elucidated by several authors (Kaya et al., 1984; Lacey and Chauvin, 1999; Lacey et al., 2000), but implementation in orchards will depend on keeping nematodes moist for six or more hours after application (Lacey et al. 2000). One consequence of the MD strategy has been the release of some secondary pests such as leafrollers that were incidentally controlled with conventional insecticides used for CM control. Bacillus thuringiensis, is regularly used in the Pacific Northwest for control of leafrollers, principally Pandemis pyrusana and Choristoneura rosaceana. The residual activity of Bt is relatively short necessitating reapplication. The recent discovery of a granulovirus in *P. pyrusana* (R. Pfannenstiel, unpub.) and a nucleopolyhedrovirus C. rosaceana will provide additional microbial options for control of these pests.

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Lacey, L. A., A. L. Knight, and J. Huber. 2000. In "Field Manual of Techniques in Invertebrate Pathology" (L. A. Lacey and H. K. Kaya, Eds.) pp. 557-576. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Index terms: Cydia pomonella, Choristoneura rosaceana, Pandemis pyrusana, granulovirus, entomopathogenic nematodes, biocontrol

[2020] THE ROLE OF FORMULATION ADDITIVES IN INCREASING THE POTENCY OF CYDIA POMONELLA GRANULOVIRUS FOR CODLING **MOTH LARVAE**

J. Ballard¹, D.J.Ellis¹ & <u>C.C.Payne²</u>, ¹Horticulture Research International, Wellesbourne, CV35 9EF, UK; ²Dept. of Horticulture and Landscape, Univ of Reading, RG6 6AS, UK.

Studies were undertaken to improve the biological efficacy of the granulovirus (CpGV) of the codling moth, Cydia pomonella, by evaluating the performance of some formulation additives that might improve virus persistence and/or virus uptake by first instar larvae. Laboratory studies, using a leaf disc bioassay demonstrated that 15% cane molasses in a CpGV formulation significantly reduced the median lethal exposure time (LET₅₀) to CpGV for neonate larvae at a CpGV dosage rate of 10⁷ occlusion bodies (OBs)/ml. Laboratory screening of a range of other compounds showed that sucrose, fructose and sorbitol (at 10% concentrations) and extracts of apple flesh and skin also gave significant reductions in the LET₅₀ of CpGV formulations containing these ingredients. Pectin, malic acid, α -farnesene, skimmed milk and two artificial sweeteners containing aspartame and saccharin, did not significantly reduce the LET₅₀ in laboratory tests. In a field trial, molasses included at 15% (v/v) in a CpGV formulation, containing a dosage rate of 1042 OBs per hectare, gave as good control of codling moth damage as virus formulations containing 0.2% skimmed milk at dosage rates of 10^{13} and 10^{14} OBs/ha. Studies of CpGV persistence on foliage revealed no significant improvement of virus persistence on apple foliage using 10% or 15% molasses formulations conspared with formulations containing 0.2% skimmed milk. A second field trial demonstrated that 10% molasses, 10% sorbitol or 0.08% afornesene significantly reduced codling moth damage to fruit when these ingredients were added to formulations of pure CpGV. Substantial sooty-mould growth (*Cladosporium* spp.) was observed on apple foliage treated with formulations containing molasses, indicating that this formulation additive has secondary consequences that would need to be taken into account if molasses was to be used in commercial CpGV formulations. Nonetheless, these studies clearly demonstrate that major biological improvements in CpGV performance can be achieved by the incorporation of formulation additives, including molasses and several other compounds, that probably function as attractants and/or feeding stimulants for codling moth larvae.

Index terms: codiing moth, biological control., feeding stimulants

[2021] CODLING MOTH (CYDIA POMONELLA) CONTROL WITH BACTERIAL AND VIRAL PREPARATIONS UNDER POLISH WEATHER CONDITIONS

R. W. Olszak & Z. Pluciennik, Research Institute of Pomology and Floriculture, 18 Pomologiczna, 96100 Skierniewice, Poland

For several decades pest control has been realized mostly with chemical pesticides many of are broadly destructive agents affecting harmful and beneficial inhabitants of plants indiscriminately. Insect pathogens are promising alternatives. They have the attributes of ideal control agents. Most are highly selective, affecting one or a few species of pests and are compatible with rules of integreted pest management (IPM) and integrated fruit production (IFP). They are used against codling moth in apple orchards. With the exception of Japan and some regions of far Eastern Asia, the codling moth occurs throughout the temperate regions of the world where apples are grown. In Europe, depend ing on the region, the pest has one, two or even three generations per annum. In Poland, the codling moth has two generations per annum, the second of which is usually less numerous (by 20-40%). For the past decades, OPs were mainly used against this pest, more recently (the last decade), a partial switch to IGRs has occurred. Experiments with insect pathogens were done in 1995 and 1998 with Bacillus thuringiensis (B.t.) applied as a market preparation "Biobite" and in 1992-1998 with - CpGV, applied as preparations "Carpovirusine" (Calliope Co., France) and "Granupom" (Hoechst Schering AgrEvo GmbH). The effectiveness of these biopreparations was assessed at harvest on the number of damaged fruits out of a sample of 800 fruits picked from trees and 200-400 dropped fruits from each treated plot. The results obtained were compared to a treatment with one of the standard pesticides (OP or IGR) and to the control plot, non- protected from codling moth. The preparations with B.t. were applied usually once or twice, whereas viral preparations were applied from two to five times depending on the programme. In all the experiments, both B.t. and the viral preparations significantly reduced the percentage of fruits damaged by codling moth caterpillars to below economic treshold level. The results were comparable to these of the standard pesticides. These results imply that, under Polish climate conditions, bacterial and viral preparations can maintain codling moth populations at a low level. Since they are safe to beneficial fauna and mammals, they can be recommended for use in orchards under an integrated management system as well as in other orchards that need to be sprayed against the 2nd generation during the summer when the pre-harvest interval excludes the use of many pesticides. Index terms: orchard, fruit, Cydia pomonella, baculovirus, Bacillus thuringiensis, granulovirus, biological control

[2022] GRANULOSIS VIRUS OF CODLING MOTH CYDIA POMONELLA: FROM LABORATORY TO FIELD

P.J. Charmillot. Swiss Federal Research Station for Plant Protection, Changins, CH-1260 Nyon, Switzerland, E-mail: pierre-joseph.charmillot@rac.admin.ch.

When tested by dipping apples in different product concentrations, Madex, a granulosis virus based product, had a LC_{50} of 0.3 ppm (mg/l) of formulated product, which is about 300 fold lower than that of Mimic (tebufenozid). Thus, the potential of the virus to control codling moth C. pomonella is exceptional. Biological tests in the laboratory on apples treated in the orchard indicated that granulosis virus had a good initial efficacy but a poor persistence due to a quick inactivation by UV light. In general, addition of products such as sugar, skimmed milk powder, Nu-Film-17 and Humin Vital increased slightly the persistence of the virus. Practical trials carried out during 7 and 8 consecutive years with 4 to 6 treatments per season allowed to maintain fruit damage at harvest and population densities of codling moth at a low level, even by reducing the dosage of virus to one half to decrease the cost of control.

Index terms: Cydia pomonella, lethal concentration, persistence, practical control

(CYDIA POMONELLA) AND THE USE OF [2023] CODLING MOTH GRANULOVIRUS IN ORGANIC AND INTEGRATED CONTROL

F. Polesny, BFL, Inst. of Phytoeind. Spargelfeldstr. 191, A-1220 Vienna, Austria fpolesny@bfl.at.

The CpGV product Carpovirusine was registered for control of codling moth in Austria some years ago. There are two nearly overlapping codling moth generations per annum in Austria. The egg laying period of the first generation lasts for about one and a half months. The egg laying period of the second generation lasts for more than a month. The use of CpGV against Cydia pomonella was evaluated in field trials. An effective treatment strategy using only CpGV requires a large number of applications during the whole period of larval hatching. Weekly applications are successful but applications at two week intervals results in an enormous decrease in efficacy. There are good opportunities to implement CpGV in integrated treatment strategies. There is no danger of cross resistance to other compounds used in Integrated Fruit Production. The combined use of CpGV with ovicidal insect growth gives good results and requires a reduced number of applications compared with traditional use of single compounds. The results of the different field trials are presented and discussed. Index terms: orchard, fruit, Cydia pomonella, baculovirus, granulovirus, biological control

[2024] CONTROL OF THE CODLING MOTH WITH $C_PGV\,\, DISSEMINATED$ by means of pheromone stations: 5 years of field trials

O. Pultar¹, F. Kocourek², J. Stara², J. Kuldova³ & <u>I. Hrdv</u>³, ¹Biola Laboratorics, Agricultural Cooperative, Chelcice, Vodnany 38901, Czech Republic; ²Research Institute of Crop Production, Drnovska 507, Praha 16106, Czech Republic; ³Institute of Organic Chemistry and Biochemistry, Academy of Sciences, Flemingovo 2, Praha 16610 Czech Republic, E-mail hrdy@uochb.cas.cz.

The method of attractant aided dissemination of *Cydia pomonella* granulosis virus (CpGV) was examined in field trials. Trials were performed on small as well on large commetcial apple orchards in Czech Republic, Central Europe. The aim of experiments which started in 1994, was to prove the following hypothesis: Males when attracted into pheromone station will be contaminated by virus, virus will be transferred to females during copulation and by ovipositing females directly on cggs and/or on fruits and leaves. Special pheromone station, i.e. modified tube trap coated inside with virus formulation and fluorescent paint and baited with codlemone dispenser was developed. Dissemination of virus formulation was assessed according to number of recaptured males in pheromone delta traps with sticky inserts. The pest situation on untreated plots, on plots treated by CpGV stations, by CpGV direct spraying and on plots under conventional insecticide treatment was compared. Efficacy of the new method was estimated by monitoring the population dynamics of coding infestation of fruits at least at two different terms (summer and autumn) during the season. The method of CpGV-pheromone stations was combined also with reduced number of direct CpGV sprayings. Factors affecting efficacy of the CpGV-pheromone station design,

virus formulation, persistence of virions, inunigration of non-contaminated males from surrounding plots, were evaluated. Dissemination of viral infection from CpGVpheromone stations into the field populations of the codling moth was confirmed. The advantage of the new method is in lower amount of virus preparation needed for treatment. The results imply the trends of decrease in population density and fruit damage, when compared to untreated control plots. The method may be efficient at initial low population densities of the pest and/or as complementary to CpGV sprayings.

Index terms: Cydia pomonella,, Integrated Pest Management, Integrated Fruit Production, pheromone traps

[2025] VERTICAL TRANSMISSION OF CpGV AND IMPROVEMENTS FOR CONTROL OF CYDIA POMONELLA POSSIBLE EXTENSION TO CYDIA SPLENDANA IN APPLES, PEARS, WALNUTS AND CHESNUT CROPS

<u>M. Guillon¹</u> & G. Biache², ¹ Natural Plant Protection S.A., B.P. 80, Route d'Artix, 64150 Noguères, France, ² I.N.R.A. La Minière, Station de Recherche de Lutte Biologique, 78285 Guyancourt, France

Granulovirus (Carpovirusine) is produced by using larvae infected by a viral strain from Mexico, distributed by the B.B.A. (Darmstadt). It has been observed that a treatment of 10^{13} OBS per hectare every 10 days gives sufficient protection on condition that the destructive population level is weak to moderate. A study carried out on Codling moths which surved the treatment did not show any difference in weight between the variant pupae : untreated control, granulovirus, chemical insecticide and alternation of chemicals and granulovirus. Neither did the moths show any malformation of ovarioles. The study showed an increase in mortality and modification of the adult emergence curves. Vertical transmission of threated orchards. Index terms; Cydia pomonella, Cydia splendana, granovirus, vertical transmission [2026] PROGRESS IN THE GENETIC IMPROVEMENT OF GRANULOVIRUSES FOR THE CONTROL OF TWO IMPORTANT APPLE PESTS

D.Winstanley¹, S.L. Wormleaton¹, R. Finch¹ & G. J. Keane¹, Dept. of Entomological Sciences, Horticulture Research International, Wellesbourne, Warwick, CV35 9EF, UK.

Cydia pomonella GV (CpGV) is a fast killing GV, normally killing its host in the larval instar in which it is inoculated. In the case of codling moth the virus must be targeted against first two instars i.e. prior to their entry into the fruit. The GV has high infectivity for codling moth; the LD_{50} is one occlusion body (OB) for neonates. However, the speed of kill is relatively slow compared to insecticides, between 4 to 6 d for neonates. This results in continued damage to the fruit post inoculation of the larvae. It has been possible to increase the speed of kill of some nucleopolyhedroviruses by genetic manipulation using strategies such as gene insertion and gene deletion. Cell lines, permissive to CpGV, have provided a useful tool for *in vitro* studies on CpGV and have allowed the successful genetic manipulation of CpGV. Recombinant CpGV (CpGV-EGT), with a deletion in the ecdysteroid UDP-glucose transferase gene (egt) has been produced. In laboratory dietbased bioassays the efficacy of CpGV-EGT has been compared to the parent CpGV genotype, derived from the CpGV Mexican isolate, in first and fifth instar larvae. The nucleotide sequence of the CpGV genome has aided the construction of transfer nucleon the production of recombinant CpGVs expressing insecticidal toxins (e.g. the itch nute toxin) and /or lacking a functional egt gene. The CpGV genome sequence information in conjunction with the GV permissive cell lines will be used to identify genes involved in host range determination, infectivity, and speed of kill. A. orana GV (AoGV) is a slow killing GV, killing its host in the final instar. It is marketed for the control of summer fruit tortrix on apples and pears. Two baculoviruses, (a granulovirus and a NPV) were jointly isolated from diseased overwintering A. orana larvae collected in the UK in 1993. The biological activity of this AoGV has been assessed in different instars of A.orana. This virus has similar restriction endonuclease fragment profiles to the Japanese, Swiss and Italian isolates of AoGV. Genetic studies are being conducted on AoGV. The relatedness of slow and fast killing GV genomes will be compared both at a genomic and genetic level. Cell lines have been established from A.orana embryo's and the feasibility will be discussed of using these to look at gene function and for producing an improved recombinant AoGV. Finally the merits of using either a fast killing compared to a slow killing GV as a biological insecticide will be considered.

Index terms: Cydia pomonella, Adoxophyes orana, granulovirus, genetic manipulation

2027] THE SPATIAL AND TEMPORAL IMPACT OF ENDEMIC NATURAL ENEMIES ON THE MORTALITY OF CHRYSOMELID BEETLES IN EUCALYPT PLANTATIONS

G. R. Allen^{1, 2} & V. S. Patel², ¹ School of Agricultural Science, Univ. of Tasmania, GPO Box 252-54, Hobart, Tasmania, 7001 Australia, E-mail Geoff, Allen@utas.edu.au; ² CRC for Sustainable Production Forestry, GPO Box 252-12, Hobart, Tasmania, 7001 Australia.

The cucalyptus leaf beetle Chrysophtharta agricola has been identified as a major threat to plantations of Eucalyptus nitens in Tasmania. We set up a replicated natural enemy exclusion experiment, across 3 yr old plantations separated by at least 20 km, to examine the impact of natural enemies on the survival of C. agricola in the field. Beetle mortality was assessed at egg, larval and pupal stages using uncaged and 'entire' tree caged treatments. After assessment of egg mortality, six selected branches on all experimental trees were loaded with clutches of first instar beetle larvae (ca. 30 larvae per clutch). Overall mortality and spatial variability in mortality both within and between trees was regularly monitored until emergence of adult beetles. Pupal mortality was assessed using litter cages, dug prior to commencement of the experiment, under each tree. To identify the parasitoid complex and the host stages attacked clutches of 'sentinel' or trap larvae exposed for the duration of each instar were seeded on further treees within the plantation. At least three primary parasitoids (two tachinids and one bracoaid) and one hyperparasitoid were present in the parasitoid guild which showed temporal separation in their timing of attack. Overall mortality in uncaged treatments exceeded 99 % across all plantations and was spatially variable both within and between trees. Variability in uncaged treatment survival was greater within trees than between trees with spider predation having a large impact on intra-tree larval survival. Within a plantation average mortality of uncaged larvae was up to 10 fold greater than for controls with the majority of loss in control cages occurring within the first few days of larval establishment. Natural enemies were concluded to have a significant impact on populations of C. agricola. Since the majority of larval damage is done in the fourth or final larval instar, yet control decisions are made in earlier instars, beetle monitoring protocols that account for spatial variability and the temporal patterns of both natural enemy attack and parasitoid induced mertality may need to be devised. Landscape approaches to the management of leaf beetles and their natural enemies should also be considered. Index terms: Chrysophtharta agricola, parasitoids, tachinids, Chrysomelidae, forest insects

[2028] SETTING UP AN ENTOMOPATHOGENIC MICROORGANISMS COLLECTION AT THE CENTRO EXPERIMENTAL DO INSTITUTO BIOLOGICO/LABORATORIO DE CONTROLE BIOLOGICO, BRAZIL

J. E. M. Almeida², A. Batista Filho², A. G. Souza³, A. C. Fattori³, ² Lab. Controle Biológico, Centro Experimental do Inst. Biológico, P. O. Box 70, Campinas, SP, Brazil. 13001-970 e-mail: jemalmeida@uol.com.br.¹ Research financed by FAPESP.³ Student supported by CNPq.

Studies concerning entomopathogenic microorganisms emphasize the importance of isolate screening for research improvement. Isolates in the same microorganism species can possess different levels of virulence. So, their storage helps their manipulation for studies of pest control under laboratory and field conditions. We are setting up an entomopathogenic microorganism collection, including isolation and identification of these organisms, as well as by exchanging isolates with Universities and Reserch Institutes. The microorganisms were isolated from soils using the dodine method. Medium with dodine is selective for isolation of entomopathogenic and phytopathogenic fungi. Fungi found on dead insects were isolated by their inoculation on plates of potato-dextrose-agar medium. The isolates were stored in culture tubes with mineral oil or in eppendorfs. The soil samples were also processed by the L media method, which allows the isolation of bacteria of the genus Bacillus. Insects suspected being killed by bacteria had their viscera inoculated on plates of solid L medium. The bacteria have been stored in culture tubes with mineral oil. The viruses were isolated from insects by maceration of the host followed by centrifugation and then stored in sterile water. The collection has 205 isolates that have been stored on rice, culture tubes and eppendorf tubes. There are 197 fungal, 5 viral and 3 bacterial isolates. Thirty-five isolates were donated by other institutions.

Index terms: Collection, entomopathogenic, microorganisms, microbial control, biological control

[2029] VOLATILITY COMPARISONS OF DIFFERENT FORMULATIONS USED TO APPLY MYCOINSECTICIDES

R.T. Alves¹, R.P. Bateman², C. Prior³ & S.R. Leather⁴, ¹EMBRAPA/Centro de Pesquisa Agropecuária dos Cerrados (CPAC), Caixa Postal 08223, CEP 73301-970 Planaltina, DF, Brazil, E-Mail ralves@cpac.embrapa.br; ²CABI Bioscience, Silwood Park, Buckhurst Road, Ascot, Berks, SL5 7TA, UK; ³The Royal Horticultural Society, Wisley, Woking, Surrey, GU23 6QB, UK; ⁴Silwood Centre for Pest Management, Department of Biology, Imperial College, Silwood Park, Buckhurst Road, Ascot, Berks, SL5 7PY, UK.

The volatility of water-based formulations with different concentrations of emulsifiable adjuvant oils was evaluated and the volatilities of oil-based and conventional water-based formulations, used to apply mycoinsecticides, were compared with that of an emulsifiable adjuvant oil-based formulation. The formulations were applied onto filter papers and weighed at different time intervals. The evaporation of all formulations increased with time. The majority of all waterbased formulations and pure Shellsol evaporated during the first 30 minutes. The half lives of emulsifiable oil formulations were approximately 20 minutes. The mixture of 50 % Shellsol T plus 50 % Ondina EL satisfied the requirements of an ULV formulation. Emulsifiable adjuvant oil formulations retained approximately 10 % of the initial weight after evaporation. This is sufficient to allow an even spread and thereby enhances the fungal infectivity on insect pests. All these results demonstrate that emulsifiable adjuvant oil fungal formulations can perform similar to oil-based formulations. They can be sprayed with the existing delivery systems and used in large scale agriculture where currently water-based formulations are predominan

[2030] EVALUATION OF APPLICATION TECHNIQUES OF AN EMULSIFIABLE ADJUVANT OIL FUNGAL FORMULATION

R.T. Alves¹, R.P. Bateman², C. Prior³ & S.R. Leather⁴, ¹EMBRAPA/Centro de Pesquisa Agropecuária dos Cerrados (CPAC), Caixa Postal 08223, CEP 73301-970 Planaltina, DF, Brazil, E-Mail ralves@cpac.embrapa.br; ²CABI Bioscience, Silwood Park, Buckhurst Road, Ascot, Berks, SLS 7TA, UK; ³The Royal Horticultural Society, Wisley, Woking, Surrey, GU23 6QB, UK; ⁴Silwood Centre for Pest Management, Department of Biology, Imperial College, Silwood Park, Buckhurst Road, Ascot, Berks, SL5 7PY, UK,

The physical effects of water-based mixtures containing an emulsifiable adjuvant oil, with and without conidia of Metarhizium flavoviride were evaluated with a range of commercially available sprayers and nozzles. The influence of adjuvant concentration on viscosity, flow rate and droplet size spectra were measured together with conidial viability and conidial concentration after spraying. Flow rate was not affected when the concentration of emulsifiable oil was increased up to 10 %. Droplet size increased when the concentration of emulsifiable oil was increased for applications with a knapsack sprayer, but it decreased when applied with motorised mistblowers. Droplet uniformity (relative Span) increased when the concentration of emulsifiable oil was increased for most of the sprayers and nozzles. High droplet densities were obtained with some nozzles from the knapsack sprayer and from the two motorised mistblowers. None of the techniques applied affected the conidial viability. The problem of conidia sedimentation in tank mixtures was greatest with motorised mistblowers. The number of conidia sprayed was more affected by the sprayers when formulated in water plus 0.1 % Agral than in water plus 1 % Codacide⁹. These results should be helpful for researchers and farmers in order to select appropriate application equipment and to make the best use of emulsifiable adjuvant oils, while maintaining adequate spray coverage with reduced spray volumes to achieve high work rates.

Index terms: Metarhizium flavoviride, emulsifiable adjuvant oil, droplet size, sprayerst. Index terms: emulsifiable adjuvant oil, evaporation, fungal formulations.

[2031] HURRICANE FORCE STORM DAMAGE IN UK TEMPERATE WOODLAND BENEFITS INVASIVE LEAFHOPPER

J.S.Badmin, Coppice Place, Selling, Kent ME13 9RP, UK.E-mail jsb5@cant.ac.uk.

In the British Isles, the evergreen shrub Rhododendron ponticum has been widely planted in woodland habitats since its introduction in the mid-sixteenth century. It is highly invasive, spreading either by seed or vegetative expansion and is now fully naturalised throughout the British Isles. The Rhododendron leafhopper Graphocephala *fennahi*, which lays its eggs in the dodendron flower buds, was imported into Europe from North America in the middle of the last century. First recorded from England in 1936, it is now well established on naturalised rhododendrons throughout south-east England and has since spread through large parts of northern Europe. This study reports the effects on G.fennahi of the hurricane-force Storm which hit Perry Woods, Kent, south-east England in 1987. The woods suffered extensive damage: 67% of conifers were snapped or uprooted, c.50% of standard oaks and beech suffered major limb damage, and stands of chestnut coppice on less exposed ground suffered <5% loss. Large canopy lacunae allowed leafhoppers such as G.fennahi associated with rhododendron shrub, which was less severely damaged, to flourish. The most noticeable changes in leafhopper abundance occurred as a delayed response to changes in vegetational composition in large canopy gaps and areas cleared after the storm. The effects were more noticeable in large rather than small gaps. The open habitat surrounding rhododendron plants proved ideal for growth and flower bud initiation, with the result that more ovipositional sites became available for the leafhopper in succeeding years. Numbers of G.fennahi subsequently reached epidemic proportions in 1990 and 1991 with adults swarming and moving onto nearby vegetation. Subsequent population decline was due largely to destruction of oviposition sites by Rhododendron bud blast Pycnostysanus azalaea transmitted by the leafhopper and shading, caused by canopy closure, which reduced flower bud initiation.

Index terms: Graphocephala fennahi, invasive pest, canopy gaps

[2032] SYNERGISM OF ENTOMOPATHOGENS AND CHEMICAL INSECTICIDES: THEORY AND APPLICATION

W. L. Baiwa & M. T. AliNiazee, Department of Entomology and Integrated Plant Protection Center (IPPC)' Oregon State University, Corvallis, OR 97331-8530, USA.

Insects like other organisms, are more susceptible to diseases when they are under the influence of stress produced by crowding, malnutrition and environmental factors. Chemical insecticides at reduced/sublethal rates can act as stressors and make insects more susceptible to the action of microbial toxins, and can be additive or synergistic when combined with microorganisms. Healthy larvae of many species of insects can not be infected with entomopathogens unless they have been first treated with weak doses of insecticides. Potentiation has been documented for interactions using the Bacillus thuringiensis (Bt)/Beauveria bassiana (Bb) and several chemical insecticides against a number of insect pests on various crops. Laboratory and field tests have shown that the amount of chemical insecticide can be greatly reduced by integrating entomopathogens into spray program, without sacrifying crop. The effectiveness of Bt can be enhanced against several lepidopterous larvae by combination with chemical insecticides at low/sublethal rates. In many crops, reduced dosages [one-fifth (0.2X) to one-tenth (1.0X) of normal field rate (1X)] compared with standard rates of organophosphorous and pyrethroid insecticides enable sufficient survival of natural enemies. Low concentrations of several insecticides either do not affect bacterial growth or improved it. A general compatibility of δ -endotoxin with different chemical insecticides has also been established. This suggests that the target species can be controlled with reduced insecticide rates in combination with Bt without greatly affecting natural enemies. This would reduce the selection pressure and conserve the susceptible gene pool and can result in reduced or delayed insecticide resistance. Reduced dosage mixtures of Bt and chemical insecticides can also reduce the problem of pest resurgence, and would be highly compatible with IPM approach. This approach was tested in laboratory and field against codling moth (Cydia pomonella) for four consecutive years. The results showed that utilization of mixtures of Bt with low rates of insect growth regulator diflubenzuron (0.25-0.50X) or pyrethroids esfenvalerate and permethrin (0.1-0.2X) in the codling moth management is possible and indeed might be beneficial. Standard application rate (2 times/generation) and timing were found to be appropriate for Bt-pyrethroid mixtures. These mixtures were selective to most predatory insects, spiders, and Zetzellia mali, however, toxic to phytoseiid species causing outbreaks of many phytophagous mite species. Bt-diflubenzuron mixtures were suitable when applied 3 times/generation. These mixtures were environmentally safe and did not cause outbreaks of phytophagous mites. Index terms: Joint action, biopesticides, microbial insecticides, insect pathogens.

[2033] COMPARISON OF THE PATHOGENICITY OF THREE ISOLATES OF *METARHIZIUM* FOR WINGLESS GRASSHOPPER: EEFECT OF DOSE AND TEMPERATURE

L. Barrientos-Lozano¹ and R.J.Milner², ¹Instituto Tecnológico de Cd. Victoria. Blvd. Emilio Portes Gil No. 1301, Cd. Victoria, Tam. México 87018. ² CSIRO Entomology, GPO Box 1700, Canberra, ACT 2601, Australia.

As part of a program to develop Metarhizium as a biopesticide for use against locusts and grasshoppers in Australia and Mexico, laboratory bioassays were undertaken to compare the pathogenicity of an Australian isolate (FI-985) of Metarhizium anisopliae var. acridum with two Mexican isolates (QF-001 and QF-002). All 3 isolates were derived from acridid locusts and have similar DNA fingerprints. However, the Mexican isolates have smaller more ovoid conidia than the Australian isolate and QF-001 grows faster at temperatures below 20°C and slower at temperatures above 30 °C than the other two isolates which have similar temperature responses. Adult wingless man the other two isotates which have a write inoculated individually on the mouthparts grasshoppers, *Phaulacridium vittatum*, were inoculated individually on the mouthparts with $0.2 \mu l$ of an oil formulation of conidia. The doses used were 10^3 , 10^4 , and 10^5 spores per insect and control insects were inoculated with the oil only. When applied as a biopesticide, it could be expected that the grasshoppers would receive a dose between 10^3 and 10^4 conidia. Insects were then incubated at each of 5 constant temperatures: 15, 20, 25, 30 and 35 °C for up to 17 days. All 3 isolates were pathogenic at the intermediate temperatures with the most effective being 30°C for all three isolates. At this temperature, two higher doses killed all insects after 5 or 6 days with all three isolates. At 20 and 25°C, mortality was high at the two higher doses but delayed. At 15 °C, FI-985 was the most effective causing 100% mortality at dose 1 after 17 days, the Mexican isolates killed 50% after 17 days at this temperature. FI-985 also performed well at 35 °C, causing 100% mortality at all doses after 8 days. At this temperature, cadavers were less likely to sporulate even thought they were incubated at high humidity at 25 °C. QF-001 was least effective at 35 °C, causing 100% mortality after 11 days at the highest dose. It is interesting that the two Mexican isolates which are morphologically and genetically indistinguishable and came from the same host, have different temperature responses. FI-985 was highly virulent over the entire temperature range suggesting that it might perform better under extreme weather conditions in the field. Recent field trials in Australia have confirmed that this isolate is very effective for control of Australian plague locust, Chortoicetes terminifera, during very hot weather.

Index terms: *Metarhizium*; biopesticide; locusts; grasshoppers; bioassay; pathogenicity; temperature

[2034] EXPERIMENTAL EVALUATION OF ADULT STAGE OF SPODOPTERA LITURA (LEPIDOPTERA : NOCTUIDAE) AS A POTENT HOST FOR ENTOMOPATHOGENIC NEMATODES, STEINERNEMA GLASERI

V. Baweia, Department of Zoology, University of Delhi, Delhi-110007, India

Entomopathogenic nematodes (EPN_a) have been shown to be virulent against soil insect pests and/or soil inhabiting stages of foliage insects, but it is slightly difficult in case of adult stage as the nematodes cannot survive in air for long. With the determination of managing the adult population of *Spodoptera litura*, a new method for alleuring the adults towards EPN, bait, was developed. The experiment was endeavoured in a cage (30x25x25 cm) under maintained laboratory conditions. Steinernema glaseri in various concentrations of honey (0% to 9%) was provided as food to the moths. Vitality of infective juveniles (IJs) of S. glaseri was ascertained in terms of number of undulations per minute subsequent to exposure to various concentrations of honey. It was noted to be significantly more (ca. 114 undulations/minute) at 0% and showed reducing trend towards high concentration (9%) of honey solution. Us could survive in all the tested honey solutions upto a period of four to five days till the liquid dried off. Adults were found to be susceptible to EPN, infection, they got parasitized and developed the characteristic ochre colour within three days. Susceptibility of female moths towards EPN, infection was assessed to be more in comparison to male moths. Per cent parasitization was observed to be maximum (ca. 100%) at 9% honey solution and it was significantly reduced (40%) at 0% honey solution. This might be primarily due to their preference to sugar rich food source. Various other parameters, which can manoeuver the suitability of adult stage of Spodoptera litura as an acceptable host for Steinernema glaseri are also discussed. Index terms: Entomophilic nematodes, EPN, bait, Biological control.

[2035] THE BENEFICIAL NEMATODE, HETERORHABDITIS MARELATUS : ITS PROMISE IN BIOCONTROL OF PESTS IN NURSERY AND FIELD CROPS

R. E. Berry¹, T.-H. Kim¹, J. Liu¹, P. W. Gothro¹, C. Armer¹ & <u>A. F. Moldenke¹</u>, ¹Dept. of Entomology, 2046 Cordley Hall, Oregon State Univ., Corvallis, OR 97330, USA. E-mail: alisonm@bcc.orst.edu.

The entomopathogenic nematode Heterorhabditis marelatus (Rhabditidae) was isolated from the coastal region of Oregon and successfully reproduces at lower temperatures than do many other nematodes used in biocontrol. It therefore holds promise for use in cooler climates where other beneficial nematodes are not effective. It also tolerates warm, dry conditions, increasing its versatility as a biocontrol agent. The nematode is an obligate internal parasite of insects. Infective juveniles invade the host through body openings or the cuticle and release symbiotic bacteria (*Photorhabdus luminescens*) that induce septicemia and kill the host. The nematodes then develop and reproduce in the host, usually passing two generations in the host before leaving as infective juveniles to begin the cycle again. We have found that H. marelatus effectively controls strawberry root weevil (Otiorhyncus ovatus) and black vine weevil (O. sulcatus) in strawberries and azaleas, mint root borer (Fumibotys fumalis) in peppermint, cranberry girdler (Chrysoteuchia topiaria) in cranberries, and Colorado potato beetle (Leptinotarsa decemlineata) in potatoes. It is somewhat effective against sciarid flies (Lycoriella spp.) in mushrooms. Although control is effective, poor rates of nematode reproduction in some of these hosts (e.g., Leptinotarsa) limits usefulness of II. marelatus as a self-sustaining biocontrol agent. Improving mass production techniques and investigating mechanisms underlying reproductive success or failure are among the ongoing projects of our group. Index terms: entomopathogenic nematodes, weevils, root borers, Colorado potato beetle, sciarid flies.

Symposium and Poster Session

[2036] TRANSMISSION OF *NUCLEOPOLYHEDROVIRUS* IN *BOMBYX MORI* L., 1758 (LEPIDOPTERA: BOMBYCIDAE)

R. M. C. Brancalhão¹, <u>L. F. A. Alves¹</u> & M. M. C. Carvalho¹, ¹UNIOESTE/CCBS, R. Universitária, 2069, Cascavel/PR, Brazil, CEP 85814-110, E-mail: elbranca@zaz.com.br.

In Brazil, sericulture is an important cottage industry, and contributes substantially to the rural economy. Paraná State contributes with 82% to the national production and employs nearby 8,000 farmer families. Silk production in Brazil, however, is low when compared with other countries. One significant problem in the sericulture production is the presence of silkworm diseases. Among these, the viral diseases occupy an important position. Prevention and control of these diseases are essential for good silk production. In a previous paper it was identified the occurrence of Nucleopolyhedrovirus-infected Bombyx mori in Paraná State. At present it was verified transmission of Nucleopolyhedrovirus in Bombyx mori (BmNPV). It was studied infected and healthy silkworm obtained from sericulture the industry. Purified BmNPV was sprayed on mulberry leaves in different concentrations (2,26 x 10⁶, 2,26 x 10⁵, 2,26 x 104), and sixty healthy fourth-instar larvae allowed to feed on treated leaves. The control larvae were fed with leaves sprayed with distillated water. The larvae were divided in four groups of fifteen organisms and maintained in a climate room until adult stage. Daily the insect were analyzed and at different stage of development some of them were prepared for observation at the optical microscope by the following techniques: larvae, pupa, adults and eggs were shacked in distillated water and afterwards it was filtrated with cotton plug, resulting the suspension. A smear of this suspension was stained with Azan adapted and viewed under optical microscope. We also prepared a smear of meconium and stained by the same technique. Occlusion bodies of BmNPV were observed in the slades prepared from larvae, pupa and meconium. Slades from adults and eggs not showed any sight of infection by BmNPV. Our observation showed an important mechanism of defense in B. mori where great quantity of BmNPV are eliminated in association with meconium. Meconium stored waste products of pupal metabolism, and the histolysis of the larval infected tissue ensure the presence of BmNPV in this structure. However, it is impossible to affirm that the BmNPV is not transmitted to the next generations because latent virus may be present and not demonstrable by this technique.

Index terms: Bombyx mori, Nucleopolyhedrovirus, meconium, development

[2037] DISPERSAL CAPABILITIES OF THE WHITEFLY PARASITOID, *EKETMOCERUS EREMICUS*

D. N. Byrne & D. E. Bellamy.

Dept. of Entomology, Univ. of Arizona, Tucson, AZ 85721, USA, E-mail byrne@ag.arizona.edu.

Short range dispersal (< 100 m) by insects is important biologically because it can provide the means to leave unsuitable habitats in search of more favorable situations. It is important agronomically because failure to take into account events such as movement by resistant individuals, vectors and natural enemies can lead to problems designing integrated pest management (IPM) programs. We are interested in movement by *Eretmocerus eremicus* Rose & Zolnerowich, a parasitoid of the sweet potato whitelly, *Bemisia tabaci*. This aphelinid has shown enough promise as a biological control agent that it has been incorporated into a large number of IPM programs backed by the public and private sectors. A better understanding of dispersal by *E. eremicus* will assist in designing release systems for this and other parasitoids. We have already learned that unmated female *E. eremicus* fly for significantly longer periods than male counterparts (10 versus 1 min). Using laboratory data, we have constructed models that predict that most males in cantalouge fields will be travel approximately 4.2 m from a release site for every 1 min of flight.

This model was verified in 1999 field experiments ($r^2 = 0.998$). Additionally, the

average rate of dispersal for males is 90.4 m² in a 4-h sampling period. Redesigned field experiments will allow us to generate the same models for female movement. Given differences in flight duration, females will likely disperse greater distances. We are also examining a portion of parasitoid fitness in the laboratory and field by measuring rates of parasitism following dispersal. Models describing female flight will be evaluated using field-generated data. These will help improve our ability to effectively deploy *Eretinocerus* spp. As well as serve as a basis for other natural enemy release programs.

Index terms: Aleyrodidae, Aphelinidae, Bemisia tabaci, migration

[2038] CHARACTERIZATION OF A *BACILLUS THURINGIENSIS* STRAIN TOXIC AGAINST LEPIDOPTERANS AND COLEOPTERANS

C. Berón, & G. L. Salerno, FIBA. Vieytes 3103. 7600 Mar del Plata. Argentina. Email: Errot Indicador não definido..

Bacillus thuringiensis is a spore-forming bacterium producing upon sporulation a parasporal crystal toxic to some invertebrates, mostly insects and nematodes. The parasporal inclusion body or 8-endotoxin, varying in quantity and type depending of the strain. The search for novel strains is important because new isolates more pathogenic than those commercialy available can be obtained, expanding the insecticide spectrum against resistant insects. In a project oriented to search for novel native strains in Argentina, the FBt 7 isolate was obtained from soil samples collected in the province of Córdoba. Phase contrast microscopy (1,000X) and scanning (15,000X) and transmission (25,000X) electron microscopy revealed the presence of a rounded inclusion which is morphologically different from the typical crystals found in kurstaki, tenebrionis and israelensis serovars. The crystals were purified by sucrose gradients (55-82 % w/v) and the apparent molecular masses of the toxin polypeptides were determined by SDS-PAGE. The electrophoretic pattern showed the presence of two major polypeptide bands at 80 and 130 KDa. The toxicological characterization of the toxin was performed using spore-crystal complex against larvae of two lepidopteran (Anticarsia gemmatallis and Spodoptera frugiperda), two coleopteran (Diabrotica speciosa and Tenebrio mollitor) and one diptera species (Aedes agypti). Mortality was observed in a preliminary assay against lepidopteran and coleopteran species. Molecular characterization by the PCR methodology support these results. Index terms: Bacillus thuringiensis, δ-endotoxin, Anticarsia gemmatallis, Spodoptera frugiperda, Diabrotica speciosa, Tenebrio mollitor

[2039] LARVAE OF *DILOBODERUS ABDERUS* (COLEPTERA, SCARABAEIDAE) PARASITED BY NEMATODES, IN ARGENTINA

N. B. Camino¹ & <u>L. C. de Villalobos²</u>, ¹ Centro de Estudios Parasitológicos y de Vectores, CEPAVE, 2 N°584, 1900 La Plata, Argentina. E-mail cepave@museo.fcnym.unlo.edu.ar; ² Facultad de Ciencias Naturales y museo, Paseo del Bosque s/n, 1900 La Plata, Argentina. E-mail villalo@infovia.com.ar

After two years of systematic studies made weekly on insecta plague of alfalfa in the Province of Buenos Aires, Argentina, a new species of nematodes (Thelastomatidae) of the genus *Leidynema*, was found in scarabeid larvae. The larvae of the scarabeid *Diloboderus abderus* (n=62), were collected manually in holes of 10 cm per 10 cm made with shovel in the area of cultivation and pericultivation. They were packed in plastic containers with soil of the place they were collected. In the laboratory, the larvae were dissected as they died (n=40). Nematodes were found in the middle intestine (n=50-80 in each larvae). These nematodes were isolated to study their reproduction. Experimental infections were made on the same host. The damage observed in the larvae, clearly evidences that this nematode species is responsible for the death of the host, when considerable in number (n>50), as they form dense packs causing intestinal obstruction and alterations in digestion that would impact in the metabolism, leading to death.

Index terms: Diloboderus abderus, nematodes, Leidynema sp., biocontrol.

Symposium and Poster Session

[2040] ANTICARSIA GEMMATALIS NUCLEOPOLYHEDROVIRUS INFECTIVITY IN SEVEN INSECT CELL LINES

M. E. B. Castro¹, Z. M. de A. Ribeiro¹, A. R. de M. Pontes & M. L. de Souza¹, ¹Embrapa Recursos Genéticos e Biotecnologia, P. O. Box 02372, Brasília, DF 70.849-970, Brazil. E-mail: elita@cenargen.embrapa.br.

The Anticarsia gemmatalis Nucleopolyhedrovirus (AgMNPV) has been applied, in Brazil, as a biopesticide to control the velvetbean caterpillar (Anticarsia gemmatalis). Although it is known that the virus is very specific to its natural host, cell culture has been required to select productive systems and to improve studies on gene regulation. The infectivity of Anticarsia gemmatalis Nucleopolyhedrovirus to different lepidopteran cell lines was investigated. The cytopathic effects induced by the virus and the production of viral particles were examined and compared in the following cell lines: Anticarsia gemmatalis (UFL-AG-286), Trichoplusia ni (TnSB1-4 and Tn368), Spodoptera frugiperda (IPLB-SF-21AE and SF9), Lymantria dispar (Ld652Y) and Bombyx mori (BM-5). Cells were propagated in TNM-FH medium supplemented with fetal bovine serum. They were seeded at 2,5x10° in 60mm² plates, inoculated with virus at a multiplicity of infection (MOI) of 10 pfu per cell and incubated at 27°C. At several times post infection (0, 12, 24, 48, 72 e 96 h p.i.) they were examined by phase-contrast microscopy. In general, cellular rounding and nuclear hypertrophy were shown already at 12 h p.i. Some cellular protusions were detected at 24 h p.i. and then disappeared at 72-96 h p.i. Polyhedral inclusion bodies (PIBs) were then observed by 48h p.i. and increased during the subsequent periods of the infection. However polyhedra were not visualized in Ld652Y and BM-5 infected cells. In addition BM-5 cells underwent extensive lysis after incubation with AgMNPV, being 70 % of them ulready lysed at 96 h p.i. Analysis by optical microscopy, at 96 h p.i., showed that the number of cells producing polyhedra reached 95% to 100 % in both Tn5B1-4 and UFL-AG-286 cells. It also reached 70%, 40% and 25% in SF21, Tn368 and SF9 cells, respectively. In parallel, measurement of viral titers (budded virus) by endpoint dilution method showed that Tn5B1-4, UFL-AG-286 and SF21 cells were highly productive. Their TCID₅₀ values, at 48 h p.i., were about 10

Index terms: Anticarsia gemmatalis Nucleopolyhedrovirus, infectivity, insect cell lines

[2041] THE EXPERIMENTAL TRIALS WITH THE VIRAL PRODUCT "Inf-He" FOR DENSITY CONTROL OF PEST POPULATIONS OF HYPHANTRIA CUNEA

<u>M. Ciuhrii¹</u>, M. Iamandei¹, T. Manole¹, ¹Dept. of Entomology, Research Institute for Plant Protection-Bucharest, Bvd. Ion Ionescu de la Brad, 8, sector 1, 71592, Bucharest, Romania, Fax.: 004-01-231.33.61;Tel.: 004-01-222.30,36; E-mail: icpp@com.penet.ro; insectfarm@penet.ro; delta@canad.ro.

Hyphantria cunea (Lepidoptera: Arctiidae) is known like a pest species which attack more then 300 species of trees and shrubs. The fall webworm, H. cunea is native to North America and is a major pest of trees in Europe and Asia. In Asia the pest is spread by two directions. One of this has reach peninsula Korea to China and South India. The second one tends to reach the Volga River and the south of Caspic Sea. The pest insect could be a real danger if his spreading in the Middle Asian territory is accomplished. This species could be an important feeding competitor of *Bombyx mori* (the common silkworm). This fact could mean the failure of the silk industry based on the silkworm rearing. In this situation the only control method that could be applied is the use of viral products based on granulosis virus, which had a selective, specific action, focuses on the fall webworm target. Over a period of 20 year we had dedicated to the research for obtaining of a viral product able to stop his migration in the Middle Asia and to be a proper method of control of the pest. In Romania the fall webworm has been introduced in 1952 and since then every year the webworm feeds on a wide variety of deciduous trees and shrubs, often resulting in complete defoliation. The species usually cats leaves late in the season and the real damage is done to the mulberry, nut and maple plantations. Attacking the trees from the inside of the cities areas the pest is producing of discomfort by inhalation of the pilosity of caterpillars. The viral product "Inf-Hc" is described by the follows characteristics: Formulation nowder

Colour	bright
grey	
Humidity(U%)	4-6%
Biological activity	85-
92%	
The alien microflora concentration	2 x
1500	
The period of validity	5
years(in refrigerator)	
pH	7,0-7,2
Dosage at ha	50 g
Index terms: Hyphantria cunea, Fall webworm, viral n	roduct VG biological control

[2042] LESSONS LEARNED DURING THE DESIGN OF AN ARTHROPOD AND PATHOGEN QUARANTINE FACILITY

R. De Clerck-Floate¹, P. Plue² & T. Lee³, ¹Agriculture and Agri-Food Canada, Lethbridge Research Centre, P.O. Box 3000, Lethbridge, Alberta, Canada, T1J 4B1, ²Agriculture and Agri-Food Canada, 930 Carling Ave., Ottawa, Ontario, Canada, KIA 0C5, ³Public Works and Government Services Canada, 1000 Canada Place, 9700 Jasper Ave., Edmonton, Alberta, Canada, T5J 4E2

The Lethbridge Research Centre of Agriculture and Agri-Food Canada has completed design for a 883 square metre (9500 square foot) quarantine facility for the containment of biocontrol arthropods and, insect and plant pathogens. During the design phase of the project, several quarantine facilities in the United States were toured and information was gathered from people involved with quarantine design and maintenance in North America and abroad. From these tours and interviews and, our own challenges in design, we have developed a list of architectural and mechanical engineering solutions to meet user and regulatory requirements and budget constraints on such a project. These include: 1) Using a clustered, modular design for small insectrearing rooms. The rooms have special ventilation to address wide temperature range capabilities, elevated relative humidity and, potential allergy problems related to the rearing of insects. 2) Lowered ceilings in insect rearing rooms and imported shipment room to give better control of escaped insects and ease in cleaning. 3) Establishment of quarantine barrier at the ceiling, above which is located all mechanical equipment in a large non-quarantine interstitial space. 4) Natural light in many areas within quarantine to enhance work with insects (e.g., for mating and rearing requirements, insect trapping, improved viewing of insects during identification and sorting). 5) Mechanical and ventilation separation of the arthropod from pathogen areas of quarantine. The pathogen suite has its own entrance with shower, controlled pressure differentials, separately-treated waste water, and HEPA filtered exhaust air. 6) Flexible, economical waste management system. This includes triple-tank septic and batch chlorine systems for treatment of liquid wastes from arthropod and pathogen parts of quarantine, respectively, and pass-through autoclave and hot-box for treatment of solid materials. 7) Individual fan coil units for cooling greenhouse compartments versus the use of dedicated air handlets.

Index terms: containment, engineering solutions, insect-rearing, mechanical systems

[2043] EFFECT OF BACILLUS THURINGIENSIS, SUBSP. AIZAWAI FOR THE CONTROL OF PLUTELLA XYLOSTELLA ON CAULIFLOWER, BRASSICA OLERACEA

S.A.M.P. Coelho¹, **M.H. Calafiori¹ & C.L. Da Silva²**, ¹Agronomic Engineering Course. CREUPI. Postal Box 05. 13990-000 - Espírito Santo do Pinhal – SP – Brazil. E-mail: cpagrpin@rantac.com.br. ²Hokko do Brasil. E-mail: issamu@hokko.com.br

Diamond back moth is an important pest of the Cruciferae, where it destroys leaves. Insecticides residues is a problem in those cultures. Thus, the use of biological control is recommendable. This experiment was carried out in Jarinu county - SP, with cauliflower, variety Chinomaru II, in October, 1999. The experimental design was complete randomized block with 4 replications in field conditions. The treatments were: 1- control; 2- Bacillus thuringiensis subsp. aizawai (Xentari - 50 g/100 \Box); 3- Bacillus thuringiensis subsp. aizawai (Xentari - 60 g/100 \Box); 4- Bacillus thuringiensis subsp. aizawai (Xentari - 80 g/100 \Box); 5- Bacillus thuringiensis subsp. Austaki (Dipel - 100 nl/100 \Box); 6- clorfluzuron (Atabron 50 CE - 75 ml/100 \Box); 7- lufenuron (Match - 80 ml/100 \Box). There was an application of imidacloptid in all treatments for the control of aphids. Plots were shaped by 10 plants. The products were applied 4 times, weekly. Evaluations were done during the harvest time. Larvae and pupae were observed in 6 plants/plot and number of holes was counted in 12 leaves/plot. The results allowed to conclude that all products controled *P. xylostella* with efficiency above 83% and there wasn't occurrence of phytotoxicity. Index terms: pathogen, insecticide, diamond back moth.

[2044] THE SPECIFICITY OF *BEAUVERIA BASSIANA* FOR THE CONTROL OF MITE PESTS OF PAPAYA

K. F. S. Collier, J. O. G. de Lima, M. C. Araújo & <u>R. I. Sanuels</u>, Department of Plant Protection, Universidade Estadual do Norte Fluminense, Campos dos Goitacazes, RJ 28015-620, Brazil, E-mail richard@uenf.br.

Phytophagous mites are responsible for huge losses in agricultural production worldwide and are capable of rapidly developing resistance to conventional pesticides. Alternative approaches to control are therefore urgently required. Natural pathogens of certain phytophagous mite species have been investigated and at least one microbial acaricide (Mycar® based on Hirsutella thompsonii) has been produced for the control of the citrus rust mite. However, this product was a commercial failure probably due to limited shelf-life. The possibility of using fungi which are not natural pathogens of phytophagous mites, has to date not been well investigated. Two such candidate species are Metarhizium anisopliae and Beauveria bassiana, which are currently being used in various insect biological control programs and are more resistant to environmental conditions than some of the natural mite pathogens. In this preliminary study we tested one isolate of Beauveria bassiana (CG 24; natural host Hemiptera: Pentatomidae) against two important mite pests of papaya, Tetranychus urticae (Acari: Tetranychidae) and Polyphagotarsonemus latus (Acari: Tarsonemidae). We also investigated the specificity of this pathogen against one species of predatory mite, Neoseiulus idaeus (Acari: Phytoseiidae), which has been shown to be important in the natural suppression of phytophagous mites. Conidial suspensions in water $(5.75 \times 10^6 \text{ conidia} \text{ ml}^{-1} \& 5.75 \times 10^8 \text{ conidia} \text{ ml}^{-1})$ were applied to papaya leaf discs. Female mites were then transferred to the then dry leaf discs, which were maintained at 25°C and ~70% RH. Mites were transferred to fresh leaf discs after 24 hours. Mortality was observed on a daily basis. For *T. urticae*, the values for TL_{50} were 6.27 days (5.75 x 10^{6} conidia ml⁻¹) and 4.13 days (5.75 x 10^{8} conidia ml⁻¹). TL_{50} for control treatments was 12.08 days. B. bassiana CG 24 was not found to be pathogenic to either P. latus or N. idaeus at the highest concentration of inoculum used here. The results show that isolates of B. bassiana should be considered as potential agents for the control of mites and can be specific, without causing mortality of beneficial predatory mites. We are currently testing a range of *B. bassiana* and *M. anisopliae* isolates for pathogenicity against both species of phytophagous mites and the predatory mite.

Index terms: Tetranychus urticae, Polyphagotarsonemus latus, Neoseiulus idaeus, entomopathogenic fungi, microbial control.

[2045] A NEW FUNGAL ISOLATE FOR THE CONTROL OF DIABROTICA SPECIOSA

V. F.Consolo.¹; G. Cabrera.²; G. L. Salerno.¹ & <u>C. Berón¹</u>, 1.-FIBA. Vieytes 3103. 7600. Mar del Plata. Argentina. E-mail: fibamdq@infovia.com.ar. 2.-SABCL-USDA. Bolívar 1559. 1686. Hurlingham. Argentina.

Many species of cucumber beetles ocurr in South America. Particularly, in Argentina the most important coleoptera pest is Diabrotica speciosa an important cucumber pest. Both larvae and adults cause serious damage in all plant organs (flowers, roots and tubers). Entomopathogenic fungi are key regulatory factors in insect populations and also are the pathogens of choice for Coleoptera. Thus the use of biological agents will be an alternative in the control of cucumber pest. The goal of this project was the search of new strains with potential toxicity for the control of D. speciosa. Sixteen fungal isolates were obtained from soil samples and dead insects (Maecolaspis bridarolii larvae and D. speciosa adults). In a screening assay the isolate FHD13, identified as Beauveria bassiana, caused 70% of mortality in the third instar of D. speciosa. The CL_{50} value calculated using six different concentrations was 3.5×10^{10} conidia/ml. Then, FHD 13 was selected for preparing biological formulations in different oils. The conidial viability in the formulates was estimated at different temperatures (4, 17 and 26°C) and periods of storage. The best formulate condition (99.5% viability) resulted in the preparation with corn oil stored at 4° C during 28 days. It was evaluated in preliminary assay the pathogenicity of conidial formulation in the third instar of D. speciosa reaching 65% of mortality. In addition protease activities were measured in the culture media of the isolates in the presence and absence of D. speciosa cuticles. Enzyme activity was several times higher in the presence than in the absence of cuticles in all the cases. However, it could not be stablished a correlation between proteolitic activity and mortality. The isolate FHD 13 may be a good candidate to be tested as bioinsecticide in large scale.

Index terms: Diabrotica speciosa, entomopathogenic fungi, Beauveria bassiana.

[2046] INFECTION OF *DIATRAEA SACCHARALIS* (LEP.; PYRALIDAE) WITH THE MICROSOPORIDIA *NOSEMA SP*

H. Conte¹, A.A. Zacaro², Cruz-Landim, C.², ¹Dept. de Biol. Celular e Genética, Univ. Est. de Maringá (UEM), Av. Colombo n. 5790, CEP 87020-900- Maringá/PR, Brasil. E-mail: licon@wnet.com.br.Brasil, ²Dept. de Biologia, Inst. Biociências, Cx. P. n. 199, Univ. Est. Paulista, UNESP, Rio Claro/SP, Brasil, CEP 13506-900.

In insects, microsporidia are the most important parasites and cause serious diseases in beneficial and pest insects. Ingestion is most common route through which microsporidia reach host tissues, but in certain lepidopteran hosts, they can reach tissues and/or haemocoele by the process of the wasp's oviposition. Specimens of D. saccharalis were reared using artificial diet and 4h instar larvae was submitted to oviposition by the braconid Cotesia flavipes (Hym.; Braconidae). After eight days, larvae parasitized were dissected and the tissues isolated, fixed, processed and analysed using transmission electron microscopy. In D. saccharalis larvae, visceral fat body is the tissue most frequently infected by microsporidia. In the initial phase of infection it was observed that adipocytes show endoplasmic reticulum around these intracellular parasites; it was also observed an increase in the number of mitochondria but in the latter phase, there is a reduction of endoplasmic reticulum contrasted with an increased vacuolization process in the cytoplasm; the ribosomes are depleted, mitochondria decrease in size and many electrondense oval and elongate structures were identified as spores of *Nosema* sp. The two tipes of spores may represent variation and need molecular biology for confirm identity of taxa. Each spore is formed by three concentric layers (an outer proteinaceous exospore, a middle chitinous endospore and an inner plasma membrane) arround a very condensed cytoplasm .We observe depletion of lipids and protein reserves resulting in fat body degeneration and may be associated with microsporidial infection. There is evidence that the destruction of fat body tissue would reduce the production of juvenile hormone, thus resulting in abnormal larval development. It was observed a reduction in the population size of adults of *C. flavipes* when its host was infected by this protozoan. In other hand, if hymenopteran parasitoids may be susceptible to the microsporidia of their lepidopteran hosts, probably this same mechanism would be affecting the decreased production in our laboratory strains of C. flavipes. It must be considered that this hymenopteran may play a major role in wide spreading microsporidia transmission mainly in laboratory conditions although the excact mode (transovarial and/or transovum) need more investigations. In this dual parasitism, both parasitoids and microsporidia compete for the lepidopteran host nutrients. Index terms: parasitism, sporozoa, lepidoptera, adipocytes.

[2047] THE SPECIFICITY OF METARHIZIUM ANISOPLIAE AND BEAUVERIA BASSIANA IN THE INFECTION OF EGGS OF THE BRAZILIAN CHINCH BUG, BLISSUS ANTILLUS

D.L.A. Coracini & R. L Samuels, Department of Plant Protection, Universidade Estadual do Norte Fluminense, Campos dos Goitacazes, RJ 28015-620, Brazil, E-mail richard@uenf.br.

An important advantage of entomopathogenic fungi in biological control, when compared with bacteria and viruses, is that fungi are capable of infecting all stages of the insects life cycle, including the egg phase. However, very few studies have been carried out on the control of pests by infection of eggs. In this study, candidate fungal isolates chosen for the control of the adult and nymph stages of pasture pest, Blissus antillus, were screened for pathogenicity against eggs. Blissus eggs were exposed to isolates of Metarhizium anisopliae and Beauveria bassiana by immersion in spore suspensions or by precision spray application using a Potter tower. The results were somewhat unexpected. All of the *Metarhizium* isolates tested were pathogenic and highly virulent, whereas most of the Beauveria isolates caused relatively low infection rates. A standard concentration of fungal inoculum (5 x 106 spores ml-1) caused 100% infection when eggs were immersed in suspensions of Metarhizium isolates for 10 min. or subjected to spraying at the same concentration. At this concentration Beauveria caused a maximum of 43% infection (isolate CG11) and a minimum of 2% infection (CG04). When the concentration was reduced to 1 x 10⁴ spores ml⁻⁴, the infection rate remained above 90% for all Metarhizium isolates. At this concentration, Beauveria treated eggs hatched normally. In order to investigate the difference in the process of infection of Metarhizium and Beauveria, the adhesion and germination of spores on the egg surface were examined using fluorescence microscopy. Calcofluor M2R (Sigma) was used to stain fungal structures at periods of 24 and 48 hours following exposure of eggs to fungal isolates. Major differences were observed between Metarhizium and Beauveria. Firstly, the number of spores on the egg surface was higher for Metarhizium. Secondly, germ tube development showed marked differences. In Metarhizium infected eggs, the germ tubes were short and rapidly formed appressoria, however, in Beauveria, the germ tubes were observed to be thin and elongated, without appressoria. These results indicate that the specificity of the two species is determined by differences in adhesion and penetration. Index terms: entomopathogenic fungi, biological control, specificity.

[2048] HOST-HANDLING BEHAVIORS OF BLACK SCALE PARASITOIDS: A CASE FOR ANT MEDIATED EVOLUTION

K. M. Duane & M. S. Barzman. Div. Insect Biology, Univ. of California, Berkeley, CA 94706, USA, daane@uckac.edu.

Oviposition behaviours play an important role in the effectiveness of insect parasitoids. Oviposition decisions are influenced by external (e.g. host abundance) and internal (e.g. parasitoid egg load) factors. Nevertheless, there has been little attention given to one external factor: predation or interference of adult parasitoids during oviposition. We suspect that differences among closely related black scale, Saissetia oleae, parasitoids (Metaphycus hageni Metaphycus anneckei, Metaphycus lounsburyi) resulted from disparate evolutionary pressure driven, in part, to reduce to host-handling times. M. anneckei oviposits through the scale's ventral integument. In contrast, M. hageni and M. lounsburyi oviposit through the harder dorsal integument. These differences resulted in different host-handling times, with host acceptance/rejection times significantly less for *M. anneckei* than for either *M. hageni* or *M. lounsburyi*. Similarly, host feeding, which required more time than oviposition, was absent in *M.* anneckei but present in *M. hageni* and *M. lounsburyi*. In laboratory studies, the faster host handling time of M. anneckei resulted in greater reproductive success in the presence of scale-tending Argentina ants, Linepithema humile. M. anneckei remained foraged significantly longer than M. hageni (when ants were present) and completed oviposition in every trial, while *M. hageni* never successfully oviposited. In a field test, scale-infested oleander plants were divided into ant-tended and ant-excluded treatments and placed near a stand of coyote brush, Baccharis pilularis, which was a source of parasitoids. Results over a 6 month period show significantly more S. oleae and lower percentage parasitism in the ant-tended than ant-excluded treatment. More interesting was the influence of ant-tending on parasitoid species relative abundance. Primary parasitoids reared from S. olene collected on coyote brush consisted of: Metaphycus helvolus, M. lounsburyi, M. anneckei, M. hageni, Coccophagus lycimnia, *C. scutellaris, C. ochraceus,* and the egg predator/parasitoid *Scutellista caerulea*. However, that these parasitoid species did not distribute evenly between the ant-tended and ant-excluded treatments. The relative proportion of *M. helvolus* and *M. barletti*, which have relatively slow host-handling times, was significantly higher in the ant-excluded treatment, while the faster ovipositing *M. anneckei* was significantly more common in the ant-tended treatment. Similar observation were made with the relative abundance of Coccophagus species. This work suggests that ant-tending may place selective pressure towards parasitoids with faster host-handling time and no host feeding requirements. With these data, we can imagine a scenario in which greater evolutionary pressure was placed on *M. anneckei* to develop faster host-handling times to improve reproductive success in regions with scale-tending ants. Index terms: Metaphycus, Coccophagus, Saissetia oleae, ant-tending, oviposition

[2049] BT COTTON: RELATIONSHIP BETWEEN BIOEFFICACY, GENE EXPRESSION AND PROTEIN

J. Daly¹, J. Finnegan², K. Olsen¹ & H. Holt¹, CSIRO Entomology, GPO Box 1700, Canberra, ACT, Australia, 2601, E-mail: J.Daly@ento.csiro.au.

Genetically engineered cotton plants expressing insecticidal proteins from *Bacillus thuringiensis* (Bt) were developed using constitutive promoters so that efficacy could be maintained throughout plant development. The initial pest management and resistance management strategies devised for Bt cotton were built around this model. The major targets of these Bt cottons are lepidopteran pests, including the Old World species, *Helicoverpa armigera* and *H. purctigera*. In Australia, commercial cultivars of cotton express the Cry1Ac protein from Bt. Mortality of the two species of *Helicoverpa* on Bt cotton declines during the season from near 100% before the plants start to square to below 40% when mature bolls are present. There are many possible causes for the decline. We have observed the relationship between the mRNA levels in leaves, the amount of Bt protein present and the bioefficacy of the leaves. Over the season increased survival of larvae on leaves is associated with a decline in Bt protein present. Down regulation of the Bt gene is likely as greatly reduced levels of mRNA from the Bt gene are present in older plants. The relationship, however, is not always evident and other factors must play a role in influencing bioefficacy of Bt cotton.

Index: Helicoverpa armigera, Bacillus thuringiensis

[2050] REMARKABLE PHYSIOLOGICAL VARIATION AMONG ISOLATES OF THE MITE PATHOGENIC FUNGUS *NEOZYGITES FLORIDANA*: NUTRITIONAL REQUIREMENTS AND CRYOPRESERVATION

I. Delalibera Jr.^{1,2}, A. E. Hajek¹, R. A. Humber³, ¹Dept. of Entomology, Cornell University, Ithaca NY 14853, USA, ²Fellow from CNPq-Brazil E-mail id24@cornell.edu; ³USDA/ARS US Plant, Soil & Nutrition Laboratory, Ithaca NY 14853, USA.

Neozygites floridana is a fungal pathogen that is currently being released in Africa for the control of the introduced cassava green mite (CGM). The inability to produce N. floridana in vitro is one factor that has hindered molecular studies to detect establishment of introduced isolates in regions where native ineffective isolates already exists. This study reports culture media and cryoprotection treatments for isolates specific to CGM. A CGM specific isolate (CNPMF 8) was compared to two other isolates with wider host ranges (ARSEF 662 and ARSEF 5376) with respect to growth in different culture media and potential for cryopreservation. The CGM isolate is more fastidious than the two other isolates and only grows in a limited number of media. IPL-41 insect cell culture medium supplemented with 5% fetal bovine serum (FBS), 0.3% lactalbumin hydrolyzate and 0.3% yeastolate afforded good growth across all isolates (> 10^7 hyphal bodies/m). FBS, the most expensive ingredient in this media, can be replaced by lipid concentrate and plurionic F-68. Cultures of ARSEF 662 and ARSEF 5376 can be cryopreserved using 5% glycerol or 7% polydextrose with standard procedures for ultra-low temperature cooling (decreasing at a rate of $1^{\circ}C/min$ to $-30^{\circ}C$ followed by rapid uncontrolled cooling to $-80^{\circ}C$ or $-196^{\circ}C$). Standard procedures are not effective for the CGM isolates and best results were obtained using rapid, uncontrolled cooling.

Index terms: Zygomycetes, Entomophthorales, culture media, Mononychellus tanajoa, cassava green mite

[2051] DESIGNING PROTEINASE INHIBITORS FOR THE CONTROL OF *HELICOVERPA* SPECIES

<u>K.M. Dunse</u>¹, M. Korsinczky², D.J. Craik² & M.A. Anderson¹, ¹Dept. of Biochemistry, La Trobe Uni, Bundoora Australia 3083, E-mail: kdunse@bioserve.latrobe.edu.au; ²Centre for Drug Design and Development, Uni. of Queensland, Brisbane Australia 4072.

Floral tissues and wounded leaves of the ornamental tobacco, Nicotiana alata, produce copious amounts of small (6kD) serine proteinase inhibitors (NaPIs) which inactivate the major digestive enzymes in several insect pests. These inhibitors are derived from a precursor protein which contains six contiguous PIs that are cleaved into two chymotrypsin inhibitors (C1+C2) and four trypsin inhibitors (T1-T4). We are investigating the effect of these inhibitors on the growth and development of H. punctigera and H. armigera larvae and their effect on chymotrypsin and trypsin enzymes in the gut. Most gut chymotrypsin and trypsin activity is inhibited by the NaPIs, but some activity is NaPI resistant. PI resistant enzymes are being isolated and characterised and are the target for the design of new inhibitors. New potent proteinase inhibitors will be selected using phage display. One of the chymotrypsins has been expressed as a fusion protein with the gene III protein of the filamentous phage M13. A library of chymotrypsin variants is being produced to select for PIs that have enhanced activity against proteases resistant to the current range of PIs. Four major families of chymotrypsins have been cloned. Using the sequence predicted from one of these clones, we have prepared a model of NaPI in complex with Helicoverpa chymotrypsin.

Index terms: Helicoverpa, phage display, Nicotiana alata, proteinase inbibito.

Symposium and Poster Session

[2052] STUDIES ON ENTOMOPATHOGENIC FUNGI AGAINST WHITE GRUB HOLOTRICHIA SERRATA (COLEOPTERA : SCARABAEIDAE) IN SUGARCANE

S. Easwaramoorthy, J. Srikanth, G. Santhalakshmi, N. Geetha, Sugarcane Breeding Institute, Coimbatore 641007, India.

Laboratory and field studies were conducted with three muscardine fungi, namely Beauveria bassiana, Beauveria brongniartii and Metarrhizium anisopliae against the white grub Holotrichia serrata (Coleoptera : Scarabaeidae) in sugarcane. The three fungi were cultured on molasses, a by-product of sugar industry, at 1.5-4.5% vis-à-vis standard media. Radial growth (cm) in culture plates at the lowest concentration of molasses was on par with that on standard media for all three fungi which did not differ between them. Biomass production (g) varied positively with concentration of molasses and at higher concentration it was on par with that on standard media; there were no differences between the three fungi. Spore production liter' of media did not vary between concentrations of molasses and standard media but it was the lowest for M. anisopliae. In the laboratory, eggs placed in plastic boxes (9 cm h x 7.5 cm d) containing soil (218.7 ± 16.5 g) treated with B. brongniartii at 5 x 10⁶ - 10⁹ spores / box suffered infection and mortality rates similar to that in control; in a second experiment with M. anisopliae, eggs dipped in a suspension of $10^4 - 10^9$ spores / ml Experiment with *an instruction*, eggs impress in a suspension of 10 - 10 spites 7 in showed higher rates of infection and mortality. In similar laboratory experiments with grubs, the three fungi at dosages of $10^4 \cdot 10^9$ spores 7 box produced higher levels of mortality in third instar (6.7-93.3%) than in second instar (20.0-60.0%); *M. anisopliae* produced the lowest levels in both instars. In other studies, *B. brongniartii* at $10^9 \cdot 10^{10}$ spores / box produced 64.0 - 72.0% mortality in the two instars. In a pot culture experiment with *B. brongniartii* at a dosage equivalent of 10^{13} - 10^{16} spores / ha, first instar grubs showed lower levels of mortality (0.0-10.7%). In different pot culture tests on third instar grubs at 10¹³ - 10¹⁸ spores / ha dosage equivalent, mortality rates were higher than those for first instar. In three field trials, *B. brongniartii* applied to soil in 7 mold crop at dosages of 10^{13} - 10^{15} spores / ha, dispensed with sorghum grains used for mass culturing, produced variable infection levels in second instar grubs collected 30 days after treatment. In the first trial, a high 48.0% infection level was obtained at 10^{14} spores / ha; in the remaining two trials, lower mortality levels (<5.0%) were noticed even at the highest dosage. Dosage, time of application, method of dispensation of the fungi need further standardization. A sequential application of M. anisopliae as an ovicide and B. brongniartii as a larvicide can be a useful biocontrol package against the soil inhabiting H. serrata. Mass culturing the fungi on molasses enables their large-scale production in laboratories set up in sugar factories. Index terms: Beauveria bassiana, Beauveria brongniartii and Metarrhizium anisopliae

[2053] ENTOMOPATHOGENIC NEMATODES AS BIOLOGICAL CONTROL AGENTS OF INSECT PESTS: A CLEARER UNDERSTANDING

P. Fairbairn, A. C. Fenton, R. A. Norman & P. J. Hudson, Inst. Biological Sciences, Univ. Stirling, STIRLING, FK9 4LA, UK.

Entomopathogenic nematodes are soil dwelling obligate parasites of insects and have been utilised as biological control agents of several crop pests. They have been successfully targeted against the Japanese beetle (Papillia japonica), black vine weevil (Ottiorhynchus sulcatus) and the mushroom fly (Sciarid spp.) to name but a few. However, the levels of success so far achieved on these insect pests have proved inconsistent between trials. In order to increase the levels of control and the degree of uniformity between scenarios, we have to form a better understanding of the biology of the system. In particular the dynamics of the infection process need to be more fully understood. Using a mathematical modelling approach we have investigated the entomopathogenic nematode infection processes and have gained a clearer understanding of the mechanisms, which are important in delivering 'successful' control. Here we present the results of experiments investigating infection in the Galleria mellonella - Steinernema feltiae system that allows us to investigate particular infection processes which are important for the development of the model. By experimentally modelling different control scenarios we demonstrate that the processes of infection are not simple linear ones, as assumed by the simple models. Infection is found to be dependent on the period of exposure and host:nematode ratio. These differences have obvious implications for the development of the model and are important for the applied biological control of insect pests. We discuss how our experimental findings lead to a clearer understanding of the situations in which entomopathogenic nematodes may be utilised to their full potential.

Index terms: Galleria mellonella, Steinernema feltiae, Modelling, Infection dynamics

[2054] MODELS OF ENTOMOPATHOGENIC NEMATODES FOR **BIOLOGICAL CONTROL**

A. C. Fenton, J. P. Fairbaire, R. A. Norman & P. J. Hudson, Inst. Biological Sciences, Univ. Stirling, STIRLING, FK9 4LA, UK.

Entomopathogenic nematodes (Nematoda: Rhabditida) are lethal obligate parasites of a wide range of insect species throughout the world, exhibiting many characteristics that make them ideal candidates as biological control agents of insect crop pests. However, to date, they are used in relatively few crop systems. As with many other biological control agents, the practical use of these nematodes at present is often based more on trial-and-error than on a firm, ecological understanding. Clearly, there is a need to build on existing biological information and develop a more comprehensive understanding of the nematode-host system to determine their optimal use as biological control agents. Here we discuss the development of a series of models of increasing complexity, designed to assess the optimal use of these nematodes under a wide range of biological control scenarios. To begin, we develop simple SI-type models to determine the broad dynamics of the system. We then add extra biological realism, such as host stage structure and evaluate control success under a range of short- and long-term biological control goals. We then develop cellular automata models to incorporate explicitly the effects of space (e.g., host refuges, dispersal rates etc) on control success. At all stages, our models are parameterised and validated by laboratory and field experiments. We begin by obtaining general parameter estimates for our simple models using the greater waxmoth, Galleria mellonella in laboratory experiments. Finally, we combine the models with field data to explore the optimal method to control the mushroom fly, Sciarid spp. (Diptera: Sciaridae) which is a major economic pest of mushroom houses in Europe and the US. We conclude that a combined approach, incorporating laboratory experiments and field data into a structured modelling framework is essential for predicting the effectiveness of nematodes as biological control agents.

Index Terms: Sciarid spp., Galleria mellonella, cellular automata, parameterisation.

OF [2055] EVALUATION THE EFFICIENCY OF RACILLUS THURINGIENSIS IN THE CONTROL OF URBANUS ACAWOIOS (LEPIDOPTERA: HESPERIDAE)

F.A. A. Ferrara^{1,2}, A. M. Lunz³, J. G. N. Wendt², J. M. Pinto² & A. G. Carvalho³, CTAIBB, Univ. Fed. Fluminense, Bom Jesus do Itabapoana, RJ, 28360-000, Brasil. E-mail: fernando@lutarc.com.br; ²Depto. de Fitotecnia, Univ. Fed. Rural do Rio de Janeiro, Seropédica, RJ, 23851-970, Brasil; ³Depto. de Produtos Florestais, Univ. Fed. Rural do Rio de Janeiro.

In the last three years, annual outbreaks of Urbanus acawoios (Lepidoptera: Hesperiidae) have been observed in the northwest and north of the State of Rio de Janeiro and south of the Espírito Santo. This moth used to appear every 3 to 5 years causing a total defoliating of the "sombreiro" Clitoria fairchildiana (Leguminosae: Faboidae). This tree is very used as ornamental plants on the edge of streets, public squares, parking and highways of the southeast area of Brazil. The action of ecological factors, among them the biotics, such as food and natural enemies, together with the non-biotics influence the fluctuation of the insects, making it necessary to adopt control measures. However, control methods that cause smaller aggression to the environment should be searched. The work sought to test the viability of Bacillus thuringiensis on second and third instars of U. acawoios as well as to determine the most effective dosage for the control of the species. The eggs were maintained in Petri plates. After the eclosion the caterpillars were fed with leaves of C. fairchildiana. The experiment about the action of B. thuringiensis on the caterpillars of second and third instars was performed in laboratory (23,48 ± 2,82 °C, 71,67 ± 3,45% relative humidity and 12 hours of fotophase) with twenty replications. The dosages of *B. thuringiensis* (Dipel® PM formulation) were 0, 50, 100, 150, 200, 400 and 600 grams / 400 liters of water. The result of mortality rate varied according to the schedule (period of exposition): 24 hours (2 to 8% for second instar and 16 to 60% for third instar), 48 hours (33 to 60% and 68 to 95%), 72 hours (64 to 100% and 88 to 100%), 96 hours (70 to 100% and 90 to 100%) and 120 hours (71 to 100% and 91 to 100%). The results showed that in higher dosages the mortality rate was higher in the first hours. However, as time passed by, mortality rate was significantly the same in all dosages, except the control for the third instar. For the second instar, the dosages were significantly the same between 150 and 600 grams / 400 liters of water, at the level of 5% of probability for Tuckey's test. Considering the results of the action of B. thuringiensis, it offers possibilities for the control of Urbanus acawoios populations taking into account the high mortality rate.

Index terms: Biological control, Clitoria fairchildiana

[2056] CONIDIAL VIABILITY OF TWO ENTOMOPATHOGENOUS FUNGI KEPT ON AQUEOUS SUSPENSION UNDER DIFFERENTS STORAGE CONDITIONS AND PERIOD

J.M.S. Ferreira¹, <u>R.P.C. Araujo²</u> & F.B. Sarro³, ¹Lab. of Entomology, Embrapa/CPATC, P.O. Box 44, Aracaju, CEP 49025-040, Brazil E-mail joana@cpatc.embrapa.br; ² Dept. of Biotecnology, Unesp, Araraquara, P.O. Box 355, CEP 14801-970, Brazil; ³ Dept. of Plant Protection, Unesp, Botucatu, P.O. Box 237, CEP 18603-970, Brazil.

The present work was carried out at Embrapa Coastal Tableland Research Center (CPATC), Aracaju, Sergipe State, Brazil, aiming to determine the conidial viability of Beauveria bassiana BbBr032/CPATC strain, isolated from Rhynchophorus palmarum and of Hirsutella thompsonii HtBrI/CPATC strain isolated from Aceria guerreronis (both strains from Sergipe, Brazil), in different storage conditions and period kept under aqueous suspension. The suspensions of B.bassiana and H.thompsonii were diluted to 109 and 107 conidia/ml concentration, respectively, then homogenized and distributed in 50ml vials. The experimental design was completely randomized, in a factorial 4x5 and 4x6 (four temperatures and five/six storage period) with three replications. The main treatments were: T1 storage in room temperature; T2 in refrigerator (4°C); T3 in freezer (-10°C) constant; and T4 in freezer (-10°C) with successive defrost at each period of evaluation. The evaluations were done at 5, 10, 15, 30 and 45 days intervals (and until 60 days for B. bassiana). Adults mortality was registered for 20 days and fungus infection confirmed in a humid chamber. Viability rates of 60.46% and 60.02% were obtained for B.bassiana when storaged for 60 days in -10°C temperature with and without successive defrost, respectivelly. Similar rates were obtained for H.thompsonii when storaged at same conditions up to 10 days. Viability losses of 47.94% and 34.74% were obtained for B.bassiana and H.thompsonii conidium maintained at room temperature for 5 days.

Index terms: Beauveria, Hirsutella, conservation, formulation

[2057] EFFICIENCY OF THE ENTOMOPATHOGENOUS FUNGUS BEAUVERIA BASSIANA (BBBR057/CPATC) STRAIN ON BLACK COCONUT BUNCH WEEVIL HOMALINOTUS CORIACEUS (COLEOPTERA: CURCULIONIDAE)

J.M.S. Ferreira¹, <u>R.P.C. Arauio²</u> & F.B. Sarro³, ¹Lab. of Entomology, Embrapa/CPATC, P.O. Box 44, Aracaju, CEP 49025-040, Brazil;² Dept. of Biotecnology, Unesp. Araraquara, P.O. Box 355, CEP 14801-970, Brazil, E-mail coqueiral@mar.com.br; ³ Dept. of Plant Protection, Unesp. Botucatu, P.O. Box 237, CEP 18603-970, Brazil.

The black coconut bunch weevil Homalinotus coriaceus Gyli (Coleoptera:Curculionidae) is considered an important pest of coconut palm in Brazil. The adult feeds on female flowers and on young nuts causing abortion and premature nut falls. The larvae form feeds on the coconut bunch burrowing a external gallery down towards the leaf petiole causing the fall of the whole bunch and severe losses in coconut production. Agricultural pests can be controlled either by classical chemical methods or biological ones. The deuteromycete fungus Beauveria bassiana has been largely used in Brazil as a bioinseticide for many pests. The present work was carried out at the Laboratory of Entomology of Embrapa Coastal Tableland Research Center (CPATC) Aracaju, Sergipe State, Brazil, aiming to determine the efficiency of the BbBr057/CPATC strain of B.bassiana found infecting adults of the coconut black bunch weevil in Sergipe. The experimental design was enterely randomized with four treatments, comprising three concentrations $(10^9, 10^8 \text{ and } 10^7 \text{ comprising three})$ conidia/ml) and the control group, five replications and 20 adults per treatment, totalizing 400 adults. The inoculation technique used was adults immersion into the fungus suspension for approximatelly 5 seconds. After inoculation, the adults were placed into individualized plastic bottles containing small pieces of sugarcane as food source. The mortality was observed daily during 20 days period. Higher infection level was obtained at concentration 10º conidia/ml (87%), out of which 71% between the 5th and 11th days of the experimental time. The concentration 10^8 and 10^7 conidia/ml showed an infection levels of 14% and 4%, respectively. No fungus infection was obtained in the control group. The results showed that the BbBr057/CPATC strain requires a minimum concentration of 10° conidia/ml to cause significative infection levels on adults of H.coriaceus. Index terms: coconut, biological control, palm

[2058] EFFICIENCY OF THE ENTOMOPATHOGENOUS FUNGUS BEAUVERIA BASSIANA (BbB+057/CPATC) STRAIN ON THE AMERICAN PALM WEEVIL RHYNCHOPHORUS PALMARUM (COLEOPTERA:CURCULIONIDAE)

J.M.S. Ferreira¹, <u>R.P.C. Arauio²</u> & F.B. Sarro³, ¹Lab. of Entomology, Embrapa/CPATC, P.O. Box 44, Aracaju, CEP 49025-040, Brazil;² Dept. of Biotecnology, Unesp, Araraquara, P.O. Box 355, CEP 14801-970, Brazil; ³ Dept. of Plant Protection, Unesp, Botucatu, P.O. Box 237, CEP 18603-970, Brasil, E-mail fbsarro@unesp.br.

Adults of Rhynchophorus palmarum (Coleoptera : Curculionidae) are vectors of the nematode Bursaphelenchus cocophilus, causal agent of "red ring", a lethal disease of coconut and other palms. The larvae form can cause death of plants by feeding on the bud tissues. The deuteromycete fungus Beauveria bassiana has been largelly used in Brazil as a bioinseticide for control of many pests. The present work was carried out in the Laboratory of Entomology of Embrapa Coastal Tableland Research Center (CPATC) at Aracaju, Sergipe, Brazil, aiming to determine the efficiency of the BbBr057/CPATC strain of B. bassiana found infecting adults of Homalinotus coriaceus (Coleoptera : Curculionidae) in field. The experimental design was completely randomized with four treatments, comprising three concentrations (109, 108, 107 conidia/ml) and the control group, five replications with 20 adults per treatment, totalizing 400 adults. The inoculation technique used was adults immersion into the fungus suspension for approximatelly 5 seconds. After inoculation, the adults were placed into individualized plastic bottles containing small pieces of sugar cane as food source. The mortality was observed daily for 20 days. Higher infection level was obtained at concentration 10° conidia/ml (91,54%). The concentration 10° and 107 conidia/ml shows a infection level of 58,22% and 38,20%, respectively. The infection in the control group was 3,77%. The results shows that the BbBr057/CPATC strains requires a concentration of 10⁹ conidia/ml to cause a significative infection level on adults of R. palmarum.

Index terms: coconut, biological control, fungus, palm

[2059] OCCURRENCE OF CULICIDAE (DIPTERA) LARVAE IN WATER HELD IN AQUASCYPHA HYDROPHORA (FUNGUS:STEREACEAE) IN CENTRAL AMAZON, BRAZIL

R. L. M. Ferreira¹, A. F. Oliveira¹, E. S. Pereira^{1,2} & N. Hamada¹, ¹Dept. of Entomology - Instituto Nacional de Pesquisas da Amazônia – INPA, Caixa Postal 478 CEP 69.011-970 Manaus- AM. Brazil. E-mail: ruth@inpa.gov.br, ²PIBIC/CNPq/INPA

Although Culicidae (mosquitoes) is an insect family with many species of medical and veterinary importance in Central Amazonia, community structure and habitats of these insects are poorly studied. The immature stages can use a wide variety of habitats. Characterization of different habitats of mosquito larvae and knowledge of community structure are basic requirements for integrated control methods. The present study was done on the August-November 1999 period in the Adolpho Ducke Reserve (INPA), located 26 Km east of Manaus (02°55'S;59°59'W), Amazonas, Brazil. A survey was conducted of the entomofauna that uses as its breeding place the rain water that accumulates in the Aquascypha hydrophora (Stereaceae) fungus. Aquascypha hydrophora grow on dead tree trunks, either fallen or standing. The fungus forms structures similar to cups or receptacles (mean diameter of 9.2 cm and height of 16.3 cm) that hold water, providing habitat for a rich aquatic entomofauna. During the study period the entomofauna was composed of 95% Culicidae (Diptera), 3% Dytiscidae (Coleoptera), 1% Chironomidae (Diptera) and 1% Chaoboridae (Diptera). The fungus grows under shade in humid environments beside streams in upland forest. Two areas were sampled where 77 A. hydrophora receptacles were examined; 64 of these had water and 54 were used by insects. The mean number of insects per receptacle was 7.8 (total number of insects = 345; maximum per receptacle = 44). The distance from the fungus receptacle to the ground varied from 4.5 cm to 210 cm; the mean water volume per receptacle was 35 ml; mean water temperature was 27°C and mean pH was 4.4. The Culicidae fauna was composed of Limatus durhami, Limatus pseudomethysticus, Limatus flavisetosus, Culex (Carrollia) urichii, Culex (Melanoconion) sp., Toxorhynchites haemorrhoidalis and Anopheles eiseni. Knowledge of the habitat of mosquitoes, especially those in forested areas, is very important as a contribution to understanding the distribution and outbreaks of vectorborne diseases.

Index terms: aquatic insects, mosquitoes, community structure, phytotelmata.

[2060] NOCTUIDAE PARASITOID COMPLEX IN GREENHOUSE VEGETABLE CROPS IN OESTE REGION (PORTUGAL)

E. Figueiredo¹ & A. Mexia², ¹DPPF/SAPI, Inst. Sup. Agronomia, Tapada da Ajuda, 1349-017 Lisboa, Portugal, ²INIA/EAN, Quinta do Marquês, 2784-505 Oeiras, Portugal; E-mail elisalacerda@isa.utl.pt.

Noctuid larvae are key pests of several outdoor and protected crops. To develop IPM schemes it is necessary to know the natural enemies present in each particular agroecosystem and to quantify the activity of these biological control agents. The identification of the species of the noctuid parasitoid complex and natural control evaluation started on 1992 with studies on *Helicoverpa armigera*. In 1995, this studies were enlarged for the other noctuid species found attacking greenhouse crops (Chrysodeixis chalcites, Autographa gamma, Thysanoplusia orichalcea, Peridroma saucia, Mamestra brassicae, Tricoplusia ni, Lacanobia oleracea, Agrotis segetum, Discestra trifolii, Phlogophora meticulosa and Spodoptera exigua) by fortnigh periodic surveys in the most important vegetable protected crops (tomato, lettuce, sweet pepper, green beans and cucumber) and laboratory rearing until adult emergence of entomological material collected. Fourteen parasition species, mainly hymenopteran, were found: eight braconids (Aleiodes sp. (two different sp.), Cotesia sp. (gregarious), Cotesia kasak, Cotesia plutellae, Macrocentrus sp. near collaris, Meteorus pulchricornis, Microplitis mediator), two ichneumonids (Ctenochares bicolorus, Hyposoter didymator), one eulophid (Euplectrus flavipes), one trichogrammatid (Trichogramma sp.) and a scelionid (Telenomus laeviceps) and a tachinid species not yet identified. Although the parasitoid complex composition varied, in species and importance for natural control, with the adopted protection strategy, noctuid species, crops, season and also along the years, the most important parasitoids revealed to be the hymenopteran larval parasitoids H. didymator and the complex C. kasak/C. plutellae and, in some years, the egg parasitoids Trichogramma sp. and T. laeviceps. Often, the first two were responsible for about 80-90% of the total parasitism. The other species have marginal importance on natural control of these key pests. The biodiversity was higher in IPM and organic farming greenhouses. Parasitism rate was also higher in organic farming, and specially, in IPM greenhouses, varying from 0% to about 30% concerning all noctuid larvae captured along time in a crop and reaching 100% in some punctual occasions.

Index terms: Hyposoter didymator, Cotesia kasak, Cotesia plutellae, Telenomus laeviceps, Trichogramma sp

[2061] ANTIMICROBIAL PEPTIDES FROM THE CATTLE TICK BOOPHILUS MICROPLUS

A. C. Fogaca¹, M.T.M. Miranda², A. Miranda³ & S. Daffre¹, ¹Dep. Parasitologia, I.C.B., Univ. São Paulo, P.O.Box 66208, CEP 05389-970, São Paulo, SP, Brazil, ²Dep. Bioquímica, Univ. São Paulo, Av. Lineu Prestes, 748, São Paulo, SP, Brazil; ³Dep. Biofísica, UNIFESP, Rua 3 de Maio, 100, São Paulo, SP, Brazil. E-mail: sidaffre@icb.usp.br. Finantial support: FAPESP and CNPq.

Arthropods have an efficient immune system to defend themselves against infections. Proteins and peptides with antimicrobial activity constitute an important part of this system. We detected a constitutive activity against Gram-positive and fungi in the hemolymph (plasma and hemocytes) and gut contents from the cattle tick Boophilus microplus. A fragment (33-61) of the bovine DDhemoglobin with antibacterial activity was purified from the gut contents by RP-HPLC. This peptide was synthesized manually by t-Boc strategy on an MBHA-resin being active in micromolar concentrations against bacteria and fungi. The activity of the synthetic peptide was analyzed also against eucaryotic cells: bovine erythrocytes and a protozoan, Leishmania amazonensis. The peptide has a weak activity against those cells. Since we were not able to detect antibacterial activity in the bovine erythrocytes, as result of endogenous process, we supposed that the hemoglobin is being processed in the tick gut, generating the active fragment. A partially purified fraction of the gut contents with proteolytic activity against hemoglobin was obtained by a size-exclusion FPLC. The product generated after the incubation of the hemoglobin with this fraction showed antibacterial activity. We are investigating if this product corresponds to the 33-61 bovine []-hemoglobin. In addition, we are purifying the antimicrobial peptides in the tick hemolymph by RP-HPLC. We detected two fractions with activity against M luteus. One of them was purified to homogeneity and the peptide molecular mass was 10.198,7 Da, determined by MALDI-TOF-MS. Its partial N-terminal amino acid sequencing (85 residues), obtained by automated Edman degradation, did not show high similarity with any data bank sequences. The full characterization of this peptide is underway.

Index terms: antimicrobial, peptides, ticks, hemoglobin and immunity.

[2062] CONTROL OF PINE SHOOTS MOOTH IN MONTERREY PINE WITH ENTOMOPATHOGENIC FUNGI

<u>R. A. France</u>, M. E. Gerding & D. A. Quintana, Inst. Inv. Agropecuarias (INIA), CRI Quilamapu, P.O. Box 426, Chillán, Chile.

The pine shoot moth (Rhyacionia buoliana) is the most important pest in the Monterrey pine plantations (Pinus radiata) in Chile. The larva feed and makes galleries in terminal buds, producing severe deformations in the main shoot. The affected shoots loose their apical dominance and render uncommercial timber. If the pest is left without control 58% of the trees can be affected with a 20% of timber reduction. The pest is currently managed with biological and chemical control, the former by the use of the larval parasitoid Orgilus obscurator, which have been an effective biocontrol. However, in young plantations, sandy soils and coastal areas this parasite is unable to keep the pest under the economic threshold, being necessary the use of chemical pesticides. We are developing an alternative to chemicals by the use of entomopathogenic fungi as a biopesticides. In 1998, 96 isolates of Beauveria spp., selected from an indigenous entomopathogenic fungi collection and cryopreserved in the Biological Control laboratory at INIA Quilamapu, were screened by topical inoculation of a sporulating culture on five third-instar larvas of R. buoliana. Four isolates, identified as Beauveria bassiana, reached 100% mortality after four days and were selected for consecutive tests. The next experiment was immersion of ten larvae (five replications) in different doses of conidial suspension (10² to 10⁸ spores/ml) for one second. LT50 and LC50 were calculated from mortality data evaluated daily. Isolation B453 reached the best pathogenicity with a LC50 of 10⁴¹ spores/ml after 9 days and a LT50 of 8 days at the LC50 concentration. Isolates B305 and B453 were massive produced in sterile parboiled rice and the resulting spores formulated with vegetable oil as a protector. A plantation of 20 ha of three years old Monterrey pine, affected by the first instar larvae of R, buoliana, was sprayed during summer 1999 by airplane, with a dose 1012 spores/ha. Persistence of the inoculum on the treated foliage was measured through feeding of fresh larvae of R. buoliana and Galleria mellonella. Also, the effectiveness of B, bassiana biopesticide was evaluated by counting the number of dead larvae vs. the damaged buds on the treated area. Preliminaries results showed the potential of B. bassiana as biopesticide and the possibility to replace the chemical applications. However, the use of formulated spores and, synchronisation between spraying time and the most susceptible stage of the pest are required before to succeed the traditional insecticides by a biopesticide.

Index terms: Rhyacionia buoliana, Pinus radiata, entomopathogenic fungi, Beauveria bassiana.

(2063] EFFECTS IN VITRO AND IN VIVO OF SOYBEAN KUNITZ TRYPSIN INHIBITORS AGAINST THE BOOL WEEVIL ANTHONOMUS GRANDIS

O. L. Franco^{1,2}, S. C. Dias^{1,2}, F. R. Melo^{1,2}, O. B. Oliveira-Neto^{1,2}, C. Bloch Jr.^{1,3}, R. G. Monnerat¹ & <u>M. F. Grossi De Sá^{1*}</u>, ¹ Embrapa Recursos Genéticos e Biotecnologia, SAIN Parque Rural, Caixa Postal 02372. Brasília, D.F Brasil, E-mail fatimasa@cenargen.embrapa.br ²Depto. de Biologia Celular, UnB, Brasília, Brazil³ Instituto de Química, UnB, Brasília, Brazil

The boll weevil, Anthonomus grandis is a major pest of cotton in tropical and subtropical areas of the Americas. The control of this pest is unknown and plant proteinase inhibitors show great potential as tools to engineer resistance of crop plants against pests. None inhibitors available and characterized have been demonstrated effects towards this insect pest. In order to identify factors involved in the boll weevil resistance, the activity of soybean Kunitz trypsin inhibitor (SKII) was analyzed in vitro and in vivo assays against larvae and adult insects of A. grandis. The commercial inhibitors purchased from Sigma was fractionated with ammonium sulfate in a range of 0-100% and applied in a reversed phase HPLC originating a major peak which showed inhibitory activity against serine-proteinases from bovine pancreas (BPT) and boll weevil larvae and adult (AGT). When neonate larvae were fed in an artificial diet containing a rich fraction of SKTI at three different concentrations (10 □M, 100 □M and 500 □M), a reduction of larval weight of 30% at 100 □M SKTI and around 65% at 500 IM SKTI was observed. Another interesting fact observed was a high deformities in pupae and adult insects treated with SKTI. At 500 □M of SKTI we observed a ratio of pupae deformities around 50% and in adult insects, this ratio increased to 81% at same concentration. In larval stage, was observed a reduction of weight and length, while in pupae stage, SKTI caused a latter metamorphosis and in adult stage, was observed some deformations as wings and thorax absences. This was the first time that an inhibitor was active in vivo and in vitro against A. grandis. By this fact SKTI can be a possible tool on engineered plants resistant against this insect pest. This work was supported by CAPES, CNPq and FAPDF.

Index terms: cotton, control

[2064] SAFETY OF *GRATIANA BOLIVIANA* AS A BIOCONTROL AGENT OF TROPICAL SODA APPLE (*SOLANUM VIARUM*): IS EGGPLANT A SUITABLE HOST?

D. Gandolfo¹, J. Medal², F. Mc Kay¹, D. Ohashi³ & J. Cuda², ¹South American Biological Control Laboratory, USDA-ARS, Hurlingham, Argentina. ²Departament of Entomology and Nematology, Univ. of Florida, Gainesville, FL., U.S.A. ³Fac. Ciencias Exactas, Químicas y Naturales. Univ. Nac. de Misiones, Argentina.

Solanum viarum Dunal (TSA) is a prickly shrub native to Argentina, Brazil, and Paraguay. Accidentally introduced in Florida during 1980's, it has spread at a dramatic rate currently infesting 1.25 millon acres in southeastern U.S. The leaf feeder Gratiana boliviana Spaeth (Cassidinae) is being evaluated as a biocontrol agent for this weed. In larval survival non choice tests G. boliviana showed a narrow host range, limited to its known natural hosts, S. viarum and S. palinacanthum, and on the cultivated S. melongena (eggplant). However, mortality on eggplant was 10 times higher than on TSA. Here we present the results of laboratory studies and field surveys to asses the risk of G.boliviana using eggplant as an alternative host. Fecundity and longevity were compared by keeping 20 newly emerged couples on TSA and eggplant. Females kept on TSA laid 3521 eggs (185 □ 35.6 eggs/□) compared with those kept on eggplant that laid 96 eggs (5 □ 1.63 eggs/□). All females that fed on TSA laid eggs compared with 45% on eggplant. Longevity was significantly shorter on eggplant (31 3.9 days) than on TSA (74 9.0 days). Ovipositional and feeding preferences were tested in multiple choice tests carried out in 1m3 cages. Two plants of each species with similar sizes, were kept for one week with 8 couples of G. boliviana (12 replications). In total 1275 eggs were laid on TSA (106 □ 54.9 eggs/rep.), and 2 eggs were laid on eggptant. In all replications leaf consumption of TSA ranged 10-50%; on eggplant some slight feeding (less than 5%) was observed in 3 replications. At the end of the test, average number of adults on TSA and eggplant was 13.2 and 0.35 respectively. Eggplant fields inside the area of distribution of G.boliviana have been surveyed since 1997 in Argentina (7 sites), Brazil (3), Paraguay (1) and Uruguay (1). Special attention was placed on organically grown fields or fields where insecticides were used only on seedlings and insect activity was observed. G. boliviana was never found on eggplant, although it was often found on TSA plants growing intermixed with the eggplant plants or at a distance of less than 100 meters. Considering the results of larval survival and adult fecundity no choice tests, the predicted population growth rate of G.boliviana on eggplant is below one, even under conditions of no food limitation and extrinsic factors of mortality excluded. We concluded that eggplant would not be an alternative host for G. boliviana.

Index terms: biological control, host specificity

[2065] SCREENING FOR NEW INSECTICIDAL COMPOUNDS PRODUCED BY ENTOMOPATHOGENIC FUNGI

C.A.T. Gava, M. Erthal Jr. & R.I. Samuels, Department of Plant Protection. Universidade Estadual do Norte Fluminense, Campos dos Goitacazes, RJ. 28015-620, Brazil. E-mail cgava@uenf.br

It is well known that certain entomopathogenic fungi produce toxic compounds, many of which have been found to be insecticidal. Avermeetin is an example of an insecticide of microbial origin with a market value of millions of dollars per annum, indicating that more microorganisms should be screened for production of novel bioactive compounds. In this study, the little known fungus Hirsutella sausserei (Deuteromycota: Hyphomycetes), was investigated. This fungus was isolated from a hymenopteran host and a pure culture obtained in vitro. Following liquid culture in BDA+ yeast extract, the culture filtrates were concentrated by freeze drying and tested for biological activity. Initial tests showed that the extracts were insecticidal, causing death when injected into 5th instar Diatrea sacharalis (Lepidoptera). In order to purify and characterise the compounds present in the extracts, reverse-phase and gel filtration chromatography were used. Sep-Pak C18 cartridges were loaded with 500 µl of x10 CF. The elution profile showed that a toxic compound was eluted in the 30-50% acetonitrile fractions, which caused death approximately three days after treatment. It was noted that a number of treated insects developed deformations due to incomplete development. This Sep-Pak fraction was run on gel-filtration chromatography in order to estimate molecular mass. Fractions corresponding to the toxic activity eluted in the molecular mass range of 15-20 kDa. The peak fractions were further tested for heat stability. It was found that boiling the fractions for 10 minutes drastically reduced toxic activity, suggesting that this compound is a protein. Protein toxins have been rarely found in entemopathogenic fungi, however Ilirsutella thompsonii is known to produce two protein toxins which are also slow acting. These toxins have not been shown to effect insect development, therefore it is possible that the toxins from *H. sausserei* are different to those of *H. thompsonii*.

Index terms: Hirsutella sausserei, toxin, insect, Diatrea sacharalis.

[2066] FIELD TRIALS ON THE EFFICACY AND PERSISTENCE OF IMPROVED FORMULATIONS OF NUCLEAR POLYHEDROSIS VIRUS AGAINST HELICOVERPA ARMIGERA ON CHICKPEA

N. Geetha ¹ "&"R.J. Rabindra², 1.Section of Entomology, Sugarcane Breeding Institt., Coimbatore-641007, 2. Department of Entomology, Tamilnadu Agricultural Univ., Coimbatore-641003

The field performance of six preparations of Helicoverpa armigera Nuclear Polyhedrosis Virus (HaNPV) was evaluated in two chickpea trials in farmers' fields in TamilNadu against a standard chemical insecticide, endosulfan and a microbial insecticide, Bacillus thuringiensis kurstaki (Btk) and an untreated control. NPV treatments comprised a simple suspension of semi purified HaNPV, a microencapsulated formulation, a wettable powder, an oil in water emulsion, an oil based suspension and freeze-dried semipurified HaNPV. and were applied at 1.5 x 10¹²POB (Polyhedral Occlusion Bodies)/ha to 40 m² plots in a 4 x 9 randomized block design. Endosulfan and Btk were applied @350g a.i/ha and 1 Kg /ha (as formulated material)respectively. Six applications of the nine treatments were made at intervals of seven to 10 days. All the treatments were applied with a back pack hydraulic sprayer except the oil formulations which were applied with a controlled droplet applicator(CDA). All treatments were applied with CDA in the second trial . Persistence of the formulations was studied by collecting leaf samples from chickpea field in both the trials at 0, 1, 3, 5 and 7 days after treatments and assaying against II instar H. armigera by leaf feeding method. Mortality due to virus was observed till 10 days.Initial larval population ranged from 10.75 to 13.75 per 10 plants among the treatments. In general, all the virus formulations were as effective as the unformulated virus and better than control as shown by the data on larval populations on V th and VII th day after sprays. Data on pod damage showed the superiority of virus treatments over control and Endosulfan. In the second trial also pretreatment count did not show any significant differences in larval populations among different treatments. All the treatments effectively reduced the larval populations over control and pod damage was lower invirus-treated plots than endosulfan and control. Data on the persistence of the formulations indicated that there was drastic reduction in larval mortality even after one day of exposure of virus to atmosphere. By third day, the mortality due to most of the viral formulations was less than 10 per cent and by seventh day it was negligible. Similar trend was observed in the second trial also. The persistence of endosulfan or Bik were not better than the virus to cause larval mortality.

Key words:Nuclear polyhedrosis virus, formulations, field trial, chickpea, Helicoverpa armigera

[2067] FIELD EVALUATION OF IMPROVED FORMULATIONS OF NUCLEAR POLYHEDROSIS VIRUS AGAINST HELICOVERPA ARMIGERA ON COTTON

N. <u>Geetha¹</u> & R.J. Rabindra², ¹.Section of Entomology, Sugarcane Breeding Instr., Coimbatore-641007; ².Department of Entomology, Tamilnadu Agricultural Univ., Coimbatore-641003.

The field performance of five preparations of Helicoverpa armigera Nuclear Polyhedrosis Virus (HaNPV) was evaluated and compared in cotton trial in farmer's field in Tamil Nadu against a standard chemical insecticide, endosulfan and a microbial insecticide, Bacillus thuringiensis kurstaki (Btk) and an untreated control. NPV treatments comprised a simple suspension of semi purified NPV, a wettable powder, an oil in water emulsion, an oil based suspension and a combination of crude suspension and \Box dose of endosulfan. The treatments were applied at 3.0 x 10¹²POB (Polyhedral Occlusion Bodies)/ha to 40m² plots in a 3 x 8 randomized block design. Endosulfan and Bik were applied @350g a.i/ha and 1 Kg /ha (as formulated material)respectively Six applications of the eight treatments were made at intervals of seven to 10 days. All the treatments were applied using a spray fluid volume of 12.5 I/ha with a controlled droplet applicator.Initial larval population ranged from 7.33 to 8.33 per 10 plants among the treatments. All the treatments had similar population levels after 2 sprays. Later on, the population reduction was higher in oil based formulations as well as the treatment with both virus and D dose of endosulfan. Data on square damage showed the superiority of virus treatments over control, Endosulfan and Btk Boll damage was significantly reduced by all the treatments compared to control, with NPV preparations performing as well or better than endosulfan and Btk standard. Final seed cotton yields per treatment were not consistent among treatments although NPV-formulations gave comparable or better yields when compared to control and Btk.

Key words: Nuclear Polyhedrosis Virus, formulations, Helicoverpa armigera, Bacillus thuringiensis kurstaki, field trail, cotton

[2068] USE OF ENTOMOPATHOGENIC FUNGI FOR THE CONTROL OF Caliroa cerasi

<u>M. E. Gerding</u>, R. A. France, L. O. Devotto & C. M. Alvarez. Inst. Inv. Agropecuarias (INIA), CRI Quilamapu, P.O. Box 426, Chillán, Chile. E-mail: mgerding@quilamapu.inia.cl.

The pear slug, Caliroa cerasi (Hymenoptera: Tenthredinidae), is a primary pest of cherry tree (Prunus avium) in Chile and its control had been exclusively based in chemicals insecticides. The insect never affect the fruits, but is able to cause 80% of leaves damage during the summer, which affect the production and tree longevity. C. cerasi has two or three generations during spring and summer. The adult is a small wasp (4.0-6.0 mm) that lays single eggs under the leaf cuticle, from where small larvae cover with dark green mucus emerge and feed until they reach 11.0 mm length. The insect pupa is found under ground, even at 70.0 num depth. The total insect cycle takes between 43 to 60 days. We have been working in a new option for pear slug control, through the use of entomopathogenic fungi. They have showed to be effective against larvae and pupae, when these fungi were applied to the foliage or soil, respectively. To select the best fungi isolates, a preliminary screening was accomplished with an indigenous entomopathogenic fungi collection (over 500 isolates), which is kept under cryopreservation by the Biological Control laboratory at INIA Quilamapu. Lab and field experiments were performed, in order to determine the larvae and pupae mortality caused by Beauveria and Metarhizium isolates. Metarhizium anisopliae (strain M221) and Beauveria bassiana (strain B323) were the most pathogenic isolates against pear slug in the lab, reaching a 100% of mortality after 7 days of inoculation. Both fungi were also evaluated in the field, where they were able to kill larvae on the foliage and pupae in the ground. The best control on the foliage was obtained with M221 (90%), better than B323 (52%) and the check. M221 was also more effective (63%) in the ground, when the inoculum was incorporated into the soil or was cover with straw mulch. Key words: Beauveria, Metarhizium, Pear slug

[2070] THE VELVETBEAN CATERPILLAR CONTROL WITH BACULOVIRUS ANTICARSIA APPLIED ON SOYBEAN CROP THROUGH A CENTER PIVOT SPRINKLE WATER IRRIGATION

S. A. Gomez¹ & D. L. Gazzoni², ¹Embrapa- Centro de Pesquisa Agropecuária do Oeste (CPAO), Caixa Postal 661, CEP 79804-970, Dourados, MS. Email:sergio@epao.embrapa.br; ²Embrapa-Centro Nacional de Pesquisa de Soja (CNPS₀), Caixa Postal 231, CEP 86001-970, Londrina, PR. E-mail: gazzoni@enpso.embrapa.br.

In the 1986/87 soybean crop season, an experiment and a validation field of experimental results were carried out at the Agricola Itamarati S/A, Ponta Porã, MS, Brazil. Both actions dealt with the velvetbean caterpillar control with its nuclear polyhedrosis virus (NPV), Baculovirus anticarsia. In the experiment 50, 75 and 100 equivalent larvae -EL- (11.E=1,3x109 polyhedral inclusion bodies) of B. anticarsia were applied, through a center pivot sprinkle water irrigation (equipment deviced to irrigate 118ha) working at full speed. The NPV suspensions, obtained from macerated dead larvae, were injected into the irrigation water with the aid of a chemical products injector (dose calibrater). The experiment was designed as a randomized block, with three replications and each plot consisted of a circle section of ca 3 ha. The evaluations of the larvae population were done by the cloth sampling method, with 10 samplings for each plot. At the date of the virus application there were the average of 14 small (≤1,5cm) and of 8 large larvae (>1,5cm) per sampling. The Santa Rosa soybean variety was at the full bloom stage with about 5% of the whole leaf area damaged by the insect. At the seventh day after the application, the doses of 50, 70 and 100LE provided control of, respectively, 96, 94 and 86%, practically without damage increment on the leaves, while the control plot (without application) suffered 15% of defoliation. The experimental result relative to the 50 EL was validated in another central pivot, in the same farm, but the virus being applied in the whole 118ha embraced by the irrigation equipment. The IAS-5 soybean variety, in the moment of the application, was also in the full bloom stage, presenting an average of 25 small and 8 large larvae and 9% of loss of leaf area. The evaluation, carried out 8 days after the application, showed that the larvae population was practically killed off, and the leaf loss reached 18% only.

Index terms: Anticarsia gemmatalis, Lepidoptera, Noctuidae.

[2069] IMPROVEMENT OF INSECTICIDAL NEMATODES- A GENETIC APPROACH

<u>I. Glazer¹ & D. Segal²</u>, ¹Department of Nematology, Volcani Center, Bet Dagan 50250; ²Department of Molecular Microbiology & Biotechnology, Tel-Aviv University 69978.

Entomopathogenic nematodes (EPN), in association with symbiotic bacteria, live in the soil where they locate suitable insect hosts, penetrate into their haemocel and release the bacterial symbionts. The bacteria multiply and kill the insect within two days. The wide host range, lack of pathogenicity to humans and livestock, and the availability of procedures for mass culture, make EPN attractive environmentally friendly bio-insecticides. However, their sensitivity to the extremes of the environment prevents them from reaching their full biocontrol potential. Selection, screening for new natural isolates, and mutagenesis have been attempted in an effort to enhance EPN tolerance to environmental harshes. Manipulation of genes involved in heat and desiccation tolerance offers a powerful attractive alternative. Recently, the technology for generating transgenic nematodes has been successfully adapted from C. elegans to EPN, opening the way for generating transgenic EPN with enhanced tolerance to environmental extremes. Indeed, transgenic EPN carrying a heat shock gene from C. elegans were shown to have increased heat tolerance. Yet, in view of the growing concern regarding the use of genetically modified organisms, we reasoned that field release of transgenic EPN will meet less opposition if the engineered genes were their own rather than from a foreign species. As a first step towards this goal we have isolated and characterized two heat shock genes from the EPN *H. bacteriophora*, and a glycogen synthase gene, involved in the biosynthesis of trehalose, which confers desiccation tolerance, from the EPN S. feltiae. Our progress along these lines will be described.

[2071] A COMPARISON OF CARABID SPECIES IN FOUR VEGETATION TYPES

G. C. Hamilton¹, J. H. Lashomb¹ & J. Ingerson-Mahar¹, ¹Dept. of Entomology, Rutgers – The State Univ. of New Jersey, 93 Lipman Drive, New Brunswick, NJ, 08901, USA, E-mail hamilton@aesop.rutgers.edu.

Differences in the numbers and types of carabid species found in soybeans, corn, azaleas, and azaleas planted with flowers (shasta daisy and coriander) were investigated over a two-year period using pitfall traps. All pitfall traps were sampled on a weekly basis during the growing season. All carabid individuals recovered were identified and used to determine weekly abundance. The data were also used to determine species richness. Weekly means were subjected to analysis of variance and mean separation tests to determine differences between habitats. A cluster analysis using the species richness values calculated for each habit was also conducted. Index Terms: Carabidae, species richness, diversity

[2072] THE USE OF PROTEASES TO ENHANCE THE INSECTICIDAL POTENTIAL OF BACULOVIRUSES

R. L. Harrison¹ & <u>B. C. Bonning</u>¹, ¹Dept. Entomology, Iowa State Univ., 418 Science II, Ames, IA 50011, USA, E-mail bbonning@iastate.edu

The basement membrane is a physical barrier to systemic infection of lepidopteran larvae by baculoviruses. One approach to improve the insecticidal activity of baculoviruses is to perforate or eliminate the basement membranes of their hosts. Towards this end, we constructed six recombinant clones of Autographa californica nucleopolyhedrovirus (AcMNPV) that expressed three proteases (Sarcophaga peregrina cathepsin L, "ScathL"; rat stromelysin-1, "STR1"; and human 72 kDa type IV collagenase, "GEL") that digest basement membrane proteins. The recombinant viruses expressed these proteases from either the carly *ie-1* promoter (AcIEITV3.ScathL, AcIEITV3.STR1, and AcIEITV3.GEL) or the late *p6.9* promoter (AcMLF9.ScathL, AcMLF9.STR1, and AcIMLF9.GEL). Recombinant protease activities were detected in the culture medium of cells infected with recombinant viruses by either gelatin/casein zymography or azocoll assay. AcMLF9.STR1 and AcMLF9.ScathL caused premature cuticular melanization of 5th instar Heliothis virescens. Melanization of internal tissues was observed in larvae infected with AcMLF9.ScathL but not in larvae infected with AcMLF9.STR1. Lethal concentration bioassays revealed no significant differences in virulence between the protease-expressing recombinants and wild type AcMNPV. Survival time bioassays revealed that AcMLF9.ScathL killed H. virescens significantly faster than wild type AcMNPV, and also significantly faster than a virus expressing an insect-selective scorpion neurotoxin from the p6.9 promoter. Larvae infected with AcMLF9.ScathL caused significantly less feeding damage on lettuce compared to that caused by larvae infected with wild type AcMNPV.

Index terms: *Heliothis virescens, Autographa californica,* nucleopolyhedrovirus, basement membrane, recombinant baculovirus insecticide.

[2073] FACTOR ANALYSIS OF SYNERGISTIC EFFECTS BETWEEN ENTOMOPATHOGENIC FUNGUS, *METARIHIZIUM ANISOPLIAE* AND SYNTHETIC INSECTICIDES TO SCRAB GRUBS

II. Hiromori, M. Hatsukade, Department of Applied Entomology, Faculty of Agriculture, Shizuoka University, Ohya, Shizuoka 422-8529, Japan, E-mail ahhirom@ipc.shizuoka.ac.jp.

Entomopathogenic fungus, *Metarhizium anisopliae* has been studied as useful biological control agent to many insect pest including the soil inhabiting pests. However, entomopathogenic fungi are easily affected by environmental factors such as tempareture, moisture and sunlight. These environmental factors made the control effects unstability in the field. To improve the unstability of fungal effects, the combined application with synthetic insecticides were developed.

Combined application of *M. anisopliae* and synthetic insecticides showed synergistic effects and resulted high mortality compared with single application of each agent. However, the mechanism of synergistic effects had been indistinct. In this study, we researched the mechanism of synergistic effects over the immunity system of scarab grubs, M. anisopliae treated with insecticides resulted decrease in hemocytes in the hemolymph of Anomala cuprea (Coleoptera: Scarabacidae) larvae. Furthermore, phenoloxidase activity in the hemolymph inhibited from both application of M. anisopliae and insecticides. These results indicated the synergistic effects were caused inhibitation of cellular and humoral defense system of A. cuprea. The observation under scanning electron microscopy, the number of conidia that adhered to cuticle of A. cuprea were increased both application of M. anisopliae and insecticides. The food consumption of A. cuprea treated with both control agents were reduced. These results indicated that the synergistic effects were obtained by restraining the action of A. cuprea and conidia of M. anisopliae were difficult to remove from the cuticle. Then, more large number of conidia were possible to penetrate into hemocoel of A. cuprea. The synergistic effects between M. anisopliae and synthetic insecticides caused inhibitance to immunity system and action of A. cuprea.

Index terms: synergism, immunity system, hemocyte, adhesion, Anomala cuprea

[2074] PHENOTYPIC VARIATION BETWEEN GENOTYPIC VARIANTS OF A NUCLEOPOLYHEDROVIRUS INFECTING PINE BEAUTY MOTH, PANOLIS FLAMMEA

D.J. Hodgson¹, **R.S. Hails² & J.S. Cory³, ^{1,2,3}Inst.** Of Virology and Environmental Microbiology, Mansfield Rd., Oxford, OX1 3SR, United Kingdom.Email: dihod@ceh.ac.uk.

Natural populations of the pine beauty moth, *Panolis flammea*, nucleopolyhedrovirus (*Pf*NPV) have been shown to contain high levels of genotypic variability, with individual host larvae containing at least 24 distinct viral genotypes. Four of these genotypic variants have been compared in bioassay experiments to ascertain whether this variation in genotype translates into differences in key phenotypic traits. Variants differed in their infectivity, speed of kill and yield upon death of the host, all factors which have the potential to profoundly influence host-virus interaction in the field. Such phenotypic variation ought to promote selection for the 'fittest' viral genotype: this begs the question why so much variation is observed in the field in this and other baculovirus systems. Coexistence of virus genotypes may be promoted by tradeoffs between phenotypic traits. Bioassay results were used to examine such tradeoffs, using mean phenotypic traits for each variant. There was a negative relationship between speed of kill and virus yield, but no correlation between these variables and infectivity. We discuss further ecological features of the *P*. *flammea* - virus interaction which may promote genotypic variation in the pathogen population. Index terms: baculovirus, bioassay, virus fitness, tradeoffs

[2075] DIFFERENTIAL TRANSMISSION OF ZUCCHINI YELLOW MOSAIC VIRUS AND TURNIP MOSAIC MOSAIC VIRUS BY MYZUS PERISCAE AND BREVICORYNE BRASSICAE

II. Huet, E. Lendler, A. Dubrovsky and B. Raccah¹, ¹Dept. of Virology, The Volcani center, Bet Dagan 50-250, Israel. braccah@volcani.agri.gov.il

Potyviruses include the largest number of plant viruses. This group include some of the most economically important viruses in annuals and perennials. Aphids transmit potyviruses in a typical non-persistent manner. Most non-persistent viruses are considered to be of low specificity for aphid vectors. However, in a recent study, we have found that *Brevicoryne brassicae* fail to transmit zucchini yellow mosaic virus (ZYMV) a virus that is readily transmissible by *Myzus persicae*. On the other hand, turnip mosaic virus (TuMV) was transmitted both by *B. brassicae* and *M. persicae*. This same strain is transmit readily by *B. brassicae*. The present knowledge suggest that the helper component (HC) serves as a bridge between the aphid's stylets and virions. Therefore, the HC of ZYMV and TuMV were purified and used for acquisition with for virions from membranes. In order to understand the specificity for aphid species, homologous and heterologous combinations of HC and viruses were examined in transmission experiments. The significance of these transmissions finding in elucidating vector specificity will be discussed.

Index terms: Brevicoryme brassicae, Myzus persicae, ZYMV, TuMV, Helper component, specificity, vector.

[2076] MOLECULAR CHARACTERIZATION OF BOMBYX MORI CYTOPLASMIC POLYHEDROSIS VIRUS SEGMENT 4

K. Ikeda & H. Mori, Department of Applied Biology, Kyoto Institute of Technology, Kyoto 606-8585, Japan, E-mail a6660001@ipc.kit.ac.jp

The cytoplasmic polyhedrosis virus (CPV) group, one of the genus *Cypovirus* classified within the *Reoviridae* family is characterized by the production of large proteinaceous crystals, polyhedra, in the cytoplasm of infected cells. Other genera *Orthoreovirus, Rotavirus, Orbivirus, Phytoreovirus, Fijivirus, Oryzavirus, Coltivirus,* and *Aquareovirus belong* to the *Reoviridae* family. Polyhedra are consisted of a single protein, C-polyhedrin, within which many mature virions are embedded. The viral genomes are composed of ten-segmented double-stranded RNAs. Outer capsid proteins of *Bombyx mori* CPV particle are VP1 and VP3 which are encoded by segment 1 and segment 4, respectively. cDNA cloning of segment 4 was carried out and the complete nucleotide sequence was determined. BmCPV genome segment 4 comprised 3,259 nt and possessed an open reading frame that encoded a predicted protein of 1,058 residues. Data base analysis showed that BmCPV VP3 was highly homologous to rice ragged stunt virus (RRSV: a member of *Oryzavirus*) P2 protein. Furthermore, phylogenetic trees derived from multiple sequence alignments of the homologous proteins from RRSV, *Nilaparvata lugens* reovirus (a putative member of *Fijivirus*), Fiji disease fijivirus. Recombinant BmCPV VP3 is expressed in insect cells by use of a baculovirus vector and the characterization will be discussed.

Index terms: cytoplasmic polyhedrosis virus, Bombyx mori, silkworm, Reoviridae.

Symposium and Poster Session

[2078] NEW ISOLATE OF *ERIOGASTER LANESTRIS* NUCLEOPOLYHEDROVIRUS IN LATVIA.

L. Jankevica¹, M. Kropa¹ & E. Jankevics², ¹Dept. of Experimental Entomology, Inst. of Biology, Univ. of Latvia, Miera street 3, Salaspils, LV-2169, Latvia, E-mail: liga_jankevica@hotmail.com; ²LU Biomedical Research and Study Centre, Ratsupites Street 1, Riga, LV – 1067

Baculoviruses rather rarely cause epizootic in pest populations under Latvian climatic conditions therefore nucleopolyhedroviruses (NPVs) have been isolated from 11 insect species. They are considered to be a safe biological insecticide and have a great potential in pest control. The present aim was to search for new isolates of NPV in the leaf-bearing forest pest populations and to determine its biological and morphological characteristics. In recent years population density of *Eriogaster lanestris* was low. In 1997 the infected larvae of *E. lanestris* with nuclear polyhedrosis symptoms were observed. Nucleopolyhedrovirus from *E. lanestris* was isolated first time in Latvia. The dimension of polyhedra was 800 to 1600 nm. Polyhedra contained large number of rod-shaped virions. Cytological preparations made by fixing the larvae of *E. lanestris* with characteristic symptoms of illness were investigated. Polyhedra of new isolate were observed in nuclei of midgut epithelial and fat cells, hypodermys, trachea and muscular sheet. Biological activity of new El NPV isolate was characterised by a bioassay using infection with disc method. Host range of new isolate was tested. Virus cause $25.4\% \pm 4.1\%$ mortality of *Malcosoma neustria* 3rd instar larvac. The next step of investigations is a comparison of viral DNA isolated from new NPV isolate. No amplification were detected in tests with El NPV using primers designed to detect DNA of different *M. neustria* NPV isolates.

Index terms: Nucleopolyhedrovirus, Eriogaster lanestris, polyhedra formation.

[2077] A PAECILOMYCES FUMOSOROSEUS MUTANT OVERPRODUCING CHITINASE DISPLAYS HIGH VIRULENCE AGAINS'T BEMISIA TABACI.

M. Iracheta, C. Hernández, L. Galán-Wong, I. Hernández-Torres, C. Rodríguez-Padilla, C. Hernández-Luna, R. Tamez-Guerra & <u>B. Perevra-Alférez</u>, Depto. de Microbiología e Inmunología. Fac. Ciencias Biológics/UANL. México. Av. Dr. Pedro de Alba y Av. Manuel Barragán. Cd. Universitaria. San Nicolás de los Garza, N. L. CP. 66450.

In recent years, biopesticides formulated with Paecilomyces fumosoroseus have demonstrated high efficiency for the Bemissia tabaci (whitefly) control. The mode of action of this fungi depend, in part, of its capacity to break and penetrate the insect cuticle by mechanical force and enzymatic degradation. The cuticle is formed by chitin microfibrils where they might constitute around 30% of the cuticle. Concern with enzymatic cuticle-hydrolysis, chitinases may play an important role in degrading the chitin barrier and increase the fungal virulence. In this study, we report the isolation of P. fumosoroseus mutants overproducing chitinases. A P. fumosoroseus strain (Pfr612. USDA-ARS) spore suspension was mutagenized with UV and plated on colloidal chitin agar (CCA) at 1.0% w/v. Those colonies showing biggest hydrolysis-halo in comparison with parental one were chosen. Four colonies were selected. In order to supervise the stability, the strains were subcultured on YPD broth (yeast extract 0.3%; peptone 1.0%; glucose 2.0% w/v) and CCA. After that, we selected a strain displaying better stability and it named as M84. Mutant and parental strains were inoculated on YPD and YPD plus colloidal chitin (YPCC) and incubated at 26°C for 168h. Fermentation parameters such as glucose consumption and biomass and N-acetylglucosamine (NAG) production were measured. Chitinases induction was evaluated in minimal medium supplemented with colloidal chitin (MMC). Bioassays were conducted by triplicate using third instar withefly nymph. The fermentation parameters on YPD showed that mutant strain yielded similar biomass production and glucose consumption than parental one. Moreover, when both strains were grown on YPCC, the NAG production start after glucose consumption, demonstrating that chitin synthesis is repressed by glucose in both strains. However these ones were fermented in MMC, the mutant strain produced almost three times more NAG than parental one. The chitinases were purified from supernatants and subject to chitinase activity on polyacrylamide plus glycol-chifn at 0.01% (*w*/y) under denaturing and native conditions. The chifn activity was revealed with white calcofluor. This assays showed the presence of single activity band of ca. 26 kDa. In laboratory bioassays M84 strain was 1.84-fold more virulent than parental one against B. tabaci nymph. Paecilomyces fumosoroseus, Bemissia tabaci, Chitinase

[2079] DNA SEQUENCE DATA USED TO VALIDATE SPECIES TAXONOMY AND ORIGIN OF UK SUBTERRANEAN TERMITE (ISOPTERA: RHINOTERMITIDAE) INFESTATION

T.M. Jenkins¹, R.II.J. Verkerk² & B.T. Forschler³, ¹Dept. Entomology, Univ. Georgia, Research Station, Griffin, GA 30223-1797, USA, E-mail: tienkin@gacs.griffin.peachnet.edu; ²Dept. of Biology, Imperial College of Science, Technology & Medicine, Silwood Park, Ascot, Berkshire SL5 7PY, UK. ³Dept. of Entomology, Univ. of Georgia, Athens, GA 30602, USA.

The first case of an established infestation of subterranean termites in the United Kingdom (UK) was identified during 1998 in Devon, England. The termites, Reticulitermes lucifugus grassei, were probably introduced to this site more than 30 years ago. We hypothesized that the source of the infestation as well as validation of species taxonomy could be accomplished through phylogeny analyses of DNA sequence data. We decided to sequence three different regions of DNA: two haploid mitochondrial DNA (mtDNA) genes and a diploid nuclear DNA (nuDNA) intergenic sequence region (ITS2). We sequenced from individual termites 1495-bp of the mtDNA, which included part of the cytochrome oxidase I (COI) gene, the complete cytochrome oxidase II (COII) gene, and the entire 350-bp ribosomal intergenic sequence (ITS2) region. Sixteen blind samples were included in the study, which represented termites collected from the UK, France and the USA. The French and USA populations were used for comparisons. All termite population samples were initially identified to species using morphological keys. Eight of the UK samples were collected at the infestation site and were characterized as R. lucifugus. Cladistic and phenetic phylogeny analyses of the individual gene sequences from all populations demonstrated that R. santonensis from France formed a monophyletic clade with R. flavipes from the United States. Reticulitermes lucifugus populations from France and the UK formed a monophyletic clade. Furthermore, there was little sequence differentiation among R. lucifugus populations. Reticulitermes virginicus and R. hageni from the USA were distinctly different from the other three species. These data suggest two scenarios. First, the UK R. lucifugus infestation is probably European in origin because this species is widely distributed throughout southern Europe. Second, R. santonensis and R. flavipes may represent one species. The type specimen for R flavipes was recovered from a greenhouse in Vienna, Austria over one hundred years ago. We suggest that R. flavipes could have been introduced into Europe early in the 19th century with the maritime trade that was conducted at that time between southern France and the United States and eventually misidentified as R. santonensis.

Index Terms: Isoptera, mtDNA, nuDNA, DNA sequence

[2080] THE POTENTIAL IMPACT OF GROBAL WARMING ON DECIDUOUS OAK DIEBACK CAUSED BY AMBROSIA FUNGUS CARRIED BY AMBROSIA BEETLE IN JAPAN

N. Kamata¹, K. Esaki², & K. Kato¹, ¹Lab. of Ecology, Fac. of Sciences, Kanazawa Univ., Kakuma, Kanazawa, Ishikawa 920-1192, Japan, E-mail: kamatan@kenroku.kanazawa-u.ac.jp; ²Ishikawa Forestry Research Institute, Sannomiya, Tsurugi, Ishikawa 920-2114, Japan

Since the late 1980s, deciduous oak dieback has been prevalent in Japan. This phenomenon has been recorded since the 1930s, but up to 1980, the epidemics continued for only a few years. More recently, however, the epidemics have continued for more than 10 years, and the area of dieback has been spreading new places where no dieback had been recorded in the past. An unidentified ambrosia fungus belonging to the genus Raffaelea is involved in this dieback. A symbiotic ambrosia beetle, Platypus quercivorus (Col., Platypodidae), is a vector of this fungus. This is the first example that ambrosia fungus carried by ambrosia beetle kills vigorous trees. Ambrosia beetles usually attack weakened or dead trees with a few exceptions like Platypus cylindrus in S Europe, Trachyostus ghanaensis in Africa, and Dendroplatypus impar in SE Asia, which attack vigorous trees but do not kill the host. According to many outbreak records of *P. quercivorus* in the evergreen oak stands in Japan, few evergreen oak trees were killed by this insect outbreak although many pinholes were found on the trunk surface (occasionally > 1/sq. cm). It was speculated that the pathogenic fungus, Raffaelea sp., was exotic and had been accidentally introduced to Japan, and that P. quercivorus was free from this fungus in places where no tree mortality occurred. However, when the oak dieback was first found in mixed forest stands of evergreen and deciduous oaks in Ishikawa Prefecture in 1997, this hypothesis was rejected because tree mortality caused by this fungus/beetle was more Hyperball than 50% of the attacked trees for *Quercus crispula* but low for other concurrent Fagaceae species (<5%) although the number of initial attacks by the beetle was similar. Concurrent oaks other than Q. crispula proved to be resistant to Raffaelea sp. An opposite tendency was found in P. quercivorus preference to tree species. Therefore, Q. cripsula was preferred least by this insect, but was the most susceptible to the symbiotic ambrosia fungus. Amongst the deciduous oak, Q. cripsula is distributed in the coolest place. Platypodids are prosperous in tropical and subtropical regions. *Platypus quercivorus* is distributed in S to SE Asia. Taiwan, and Japanese Archipelago. Oak dieback occurs in northern/high margins of *P. quercivorus* distribution and southern/low margins of Q. crispula distribution. Oaks other than Q. cripsula are resistant to Raffaelea sp. probably because a stable relationship has been formed among the tree, fungus, and insect in a long evolutionary process. Quercus crispula was probably left out of the coevolution. We hypothesized that oak dieback in Japan was the result of the warm climate since the late 1980s, which made the fateful encounter of P. quercivorus with Q. cripsula by pushing the distribution of P. quercivorus to a more northern and higher place. Because P. quercivorus can realize a high reproduction rate on dead brood trees, this beetle can propagate more rapidly on O. crispula than on other resistant oaks. It is speculated that future global warming will accelerate overlapping P. quercivorus and Q. crispula distributions, and that the dieback of Q. crispula will be more prevalent.

Index terms: Platypus quercivorus, Raffaelea sp., Quercus crispula, distribution

[2081] ENTOMOPHAGS OF THE POPLAR LEAF BEETLE IN TURKMENISTAN

E. Kokanoya, National Institute of deserts, flora and fauna 59, Azady Str., 744000 Ashgabad, Turkmenistan.

The poplar leaf beetle Plagiodera versicolora (Coleoptera, Chrysomelidue) is the main defoliator of various species of the willow (Salix spp.) in natural bioccenoses of the Kopet-Dag Mauntains and the cultural landscapes of the foothills. P.versicolora develops in Turkmenistan in three generations year and reaches it's maximum population in the first one. Natural enemies diminish the population of the beetle in the larval and pupal stages. In Turkmenistan the set of parasites P.versicolora uncludes four species relating to the families Eulophidae, Preromalidae (Hymenoptera) and Tachinidae (Diptera). Pediobius routensis (Eulophidae) developed as a primary parasite from the larva of the leaf Beetle and it was also developed as a primary parasite from the caterpillars of the elaeagnus leaf roller Apotomis lutozana. Schizonotus latus (Pteromalidae) was developed as a primary parasite from the pupas of P.versicolora. The parasite larvae develop 8-10 days. Under the conditions of a closed environment, without water, the parasites live 3 or 4 days. When fed with sugar syrup their lifetime is 8-11 days. In ecologically pure surroundings the damage to the P.versicolora was high - up 44%. As a secondary parasite, the Sch. latus was developed from the pupas of the Anthomyiopsis plagioderae, which is a primary parasite of the P.versicolora. Schizonotus sieboldi (Pteromalidae) the primary-secondary external parasite was developed from the pupas of the poplar leaf beetle. It is encountered rarely. Anthomyjopsis plagioderae (Tachinidae) primary single internal parasite evolved from pupas of the P.versicolora. It is encountered rarely. The compiling a summary list of the parasites of Plagiodera varsicolora within the confined of it's holarctic areal showed almost everywhere, the larvae of the leaf beetle are infected by the Schizonotus sieboldi.

[2082] BASELINE SUSCEPTIBILITY OF BREVIPALPUS (ACARI: TENUIPALPIDAE) TO ORGANOTIN ACARICIDES IN BRAZILIAN CITRUS GROVES

R. H. Konno, C. R. Franco & C. Omoto, Depto. de Entomologia, Fitopatologia e Zoologia Agrícola, Escola Superior de Agricultura "Luiz de Queiroz", Univ. de São Paulo, Av. Pádua Dias, 11, 13418-900 Piracicaba, SP, Brasil, E-mail celomoto@carpa.ciagri.usp.br

The mite Brevipalpus phoenicis is one of the most important pests of Brazilian citrus because it vectors the citrus leprosis virus which affects the productivity and quality of the fruit. Control of B. phoenicis has been done mainly by the use of chemicals Approximately 44% of active ingredients used for controlling citrus mites in Brazil belongs to the organotin group. Because of intense use of organotin acaricides, the objective of this work was to evaluate the baseline susceptibility of B. phoenicis to the acaricides fenbutatin oxide and cyhexatin. B. phoenicis populations were collected from citrus groves which received different regimes of organotin acaricide applications in the past 4 years (no organotin acaricide use, use of organotin acaricide in alternate years, use of organotin acaricide once per year). The toxicological characterization of a susceptible reference population of B. phoenicis was performed with a residual leaf spray bioassay. Citrus leaf disks were sprayed with a Potter spray tower. Then, leaf Idisks were placed on a small petri dish containing an agar-water mixture at concentration of 2.5%. Then, 10 adult mites were transferred on each disk. Bioassay dishes were kept in a climatic chamber at temperatue of 25 ± 1 °C and photoperiod of 14:10 (L:D). The mortality was evaluated 24 hours after mite infestation. Mortality data were subjected to Probit analysis to estimate the LC50 and to define a diagnostic concentration for monitoring resistance. The estimated $LC_{50}s$ were 59.33 µg of lenbutatin oxide/mL and 9.48 µg of cyhexatin/mL of distilled water. The diagnostic concentrations of 180 μ g of fenbutatin oxide/mL and 56 μ g of cyhexatin/mL of distilled water were chosen for monitoring the susceptibility of *B. phoenicis* to these acaricides. No significant differences in susceptibility of *D. phoenicis* to organotin acaricides were observed in populations collected from citrus groves which received different regimes of organotin acaricide applications. The susceptibilities to fenbutatin oxide and cyhexatin of B. phoenicis populations collected from commercial citrus groves were similar to that of the susceptible reference population. No success was obtained in attempt to select an organotin-resistant strain under laboratory conditions. Index terms: citrus, fenbutatin oxide, cyhexatin.

[2083] COMBINED APPLICATION OF MATING DISRUPTION AND BACILLUS THURINGIENSIS FOR CONTROL OF THE BERRY MOTH IN GREEK ISLANDS, LIMNOS AND SAMOS

A.G. Koutroubas¹, E. I. Navrozidis², Z.D. Zartaloudis² & G.K. Salpigidis², ¹National Agriculture Research Foundation, Plant Protection Institute of Volos, 380 01 Volos, Greece.2. National Agriculture Research Foundation, Plant Protection Institute of Thessaloniki, 570 01 Thermi, Thessaloniki, Greece.

The berry moth (Lobesia botrana D+S Lepidoptera Tortricidae) is the most important pest of grapeving in South Europe. Its main host plant is the european grapevine. (Vitis vinifera L.). During the last three years an integrated control program against the berry moth was applied in the Greek islands of the Aegean Sea, Limnos and Samos. In a vineyard of 25 ha in Limnos and 30 ha in Samos, the method of mating disruption was applied against the first and second generation of the berry moth while Bacillus thuringiensis in the rest of vineyards of the islands an integrated control program with two sprays of Bacillus thuringiensis per generation was applied, against the moth. The results showed that the dry and warm climate of the islands was the main reason for the significantly and gradual reduction of stored pheromones in the dispensers during the mating disruption. Therefore, it was necessary to spray against the third generation with Bacillus thuringiensis. In both cases the results were satisfactory when compared with the usual chemical control in which many applications of wide spectrum insecticides were used. The number of beneficial arthropods were increased significantly in the vineyards where mating disruption method and Bacillus thuringiensis were applied.

Index terms: Vitis vinifera , Lobesia botrana, Integrated management
[2084] INDUCED DISEASE RESISTANCE IN NORWAY SPRUCE AND ITS IMPLICATIONS FOR BARK BEETLE POPULATION DYNAMICS

P. Krokene, E. Christiansen & H. Solheim, Norwegian For. Res. Inst., N-1432 Ås, Norway.

A series of experiments since 1995 have demonstrated that pretreatment inoculation of Norway spruce (Picea abies) stems with pathogenic fungi induce enhanced resistance to subsequent massive fungal infections or mass-attacks by bark beetles. This induced resistance response follows dose-response dynamics, is non-systemic and induces resistance only in the pretreated stem section, is non-specific with respect to the type of pretreatment, and enhances tree resistance for up to one year after pretreatment. (1) Dose-response dynamics: Norway spruce trees (~16 m high) from a single clone were pretreated with low, medium and high dosages of cork borer inoculations with sterile agar or the virulent blue-stain fungus *Ceratocystis polonica*. Three weeks later all trees were subjected to a massive C. polonica inoculation. Control trees that received no pretreatment were killed by the mass inoculation. The high and medium fungal pretreatments reduced fungal colonization by 76-97% relative to the control, whereas the low dosage reduced colonization by 20-40%. Pretreatment with fungus was always much more effective than pretreatment with sterile agar. (2) Non-systemic response: Protection was demonstrated to be local and not systemic in an experiment where trees were pretreated with a medium dosage of C. polonica on the lower bole and mass inoculated further up the stem. (3) Pathogen non-specificity: Protection is also pathogen non-specific, as pretreatment with different fungi (Nectria fuckeliana, Heterobasidion annosum, C. polonica) all induce enhanced resistance to mass inoculation with C. polonica. Pretreatment with sterile agar or an avirulent C. polonica isolate induce only weak resistance, and the effectiveness of induction seems to depend on the amount of host tissues that is killed by the pretreatment. (4) Long-term protection: The induced disease response increases tree resistance for at least 1 year after pretreatment. An experiment where trees were pretreated 1-52 weeks before mass inoculation demonstrated that a 1-week interval was insufficient to induce resistance, 3, 6 and 9 weeks were equally effective, and even 52 weeks gave increased tree resistance compared to the untreated control trees. Induced disease resistance in Norway spruce has important implications for the population dynamics of bark beetles. Sub-lethal beetle/fungus attacks will not weaken trees and render them more susceptible to later attacks. On the contrary, such attacks will enhance tree resistance and increase the tree's ability to defend itself against subsequent attacks. Thus, inducible disease resistance in Norway spruce and other conifers could hasten the collapse of bark beetle outbreaks once the beetle population starts to decline and fewer beetles can be summoned to mass-attack trees.

Index terms: blue-stain fungi, induced disease resistance, Ips typographus, Norway spruce, systemic acquired resistance (SAR)

[2085] BIOEFFICACY AND PERSISTENCE OF NPV AGAINST SPODOPTERA LITURA ON COTTON SPRAYED AT DIFFERENT TIMINGS OF THE DAY

Gururai G. Kulkarni¹, P.S. Ilugar² & P.D. Sharma³, ¹⁷³Department of Entomology, CCS HAU, Hisar-125 004, INDIA, ²UAS, Dharwad - 580 005 (Karnataka)

Studies on the persistence of Spodoptera litura Fab. NPV (SINPV) on cotton @ 300 LE/ha with and without sunlight protectant (Boric acid @ 0.1%) at different timings of the day have revealed that SINPV persisted longer when sprayed along with sunlight protectant as compared to when applied alone. Amongst all treatments, higher mortality of *S. litura* larvae was recorded in monorotophos compared to NPV treatments. Among the timings of NPV, application as evening spray (4-6 pm) recorded higher mortality than afternoon (1-3 pm) and morning (9-11 am) sprays in immediately after spray treatment (0 hrs). When the pest was exposed to treated cotton leaves monocrotophos recorded 76.63 and 75.66 per cent larval mortality in 1996 and 1997 seasons respectively, followed by NPV + BA application at 4-6 pm (75.81 and 75.09%), NPV alone at 4-6 pm (63.71 and 60.74%), NPV alone at 1-3 pm (58.46 and 55.22%) and NPV alone at 9-11 am (52.28 and 49.91%) and when sprayed in evening hours, in descending order during 1996 and 1997 respectively. Like wise performance of SINPV along with sunlight protectant at all timings of spray was better than NPV alone.

Key words : Persistence, SINPV, Spodoptera litura, cotton

[2086] DEVELOPMENT OF ENTOMOPATHOGENIC NEMATODES FOR CONTROL OF OVERWINTERING CODLING MOTH LARVAE

L.A. Lacey, T.R. Unruh, R. Chauvin, H. Headrick, and J. Upton, USDA-ARS-YARL, Wapato, WA 98951 USA

ntomonathogenic nematodes (EPNs) have potential as biological control agents of overwintering codling moths. The tree trunk habitat of prepupae and pupae offers a protected environment in which infective nematodes can better survive while searching for and infecting cocooned codling moth larvae. Fruit bins are also used by codling moth larvae as sites in which to spin cocoons. In orchards where codling moths have been controlled during the growing season, infested bins may provide a significant source of invading moths. Treatment of bins for control of codling moth larvae prior to placement in orchards is not currently done. Interventions that could be applied to bins that are safe for humans and that are environmentally friendly would be highly advantageous. Our research demonstrates that entomopathogenic nematodes can provide effective and affordable control of codling moth larvae in fruit bins. The most important factors that influence efficacy of EPNs for codling mot control include the species of EPN, temperature and critical exposure time. Steinernema feltine and S. carpocapsae are among the most active species against codling moth larvae. Larvae that had been treated with infective juveniles (IJs) of S. carpocapsae and incubated at 95+% RH and 25 C are controlled when moisture is maintained for 8 hours or longer. Temperature below 15 C reduces the larvicidal activity of S. carpocapsae, but S. *feltiae* remains active below 10 C. Orchard trials of *S. carpocapsae* were conducted under various moisture conditions in summer 1998. Application of 10⁶ IJs/tree using a hand-gun sprayer provided 95% mortality when trees were wetted before application of nematodes and at regular intervals for 6 hours after treatment. Field trials of S. carpocapsae and S. feltiae in summer 1999 compared airblast sprayer and hand-gun sprayer for application of 2 x 10⁶ IJs/tree. Good control was obtained using S. feltiae with both sprayers and fair to moderate control was obtained with S. carpocapsae when moisture was maintained. Trials in autumn 1999 using a back pack sprayer revealed good activity for both species when temperatures were above 18 C during the six hours following treatment. However, when temperature was lower than 15 C during the six hours following treatment, S. feltiae significantly out performed S. carpocapsae. Diapausing codling moth larvae in fruit bins were highly susceptible to IJs of both EPNs. Immersion of bins in suspensions of S. carpocapsae ranging from 5 to 100 infective juveniles/ml of water resulted in 68-100% mortality.

Index terms: Steinernema carpocapsae, Steinernema feltiae, Cydia pomonella

[2087] FIELD TESTS OF THE INFECTIVITIES OF BEAVERIA BASSIANA (DEUT: HYPHOMYCETES) ISOLATE IMI 335249 AGAINST PANTORIIYTES PLUTUS (COL: CURCULIONIDAE) IN A COCOA SYSTEM

S. Laup, Cocoa & coconut Research Institute, P.O.Box 1846, Rabaul, ENBP, Papua New Guinea

Weevils of the genus Pantorhytes are major pests of cocoa. There is a lack of sustainability in the present control measures against Pantorhytes. The application of Beuveria bassiana on cocoa pods indicated that P. plutus was susceptible to B. bassiana isolates IMI 335249. P. plutus picked up viable conidia applied to the cocoa tree at 1 x 10⁸ conidial concentration in oil formulation. Oil enhanced infection of P. plutus by Beauveria and lower infection incidence resulting from application of conidia in water formulation. Conidia stayed viable in the cocoa ecosystem for more that two months. There was a gradual mortality count couple with the number of insect infected from day 3 to day 30, after a session of fungal application into the cocoa ecosystem. Pickup of viable conidia and infection depends to a large extend on the density of individual insects plus the probability of pickup of conidia by healthy individuals. Symptoms of infection mostly on the intersegemental regions. An approach to the field application of fungal entomopathogen is presented and discussed within the framework of an integrated control management system of Pantorhytes in cocoa ecosystem.

Index terms: Beauveria, infection, Pantorhytes, pest, cocoa, integrated mangement

[2088] IMPACT OF XYLELLA FASTIDIOSA DISEASES IN SOUTH AMERICA

R.P. Leite Jr.¹, ¹Área de Proteção de Plantas, IAPAR, C.P. 481, Londrina, PR 86001-970, Brasil, E-mail ruileite@pr.gov.br. Fellow of CNPq.

Diseases caused by Xylella fastidiosa have been reported from South America as early as the 30's. Plum leaf scald disease (PLS) was first reported in the delta region of the Paraná River, Argentina, in 1935. The disease was later reported from Brazil and Paraguay. PLS was very severe on Japanese plum (Prunus salicina L.) and its hybrids. Contaminated propagative plant material played a major role in the spread of the disease to new areas. The presence of insect vectors is very important for the spread of the bacterium from tree to tree within plum orchards. Orchards of the widely planted Japanese plum Santa Rosa cultivar was vanished by PLS in the Brazilian States of Paraná, Santa Catarina and Rio Grande do Sul in the middle 70's and early 80's. Nowadays, PLS is present in almost all plum growing areas of Argentina and Brazil. Highly praised PLS resistant plum cultivars are not available for planting. Strategy for control of PLS involves basically the planting of disease free nursery trees in isolated areas. Citrus variegated chlorosis (CVC) caused by a strain of X. fastidiosa was first reported in the Northwest region of the State of São Paulo, Brazil, in 1987. A similar disease of citrus called "pecosita" had been reported in the region of Missiones, Argentina, since 1984. CVC is a very serious disease on sweet oranges (Citrus sinensis Osb.), affecting all commercial cultivars of oranges, such as Pera, Hamlin, Natal, Valencia and Folha Murcha. The disease has not been observed in other Citrus spp., as mandarins, lemons, acid limes, and grapefruit. Contaminated nursery trees was the most import way for the spread of CVC to new areas. Several sharpshooters of the Cicadellidae family have been identified as vectors of X. fastidiosa in citrus. The disease is already present in all major citrus growing areas of Brazil, and in the Northeast citrus growing area of Argentina. Disease control strategy involves the production of healthy nursery trees under screenhouse conditions, control of insect vectors, and pruning of affected sweet orange trees. More recently, X. fastidiosa has been associated with a leaf scoreh type of disease on coffee trees (Coffea arabica) in Brazil. Infected coffee trees show marginal necrosis of the leaves, short internodes, and dieback of branches. Association of X. fastidiosa with coffee trees is widely spread and has been found in all coffee growing regions of Brazil. However, no assessment of the damage caused to the coffee crop has been made yet.

Index terms: Citrus, Coffee, Plum, CVC, citrus variegated chlorosis, plum leaf scald

[2089] DOSAGE-RESPONSE VALUES OF B.t.i. AGAINST AEDES AEGYPTI IN VARIOUS CONTAINER IIABITATS

L. A. De Leon, Panama Canal Authority, ESMS, P.O. Box 025594, Miami, FL 33102 - 5594, E-mail : Ideleon@pancanal.com

Field bioassays to determine the effectiveness of *Bacillus thuringiensis* serovar. *israelensis* (*B.t.i.*), were essential steps in the adoption of a standard preparation of the biolarvicide (Acrobe@ 1,200 international toxic unit [ITU/mg) in an aqueous suspension, for routine mosquito control operations against the *Aedes aegypti*. Progeny of field caught larvae reared up to the adult stage were obtained for the tests. Four classes of artificial container habitats (e.g., plastic container, glass bottle, metal bucket and tire) were used comparable to most common situations found within the Panama Canal Commission's housing and operational areas. Exposure to normal environmental conditions was duplicated. Results showed a general susceptibility of the local population of *Aedes aegypti*, and compare larvicidal activity in the various larval habitats tested. The bacterial suspension showed insecticidal stability under a range of temperature and other environmental conditions. Dosages of *B.t.i* ranged from 3 to 20 milliliters per liter, and mortality ranged from 20 to 100 percent. But concentrations of 4ml/liter and 11.2 ml/liter were the adjusted values for the LD50 and LD90 respectively in the overall picture. Toxicity appeared more prevalent in plastic containers, followed by metal tanks, glass bottles and finally tires, however 100% mortality was attained at the concentration of 20 ml/liter in all the containers. A rounded off dosage of 1 pint of Acrobe® per 5 gallons of water was calculated for large working volumes. [2090] DOSAGE-RESPONSE VALUES OF Acrobe ® BIOLARVICIDE AGAINST Aedes aegypti LARVAE IN VARIOUS CONTAINER HABITATS

L.A. De Leon

Panama Canal Authority, ESMS, P.O. Box 025594, Miami, FL 33102 - 5594 E-mail: Ideleon@pancanal.com

Field bioassays were made to determine a practical dosage of Acrobe @ biolarvicide, Bacillus thuringiensis israelensis (B.t.i.), prior to the adoption of a standard operational preparation of this commercial formulation (1,200 international toxic units of B.t.i /mg) as an aqueous suspension for routine mosquito control against Aedes aegypti larvae. Progeny of adults reared from field caught larvae were used. Four classes of artificial containers (plastic ice cream tubs, glass bottles, metal buckets and used tires) represented some of the most common breeding habitats found within the Panama Canal Authority's housing and operational areas. Exposures were made under local environmental conditions. Results showed an overall susceptibility of the indigenous population of Aedes aegypti and discriminated larvicidal activity of B.t.i in the listed larval habitats. Bacterial suspensions showed insecticidal stability under a range of temperatures and existing environmental regimes. Dosages of Acrobe @ ranged from 3 to 20 milliliters per liter and mortality varied from 20 to 100 percent. Concentrations of 4ml/liter and 11.2 ml/liter provided adjusted values for the LD50 and LD90 mortality levels respectively. Toxicity was greatest in plastic containers, followed by metal buckets, glass bottles and finally used tires, however 100% mortality was attained at a concentration of 20 ml/liter in all types of containers. Based on this study, a rounded dosage of 0.5 liters (approx. 1 pint) of Acrobe@ per 19 liters (approx, 5 gallons) of water was recommended as a practical mix for field applications of Acrobe @, (also sold in international markets as BMP-144X).

[2091] GROWTH OF FUNGI CULTIVATED BY CUTTING ANTS ON MURASHIGE & SKOOG NUTRIENT SOLUTION IN DIFFERENT PH

A. E. Loeck¹, C. R. Pierobom¹, A. P. Afonso¹, C. Zanela¹ & S. Coimbra¹, ¹Dept. of Fitossanidade, Univ. Federal of Pelotas, C. P. 354, RS CEP: 96.010-900, Brasil, Email: alcienim@ufpel.tche.br

For Random Amplified Polymorfic DNA (RAPD) analyses there is the need of growing fungi in a mineral culture medium to avoid contamination with DNA organic components. A experiment was done with the fungi cultivated by Atta laevigata (F.Smith, 1858) and Acromyrmex laticeps (Emery, 1905) grown in Murashige & Skoog Basal Salt with pH 4, 5, 6 and 7. Petry dishes were incubated at 25 1°C, in the dark, for 63 days. Bigger colony diameter occurred at pH 4 and 5 for both fungi.

Symposium and Poster Session

[2092] EFFICIENCY OF DIFFERENT CULTURE MEDIA IN THE IN VITRO GROWTH OF FUNGI CULTIVATED BY DIFFERENT LEAF CUTTING ANT SPECIES

A. E. Loeck¹, C. R. Pierobom¹, A. P. Afonso¹ & C. Zanela¹, ¹Dept. of Fitossanidade, Univ. Federal of Pelotas, C. P. 354, RS CEP: 96.010-900, Brasil, E-mail: alcienim@ufpel.tche.br

Aiming to increase growth of fungi cultivated by leaf cutting ants the following culture media were compared: Pagnocca (glucose 10g, sodium chloride 5g, peptone 4g, malt extract 16g, agar 10g, water 1000 ml); MS (ammonium nitrate 1650 mg, boric acid 6,2 mg, calcium chloride (anhydrous) 332,2 mg, cobalt chloride. $6H_2O$ 0.025 mg, cupric sulfate. $5H_2O$ 37.26 mg, ferrous sulfate 180.7 mg, manganese sulfate 16.9 mg, mollybdic acid (sodium salt).2H₂O 0.25 mg, org. gobalt chloride 0.83 g, potassium nitrate 1900 mg, potassium phosfate monobasic 170 mg, zinc sulfate. 7 H₂O 8.6 mg, agar 18g) and celulose asparagine (ammonium sulfate 0.5 g, L-asparagine 0.5 g, potassium phosphate 1 g, potassium chloride 0.5 g, mgnesium sulphate 0.2 g, calcium chloride 0.1 g, yast extract 0.5 g, cellulose 10 g, agar 20 g, water 1000 ml).Fungi from colonies of Atta sexdens piriventris Santschi, 1918 and Acromyrmex heyer Forel 1899, were used. Incubation was in BOD at 25 1°C, in the dark. Fungi from Atta sexdens piriventris developed colonies with bigger diameter in Pagnocca medium and smaller in MS. Colonies of fungi from Acromyrmex heyeri were also better in Pagnocca but the smallest diameters were in V8, with growth in MS superior to fungi from Atta sexdens piriventris. The results show interaction among isolates and culture media and also the possibility of in vitro growing of fungi cultivated by leaf cutting ants in a mineral medium.

[2094] EFFECTS OF VETIVER OIL AND ITS CONSTITUENTS ON COPTOTERMES FORMOSANUS AND ITS SYMBIOTIC FAUNA

L. Maistrello¹ & G. Henderson¹, ¹Dept. of Entomology, Louisiana State University Agricultural Center, 402 Life Sciences Bldg., Baton Rouge, LA 70803, USA, E-mail: Imaistrello@agetr.lsu.edu

Vetiver grass (Vetiveria zizanioides) is an Indian native plant whose domesticated type is cultivated worldwide in tropical and subtropical regions for its effectiveness against soil erosion and for the commercial importance of its oil, extracted from the roots. Vetiver grass is known to be naturally resistant to arthropod pests and diseases and vetiver oil is reported to repel insects from skin and clothes and to have a potent topical irritant activity on flies and cockroaches. Vetiver oil is an extremely complex mixture of 300 compounds: among these nootkatone and α - and β -vetivone have been identified to show termite repellent properties. Lower termites, such as C. formosanus, rely on the protozoa living inside their gut for the digestion of their cellulose food. Therefore substances negatively acting on protozoa survivorship may indirectly affect termite survival. As part of our research on natural product efficacy against Formosan subterranean termites, experiments have been performed to test the response of C. formosanus to various substrates and food sources treated with vetiver oil, nootkatone and α - and β -vetivone. Evaluations of tunneling behavior, measurements of food consumption, variation in the number of different species of symbiont protozoa present over time, variation in individual termite weight and termite survivorship were recorded. The results showed that vetiver constituents, especially nootkatone, negatively effect termite physiology and behavior and may represent promising natural alternatives as termite repellents.

Index terms: Formosan subterranean termites, Vetiveria zizanioides, nootkatone, termite repellents, symbiotic protozoa

[2093] FIELD TRIAL WITH THE ENTOMOPATHOGENIC FUNGUS METARHIZIUM ANISOPLIAE VAR. ACRIDUM AGAINST BANDS OF THE GRASSHOPPER KHAMMATOCERUS SCHISTOCERCOIDES IN BRAZIL

B.P. Magalhães¹, M. Lecoq², M.R. de Faria¹, F.G.V. Schmidt¹, J.B.T. Silva¹ & W.D. Guerra³, ¹Embrapa Genetic Resources and Biotechnology, P.O. Box 2372, Brasília, DF, Brazil, CEP 70849-970; ²CIRAD (Prifas), B.P. 5035, 34032 Montpellier Cedex I, France; ³MA/DFA, Alameda Anfbal Molina s/n, Várzea Grande, MT, Brazil, CEP 78115-140.

The efficacy of a mycoinsecticide formulated in vegetable oil was tested in Brazil against the grasshopper *Rhammatocerus schistocercoides*. A set of experiments was conducted in the Chapada dos Parecis region (Mato Grosso state), a permanent zone of outbreaks for this pest. Experiments were performed in zones of natural vegetation, against grasshopper bands in the third nymphal instar. Three nymphal bands were treated with a the mycoinsecticide formulation based on conidia of the entomopathogenic fungus *Metarhizium anisopliae var. acridum* (= *M. Javoviride*), strain CG 423. Three non-treated bands were used as control. The application was made with the aid of a hand-held ULV sprayer adjusted to deliver 2 litres of the formulation/ha, each containing 1 x 10¹³ conidia. Treatments were limited to the surface of the grasshopper bands and their immediate borders (5-10 m). The efficacy of the mycoinsectise, density, behaviour and daily movement of the band), allowing the insects to move freely in their natural environment. Insects were regularly surveyed and maintained in the laboratory, allowing estimates of the product 10 days after treatment. At 14 days post-spraying, mortality caused by the mycoinsecticide in the field was approx. 88%.

Index terms: entomopathogenic fungus, Metarhizium anisopliae var. acridum, Metarhizium flavoviride, grasshopper, Rhammatocerus schistocercoides, oil formulation, field trial

[2095] LARGE SCALE BACILLUS SPHAERICUS PRODUCTION

L. M. de A. C. Maranhão¹, E. M. M. M. Rios², D. M. P. da Silva¹, F. J. Cavalcanti Neto¹, W. M. Ferreira¹ & A. C. da Silva¹, ¹Empresa Pernambucana de Pesquisa Agropecuária - IPA, C.P. 1022, Recife, PE, Brasil; ²Universidade Federal de Pernambuco - UFPE, Av. Prof. Morais Rego, s/n, CEP 50.670-901, Recife, PE, Brasil. Support: Departamento de Antibióticos/UFPE, FACEPE, FINEP.

Bacillus sphaericus production for Culex quinquefasciatus control is implanted in Empresa Pernambucana de Pesquisa Agropecuária - IPA, as a result of institutional interactions. The fermentative process employs culture medium based in skim milk, supplemented with mineral salts, producing, after 48 hours, at 30°C, a fermented broth containing about 10° viable spores per milliliter and LC₅₀ = 30µg/L. The innoculum, corresponding to 3% of the final volume of fermentation, is prepared in nutritive broth enriched with yeast extract, adopting a propagation schema which employs from agitated flasks to bottles containing 15 liters of the medium, with air injection. The control of the fermented broth includes the survey of microorganisms which could contaminate the process. Tests accomplished with the material kept under refrigeration, indicated toxic activity stable for six months. The field assays, accomplished in many cities in different regions of Pernambuco State, showed efficiencies of 80 to 100% and a persistence varying from 2 to 167 days, depending on conditions and peculiarities of the sites treated: lakes, waterways, cesspools, gutters, inspection boxes.

Index terms: Bacillus sphaericus, Culex quinquefasciants, entomopathogenic bacteria.

[2096] EFFECT OF SUNLIGHT ON THE RESIDUAL ACTIVITY OF A TABLET FORMULATION BASED ON BACILLUS THURINGIENSIS ISRAELENSIS AGAINST AEDES AEGYPTI LARVAE

M. A. V. Melo¹ & L. Regis², ¹ Mest. em Biologia Animal, Dept. de Zoologia, Univ. Fed. de Pernambuco, Av. Moraes Rego, CEP-50670-420, Recife, PE, Brazil. ²Dept. de Entomologia, Centro de Pesquisas Aggeu Magalhães/FIOCRUZ, Av. Moraes Rego, CEP-50670-420, Brazil, E-mail mavarjal@cpqam.fiocruz.br. Supported by FACEPE/CAPES (PNPPG) and CNPq.

A tablet formulation of *Bacillus thuringiensis israelensis* Vectobac® Abbott (5000 ITU/mg) showed an initial efficacy against *Aedes aegypti* larvae in previous laboratory tests. The aim of this study was to investigate the effect of sunlight on its residual activity. Experimental containers filled with 40 litres of tap water and treated with one tablet, were submitted to two different conditions: indoor and outdoor. Outdoor containers were kept either in shade or exposed to direct sunlight for 120 minutes daily. Seventy early fourth-instar larvae were then introduced every three days into each container, and the percentage mortality was determined 48 hours thereafter. The containers were removed when less than 70% mortality was recorded. The formulation showed good efficacy after application, killing 100% of the larvae under both conditions, but significant difference in residual activity were observed. Lower persistence was observed in the outdoor, sun-exposed experiment (5 days) when compared with the shade and indoor test where the product remained active for 23 and 44 days, respectively. These results suggest that the toxins are degraded by ultraviolet light (UV). We conclude that product shows good residual activity when used indoor, lasting for more than 40 days.

Index terms: Bacillus thuringiensis israelensis, Aedes aegypti, formulation, control persistence

Symposium and Poster Session

[2098] INTERACTION OF THE ENTOMOPATHOGENIC FUNGUS, PAECILOMYCES FUMOSOROSEUS (DEUTEROMYCOTINA: HYPHOMYCETES) WITH THE PARASITOID, APHELINUS ASYCHIS (HYMENOPTERA: APHELINIDAE) AND THEIR COMPETITION FOR AN APHID HOST

A. L. M. Mesquita¹ & L. A. Lacey², ¹Embrapa/CNPAT – Cx. Postal 3761 60511-110 Fortaleza-CE Brazil, E-mail: mesquita@cnpat.embrapa.br

European Biological Control Laboratory, USDA-ARS, Parc Scientifique Agropolis, 34397 Montpellier Cedex 5, France

The interaction between the hyphomycete, Paecilomyces fumosoroseus, the Russian wheat aphid, Diuraphis noxia, and its common parasitoid, Aphelinus asychis, was investigated under laboratory conditions to determine if fungal infection of the aphid host had some effect on oviposition and feeding behavior of the female parasitoid and on development of parasitoid progeny. Similarly, the effect of previous parasitization by the wasp on the ability of the fungus to produce subsequent infection and interfer with parasitoid development within host aphids was investigated. The aphids were first infected with 2 times the LD₉₅ of P. fumosoroseus for D. noxia 3rd instars (5.2 x 104conidia/cm2) and at various intervals afterward exposed to 4-5 d-old parasitoid females for 1 h. Various combination of treatments were examined: exposure to P. fumosoroseus and parasitization simultaneously; aphids being infected and then exposed to the parasitoid 24, 48, and 72 h afterwards; aphids being killed by the fungus and exposed to the parasitoid (maximum 24 h after death); parasitoid alone; and fungal infection alone. The fungus required 3-5 d to kill the host and the parasitoid took 6 d at 22-24 C, 80-87% RH. The average number of aphids stung by parasitoids was not influenced by host infection with *P. funnosoroseus* but duration of ovipositor insertion was influenced by the length of the time interval between exposure to P. fumosoroseus and subsequent exposure to parasitoid females. A. asychis females spent considerably less time with their ovipositor inserted in dead aphids and aphids that had been exposed to P. fumosoroseus 72 h prior to contact with the parasites. The number of dead aphids fed upon by parasitoids was significantly less than in the other treatment groups. These observations indicate that probing by A. asychis provides information concerning host suitability. The percentage of successfully parasitized D. noxia was significantly reduced as a function of the time between infection with P. fumosoroseus and parasitization.

Index terms: Russian wheat aphid, *Diuraphis noxia*, biological control, natural enemy interaction.

[2097] GENERA OF ENCYRTIDAE (HYMENOPTERA: CHALCIDOIDEA) PARASITOIDS OF MEALYBUGS (HEMIPTERA: PSEUDOCOCCIDAE) IN NEOTROPICAL REGION

A. O. Menezes Jr.¹, ¹Universidade Estadual de Londrina, Depto. de Agronomia, Cx. Postal 6001, Londrina, PR 86.051-970, BRAZIL, E-mail ayres@sercomtel.com.br

Many species of mealybugs are known to feed on a variety of agricultural crops. When in high numbers, they could damage the host-plant by sap-sucking, injecting toxins, transmitting viruses or excreting honeydew. Normally, mealybug populations are kept under acceptable levels by natural enemies as predators and parasitoids, particularly in their original regions. Almost all primary parasitoids of mealybugs belong to the chalcidoid family Encyrtidae, represented by species of more than 50 genera in New World. Certainly, these parasitoids play a major role in regulating the populations of mealybugs that, otherwise could arise to pest levels. Many species os encyrtids have been used in biological control programmes along the XX century against mealybugs pests such as Dysmicoccus brevipes on pinapple, Antonina graminis on pasture grasses, Saccharicoccus sacchari on sugarcane and others. The control of the cassava mealybug in Africa is a recent successful case where neotropical species were used as biocontrol agents. The specimens studied were obtained from field collecting (swep net and yellow pan trap), host emergence and museum loan. Fifty five genera of eight tribes belonging to the Encyrtinae and Tetracneminae subfamilies were treated, including mostly of the primary and secundary parasitoids associated to mealybugs in the Neotropical region. An identification key to generic level and a diagnoses were provided to each genera, complemented with information related to number of described species, known hosts and geographical distribution. As a result of field and host collecting in Brazil, five genera were registered for the first time to the country, viz. Aeptencyrtus De Santis, Clausenia Ishii, Cocidoxenoides Girault, Holcencyrtus Ashmead and Parapyrus Noyes. The following were also obtained from fieldwork: Accrophagus Smith, Metaphycus Mercet, Pseudaphycus Clausen, Cheiloneurus Westwood, Prochiloneurus Silvestri, Aenasius Walker, Blepyrus Howard, Zarhopalus Ashmead, Guhaniella Timberlake, Anagyrus Howard, Apoanagyrus Compere, Gyranusoidea Compere, Leptomastix Förster, Leptomastidea Mercet, Tetracnemoidea Howard and Tetracnemus Westwood. Species of Aenasius, Anagyrus and Apoanagyrus were the more often collected associated to mealybug-hosts during the survey

Index terms: Encyrtinae, Tetracneminae, Aenasini, Anagyrini.

[2099] GENETIC CHARACTERIZATION OF BACULOVIRUS SSMNPV, A PATHOGEN OF STILPNOTIA SALICIS (LYMANTRIDAE) ISOLATED IN POLAND

<u>J Michalik^{1,2}</u>, E.Szolajska¹, J.Ziemnicka³ & L.Strokovskaya⁴, Inst. Biochem. & Biophys ,PAS, Pawinskiego 5A, 02-106 Warsaw, Pl, Kielee,Pl Inst.Plant Protection Miczurina 10, 0 Poznan,Pl, Inst. Mol.Biol.,Zabolotnogo115, Kiev Uk.

Baculoviruses comprise a diverse group of pathogens infectious for arthopods particulary lepidopteran insects. Over 500 species of insects have been reported to be infected with baculoviruses, which include members of the occluded subgroups A (nuclear polyhedrosis viruses, NPVs), B (granulosis viruses) and the non-occluded subgroup C. Although all baculoviruses have a double-stranded, supercoiled DNA genome packed in rod-shaped enveloped nucleocapsid , the size of the genome differs considerably between baculovirus isolates. In addition baculoviruses demonstrate diversity in viral infectiwity spectrum for host insects with many baculoviruses demonstrating a very narrow host range (Crook, 1981). Despite the evident diversity of baculovirusers , little is known about genetic relationships existing between different members. A series of investigators have compared the relatedness of the genoms of the multicapsid NPV of Orgyia pseudotsugata (OpMNPV) and Autographa californica (AcMNPV). It was observed Baculovirus infecting satin moth (Stilpnotia salicis) larvae, living on poplar trees, was isolated from dead larvae of last instar and characterized by restriction analysis of the genome. SsMNPV is typical nucleopolyhedrovirus of the genome size established as 128-134 kb, based on Hind III and Sac I restriction analysis. The only permisive cell line found by us for virus propagation in laboratory was IPL-Ld-65Y, coming from Lymantria dispar larvae. Restriction analysis made with several typical enzymes revealed that the most useful for further analysis of the genome are: Hind III, Xho I, Sac I, Eco RI, Pvu II, Sal I and Pst I. Partial sequence analysis of SsMNPV genome revealed that there is a big homology of several gen sequences to Orgyia pseudotsugata. In pohyhedrin gen this similarity is as high as 99%. Also flanking sequence of polyhedrin gen: promotor region and ORF1629 show very high sequence similarity. Also the orientation of polyhedrin and ORF 1629 in baculovorus genome is characteristic to Orgyia pseudotsugata and opposite to Autographa californica This suggests that SsMNPV isolated in Poland is a variant of OpMNPV virus although a natural hosts for both viruses live on different continents: Europe and America.

[2100] RESPONSE OF COPTOTERMES FORMOSANUS SHIRAKI TO ISOLATES OF METARHIZIUM ANISOPLIAE IN THE UNITED STATES: VIRULENCE AND REPELLENCY

R. J. MILNER¹, <u>J. E. POWELL²</u>, & M. S. WRIGHT³, 1csiro Entomology, Gpo box 1700, act 2601, Australia; 2usda, Agricultural Research Service, P O Box 225, Stoneville, Ms 38776, Usa, e-Mail: jpowell@ars.usda.gov; 3usda, Agricultural Research Service, 1100 Robert E. Lee Boulevard, New Orleans, la 70124, Usa.

One of the challenges to controlling subterranean termites is their ability to avoid toxic materials. When using fungi, one goal is to get the workers to spread the pathogen throughout the nest. This can only take place if the fungus is not highly repellent. We found that Coptotermes formosanus responded differently to the four isolates of Metarhizium anisopliae var. anisopliae that we applied in a wide range of doses. Three isolates were isolated originally in Australia (FI-610, FI-1186, FI-1248) and one in the USA (FI-1218). Conidia were produced on moist, sterile rice. Ten-fold serial doses ranged down from 3x10⁸ conidia/ml. Workers were dosed by dipping in the fungal suspension, then 40 insects were used per isolate at each dose for each colony tested. Four replications were monitored. Infection was confirmed by allowing sporulation to occur on dead test insects. FI-610 was the most virulent isolate and caused 100% mortality down to dose 3 (actual dose 5×10^5 conidia/ml). FI-1186 was least virulent causing 97.3% mortality at dose 2 (5 x 106 conidia/ml). Overall, all four isolates were virulent for the Formosan subterranean termite. To clarify differences in virulence between isolates, another bioassay was established using a more restricted range of doses. The most virulent isolate here was FI-1248, with FI-1186 again exhibiting less activity against worker termites. Little difference existed between FI-610 and FI-1248, with FI-1218 being less virulent and FI-1186 being least virulent. Compared with similar bioassays undertaken in Canberra with Coptotermes lacteus workers, C. formosanus is less susceptible to the four isolates. Further experimentation confirmed pathogenicity of each of the isolates when spores were combined with a formulation. Even at the highest dilution, 1:100 spores/formulation, strains HI-610, HI-1218 and HI-1248 resulted in >90% mortality between 2 and 5 days. This dilution scheme probably best represents the self-dosing regime in which *Metarhizium* will be used to control the Formosan subterranean termite through field applications. Based on laboratory observations, repellency of the Formosan subterranean termite to spores in order of least to greatest was FI-1186, FI-1248, FI-610 and FI-1218.

Index terms: Formosan subterranean termite, biological control, behavior, entomopathogen, fungus

[2101] DETECTION OF WOLBACHIA FROM ORIUS SPP. IN JAPAN

K. Miura¹², Y. Tagami², I. Ohta¹ & T. Shimizu³, ¹ Chugoku Natl. Agri. Exp. Stat., Fukuyama 721-8514, JAPAN, E-mail miurak@cgk.affrc.go.jp;² Hiroshima Univ., Higashi Hiroshima 739-8528, JAPAN;³ Natl. Ins. Seri. Entomol. Sci., Tsukuba 305-8634, JAPAN.

Five species of Orius ,which are important natural enemies, were examined for Wolbachia infection. Amplifies bands were detected from all investigated species with Wolbachia-specific polymerase chain reaction primers. Bacterial 16SrDNA was amplified by PCR and then sequence them. Molecular phylogenetic analysis demonstrated that the sequence belongs to a monophyletic group of the genus Wolbachia in the a-Proteobacteria. In 15 geographic populations of Orius spp., all the individuals examined possessed the Wolbachia. This fact indicates that Wolbachia was universally distributed among natural populations of Orius spp. We generated DNA sequences from Gene Bank. Phylogenetic analyses indicated that all the Wolbachia symbionts in Orius spp. may be descendants of a single ancestral infection. Index terms: Orius spp., Wolbachia, symbiont.

[2102] A CULTURE COLLECTION OF BACILLUS THURINGIENSIS AND BACILLUS SPHAERICUS PATHOGENIC TO INSECTS

R. G. Monnerat, J. O. Silva-Werneck, S. F. Silva, K. Bonfim, R. P. Pessanha, M. S. Aguiar & S. D. N. Nobre, Embrapa Recursos Genéticos e Biotecnologia, Parque Estação Biológica PqEB Final W3 Norte, P.O Box 02372. Brasília, DF, E-mail rose@cenargen.embrapa.br

Since 1989, the Microbial Pest of Control Laboratory of Embrapa Genetic Resources and Biotechnology Biological has isolated (WHO, 1985), identified, characterized and storicd *Bacillus spp.* to control insects pests with the purpose of creating a culture collection. The isolates are stored in sterile filter paper strips in glass sealed anpoules. This way, the isolates genetic characteristics are preserved for a long term, without suffering contamination. At present the culture collections contains 277 isolates of *Bacillus sphaericus* and 439 *Bacillus thuringiensis*. Pathogenicity tests were done against Diptera (*Culex quinquefasciatus and Aedes aegypti*), Lepidoptera (*Anticarsia gemmatalis, Plutella xylostella* and *Spodoptera fragiperda*) and Coleoptera (*Anticarsia gemmatalis, Plutella xylostella* and *Spodoptera fragiperda*) and Coleoptera (*Tenebrio molitor*). From 277 isolates of *Bacillus sphaericus*, 85 have already been serotyped. The majority (78) serotype H5aH5b and 125 are efficient against the urban mosquito *Culex quinquefasciatus*. From 439 isolates of *Bacillus thuringiensis*, 107 are serotyped and 329 were evaluated against *Aedes aegypti* and 55 showed positive results. Also, 350 were tested against *Culex quinquefasciatus* 27 showed positive results. From 432 evaluated against *Culex quinquefasciatus* 27 showed positive *against Plutella xylostella*, 87 are pathogenic and from 202 evaluated against *Tenebrio molitor*, 16 can be considered pathogenic.

Index terms: Culex quinquefasciatus, Aedes aegypti, Anticarsia gemmatalis, Plutella xylostella, Spodoptera frugiperda, Tenebrio molitor.

[2103] PATHOGENICITY OF NEW ISOLATES OF BACILLUS THURINGIENSIS AGAINST LEPIDOPTERAN AND DIPTERAN PESTS

R.G. Monnerat¹, S.F. Silva¹, K. Bomfim¹, R.P. Pessanha¹, M.S. Aguiar¹, S.D. Nobre¹ & J.O. Silva-Werneck¹, ¹Embrapa Recursos Genéticos e Biotecnologia, P. O. Box 02372, 70849-970, Brasília, DF, Brazil. E-mail: rose@cenargen.embrapa.br

Bacillus thuringiensis is an aerobic bacterium that during sporulation synthesizes crystalline inclusions composed of δ-endotoxins. These toxins show specific activity against insects and other invertebrates. The use of this agent in insect biological control is a promising alternative in view of technical, economic and environmental considerations, since its action is restricted to the target insects, and is harmless to other organisms. Bioinsecticides based on B. thuring iensis have been successfully used against lepidopteran, dipteran, and coleopteran pests. B. thuring iensis is ubiquitous, isolated from soil, water and dead insects. Laboratories worldwide look for new strains of this bacterium aiming to find isolates with different activity spectra or greater efficient against certain insects than known isolates. The goal of this work was to evaluate the pathogenicity of new isolates of B. thuringiensis from soil samples of different Brazilian regions, deposited in the Bacillus Germplasm Bank of Embrapa Genetic Resources and Biotechnology, against the velvet caterpillar (Anticarsia gemmatalis), fall armyworm (Spodoptera frugiperda), and mosquito larvae (Aedes aegypti). Sixty nine isolates were tested by selective bioassays, using an artificial diet, under controlled conditions. Fifteen of the isolates caused mortality equal or greater than 40% in *A. gemmatalis* and 9 produced this mortality level in S. frugiperda.

Index terms: Anticarsia gemmatalis, Spodoptera frugiperda, Aedes aegypt, biological control.

[2104] ANOTHER CASE OF INSECT AND TARSONEMID MITE (ACARI: TARSONEMIDAE) ASSOCIATION

G. J. de Moraes^{1,2}, A. C. Lofego¹ & E. Berti Filho¹, ¹Depto. Entomol., Fitop. e Zool. Agrícola, ESALQ/ USP, 13418-900 Piracicaba-SP, Brazil, E-mail gimoraes@carpa.ciagri.usp.br; ²CNPq Researcher.

Mites of the family Tarsonemidae are considered to have the greatest diversity of feeding habits within the Acari. The genera in the subfamily Acarapinae are known to be parasitic on insects, and can be recognized by the long, nearly straight cheliceral stylets and the invariable absence of prodorsal trichobothria in all stages of both sexes. The subfamily is divided into two tribes, Acarapina (Acarapis) and Coreitarsonemia, Asiocortarsonemus and Coreitarsonemus), the former associated with Apis bees and the latter, with Coreidae bugs. The bette Homalinotus coriaceus, Curcutionidae, is a Neotropical borer of floral peduncles of different palm trees in Brazil, where it is widespread. All stages of a new tribe, genus and species of São Paulo, Brazil. Nothing is known about the possible effect of the mite on the host. This is the first report of an association of Acarapinae with an insect in the order Coleoptera.

Index terms: Curculionidae, Arecaceae, mite, Acarapinae, parasitism

[2105] DESTRUCTION OF BACTERIA IN THE DIGESTIVE TRACT OF THE MAGGOT OF THE GREEN BOTTLE FLY, *PHAENICIA SERICATA*

<u>K. Y. Mumcuoglu</u>,¹ J. Miller,¹ M. Mumcuoglu,¹ M. Friger² & M. Tarshis³, ¹Dept. of Parasitology, The Kuvin Center for the Study of Infectious and Tropical Diseases, ²The Interdepartmental Unit, The Hebrew University-Hadassah Medical School, Jerusalem, and ³Department of Epidemiology and Health Evaluation Services, Faculty of Health Sciences, Ben-Gurion University, Beer-Sheva, Israel

Maggots of the green bottle fly, Phaenicia sericata were first used for the treatment of suppurative skin infections by Baer in 1931. This method was used extensively in the 1930's and 1940's, and then abandoned with the introduction of antibiotics and the use of aggressive surgical debridement. Ten years ago maggot debridement therapy was reintroduced and thousands of patients have been treated by this technique in USA, Great Britain, Germany, Switzerland, Sweden and Israel. Baer observed that the maggots significantly reduced the number of bacteria in wounds and called them "viable antiseptics". He suggested that bacteria are killed as they pass through the maggot intestinal tract. In order to investigate the fate of bacteria in the alimentary tract, sterile maggots were incubated with a GFP-producing E. coli and the digestive tract was subsequently removed. The presence of bacteria in the different parts of the intestinal tract was studied using a Zeiss 410 laser scanning confocal microscope. A computer program was used to analyze the intensity of the fluorescence. The crop and the midgut were the most heavily infected areas of the intestine. A decrease in the amount of bacteria toward the end of the midgut was observed. The number of bacteria decreased even more significantly in the anterior part of the hindgut and practically no bacteria were seen in the posterior end, near the anus. The viability of bacteria in successive regions of the alimentary tract was studied on LB agar plates.

[2106] POTENTIAL IN AUSTRALIA FOR A HELICOVERPA BACULOVIRUS

D.A.II. Murray, R.J. Lloyd & J. Boddington, Department of Primary Industries Po Box 102 Toowoomba Q 4350 Australia.

Helicoverpa armigera is a scourge for producers of fibre, grain, fodder and food crops in Australia, costing an estimated A\$225M annually in chemical control and lost production. Reliance on conventional synthetic insecticides has turned a full circle. More than 20 years ago a Helicoverpa nucleopolyhedrovirus (NPV) made a foray into the Australian insecticide market. Eventhough it had many of the altributes of a successful biopesticide, it did not compete in the market place with the new synthetic pyrethroids and carbamates. Insecticide resistance to these insecticide groups has changed the outlook as control of H. armigera is unreliable using conventional chemistry. There are also increasing pressures to adopt sustainable insect pest management approaches that embrace a responsible attitude towards the environment and the community. In late 1998, a Helicoverpa NPV, under the trade name Gemstar®, was registered in Australia for Helicoverpa spp. control on grain sorghum and chickpea. Registration on cotton was approved in January 2000. The imported product costs about A\$60/L and is used at rates from 100 to 500 mL/ha. There has been an amazing uptake of Gemstar in the marketplace as pest managers recognise the potential contribution of this product. Limited use on a suite of other crops is allowed under permit. The adoption of Gemstar has been accompanied by a growing acceptance that total pest control is not achievable nor necessary in many of today's crops. Conservation of natural enemies is fundamental to this approach. Gemstar has delivered the goods, but it should not be used like any other insecticide. Education and understanding how Gemstar works are crucial, as are application and tinuing. Much of the current effort with Gemstar is to improve its performance and broaden the registration suite. The addition of milk powder has repeatedly improved field performance of Gemstar. Various other additives have been evaluated, but none of these were equivalent to milk powders. Increasing persistence of NPV through the use of UV protectants has not been delivered, and in some crops multiple low rates are viewed more favourably than a single high rate application. Ultra low volume application has demonstrated its potential for cost effective *Helicoverpa* management in grain sorghum. An *in vitro* NPV was equivalent to Gemstar in initial field trials. The future for Helicoverpa NPV in Australia is very promising. It has comented a niche in the marketplace, and this will invariably expand as users fully understand its capabilities. A locally produced in vitro product will also strengthen its share in a competitive insecticide market. An exciting time is dawning as finally some successful IPM programs are being developed. Just as before, the threat lies in new chemistry that provides a 'simple, quick fix' solution.

Index terms: Helicoverpa armigera, nucleopolyhedrovirus, NPV, in vitro

[2107] PHYLOGENETIC RELATIONSHIPS AMONG EUPTYCHIINE BUTTERFLY GENERA USING MORPHOLOGY AND MOLECULAR DATA

D. L. Murray, Dept. of Entomology, Louisiana State Univ., Baton Rouge, LA 70803, USA, E-mail dmurray@unix1.sncc.lsu.edu.

There are approximately 300 species and 43 genera of wood nymph butterflies in the diverse subtribe Euptychina (Nymphalidae: Satyrinae). Euptychines range from central United States to Argentina, with the greatest diversity in the Amazon, and are found in a wide variety of habitats. The natural history and evolutionary relationships of these butterflies are largely unknown even though the group contains some of the most abundant and widely distributed butterflies in the Americas. Little work has been attempted on the group since the 1960=s, and the present classification is one of the most confusing in butterfly systematics. Traditional adult morphological character systems have not been useful in resolving the generic classification of the group or even confirming monophyly of the euptychine clade. In this study phylogenetic relationships among genera are hypothesized from cladistic analysis of larval and molecular characters. In surveying larvae for informative characters, all available instars were used, and analysis includes serial homologies of setae through the instars. Molecular data used is from DNA sequencing of the motochondrial gene cytochrome oxidase I (COI). Congruence between morphological and molecular cladograms is discussed, and comparisons are made to life history traits.

Index terms: Lepidoptera, Satyrinae, Euptychiina, larval characters, cytochrome oxidase I

[2108] COMPARATIVE EFFICACY OF BACILLUS THURINGIENSIS FORMULATIONS FOR CONTROL OF RICE LEAF FOLDER AND THEIR EFFECTS ON BIODIVERSITY IN RICE ECOSYSTEM

N. Muthukrishnan, K. Chozhan, M.S. Venugopal & R. Janarthanan, Department of Agricultural Entomology, Tamil Nadu Agricultural University, Agricultural College and Research Institute, Madurai 625 104, Tamil Nadu, India. E-mail nmuthu64@hotmail.com

Rice leaf folder Cnaphalocrocis medinalis is a serious pest in Tamil Nadu, India. We aimed at evaluating susceptibility of C. medinalis to commercial formulations of Bacillus thuringiensis in laboratory and wetland cropping system. In vivo experiments were conducted to measure dose and time-mortality relationship between larvae and wide range of doses, and compared with monocrotophos. Leaf folder larvae exposed during 1st and 2nd instar were much more susceptible than older larvae. No significant differences in susceptibility were found among 4th and 5th instars at lower doses. At higher concentration, 4th and 5th instar larvae had significantly lower mortality than did 3rd instar. The LC₅₀, LC₅₀, LT₅₀ and LT₅₀ values for older larvae were many-fold higher than those of 1st and 2nd instar. Formulation-wise dose and time-mortality relationship of 2nd instar larvae indicated that Halt WP was lethal to 50% larvae at 2g/l and at 16h post treatment (PT), and to 90% larvae at 8.5g/l and at 39h PT. Delfin 2g/i and at 16n post treatment (F1), and 05 90% taivag at 6.3g/i and at 35n F1. Definition WG accounted 2.5g/i and 34h PT as LC_{50} and LT_{50} values, and 11g/i and 95h PT as LC_{90} and LT_{90} values respectively. Agree WP was toxic at 2.8g/i and at 46h PT (LC_{50} and LT_{50}), and 12.7g/i and at 108h PT (LC_{90} and LT_{90}). Biobit WP contributed 50% kill at 3.5g/i and at 73h PT, and 90% kill at 16.3g/i and at 166h PT. Thuricide WS was least effective as its lethal values were 5.2ml/l and 120h PT for 50% mortality, and 20ml/l and 220h PT for 90% kill. However, monocrotophos 36 WSC contributed 50% mortality within 6h PT and at 2ml/l, and 90% mortality at 2.8ml/l and at 14h PT. Based on these results, field evaluation was conducted using low and high rates of application. Monocrotophos at 1000ml/ha was effective in minimizing larval control and leaf damage, and also reduction in biodiversity of non-target fauna. Halt 1250g/ha, Delfin 1500/ha, Agree WP1500kg/ha and Biobit 1750g/ha provided fair to excellent larval control, minimum leaf damage and yielded higher, and enabled good survival in predatory Coleoptera and spiders, and parasitic Hymenoptera. The significance of these results for effective integrated pest management strategies is discussed.

Index terms: Cnaphalocrosis medinalis, B.t. formulations, Dose and time-mortality, held evaluation, natural fauna

[2109] EFFECT OF A FORMULATION OF BACILUS THURINGIENSIS VAR. KURSTAKI ON THE IMMATURE STAGES, LONGEVITY AND FEEDING PREFERENCE OF PODISUS NIGRISPINUS

<u>M. L. Nascimento¹</u>, G. J. de Moraes², D. F. Capalbo³ & A. H. N. Maia³, ¹Dept. Plant Production - FCA/UNESP - Campus of Botucatu P. O. Box 237, E-mail: malu@fca.unesp.br; ²Depto. Entom., Fitop. e Zool. Agricola, ESALQ/USP, 13418-900 Piracicaba, SP; ³EMBRAPA/CNPMA P. O. Box 69, Jaguariúna, SP, Brazil.

The Pentatomidae Podisus nigrispinus is frequently mentioned as a promising biocontrol agent of eucalyptus leaf feeding caterpillars. The pathogenic bacteria Bacilus thruingiensis var. kurstaki (Btk) has been widely used for the control of eucalyptus pests. This studies was conducted to evaluate the effect of a formulation of Btk on the immature stages and on the longevity of two consecutive generations of P. nigrispinus, and toverify the feeding preference of that predator when offered healthy and diseased caterpillars. One hundred eggs of P. nigrispinus were obtained from 5 females and and omly divided into 2 groups of 50 eggs, each maintained by itself in a rearing arena. One of those groups was permanently fed healthy Bombix mori caterpillars (t1), and the other, caterpillars of the same species infected by Btk (t2). For the feeding preference test, 10 recently emerged adults of each sex were used, putting each insect individually in a small Petri dish. The duration of the immature phase was about the same in both treatments and in both generations, ranging from ca. 18 to 21 days. Survivorship was higher for t1 (ca. 80 and 64% in the first and second generations) than for t2 (ca. 56 and 42%, respectively). Significant differences in longevity were observed for males (first and second generation) and females (second generation), been always higher in t2. Healthy and diseased caterpillars were equally accepted as food by P. nigrispinus.

[2110] SUSCEPTIBILITY OF IMMATURE STAGES OF *THYRINTEINA ARNOBIA* (LEPIDOPTERA: GEOMETRIDAE) TO A POSSIBLE PICORNAVIRUS

M.L. Nascimento¹, C.F. Wilcken¹, Q. Novaes², J.A.M. Rezende², E.W. Kitajima³, & C. Orlato¹, ¹Dept. Plant Production - FCA/UNESP - Campus of Botucatu - E-mail: malu@fca.unesp.br; ²Dept. of Entomology, Plant Pathology and Zoology; ESALQ/USP, 13418-900 Piracicaba, SP; ³NAP/MEPA, ESALQ/USP, 13418-900 Piracicaba, SP. Brazil

Thyrinteina arnobia (Stoll) (Lepidoptera: Geometridae) is one of the most destructive pest among defoliator insects in commercial forests of Eucalyptus in Brazil. Chemical control of this pest has not been used due to the extension of planted area and environmental contamination risks. Recent electron microscopy examination of thin sections of tissue from dead larvae of T. arnobia showed the presence of numerous isometric virus-like particles, morphologically similar to viruses belonging to the family Picornaviridae. Purified virus particles were obtained by differential centrifugation of extracts from contaminated larvae and used for antiserum production and to evaluate the susceptibility of different larvae instars to virus infection. The experiments were carried out under laboratory conditions. First to sixth larvae instars, reared on artificial diet, were individually placed in acrylic pots and fed with Eucalyptus grandis leaves previously sprayed with a suspension of unknown concentration of purified virus. The experimental design was randomized in a 2 x 6 factorial. All larvae instars were susceptible to virus infection and died after days feeding. Sixth larvae instar showed the lowest susceptibility to virus infection. Antiserum strongly reacting with purified virus and infected larvae was produced and will be used for further serological and molecular characterization of the putative picornavirus as well as to understand its epidemiology. This entomopathogenic virus species may open up a new perspective for biological control of this pest in Eucalyptus.

Index terms: virus, eucalyptus, biological control

[2111] EFFICACY OF SPINOSAD NATURALYTE INSECT CONTROL AGAINST LOBESIA BOTRANA (LEPIDOPTERA: TORTRICIDAE) ON GREEK VINEYARDS

E.I. Navrozidis¹, E. Pitarn², Z.D. Zartaloudis¹, G.K. Salpigidis¹, D.G. Stavridis³, & A.G. Anthomelidis¹, ¹. National Agriculture Research Foundation, Plant Protection Institute of Thessaloniki, 570 01 Thermi, Thessaloniki, Greece. ². National Agriculture Research Foundation, National Agriculture Research Foundation, National Agriculture Research Foundation, Sigialias 19 & Chalepa, 151 25 Marousi. ³. Technological Educational, Institution of Thessaloniki, School of Agricultural, Technology Department of Plant Production, Lab. of Plant Protection, P.O. Box 145 61, 54 101 Thessaloniki - Greece.

Lobesia botrana (Grape berry moth) is the most destructive pest in Greek vineyards. Broad spectrum insecticides, that are used on grapes may be toxic to beneficial organisms. Spinosad is a new product from Dow AgroSciences derived from the actynomycete bacterium Saccharopolyspora spinosa and is the first active ingredient in the Naturalyte class. In Greece, Grape berry moth has three generations per year. Field trials were conducted during the period 1996-1999 aimed at evaluating the efficacy of spinosad. The product was applied in two spray programs. One was targeted at the beginning of the adult flight and the other at the peak, using a range of rates from 4.8-9.6 g.a.i./hl. Flufenoxuron was used as a standard, at the beginning of the flight and labdacyhalothrin at the peak of the moth's flight. Spinosad's ovicidal activity was also evaluated in laboratory experiment. The product was applied on 1, 2 and 3 days old eggs and flufenoxuron and fenoxycarb were used as references. The results of the field trials showed that spinosad was very effective in controlling the grape berry moth using both spray programs. At the beginning of adults flight the rates of 4.8-7.2 g.a.i./hl provided 86-94 % control. The same sates recorded slightly lower efficacy when applied at the peak of grape berry moth flight. This shows that spinosad is very flexible in the timing of application. Flufenoxuron was numerically inferior to spinasad rates, beginning from 7,2 g.a.i./hl and labdaeyhalothrin was weak and inconsistent across the years. The results of the laboratory experiments indicated that spinosad ovicidal activity increased with the age of the eggs. The mortality of 1, 2 and 3 days old eggs was 42.15% and 40.7% and 71.0% respectively. None of reference products showed more than 42 % mortality. In addition, spinosad was very selective to the important predator Chrysopa carnea (Neuroptera: Chrysopidae). Because of its low toxicity to this non target insect, spinosad fits well to an Integrated Pest Management program.

[2112] COMPATIBILITY OF ENTOMOPATOGENIC FUNGI WITH NEONICOTINOIDS INSECTICIDES

P.1. Neves¹, E. Hirose², P. T. Tchujo³ & A. Moino Jr.⁴, ¹Univ. Est. de Londrina (UEL), C.P.6001,86051-970, Londrina/PR-Brazil. E-mail pmojneve@uel.br; ² Fellowship CAPES/Univ. Est. de Londrina (UEL), C.P.6001,86051-970, Londrina/PR-Brazil. Fellowship PIBIC/CNPq/UEL, C.P.6001, 86051-970, Londrina/PR Brazil; ³Univ. Fed. Lavras, C.P.37, 37200-000, Lavras/MG-Brazil. E-mail alcmoino@ufla.br.

The in vitro fungitoxic effect of the neonicotinoid insecticides acetamiprid (Saurus 200 SP), imidacloprid (Confidor 700 WDGr) and thiamethoxam (Actara 250 WG) in three SF), imidacioprid (Confidor 100 wDOr) and infamethoxam (Actara 250 wO) in three concentrations (AR= average field recommendation, 0.7AR and 1.3AR) to entomopathogenic fungi *Beauveria bassiana*, *Metarhizium anisopliae* and *Paecilomyces* sp. was studied. The effect of insecticides on conidia germination, vegetative growth and conidiogenesis was compared. Insecticides had no effect on conidia germination, except under the higher concentration (1.3AR) of acetamiprid (Saurus 200 SP), in which significant inhibition of M. anisopliae occurred. B. bassiana and *M. anisopliae* vegetative growth was significantly inhibited by the three concentrations of acetamiprid (Saurus 200 SP) treatment only. Thiamethoxam (Actara 250 WG) treatment, in the AR and 1.3AR concentrations, was significantly inferior, for *B. bassiana* vegetative growth. *Paecilomyces* sp. vegetative growth was higher than that of the control in the following treatments: 0.7AR and AR of acetamiprid (Saurus 200 SP), all concentrations of imidacloprid (Confidor 700 WDGr) and in the two smaller concentrations, 0.7AR and AR, of thiamethoxam (Actara 250 WG). Conidia production was significantly smaller for *Paecilomyces* sp. and *M. anisopliae*, in the higher concentration (1.3AR) of acetamiprid (Saurus 200 SP) treatment and, for Paecilomyces sp., in the higher concentration (1.3AR) of initiacloprid (Confidor 700 WDGr). Thiamethoxam (Actara 250 WG) inhibited *M. anisopliae* conidia production significantly, in the small concentration (0.7AR) only. Significant increase in the conidia production of Paecilomyces sp. fungus was observed in the following treatments: two small concentrations, (0.7AR) and AR of acetamiprid (Saurus 200 SP), and in the two higher concentrations, AR and (1.3AR), of thiamethoxam (Actara 250 WG) treatments. The use of insecticides, in the formulations and tested concentrations, in major cases, has no negative effect on the germination, vegetative growth and conidia production of *B. bassiana*, *M. anisopline* and *Paecilomyces* sp. So in an IPM program where this entomopathogens are important pest regulators this products in this formulations and concentrations may be used.

Index terms: selectivity, acetamiprid, imidacloprid, thiamethoxam.

[2113] GROOMING CAPACITY INHIBITION IN CORNITERMES CUMULANS INOCULATED WITH ENTOMOPATHOGENIC FUNGI WHEN TREATED WITH IMIDACLOPRID

P.J. Neves¹; S.B. Alves² ¹UEL, C.P.6001,86051-970, Londrina/PR-Brazil.E-mail pmojneve@uel.br; ²ESALQ/USP C.P.9, 13418-900,Piracicaba/SP-Brazil. E-mail sebalves@carpa.ciagri.usp.br;

This study was carried out to attest inhibition in C. cumulans grooming behavior when treated with entomopathogenic fungi and sublethal concentrations of imidacloprid insecticide. Observations were made under the Scanning Electronic Microscope (S. E. M.). The 100 and 10 ppm concentrations of imidacloprid were chosen once they provide a sharp reduction in activity soon after contamination and a lower death rate up to 24 hours. So, under these circumstances, the establishment of the pathogen should take place up to a level where it can compete and beat the antagonists present in the host. The grooming capacity in termites may be observed by comparing the quantity of B. bassiana and M. anisopliae conidia deposited on the worker cuticle soon after application and six hours after when no more conidia was observed on the insect. The termite workers showed an efficient grooming mechanism which allowed the removal of all conidia from the cuticle of soldiers and other workers, in the first hours after fungal application. Grooming is carried out by the workers, among themselves and on the soldiers, probably using structures similar to brushes found on the end of the mandibles. When in contact with the insecticide imidacloprid, in sublethal concentrations, there was a inhibition of grooming behavior that allowed conidia to germinate and penetrate the insect cuticle, causing infection. This grooming inhibition occurred because insect activity is considerably reduced with the use of a stressor (imidacloprid) at low concentrations. This association is important for the use of this two entomopatogenic fungi in C. cumulans mount termite field control.

Index termes: Beauveria bassiana, Metarhizium anisopliae, mount termite.

[2114] DEVELOPMENTAL CYCLES OF THE ENTOMOPATHOGENIC FUNGI BEAUVERIA BASSIANA AND METARHIZIUM ANISOPLIAE ON THE TERMITE CORNITERMES CUMULANS AS DETERMINED FROM SCANNING ELECTRON MICROSCOPE (SEM) STUDY

P.J. Neves¹; S.B. Alves² & R. M. Pereira³ ¹UEL, C.P.6001,86051-970, Londrina/PR-Brazil. E-mail pmojnevc@uel.br; ²ESALQ/USP C.P.9, 13418-900,Piracicaba/SP-Brazil. E-mail sebalves@carpa.ciagri.usp.br; ³Dept. Entomology and Plant Pathology, University of Tennessee, PO Box 1071, Knoxville, TN 37901-1071, USA. E-mail rpereira@utk.edu

Techniques for preparation of Beauveria bassiana and Metarhizium anisopliae-treated Cornitermes cumulans for scanning electron microscope (SEM) observation were compared for the external study of fungal development on the insect. Fixation of the insects in 4% glutaral dehyde for 6 hours, followed by immersion in 1% $\mathrm{OsO_4}$ for 1 hour, dehydration in acetone series, and critical-point drying under CO2 provided the best results. The external development of M. anisopliae and B. bassiana on the termite Cornitermes cumulans is study. The observations shows that M. anisopliae conidial germination occurred on several regions of the termite body mainly between 6 and 12 h and penetration mainly between 12 and 24 h after fungal application. Several penetration points were observed originating from the same germ tube. Colonization of the host by M. anisopliae occurred between 24 and 72 h, and most insects died between 72 and 96 h. Conidiogenesis initiated between 96 and 120 h reaching its peak between 144 and 166 h. Development of B, bassiana was similar with mainly conidial germination between 6 and 12 h, and penetration between 12 to the 24 h. Colonization occurred between the 24 and 72 h. Growth of B. bassiana mycelia out of the cadavers and the beginning of conidiogenesis occurred earlier than with M. anisopliae, between 72 and 96 h. Full sporulation of B. bassiana occurred between 120 and 144 h.

Index termes: mount termite, entomopathogens, fixation techniques.

[2115] PATHOLOGY AND SUSCEPTIBILITY STUDIES ON URBANUS ACAWOIOS (LEPIDOPTERA: HESPERIDAE) LARVAE INFECTED BY BACILLUS THURINGIENSIS VAR. KURSTAKI (H-3A:3B)

M. D. Nogueira¹ & <u>M. E. M. Habih²</u>, 1National Institute of Amazon Research (INPA).2Dept. Zoology, IB, University of Campinas (UNICAMP), SP, 13083-970. Email: mohamed@reitoria.unicamp.br

Due to the lack of informations concerning. Urbanus acawoios (Lepidoptera: Hesperiidae), and the severe damage caused by it in Clitoria racemosa trees in Manaus, AM, the present research was conducted. The study was undertaken under laboratory conditions, in order to investigate the possibility of its microbial control, utilizing a commercial formulation, Dipel, based on Bacillus thuringiensis var. kurstaki (H-3a:3b). The larval mid-gut contents of this insect species showed to be highly alkaline, with a pH varying between 8.4 and 9.2, with an average of 8.7, indicating initially, a possible susceptibility of the larval stage to such a pathogen. Such an indication, could be posteriorly confirmed by bioassays. During the preliminary tests, a dosage, equivalent to 110 g / ha $(17.40 \text{ IU/cm}^2 \text{ of leaf-covered} \text{ area})$ was utilized and resulted in median lethal times (LTs₅₀) of 42.28, 37.18, 28.00 and 51.87 hours for the 3^{nd} , 4^{th} , beginning of the 5^{th} and end of the 5^{th} instar active period, respectively. Giving more attention for the 3^{rd} instar larvae, three dosages were applied: 80 g/ha (13 IU/cm²), 150 (25 IU/cm²) and 280 g/ha (45 IU/cm²). In this case, the LTs₅₀ were calculated as 42.62, 30.77 and 30.06 hours, for each dose, respectively. External symptoms of the bacterial disease were studied among 5th instar infected larvae. Cessation of feeding and blockage of food uptake, regurgitation, general paralysis, darkening of tegument reaching black color, are the most important alteration before reaching death. The mid-gut histopathological changes caused by the δ-endotoxin of B. thuringiensis, included enlargement of the epithelial cells, cytoplasm vacuolization, chromatin condensation, dissociation and destruction of the epithelial cell boundaries, degeneration of the epithelial microvillous surface, cell bursting and scattering of their cytoplasmic contents in the lumen. The results obtained during the present work could indicate applications of B. thuringiensis, as a promising method for the microbial control of this urban pest.

Index terms: biology, outbreaks, pathology, entomopathogen.

[2116] ULTRASTRUCTURAL AND MOLECULAR IDENTIFICATION OF A WOLBACHIA ENDOSYMBIONT IN A SPIDER, NEPHILA CLAVATA

H. W. Oh, M. G. Kim, S. W. Shin & H.-Y. Park, Insect Resources Laboratory, Korea Research Institute of Bioscience and Biotechnology, 52 Eoun-dong, Yusong, Taejon, 305-600, Korea, E-mail hypark@mail.kribb.re.kr.

Wolbachia-like bacteria were observed in the egg cells of golden orb-weaving spider, Nephila clavata, by means of transmission electron microscopy. The bacteria exhibited the typical morphology of Wolbachia, including three enveloping membranes. Based on the amplification and sequencing of partial 16S rDNA and ftsZ gene, the bacteria were identified as Wolbachia, intracellular, transovarially inherited α proteobacteria in invertebrates. Phylogenetic analysis based on 16S rDNA and ftsZ gene sequences invariably indicated that the intracellular bacteria from N. clavata belonged to group A Wolbachia, which were found only from insects. Clustering of Wolbachia from N. clavata with group A Wolbachia indicates that the bacteria were probably transferred horizontally from insects to the spider via predator-prey relationship.

Index terms: intracellular bacteria, phylogenetic analysis, 16S rDNA, ftsZ gene

[2117] SELECTION OF CULEX QUINQUEFASCIATUS POPULATION RESISTANT TO BACILLUS SPHAERICUS STRAIN 2362

C. M. F. Oliveira¹, M. H. N. L. Silva-Filha¹, <u>M. A. V. Melo²</u> & L. Regia¹, ¹Dept. de Entomologia, Centro de Pesquisas Aggeu Magalhães/FIOCRUZ, Av. Moraes Rego, CEP-50670-420, Brazil, E-mail mavarjal@cpqam.fiocruz.br. ² Mest. em Biologia Animal, Dept. de Zoologia, Univ. Fed. de Pernambuco, Av. Moraes Rego, CEP-50670-420, Recife, PE, Brazil. Supported by FACEPE/FIOCRUZ and OMS.

Bacillus sphaericus (Bs) products have been successfully used in vector control programs in many countries. Recently, Bs resistance has been reported in Culex field populations from Brazil, India, France and China. The present study aimed to select a resistant population of C. quinquefasciatus to Bs 2362 strain and to investigate the resistant population of C. quinquefasciatus to BS 2502 strain and to investigate the resistance mechanism. The potential of Bs strain IAB59 as an alternative for controlling resistant larvae was also studied. C. quinquefasciatus population was selected in laboratory from eggs rafts collected from several breeding sites in a district of Recife city, Brazil. A selection pressure between 50 and 94% was imposed to close to 10,000 4th instar larvae at each generation, throughout 35 generation's (F35). This population showed at F18 a low level resistance: the resistance ratio (RR) reached 18fold. The continuous selection of this population leaded to a RR close to 2,500-fold at F35. Preliminary "in vitro" binding assays between the radiolabelled Bs toxin and brush border membranes fraction (BBMF) from larvae midgut suggested that resistance mechanism observed at F35 is correlated to a very low specific binding between the toxin and the BBMF. Investigation of cross-resistance to other Bs strains showed that larvae from F35, highly resistant to the strain 2362, are susceptible to the strain IAB 59 since It displayed a RR of 6-fold only. Those strains might show different modes of action and IAB59 is a promising agent to the management of Bs resistance in mosquito populations.

Index terms: Bacillus sphuericus, Culex quinquefasciatus, resistance, cross-resistance

[2118] VIRULENCE OF BEAUVERIA BASSIANA ISOLATES TO OLIGONYCHUS YOTHERSI (ACARI: TETRANICHIDAE)

<u>R.C. Oliveira</u>¹, L.F.A. Alves² & N.L. Gais², ¹UEL, Dept. de Agronomia, C.P. 6001, 86051-970, Londrina, PR, Brazil; ²UNIOESTE/CCBS, R. Universitária, 2069. Cascavel/PR, Brazil, CEP: 85814-110, E-mail: lasg@unimidia.com.br

Ilex paraguariensis ("erva mate") is the important culture in some region of Brazil, Argentine and Paraguay. Its foliage is used to prepare tea and "chimarrão". The monoculture plantation of erva mate favored the occurrence of phytophagous insects and mites, including Oligonychus yothersi. This mite has been commonly observed in the last years in Brazil. They cause the premature defoliation reducing the leaves production. Aiming minimize the use of chemical acaricides the studies were carried out at Laboratory of Zoology of UNIOESTE at Cascavel, State of Paraná, Brazil. It was evaluated the pathogenicity and virulence of 21 isolates from entomopathogenic ungus Beauveria bassiana to control of Oligonychus yothersi. The isolates were obtained from the collection of Biological Institute Experimental Center in Campinas, state of São Paulo, Brazil. The water suspensions with 1,0 X 108 conidia/mL were sprayed on the leaf discs with 20 adult females of mites. After the application, the leaf discs were transferred to B.O.D. chamber for incubation at 26 ± 1°C, 80 ± 10% of relative humidity and 14 hours of photophase. It was verified that all isolates were pathogenic to the mites causing 30 to 90% of corrected mortality and means values of LT_{50} ranging from 3 to 5 days. Six days after inoculation, CB82, CB84 and CB87 isolates were the most virulent killing 90% of mites. The reproduction of fungus on the cadaver was highest for CB31, CB64 and CB87 isolates and the last one was the most promising to control O. yothersi.

Index terms: Oligonychus yothersi, microbial control, mite, acari.

[2119] CHARACTERIZATION OF THE PROTEOLYTIC ACTIVITY OF ANTHONOMUS GRANDIS AND ISOLATION OF CDNAS ENCODING SERINE AND CYSTEINE PROTEASES

O. B. Oliveira-Neto^{1, 2}, J. A. N. Batista¹, R. R. Fragoso^{1, 2}, S. C. Dias^{1,2}, R. G. Monnerat¹ & <u>M. F. Grossi-De-Sá</u>¹, ¹ Embrapa Recursos Genéticos e Biotecnologia, SAIN Parque Rural, Caixa Postal 02372. Brasília, D.F. Brasil, e-mail fatimasa@cenargen.embrapa.br²Depto. de Biologia Celular, UnB, Brasília, Brasil

Anthonomus grandis (Coleoptera: Curculionidae), the boll weevil, has a widespread distribution in Brazil, and is an important pest of cotton (Gossipium hirsutum). Control by conventional means is especially difficult due the build up of resistance to pesticides within the population. The insect localization in the buds also provides protection against pesticides. We have investigated proteolytic activities in the guts of larval A. grandis and have shown it to be largely due to extracellular serine proteases and less abundant cysteine proteases in both larval and adult stages. Amplification by RT-PCR with primers for both protease classes, using total RNA from larval stage, has lead to the isolation of several incomplete cDNAs encoding six serine and two different cysteine protease classes. The sequences of the serine proteases show a high degree of divergence between themselves and little similarity with other serine proteases sequences present in the database which participate in many vital physiological process, from nutrition to morfogenetic regulation. Based on 5' and 3' RACE techniques, the complete cDNAs sequences were isolated. The availability of these protease genes will allow their in vitro expression and the selection of specific inhibitors through the screening of a library of mutant inhibitors by phage display. The regulation of these protease-encoding genes, and the nature of the response to dietary protease inhibitor, are relevant for the elucidation of the mechanism of induced insensitivity to protease inhibitors.

Supported by EMBRAPA, PADCT and CNPq. Index terms: cotton, physiological process

[2120] THE EFFECT OF CULTURE MEDIA ON VIRULENCE OF PAECILOMYCES AMOENEROSEUS ON SILVERLEAF WHITEFLY BEMISIA ARGENTIFOLII

G.Ottoni¹ & R.Creamer², ¹Universidade Federal de Goiás, Escola de Agronomia, Cx. P. 131, Goiânia, GO, Drazil, Cep: 74001-970, e-mail ottoni@agro.ufg.br; ² New Mexico State Univ., Dept of Entom., Plant Path. and Wood Sciences, Box 30003/MSC 3BE, Las Cruces NM, 88003, U.S.A.

In the Centro Oeste Region in Brazil, an entomopathogenic fungus had been isolated from Tibraca limbativentris (Hemiptera: Pentatomidae) in 1986. The fungus, identified as Paecilomyces amoeneroseus, was gently sent by Embrapa-Rice and Beans to the U.S.A., and it's potential as a biological control agent against Bemisia argentifolii has been reported. The future success of this fungus as a commercial insecticide depends upon developing effective and practical culturing techniques. By testing different media, we can determine which promotes faster growth or better sporulation of the pathogen, without compromising its virulence. Different culture media have been used for Paecilomyces spp. and other entomogenous fungi. The objective of this experiment, carried out at the University of California, Riverside, was to screen five different culture media for their ability to promote growth, sporulation, and virulence of *P. amoeneroseus*. Silverleaf whiteflies collected from agricultural areas in the Imperial Valley, CA, and CP211 was the fungal isolate. Colony growth was more rapid on modified Czapeck-Dox and PDA than on Yeast Extract or modified NRRL Cornsteep/Molasses media. Conidia production was greatest on the modified NRRL Cornsteep/Molasses medium, however this medium resulted on slow radial growth. A difference in virulence of isolates growing on these five culture media was not detected, although colony coloration varied. Other features such as conidia shape and size remained invariable. Synnemata production was not observed on any of the assayed media. When molasses was added to the NRRL Cornsteep medium, conidia production increased, which leads us to recommend it as a good medium for P. amoeneroseus. The experiment revealed that saprophytes produce conidiophores external to the insect cadaver, which could be mistaken for the sprayed entomopathogen, leading to inaccurate mortality assessment in biological control assays. It is necessary to re-identify fungi on dead whiteflies showing fungal sporulation and to verify that it is not a saprophyte. We suggest that these procedures become routine in biological control experiments.

Index terms: entomopathogen, virulence, culture media, sporulation, biological control

[2121] SUSCEPTIBILITY OF DIFFERENT LIFE STAGES OF *BEMISIA ARGENTIFOLII* TO THE ENTOMOPATHOGENIC FUNCUS *PAECILOMYCES AMOENEROSEUS*

<u>G. Ottoni</u>¹ & R. Creamer², ¹Universidade Federal de Goiás, Escola de Agronomia, Cx. P. 131, Goiânia, GO, Brazil, Cep: 74001-970, e-mail ottoni@agro.ufg.br; ² New Mexico State Univ., Dept of Entom., Plant Path. and Wood Sciences, Box 30003/MSC 3BE, Las Cruces NM, 88003, U.S.A.

A variety of entomopathogenic fungi have been reported to infect whiteflies Bemisia spp., offering potential for biological control. The age and the stage of an insect can affect the susceptibility to an entomopathogenic fungus. The objective of this study was to determine the influence of insect life stage on *B. argentifolii* Bellows and Perring susceptibility to *Paecilomyces amoeneroseus* (Hennings) Samson. Bioassays were carried out with P. amoeneroseus isolate CP211, obtained from Embrapa-Rice and Beans located in Goiânia, Brazil. Silverleaf whiteflies (B. argentifolii) were collected from agricultural areas in the Imperial Valley, California. Conidial suspension adjusted to 108 spores/ml was sprayed onto bean plants containing all life stages of the whitefly. After spraying, plants were kept in cages under controlled conditions. Mortality was evaluated 7 days after spraying and quantified as the percentage of infected eggs, nymphs and adult whiteflies per each two leaves, compared to the water-Tween-sprayed control. Insects were considered infected when mycelial growth could be observed external to the cadaver. Abbot's adjustment (Abbot, 1925) was used in the analysis because some mortality is caused by exposure to water spray and saprophytic fungi can grow on dead insects. The results of this experiment showed a significant difference in the susceptibility of adults, nymphs and eggs under laboratory conditions. The adult stage suffered the highest infection rates (67%). Nymphs were also susceptible, although levels were less than 9% infection. Efficacy of P. amoeneroseus against whitefly nymphs does not reach levels as high as other entomopathogens. However, this fungus causes a much faster infection under laboratory conditions, killing the insect in just 4 to 7 days. Eggs of whitefly species usually present low rates of infection or even no infection at all. Our results showed a frequency of 4.1% eggs infection.

Index terms: Bemisia argentifolii, Paecilomyces amoeneroseus, biological control

[2122] PIPERONYL DERIVATES BASED ON SESAMIN AND THEIR INHIBITION OF THE SYMBIOTIC FUNGUS OF LEAF-CUTTING ANTS

<u>F.C.Pagnocca¹</u>, S.R.Victor¹, O. C. Bueno¹, M.J.A. Hebling¹, M. Bacci Jr.¹, F.R.Crisósotomo² & J.B. Fernandes², ¹ Centro de Estudos de Insetos Sociais, Universidade Estadual Paulista,UNESP, Campus de Rio Claro, Caixa Postal 199, CEP 13506-900, Rio Claro,SP, Brazil, Email: pagnocca@rc.unesp.br; ² Departamento de Química, Universidade Federal de São Carlos, Caixa Postal 676, CEP 13565-905, São Carlos.SP, Brazil

Leaf-cutting ants are dominant herbivores and significant pests in agriculture and forestry in Brazil. They use plant material as substrate for culturing a symbiotic fungus. The ants exhibit preference for some plant species in a process related with chemical and physical properties of the plants. Virola sebifera Aubl. (Myristicaceae) is a native species of Brazil's cerrado which produces some lignaus sazonally. In a previous work we have described that some lignans are inhibitory for the development "in vitro" of the fungus Leucoagaricus gongylophorus and sesamin, a furofuranic lignan, was the most toxic of them. Six compounds were synthetized having the sesamin moiety as a model for evaluation of their activity towards the fungus. Thus, three of them were 3,4 methylenedioxybenzyl ethers and the others were 3,4 methylenedioxybenzyl (hydroxy) ethers. The assays of fungal inhibition were performed by addition of these compounds to the culture medium at concentration increasing from 10 µg/mL to 100µg/mL at 10 µg/mL intervals. A mycelial suspension containing 4.5 ± 0.5 mg dry weight/mL was inoculated in the tubes which were incubated at $25^{\circ}C$ / 30 days. The results were expressed in percentage of inhibition in relation to the control. For concentrations of 25µg/mL through 100µg/mL we found 80-90% of inhibition on fungal development In both groups of compounds the best inhibitory effect was observed with those compounds having eight carbons in the side chain. This inhibition was correlated with the size of the side carbon chain. Other compounds with similar basic structures are being developed in order to evaluate if the inhibitory effect can be enhanced with longer side chains. Index terms: Piperonyl compounds, antifungal activity, Atta sexdens, Leucoagaricus gongylophorus

[2123] FUNGI ASSOCIATED TO SCOLYTIDAE BEETLES IN PUERTO RICO

F. II. Pedreros¹ & J. D. Lodge², ¹Dept. of Biology, Univ. of Puerto Rico, P O Box 23360, San Juan 00931-3360 Puerto Rico, E-mail f.pedreros@eudora.com, is975999@upracd.upr.clu.edu; ²USDA-Forest Service, Palmer 00721, Puerto Rico.

Bark beetles (Coleoptera: Scolytidae) are well known by their ability to bore in both living and decaying woody tissues. Most of the species live symbiotically with fungi, which help the insects in establishing an appropriate brood chamber and, in some cases, constitute the only food source of the insects. In this work we sampled Scolytidae from some common plants in Puerto Rico (Caoba: *Swetenia mahogany* and *Plumeria alba*) and we study the structure and composition of the Scolytidae associated funga! community. We found four taxa of beetles: three morphospecies of *Xyleborus* and one *Hypotenomus*. Most common symbiont fungi were *Ophiostoma*, *Ceratocystis* and their anamorphs. An insect pathogen, *Metarrhizium* was also found. Additionaly, we found *Fusarium*, a potential plant pathogen. Other environmentally common fungal taxa, as *Penicillium*, *Trichoderma* and *Ciadosporium*, were found associated to Scolytidae too. There are enough data to suspect that Scolytidae are able to disperse plant pathogens, and this trait associated to their boring ability, places Scolytidae as an economically important taxon.

Index terms: Ophiostoma, Ceratocystis, beetles and fungi

HYPOTHENEMUS HAMPEI

<u>R.C. Pereira</u>, J. O. G. de Lima & R. I. Samuels, Department of Plant Protection, Universidade Estadual do Norte Fluminense, Campos dos Goitacazes, RJ 28015-620, Brazil, E-mail richard@uenf.br.

The coffee berry borer (CBB) is considered to be one of the most important pest species of coffee. CBB originated in Africa but has now spread to all major coffee growing regions of the world. This insects life cycle, spending prolonged periods within the coffee berry, means that conventional as well as biological control methods have failed to prevent serious crop losses. Entomopathogenic fungi appear to be good candidates for biological control as natural epizootics have been regularly reported, causing significant reductions in the pest population. However, applications of *Beauveria bassiana* under field conditions in Colombia, have been very disappointing. Therefore, the pathobiology of the interaction between CBB and entomopathogenic fungi such as B. bassiana and Metarhizium anisopliae, requires further investigation. In order to study virulence of fungal isolates utilising a non-intrusive method of infection, CBB were exposed to conidia which had been applied to filter paper, noninfested coffee grains and coffee grains recently infested by CBB. None of the fungi used here were isolated from CBB, however all 3 isolates tested were pathogenic to CBB. In the first tests, CBB were exposed to filter paper onto which had been applied 1×10^7 conidia⁻¹ of each isolate tested. The values for TL₅₀ were 4.12 days (LPP1: B. bassiana); 5.2 days (CG11; B. bassiana); 6.07 days (E-9; M. anisopliae). The most virulent isolate from the first tests, LPP1, was then applied to infested and non-infested coffee grains using 3 concentrations of inoculum (1 x 10⁷; 1.2 x 10⁶; 1 x 10⁵ conidia⁻¹). At the highest concentration used here, CBB mortality was 80% when insects were exposed to non-infested grains which had been treated with conidia. The same concentration of conidia applied to already infested grains caused 65% mortality. These results indicate that applications of fungi should be made before or shortly after CBB infestations. We are currently comparing the virulence of B. bassiana found naturally infecting CBB, with isolates from other host insects.

Index terms: Beauveria bassiana, Metarhizium anisopliae, biological control, entomopathogenic fungi.

[2125] GENETIC VARIABILITY AMONG BEAUVERIA BASSIANA AND PAECILOMYCES FUMOSOROSEUS.

<u>B. Pereyra-Alférez</u>, L. Galán-Wong, M. Iracheta, C. Rodríguez-Padilla, J. Contreras & R. Tamez-Guerra.

Depto. de Microbiología e Inmunología. Fac. Ciencias Biológics/UANL. México. Av. Dr. Pedro de Alba y Av. Manuel Barragán. Cd. Universitaria. San Nicolás de los Garza, N. L. CP. 66450.

Beauveria bassiana and Paecilomyces fumosoroseus represent two of most efficient biological tool for Bemissia tabaci (whitefly) control. In order to evaluate the genetic variability among B. bassiana and P. fumosoroseus strains, we performed a random amplified polymorphic DNA (RAPD) system. Our assays were carried out using 20 primer containing 60-70% GC. Both fungi strains were isolated in USA and México from whitefly (16), Trichoplusia ni (4), ant (2) and domestic fly (4). The strain were grown on YPD-broth for 4 days at 28°C and total DNA was purified. The RAPD's were made by duplicate and repeated twice using 2 independent DNA samples. RAPD products were loaded on polyacrylamide gels. Both fungus yielded consistent and reproducible DNA band profile, 2 to 17 DNA bands, ranging from 0.1 to 4.0 kbp, with 8 primers High variability was observed within B. bassiana strains was observed. The B. bassiana strains share only one band of 0.7 kbp. This band was constant in all isolates and it was independent either geographic origin or insect host. However, the P. fumosoroseus strains displayed very similar DNA pattern band. Results with OPA-13 primer showed a profile of 4 bands, 2 very conserved not only in size (0.1 and 1.1 kbp), but also in intensity, the exception was a mexican whitefly isolate, who did not yield minor band. The dv (dissimilarity value, 1-F) was calculated. The P. fumosoroseus strains showed a dv= 0.48 and B. bassiana a dv=0.55. These values reveled that B. bassiana had more divergence than P. fumosoroseus. This fact might be related with origin of the samples, because while main P. fumosoroseus strains were isolated from B. tabaci, B. bassiana ones were obtained from different host. In order to know the similarity and relationship within fungus, we done a cluster analysis for each genus. This analysis reveled high similarity between host or geographic origin in both genus.

Paecilomyces fumosoroseus, Beauveria bassiana, RAPD, Genetic variability

[2126] CODLING MOTH (CYDIA POMONELLA) AND THE USE OF GRANULOVIRUS IN ORGANIC AND INTEGRATED CONTROL

F. Polesney, BFL, Inst. of Phytoemd. Spargelfeldstr. 191, A-1220 Vienna, Austria

The CpGV product Carpovirusine was registered for control of codling moth in Austria some years ago. There are two nearly overlapping codling moth generations per annum in Austria. The egg laying period of the first generation lasts for about one and a half months. The egg laying period of the second generation lasts for more than a month. The use of CpGV against *Cydia pomonella* was evaluated in field trials. An effective treatment strategy using only CpGV requires a large number of applications during the whole period of larval hatching. Weekly applications are successful but applications at two week intervals results in an enormous decrease in efficaey. There are good opportunities to implement CpGV in integrated treatment strategies. There is no danger of cross resistance to other compounds used in Integrated Fruit Production. The combined use of CpGV with ovicidal insect growth gives good results and requires a reduced number of applications compared with traditional use of single compounds. The results of the different field trials are presented and discussed. Index terms: orchard, fruit, *Cydia pomonella*, baculovirus, granulovirus, biological control

[2127] CONTROL ASPECTS OF ORYZOPHAGUS ORYZAE WITH BEAUVERIA BASSIANA, METARHIZIUM ANISOPLIAE AND FIPRONIL IN WATER-SEEDED RICE

II. F. Prando¹, D. R. Sosa-Gómez² & G. H. Rosado Neto³, ¹EEI-Epagri, Cx. Postal 277, 88301-970, Itajaí, SC, Brazil. E-mail: hfprando@zaz.com.br; ²Embrapa Soja, Email: sosa@cnpso.embrapa.br; ³Zoologia/Entomologia UFPR E-mail: pgento@ufpr.br

The rice weevil Oryzophagus oryzae (Costa Lima) is associated with rice yield losses in Rio Grande do Sul and Santa Catarina states, Brazil. In Rio Grande do Sul, annual losses range from 13.5 million dollars to over 21.0 million dollars. In order to minimize this, rice growers use extremely toxic insecticides with irrigation water. The laboratory tests were concerned with the viability and susceptibility of the entomopathogenic fungi *Metarhizium anisopliae* (CNPSoMa12) and *Beauveria* bassiana (Ep01 and CB66) to sunlight and ultra-violet light. The effect of cuticle lipid extracts of O. oryzae and Cosmopolites sordidus Germar on these microorganisms, was investigated. O. oryzae and C. sordidus lipid extracts and hexane and three isolates of entomopathogenic fungi (Ep01, CB66 and Ma12) were used in a 3 x 3 factorial design. The field experiments were conducted in two consecutive years. A total of 13 treatments in four replications and in a completely randomized plots (3 m x 6 m) was used. Rice cultivar, Epagri 108, was water- seeded under 10 cm layer of water. All treatments were hand applied using a watering pot three days after seeding, except where seeds were treated. The viability rate of conidia isolates of M. anisopliae and of B. bassiana was 95%, 89% and 86% for isolates Mal2, Ep01 and CB66, respectively. The isolate CB66 was significantly affected by sunlight after a 4 hourexposition. The cuticle lipid extract of O. oryzae significantly stimulated germination compared to the cuticle lipid extract of C. sordidus. The isolate Ep01 showed greater germination and growth performance. Field experiments showed that biological and chemical treatments reduced significantly the amount of O. oryzae in treated plots as compared to control treatment. Fipronil treatments caused significantly reduction on the number of larvae, higher plants and lower water content of grains. The use of the entomopathogenic fungi *B. bassiana* and *M. anisopliae* to control *O. oryzae* is a feasible practice applied in combination with chemicals. Fipronil is efficient to control O. orygae and can be applied by hand (watering pot) after seeding or by seed treatment methods.

Index terms: biological control, microbial

[2128] POINT Contamination of gypsy moths population by LdNPV by means of pheromone traps

<u>O.Pultar</u>¹ & M.Švestka², ¹Biola laboratories, Agricultural Cooperative, Chelčice, Vodňany 38901, Czech Republic, biola@iol.cz; ²Výzkumný ústav lesního hospodářství a myslivosti, Dvo řákova 21, Znojmo 66902, Czech Republic.

The method of attractant aided dissemination of Lymantria dispar polyhedrovirus (LdNPV) was examined in the oak. The hypothesis of these experiments is: Males attracted into pheromone traps will be contaminated by virus, this one will be transferred to females during copulation and after by females on the eggs or/and on the place of oviposition. Virions should be able to infect the caterpillars during hatching or they can be contaminated by virions and then transfer them on their bodies into canopy of trees and to start infection during feeding by contaminated leaves. In 1998 density of pheromone traps was examined which is able to contaminate population of the gypsy moth without an efect of disruption. Number od 8 (plot A) or 16 (plot B) cylindrical traps with contaminating mixture (indifferent filling material, LdNPV and fluorescent paint for marking of males) were installed per hectar on the twoo plots 3 ha each. 3 monitoring pheromone traps and 2 traps with caged virgin females and sticky inserts for recapturing of males were installed on the same plots and on the check plot without contaminating traps (plot C). Recaptured males were examined under UV light. There 6.1; 10.3 and 8.7 males per one pheromone trap or 2.0; 6.8 and 11.0 per one female-containing trap were catched on the plot A, B and C, respectively. 31% and 34% of the males captured into pheromone traps and 25%, 11% and 21% of the males captured into female-containing traps were marked in the plot A, B and C, respectively. In 1999 different forms of pheromone traps (cylindrical and delta-shaped) were examined installing 4 cylindrical and 4 delta traps/ha on the area of 3 ha. Average contamination 40% of recaptured males was detected. 9% and 29%originates in the delta traps and cilindrical traps, respectively and 2% in the other experimental plot. These results are presented and diskused in the poster. Index terms: Lymantria dispar, fluorescent point, delta trap, cylindrical trap

[2130] ULTRASTRUCTURAL ASPECTS OF THE COLONIZATION PROCESS OF ECDYTOLOPHA AURANTIANA BY THE ENTOMOPATHOGENIC NEMATODE STEINERNEMA GLASERI

J. C. V. Rodrigues¹; M. M. Aguillera² & J. F. Garcia², ¹ Centro de Energia Nuclear na Agricultura, Univ. de São Paulo, C. Postal 96, 13400-970 Piracicaba, SP, Brazil. Email: jcvrodri@cena.usp.br. /Centro de Citricultura –Inst. Agron. de Campinas; ² Centro de Ciências Agrárias, Univ. Fed. de São Carlos, C. Postal 153, 13600-970 Araras, SP, Brazil. E-mail: marineide@dbv.cca.ufscar.br.

The lepidopteran Ecdytolopha aurantiana is an old Brazilian citrus pest, that in the larval phases attacks citrus fruits, mainly sweet-oranges. Recently, that species presented outbreaks, responsible for great economic losses, estimated in US\$ 50 million in 1999. Intensive search for efficient control methods that might contribute to the reduction of the pest population levels in orchards has been developed. The proposal of using entomopathogenic nematodes to control this pest is recent. This work reports ultrastructural observations of the larval colonization process in the last larval instar by the entomopathogenic nematode, Steinernema glaseri, isolated from Sta. Rosa de Viterbo, SP-Brazil. Larvae with characteristic signs of nematode infection (cadavers infected were flaccid and brown colored) were prepared for observation at the transmission (TEM) and scanning (SEM) electron microscopes. The specimens were fixed in glutaraldehyde - paraformaldehyde; post-fixed in osmic acid and dehydrated in acetone. For TEM analysis, specimens were embedded in epon resin and sections were stained with uranyl acetate, lead citrate and examined in a Zeiss EM 900 microscope. For SEM analysis, specimens were dryed by critical point (CO2 liquid) and sputter with gold. Control specimens without nematodes exposition were also prepared. Ultrathin sections of infected larvae indicated the nematode colonization and showed bacterial presence associated to the colonized places of the larval body, fact that is explained by this entomopathogenic nematode group feeding and acting in association to symbiontic bacteria. In the last incubation period (96 hours) the nematode number observed was high, occupying practically the whole larval body. This suggests a great rate of this nematode reproduction in E. aurantiana and also the high potential of this biological control agent for this pest. Index terms: Citrus, biological control, electron microscopy

[2129] WHITEFLIES AND THEIR PARASITOIDS' STATEMENTS IN HORTICULTURAL PROTECTED CROPS IN PORTUGAL

M.R. Queirós, C. Marques, <u>E. Figueiredo</u> & A. Mexia, DPPF-SAPI, Instituto Superior de Agronomia, Tapada da Ajuda, 1349-017 Lisboa, Portugal; E-mail elisalacerda@isa.utl.pt.

Whiteflies are a key pest in horticultural protected crops in Portugal. The Trialeurodes vaporariorum species is already reported all over the country and is the only species found in the region of the Ribatejo e Oeste, in a preliminary study carried through the period of 1996 the 1998 (Marques & Mexia, 1998). The Bemisia tabaci species, detected in 1992 in the Algarve region, is causing serious losses to the tomato growers, in the last years, because of the transmission of the TYLCV (Louro et al., 1996). A monitoring scheme for this species was set up in the Ribatejo e Oeste region in order to evaluate its presence related with the risk of TYLCV infection. Leaves/leaflets infested with "pupae" and nymphs of whitefly species were collected on tomato crops at 85 greenhouses from June to December 1999. Identification of the specimens was made based on the differential morphological characteristics of the emerged adults or, in case of doubt, by diafanization and microscopic observation of relevant characters. Although B. tabaci have been already found punctually in outdoor in the region, its presence was not observed in the studied greenhouses. Climatic factors like relative humidity and temperature conditions may not be favourable to the proliferation of the species (Queirós et al., 1999). However, it was detected, an increase of the populations of B. tabaci in relation to species T. vaporariorum in Algarve protected crops. In order to confirm the displacement of T. vaporariorum by B. tabaci, infested leaves/leaflets were collected in this region in 45 greenhouses, at two moments, June and October, periods of population peaks of species B. tabaci. The parasitoids species Encarsia formosa, Encarsia pergandiella, Encarsia tricolor and Amitus fuscipennis found in a preliminary study in the Oeste region at 1996-1998 (Marques & Mexia, 1999) were found in both Ribeteio e Oeste and Algarve region. However, other species were observed in the Algarve region waiting for identification.

Index terms: Bemisia tabaci, Trialeurodes vaporariorum, Encarsia sp., TYLCV

[2131] INSECTS AFFECTING SWEETPOTATO HARVEST

D. S. Ruberti¹ & M. M. Scandiani¹, ¹Laboratorio Agrícola Río Paraná. Ruiz Moreno 225, San Pedro, Buenos Aires, 2930, Argentina. E-mail: Erro! Indicador não definido.

The sweetpotato crop grows during spring and summer when the population insects are highest. The roots are attached since development beginning until harvest time. When insect attacks are very important, the sweetpotatoes commercial quality decreases considerably. During the 1998/1999 season, ten checks plots of 50 m length by 4 m with, placed in San Pedro area, were sampled at harvest time. There were not treated with insecticides. It was taken the 10% of the production from each check plot to analyze. As a result the following insect damage was determined: wireworms: 60 %, *Diabrotica sp.*: 55%, Other white grubs: 20%. These evaluations include since a few to a lot of damage. The lost threw away harvest was 54% due to the intensive damage caused by insect attack. These percentage are higher than those from the two last years, 21% (1996/97); 39% (1997/98). Index terms: wireworms, while grubs, damage

[2132] CARACTERIZATION OF NEW STRAINS OF BACILLUS THURINGIENSIS TOXIC AGAINST BOLL WEVILL, ANTHONOMUS GRANDIS

S. C. Dias, R. P. Pessanha, O B. Neto, M. F. Grossi De Sá & <u>R. G. Monnerat</u>, Embrapa Recursos Genéticos e Biotecnologia, SAIN Parque Rural, Caixa Postal 02372. Brasília, DF, e-mail: rose@cenargen.embrapa.br

The boll weevil, is a major pest of cotton in subtropical and tropical areas of the America continent. Most species of Anthonomus has preference for floral buds and fruits of its target plant. The infected tissues are used as food source and as development habitat, causing damage to cotton fibers. The control of this pest can be done by chemical methods and earliness cultivars. Presently, only broad spectrum insecticides are used to control this insect. If any efficacious biological agent became available which avoided the upsets in natural control typically associated with broad spectrum insecticides it could become an important component of cottton IPM programs througout the America. The complex spore-cristal of native strains of Bacillus thuringiensis was added to artificial diet. Neonate larvae, 48 hs after hatching, were puted in small orificie in artificial diet in Petri dishes. After four days the mortality of larvae was evaluated and the survivors were transfered to a new diet without Bacilus. After 15 days the final mortality was calculated. It analized 11 strains of Bacillus thuring iensis and % mortality range from 72,4 (S1342) 50,6 (S725). The % mortality in the control treatment was satisfactory. The positive control was Bacilus thuringiensis subesp. tenebriones which mortality range 50 a 70%. All the strains evaluated showed similar mortality to Btt, which is reference strain for mortality in Coleoptera.

Index terms: cotton, complex spore-cristal

[2133] POTENCY OF *BACILLUS THURINGIENSIS* AGAINST INSECTS OF STORED PRODUCTS

H.S. Salama & A. Abdel-Razek, National Research Centre, Dokki, Cairo, Egypt

Isolates of *Bacillus thuringiensis* (*B.t.*) were obatined from 56 samples of grains and flour mills in Egypt and Canada. Classification according to crystal morphology indicates dominance of the bipyramidal crystal type in isolates from grain samples while the bipyramidal and bipyramidal-rectangular types dominated other types in isolates from flour mills. Serological techniques were used to categorize *B.t.* isolates. Polymerase Chain Reaction (PCR) has been also used to allow rapid determination of the presence or absence of DNA sequence. A bioassay was made to determine the potency of the active isolates against the Indian meal moth *Plodia interpunctella* and the red flour beetle *Tribolium castaneum*. A high activity against *P. interpunctella* was recorded for the isolate coded E-AS16A (*B.t.* var. *indiana*) with LC₅₀ of 17.5 ug/g compared to 31.35 ug/g for the standard HD-1-S-1980. With *T. castaneum*, the highest activity was recorded for the isolate coded E-AS16B (*B.t.* var. *morrisoni*) and the LC₅₀ was 1921 ug/g. The susceptibility of different larval instars of both insect species to *B.t.* var. *morrisoni* has been investigated and showed a decrease with increasing age. Index terms: *Plodia interpunctella*, *Tribolium castaneum*, PCR, serology, *B.t.* isolates. [2134] DEVELOPMENTAL STAGES OF PHTHORIMAEA OPERCULELLA AS AFFECTED BY BACILLUS THURINGIENSIS

H.S. Salama & M. Sabbour, National Research Centre, Dokki, Cairo, Egypt

Bacillus thuringiensis var. galleriae HD-234 (B.t) affects the different larval instars of the potato tuber moth Phthorimaea operculella in varying degrees showing a gradual increase with the increase of the larval age. This endotoxin also showed an activity against other developmental stages. Prepupae and pupae sprayed with B.t. gave malformed moths with short longevity, low egg production and fertility. The effectiveness of B.t. has been also demonstrated against the moth and eggs. The moth longevity, egg production and fertility were affected when fed on sucrose diet with B.t. at certain concentrations; the effect progressively increased with the increase of concentration of the endotoxin. When egg masses were sprayed with B.t. the incubation period was prolonged. The survival of the hatched larvae was reduced when treatment was made shortly before egg hatching. On the basis of these findings, B.t. sprays may be recommended against various developmental stages with significant prospectives.

Potato tuber moth, pupae, eggs, B.t. var. galleriae

[2135] POTENTIATION OF *BACILLUS THURINGIENSIS* AGAINST LEPIDOPTEROUS INSECTS USING SAFE CHEMICAL ADDITIVES

II.S. Salama, National Research Centre, Dokki, Cairo, Egypt.

Biochemical appreaches have been developed to potentiate the activity of Bacillus thuringiensis (B.1.) varieties against various lepidopterous insects including Spodoptera littoralis, Agrotis ypsilon, Plodia interpunctella, Chilo agamennon and Pyrausta nubilalis. These approaches were based on the incorporation of some selected safe, non toxic and cheap chemicals with the endotoxin fed to the insect larvae. The tested chemicals include inorganic salts, protein and lipid solubilizing agents, amino acids and amides. Some of these chemicals significantly enhanced the endotoxin potency against the tested species but in varying degrees. Examples of the tested inorganic salts were CaCO₃, CaO, ZaSO₄ and K₂CO₃ (0.1 %) which increased the B.1. effectiveness by many folds against target insects. Large scale field experiments confirmed these results against lepidopterous insects on different field and vegetable crops. The mode of action of the tested compounds has been dicussed in the light of the results obtained.

Index terms: Inorganic salts, amino acids, protein solubilizing agents, Spodoptera littoralis

[2136] THE USE OF *BACILLUS THURINGIENSIS* TO CONTROL LEPIDOPTEROUS INSECTS ON POTATO CULTIVATIONS IN EGYPT

H.S. Salama, S.A. Salem, F.N. Zaki & A. Abdel-Razek, National Research Centre, Dokki, Cairo, Egypt.

The possible use of *Bacillus thuringiensis (B.t.)* preparation (Dipel 2X) as a substitute for chemical insecticides (Lannate and Hostathion) was evaluated against the two major insect pests of potato crop, *Agrotis ypsilon* and *Spodopera exigua*. Both the biopesticide and chemical insecticides were effective on the target insects. One spray or bait application of Dipel 2X at the rate of 750 gm/feddan provided a satisfactory protection of the potato crop against infestation with *A. ypsilon* or *S. exigua*. The average yield obtained from treated plots was 5.52 ± 0.33 tons/f compared to 5.9 + 0.4tons/f from plots treated with the chemical insecticide Lannate spray or Hostathion bait. The average yield in the control plots was significantly lower being 2.1 ± 0.32 tons/f. Incorporation of calcium oxide, significantly potentiated the effectiveness of *B.t.* against the target insects under field conditions. These results increase the promising prospectives and encourage the utilization of safe *B.t.* preparations as a substitute of hazardeous chemical insecticides against lepidoptera infesting potato cultivations.

Index terms: Agrotis ypsilon, spodoptera exigue, Lannate, Hostathion, Dipel 2X

[2138] ENTOMOPHTHORALEAN PATHOGENIC FUNGI (ZYGOMYCOTINA – ZYGOMYCETES) IN THE NATURAL CONTROL OF INSECTS – PROSPECTS IN SOUTHERN OF BAHIA, BRAZIL

S.E.M. Sánchez¹, A. L. Freitas², L. S. Lima³, G. B. Silva³, C. S. de Almeida³ & J. B. Lenl³, ¹ Prof. Dr. Researcher, Univ. Estadual de Santa Cruz – UESC, Dept. de Ciências Agrárias e Ambientais – DCAA. Rod. Ilhéus/Itabuna Km. 16 Bahia, Brazil. Fone: (073) 680 5261 Fax: (073) 630 5129 saul@jacaranda.uescba.com.br; ² Fellowship DCB – Program PIBIC/ CNPq; ³ Fellowship DCAA/ DCB – Program UESC

Research on entomophthoralean fungi in southern Bahia State, Brazil included enzootic and epizootic studies on the dynamics of entomophthoromycosis and on its interrelation with insect populations of various insect orders, geographical distribution and incidence on crops, natural grasses and other substrates. This work is being conducted in an orderly and sequencial manner, and the pathogens identified microscopically together with the biometric data of the structure of the fungi. The results are important for the region as they confirm the presence of *Erynia* on Calliphoridae and Sarcophagidae (Diptera) and on Formicidae *Paratrechina* sp. (Hymenoptera). *Entomophthora* was present on domestic muscid flies and *Entomophaga* on Acrididae and Gryllidae (Orthoptera). We also identified *Conidiobolus* on Coleoptera, Diptera and Homoptera, *Entomophaga* on Psychodidae *Telmatoscopus albipurciatus* (Diptera), and on Tipulidae (Diptera), and an unnidentified adult microlepidopteran. The biological material collected in the region demonstrates the effectiveness of these pathogens in the natural control of these insect populations. During the project (May 1998 to December 1999), the means monthly temperature and the relative humidity of the region varied from 20.5 to 25.0 °C and 82.0 to 88.8 % respectively; ideal conditions for the development of entomophthoromycosis.

Key words: Entomophthorales, Characterization, Identification, Geographical distribution, Incidence, Bahia-Brazil.

[2137] MICROBIAL CONTROL OF TICKS

<u>M. Samish¹, G. Gindin², E. Alekseev¹, I. Glazer², ¹Kintron Veterinary Inst., P.O.Box</u> 12, Bet Dagan 50250, Israel. E-mail: msami_vs@netvision.net.il; ²A.R.O., The Volcani Center, P.O.Box 6, Bet Dagan 50250, Israel.

Even though microbial control of plant pest is investigated and used for decades this aspect of tick control is as yet highly neglected. Indeed there exists as yet not even one commercial anti tick biocontrol agent. Ticks throughout their life cycle spent most of the time in hiding places in the upper layer of the ground i.e. under clods of earth, under leaf cover or even buried a few cm of soil. Such relatively moist places are suited for the development of entomopathogenic nematodes and fungi. Our trials showed that entomopathogenic nematodes (200 Us/dish) kill about half of the engorged Boophilus annulatus female ticks within 1.9 days and 90% in 5 days. Spraying nematodes on soil in buckets (50 IJs/cm²) killed 50 or 90% of the ticks on day 5 or 10 post contact respectively. Other tick species were found to be less susceptible to nematodes. The nematode strains most virulent in petri dish test were not the best in soil test. Dipping *Boophilus annulatus* engorged females in a spore suspension of the entomopathogenic fungus *Metarhizium anisopliea* $(1x10^7/ml)$ caused a mortality of some 50% within 6 d and 90% in 7 d. The surviving females laid 92% fewer eggs than the control. Only 2% of these eggs hatched and all larvae died within 6 d. Various stages of Hyalomma excavatum and Rhipicephalus sanguineus were found to be sensitive to the same fungi. The fungi strains differed markedly in their anti tick virulence. These results indicate that there exists quite a high potential for a microbial control of ticks. Further research is still required to hopefully transfer these findings into practical recommendations to farmers.

Index terms: Boophilus, Heterorhabditidae, Metarhizium, Rhipicephalus, Stainernematidae.

[2139] OBSERVATIONS ON THE VICE-LIKE STRUCTURES IN PUPAE OF PLUSIINAE (LEPIDOPTERA, NOCTUIDAE)

<u>L. Sannino¹</u>, B. Espinosa² & J. A. Tsitsipis³, ¹Ist. Sper. Tabacco, via P. Vitiello 66, 84018 Scafati (SA), Italia; ²Dipt. Ent. e Zool. Agraria, Univ. Napoli "Federico II", 80055 Portici, Italia; ³Laboratory of Entomology and Agricultural Zoology, Univ. of Thessaly, P.O. Rox 38334, Pedion Areos, Volos, Greece.

On the body dorsal surface of the Plusiinae pupae found on Mediterranean tobacco cultures are usually present particular structures, such as the vice-like and the semiannular structures, the shape of which is useful for species identification, as they are typical. In this paper the vice-like structures morphology of five species (Autographa gamma, Chrysodeixis chalcites, Diachrysia chrysitis, Macdunnoughia confusa, Trichoplusia ni) is comparatively described, highlighting the differences among them, until now little understood, and also trying to provide a functional explanation. Moscher (1916), listing the Plusiinae pupal features, mentions "prominent grooves" present on the posterior margin of metathorax and the first four abdominal segments, but does not indicate a possible function. Vice-like structures, usually three in number, are arranged between the adjacent margins of the first four abdominal segments. Each of them consists of two jowls, the caudal and the cephalic one. In gamma, the caudal jowl is regularly rounded and provided with uniformly distributed papilliform reliefs, while the cephalic one is prominent in the middle. In chalcites, the caudal jowl is very arched and thinly rounded, rugose on the contact surface only; the cephalic jowl is smooth and very arched. In chrysitis, the vice-like structures are very noticeable: the anterior jowl is swollen with transversal ridges, while the posterior consists of a noticeable squat prominent tubercle-shaped and rugose protuberance. In confusa, the caudal jowl is flattened on the contact surface and provided with irregular papilliform reliefs (concentrated mainly on the flat margin), while the cephalic one is straight in the middle. In ni, the caudal jowl is sinuous, sinuate in the middle and provided with very small reliefs on the extreme margin only; the cephalic jowl, instead, presents a transversal cavity, wave-like on the top and prominent. Plusiinae pupate on the foliage of the food plant in a flimsy silk cocoon. As a consequence, the pupa is easily exposed to predator attacks and wind shakes. The anchorage provided by cremaster, although enforced by the special spiral-shaped spines, is ineffective against transversal motions, which could be offset by a dorsal blocking device, instead. Vicelike structures enable pupa, in its normal lying position, to have a secure grip to the cocoon silk threads, which are squeezed as in a vice. The function of the aforesaid structures is hypothesised to be the tenacious blocking of the pupa to the cocoon silk. Index terms: Lepidoptera, pupae, dorsal structures

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[2140] SELECTION OF ENTOMOPATHOGENIC FUNGI FOR USE IN COMBINATION WITH SUBLETHAL DOSES OF IMIDACLOPRID: PERSPECTIVES FOR THE CONTROL OF THE LEAF-CUTTING ANT ATTA SEXDENS (L.) (HYMENOPTERA: FORMICIDAE)

A.V. Santos, B.L. Oliveira & <u>R.I. Samuels</u>, Department of Plant Protection. Universidade Estadual do Norte Fluminense, Campos dos Goitacazes, RJ. 28015-620, Brazil. E-mail richard@uenf.br

The leaf-cutting ant Atta sexdens is a serious pest in tropical and sub-tropical regions. To date, no biological control strategy has been succesfully addressed for this insect. On the one hand, entomopathogenic fungi are promissing natural enemies of ants, since they are capable of overcoming the complex social organization of these insects. as reported by the incidence of natural epizootics. However, leaf-cutting ants posses many behavioral strategies which reduce the effectiveness of fungal infections. In the first part of this study four isolates of the fungus Beauveria bassiana (LPP1, LPP2, CG05 and CG24) and one isolate of Metarhizium anisopliae (E 9) were tested against adult foragers of A. sexdens. Ants were allowed to walk on filter paper discs, inside and holdes, previously impregnated with 1 ml of a conidia suspension $(1.2 \times 10^7 \text{ conidia/ml})$, maintained in a glass chamber (100% RH, 26° C) for 24 h and subsequently, transferred to sterile Petri dishes, maintained at 26° C, 70% RH, 24 h dark. The LT50 for LPP2, LPP1, E9, CG24 and CG05 was 3.41, 3.52, 3.91, 4.12 and 4.61 days, respectively. Experiments were carried out to test the toxicity of imidacloprid (IMI) to A. sexdens. Concentrations of 100, 10, 1 and 0.1 ppm IMI were dissolved in a saturated sucrose solution and ants were subsequently exposed to cotton wool balls soaked in the insecticide. Mortality was evaluated after 5 days exposure. Percent mortality was 90.49, 63.80, 27.63, 8.57 and 9.51 for 100, 10, 1, 0,1 ppn and the control group, respectively. Insects treated with 0.1 ppm were observed to have reduced locomotory activity, reduced aggressiveness and grooming behavior 24 h after exposure to IMI. A preliminary test was carried out to evaluate the combination of a sub-lethal dose of IMI (0,1 ppm) and infection by LPP2. Mortality due to fungal infection alone was 66.67%. Mortality of insects treated with IMI followed by exposure to the fungus was 83.33%. These results indicate that IMI increases the susceptibility of ants to infection.

Index terms: Beauveria bassiana, Metarhizium anisopliae, insecticide, biological control.

[2141] MASS PRODUCTION OF *BACULOVIRUS ANTICARSIA* TO CONTROL *ANTICARSIA GEMMATALIS* IN SOYBEANS: RESEARCH PROGRAM FROM THE AGRICULTURAL COOPERATIVES OF THE PARANÁ STATE

<u>B. Santos</u>¹, ¹Departamento de Patologia Básica, Universidade Federal do Paraná, Caixa Postal 19031, Curitiba, PR 81531-970, Brasil, E-mail santosb@garoupa.bio.ufpr.br

The mass production program of Baculovirus anticarsia aiming the production of biological insecticide for the control of the velvet bean caterpillar, Anticarsia gemmatalis in soybeans, accomplished by the Agricultural Cooperatives of the Paraná State started in 1987 in Cascavel City. The technology was developed by EMBRAPA/SOJA in Londrina, Paraná. The production of the virus is wholly accomplished in the field from December to January, using the natural occurrence of the caterpillar in the soybean crops in the Western Paraná. The virus is sprayed when samplings indicate larvae populations levels ranging 40 to 60 caterpillars per 2 m long. The collection of the dead caterpillars is accomplished by rural workers about 8 days after the spraying. About 188 workers are used (ranging from 20 to 496) a day for the collection, being obtained ca. 1.54 kg caterpillars/person/day. The mass production of dead larvae collected from the field offers as the main advantage a the great production, low cost, in a short period of time. However, this method presents great variation in the annual production, as its disadvantage. The annual average production along the past 13 years of program is 3.575 kg of infected caterpillars (from 295 to 12.347 kg), enough to 197.000 ha of soybean crops. This great variation in obtaining infected caterpillars is mainly due to several factors which act on the population of A. gemmatalis. The most important one is the weather. Companies that are interested in this agribusiness demand for a system of constant production of the caterpillars for obtaining of a balanced revenue. So, it is necessary to develop creation techniques of A. gemmatalis in laboratory with an industrial profile, seeking a constant and maintainable annual production along the time. In Brazil, it has been looked for to modernize the technique of formulation and some evolutions were obtained recently with mechanization of the extraction of the virus from caterpillars. Index terms: Lepidoptera, Noctuidae, biological control, baculovirus.

[2142] TRANSINFECTION OF *WOLBACHIA* ENDOSYMBIONTS AMONG THREE SPECIES OF LEPIDOPTERAN INSECTS

T. Sasaki¹, Y. Fujii¹, D. Kageyama², S. Hoshizaki² & H. Ishikawa¹, 1Dept. of Biological Sciences, Graduate School of Science, Univ. of Tokyo. Hongo, Tokyo 113-0033, Japan, Email sasaki@biol.s.u-tokyo.ac.jp; 2Dept. of Agricultural and Environmental Biology, Graduate School of Agricultural and Life Sciences, Univ. of Tokyo, Yayoi, Tokyo 113-8657, Japan.

The bacteria of the genus Wolbachia are intracellular endosymbionts harbored by many arthropod hosts. They are known to cause various reproductive alterations in their hosts such as thelytokous parthenogenesis, male killing, feminization and cytoplasmic incompatibility (CI). CI is a reproductive incompatibility that results in mortality of the embryos when uninfected females are mated to infected males or when female and male are infected with different Wolbachia strains. Phylogenetic analyses of Wolbachia carried by various arthropods have shown that they are divided into two major groups, A and B. It has also been shown that the effects of Wolbachia infections on the hosts are not congruent with the bacterial phylogeny. In an attempt to determine whether the difference in the mode of reproductive manipulation by Wolbachia depends on the difference in the bacteria or in the host, we performed transinfection experiments using three species of Lepidopteran insects, the Mediterranean flour moth Ephestia kuehniella, the Almond moth Ephestia cautella and the Adzuki bean borer Ostrinia scapulalis. E. kuehniella is infected with a A-group Wolbachia strain, and E. cautella is doubly infected with two strains of Wolbachia, one belongs to A group and the other to B group. Wolbachia infections in these moths are associated with the expression of CI. The B group Wolbachia harbored by O. scapulalis induces feminization of genetic males into functional females. Transferrs of the Wolbachia was Wolbachia of O. scapulalis was transferred into E. kuelmiella from which its natural infection had been removed by tetracycline treatment, the transinfected line showed the phenotype of male-killing. In the transinfection experiment from E. cautella to E. kuehniella, we obtained three lines different in the infection status, single infection with A-Wolbachia, single infection with B-Wolbachia and double infection with both A- and B-Wolbachia. The transinfected E. kuehniella carrying only B-Wolbachia originating in E. cautella expressed CI. On the other hand, the transinfected lines that had received A-Wolbachia from E. cautella expressed male-killing. These observations suggested that the phenotype induced by Wolbachia is determined by the interaction between the bacteria and hosts.

Index terms: Wolbachia, transinfection, feminization, cytoplasmic incompatibility, male-killing.

[2143] NEW HOST RECORD OF A GUT FUNGUS OF MYRIAPODA, ENTEROBRYUS OXIDI (TRICHOMYCETES; ECCRINALES)

II. Sato, Insect Pathology Laboratory, Forestry and Forest Products Research Institute, Kukizaki Ibaraki 305-8687, Japan, E-mail Hirokis@ffpri.affrc.go.jp.

Trichomycetes is a class of fungi belonging to Zygomycota. Species of this class are living in digestive tracts of insects, myriapoda, and other arthropods. Spores are produced in the gut and released to environment as fecal contaminants. By feeding the spores next infection begins. In the gut the spores germinate and produce appressorium to attach to the host's gut cuticle. Each species has special site to attach in the gut. Enterobyus is a genus which is living in the specifically hindgut of myriapoda. Hostspecificity of Trichomycetes, especially Eccrinales, hardly studied. Though this genus has been recorded from Japan, for the limited number of specimen there have been no identified species in this genus in Japan. In this study, a species of Enterobryus was derived from a species of myriapoda, Oxidus gracilis. From the morphological characteristics, this fungus was identified as Enterobryus oxidi. Subsequently, a species of Enterobryus was derived from other species of myriapoda, Niponia nodulosa. The fungus was thought morphologically also identical to Enterobyus oxidi. The two species of myriapoda are commonly sharing habitat and eat decayed leaves and soil. It is thought that the spores of E. oxidi had chances to be fed by those animals. All species of Enterobryus have been described from only one genus or one species of the host animal. Oxidus gracilis and Niponia nodulosa belong to the family, Paradoxosomatidae and Cryptodesmidae, respectively. Enterobryus oxidi had a wider host spectrum than genus.

Index terms: Oxidus gracilis, Paradoxosomatidae, Niponia nodulosa, Cryptodesmidae, Enterobryus oxidi

[2144] BACULOVIRUS-MEDIATED EXPRESSION AND ANTIFUNGAL ACTIVITY OF A DIAPAUSE-SPECIFIC PEPTIDE OF THE ADULT LEAF BEETLE

K. Sato¹, II. Tanaka² & K. Suzuki², ¹Dept. of Appl. Microbiol., Iwate Biotech. Res. Center, Kitakami 024-0003, Japan, E-mail: kensato@sv02.ibrc.pref.iwate.jp; ²Dept. of Biosci, and Technol., Fac. of Agric., Iwate Univ., Morioka 020-8550, Japan.

A diapause-specific peptide, diapausin, of the leaf beetle, Gastrophysa atrocyanea, exhibits antibiotic activity against some phytopathogenic fungi. However, it is difficult to yield high amounts of pure active diapausin required for precise assay of antifungal activity from small bodies (length: about 5 mm) of the adult leaf beetle. We have, therefore, expressed a diapausin cDNA cloned from the leaf beetle using Bombyx morifbaculovirus system. Recombinant diapausin secreted in the hemolymph was purified by a combination of acidic methanol-extraction and reversed-phase high performance liquid chromatography. Purity of recombinant diapausin was checked at each purification step by SDS-tricine PAGE and/or Western blotting using anti-diapausin antiserum. The final yield of purified recombinant diapausin was about 25% or equivalent to 50-µg/ml hemolymph. Western blotting analysis indicated that the size of recombinat diapausin (simply described below as diapausin) (4.5 kDa) was consistent with the size for natural diapausin. Diapausin exhibited a broad spectrum of antifungal activity against phytopathogenic fungi including Alternaria alternata, Botrytis cinerea, Fusarium oxysporum, F. solani and Verticillium dahliae. Concentrations of diapausin for 50% inhibition of fungal growth varied from 10 to 130 µg/ml. Diapausin did not overcome spore germination, but inhibited mycelial growth. The antifungal activity of diapausin against F. solani was affected by the presence of cations, e.g., Ca2+ and K+. On the other hand, diapausin was nontoxic for such entomopathogenic fungi as Metharhizium anisopliae and Paecilomyces farinosus. We are now attemting to express diapausin genes in tobacco plants, Nicotiana tabacum. Index terms: Gastrophysa atrocyanea, Bombyx mori, fungi, diapausin.

[2145] WOLBACHIA ARE DISTRIBUTED THROUGHOUT SOMATIC AND GENITAL ORGANS OF A MULBERRY LEAFHOPPER, HISHIMONOIDES SELLATIFORMIS

<u>M. Sato</u>, W. Mitsuhashi, T. Saiki, W. Wei, K. Watanabe & II. Kawakita, National Institute of Sericultural and Entomological Science, Tsukuba, Ibaraki 305-8634, Japan, E-mail: satomamo@nises.affrc.go.jp.

Wolbachia belong to the alpha subclass of the purple bacteria, and are known as intracellular symbionts to cause reproductive and sex-ratio disorders in many insects. They have been well described in the region of insect reproductive organs, but yet the presence within somatic organs has been poorly documented. By PCR assays and electron microscopy (EM), we examined the distribution of Wolbachia in both somatic and genital organs of *Hishimonoides sellatiformis*, which is an insect vector of mulberry dwarf-phytoplasma. Each insect's organ was carefully collected from leafhopper bodies in saline solution. For PCR assays, a template DNA was prepared from insect organs by using the CTAB method, and primers constructed by O'Neill et al. (1992) and our own were used to amplify 16S rDNA of Wolbachia. In all somatic organs such as brains, salivary glands, midguts, fat bodies, and thoracic ganglia, PCR products were obtained in a predicted size. The similar size of DNAs were amplified in several genital organs (ovaries, seminal receptacles, and testes), eggs, and newly hatched nymphs of the insect. The PCR product was identified as 16S rDNA of Wolbachia by its sequencing, which showed that our organisms belong to group A Wolbachia. In addition, rod-shaped bacteria (1 x 0.3 []m) were observed by EM in somatic organs, including mycetomes, brains, salivary glands, midguts, fat bodies and thoracic ganglia, and ovaries. The organisms closely resembled Wolbachia previously reported in shape, so that they were strongly suggested to be Wolbachia. Thus, we verified that Wolbachia are distributed throughout every somatic organ as well as others of genital type. The further studies will be required to verify the potential significance of Wolbachia infections in non-reproductive as well as reproductive organs.

Index terms: PCR detection, electron microscopy, symbiont

[2146] IDENTIFICATION OF ENDOPHYTIC BACTERIA IN CITRUS WITH BIOCONTROL ACTIVITY AGAINST *DIAPREPES ABBREVIATUS* (COLEOPTERA: CURCULIONIDAE)

R. G. Shatters, Jr., & A. Weathersbee, USDA, ARS, U. S. Horticultural Research Laboratory, 2001 South Rock Road, Fort Pierce, FL 34945, USA.

Research in the last few years has shown that diverse populations of bacterial species termed endophytes can live internal to plant tissues. Some of these organisms are obligate endophytic bacteria while others are more opportunistic. Although a few of these bacteria can be regarded as nathogenic, many induce no pathogenic symptoms on the host plant, and in fact, some endophytic bacteria improve the fitness of the host, and have been shown to be effective as biocontrol agents against pathogenic microorganisms. The effect of these endophytic bacteria on plant pest insects has not yet been studied, and was the basis of this report. We have isolated 72 endophytic bacteria from 14 different citrus varieties located in Fort Pierce, Florida, USA. The bacteria were isolated from new-growth stem tissue with three successive sterilizations steps using bleach, formaline, and ethanol. The surface sterilized stems were then imbedded on enriched nutrient agar plates (containing cyclohexamide to prevent fungal growth) and incubated at 30°C for 3-days. Stem pieces showing no bacterial growth were split open and placed on new nutrient agar plates. Bacterial growth observed within two days on the new plates was sampled for isolation by successive single colony transfer, and used for species identification. These isolates were identified by gas chromatographic profiling of the methyl esterase derivatives of isolated fatty acids. The fatty acid methyl esterase (FAME) profile was used to determine the genus and species using the Sherlock System software developed by MIDI, Inc. Isolates were shown to represent a diverse group of bacteria with members from 14 different genera. Using these bacterial isolates, a plate-screening assay was developed to test the effect of these bacteria on the larvae of a major citrus pest weevil; Diaprepes abbreviatus. Out of all isolated endophytes, 6 were toxic or pathogenic to D. abbreviatus. Bacteria that killed the D. abbreviatus larvae belonged to only three of the 14 genera isolated from citrus plants. These three genera included Bacillus, Pscudomonas, and Clavibacter. All three were active against D. abbreviatus larvae in petri-plate assays and in D. abbreviatus larvae growth medium. Results are presented with respect to the use of bacterial endophytes for the control of insect pests on crop plants.

Index terms: Diaprepes abbreviatus, endophyte, citrus, biocontrol

[2147] THE LONG-TERM EFFECT OF MICROSPORIDIA (NOSEMA SP., POLISH ISOLATE) ON THE GYPSY MOTH (LYMANTRIA DISPAR, LEPIDOPTERA: LYMANTRIIDAE) IN LABORATORY EXPERIMENTS

<u>A. Sierpinska</u>, Forest Research Inst., Bitwy Warszawskiej 1920 r. No. 3, 00-973 Warsaw, Poland, E-mail: A.Sierpinska@ibles.waw.pl

An isolate of Nosema sp. was found in gypsy moth larvae from Biebrza National Park in the north-east of Poland in 1997. Microsporidium infected 91 % of larvae. So high prevalence of the isolate in the gypsy moth population encouraged to the estimation of long-term influence of single infection on laboratory reared gypsy moth. In 1998 2nd instar gypsy moth larvae (New Jersey Standard Strain) were infected with spores of Polish microsporidian isolate. Larvae were feeding spores spread on the surface of an artificial diet. Five concentrations were used: 6.8 x 10⁰, 6.8 x 10¹, 6.8 x 10², 6.8 x 10³ and 6.8 x 104 spores / µl. Sixty larvae per concentration (and sixty control, not infected larvae) were reared in small groups: 2-10 larvae depending on the instar until pupation. For 1998 generation an influence of the infection on larval development, pupation, construction and the interface of an egg mass were observed for all concentrations. The above observations were done for 1999 and 2000 generations only for larvae infected with spores in the lowest and the highest concentrations. Except for observations mentioned above, also the amount of fertile and not fertile eggs in every egg mass were counted as well as numbers of hatching larvae. The larval development of 1998 generation infected with microsporidia was slightly delayed, but the mean pupal weight did not differ for infected and not infected larvae. The 1998 control females laid significantly longer egg masses than females infected as 2nd instar larvae with the highest concentration of spores. The mean amount of hatching 1999 larvae was 7-fold lower and the mean amount of not fertile eggs per egg mass was 2-fold higher for larvae infected in the previous generation with spores in the highest concentration, than for larvae infected with spores in the lowest concentration. Similar observations were noted for the next, 2000 generation of laboratory reared gypsy moth. The results showed that Polish microsporidian isolate is able to reduce gypsy moth population density in long-term laboratory experiment and suggested, that the isolate is probably transmitted transovarially.

Index terms: Lymantria dispar, Nosema sp., long-term effect

[2148] EPIZOOTY OF *NOMURAEA RILEYI* IN SPODOPTERA FRUGIPERDA LARVAE IN THE CORN CROP, ZEA MAYS

R.C. Siloto¹, J. E. M. Almeida² & A. Raga¹, ¹ Lab. Entomologia Econômica, Centro Experimental do Inst. Biológico, P. O. Box 70, Campinas, SP, 13001-970, Brazil, Email: rcsiloto@carpa.ciagri.usp.br. ² Lab. Controle Biológico, Centro Experimental do Inst. Biológico, P. O. Box 70, Campinas, SP, 13001-970, Brazil.

In January 2000 Spodoptera frugiperda larvae, more than 2 cm of length, was observed naturally infected by (ungi Nomuraea rileyi in corn crop, in Casa Branca County (21°40'S; 47°10'W; 545 m), State São Paulo, Brazil. An evaluation in the field was realized in 100 plants of two lines, with approximately 90 days of age. 'Master' showed 62% of infested plants by S. frugiperda, 84% of infested plants with fall armyworm were infected with N. rileyi and 78% larva mortality. In Exceller', 40% of plants were infested with S. frugiperda, 77% of infested plants with S. frugiperda were infected with the fungus and 76% larva mortality. Up to fifteen days before the epizooty lhe local precipitation estimated in 421 mm. In the same period the medium temperature and relative humidity registered were 25 °C and 80%, respectively. It was observed that N. rileyi epizooties occurred at 26°C and 60 to 100% relative humidity. Therefore, after rainy periods and mild temperatures, followed by an dry period provide good conditions for the N. rileyi development, an important agent of natural biological control.

Index terms: Fall armyworm, entomopathogenic fungi, lines, biological control.

[2149] ENZYME PRODUCTION BY THE FUNGUS SYMBIOTIC WITH THE ANT MYCETAROTES PARALLELUS

<u>A. C. O. Silva</u>, ., M. Bacci, Jr, F. C. Pagnocca, , O. C. Bueno, M. J. A., Hebling Centro de Estudos de Insetos Sociais, Universidade Estadual Paulista, Ric Claro, SP. CEP.13506-900, Brazil – e-mail: acos@rc.unesp.br. Financial support: Fundação de Amparo a Pesquisa do Estado de São Paulo - FAPESP 95/4229-2 and 97/13383-0 and master degree fellowship FAPESP 97/04104-0.

Ant symbiotic fungi are thought to contribute to the insect nutrition through enzymatic degradation of organic matter. Among this matter, polysaccharides are known to be promptly metabolized by the fungus of the higher Attini ant Atta sexdens. However few is known on the metabolic ability of the fungi symbiotic with Lower Attini Ants. In the present investigation we have characterized the metabolism of polysaccharides and proteins by the fungus symbiotic with the Lower Attini ant Mycetarotes paralellus. This fungus was able to grow and degrade several polysaccharides as well as their hydrolysis products and proteins. Xylan was the most efficiently assimilated polysaccharide and thus it is likely the more important plant polysaccharide supporting fungal growth inside ants nests. Cellulose, the most abundant plant polyssacharide, was not efficiently metabolized by the fungus. Pectin was efficiently degraded but poorly assimilated, indicating that the high production of pectinase may be primarily used to macerate the plant tissue, removing the cement which keeps vegetation cells attached to each other, and thus access the other nutrients from plants. All proteins utilized as carbon sources have been promptly degraded by the fungus, but poorly assimilated. Thus it is likely that proteins, as well as pectin, are degraded by the fungus to expose other nutrient from plants. Finally, the fungus was also found to poorly degrade and assimilate chitin, which seems not to be an important carbon source inside ants' nest. The results obtained in the present investigation indicate that the symbiotic fungus of Mycetarotes paralellus is able to mediate the ants nutrition on several polysaccharides and proteins. If the fungal behavior in laboratory cultures typifies its role in nature, xylan and starch may be the most important carbon sources for fungal growth inside ants' nests. Since ants nutrition relies on the fungus, these polysaccharides may play an important part in ants nutrition as well.

[2150] BIOLOGIC CONTROL OF CULEX QUINQUEFASCIATUS IN CITIES FROM PERNAMBUCO STATE APPLYING BACILLUS SPHAERICUS

D. M. P. da Silva¹, L. M. de A. C. Maranhão¹, E. M. M. Rios², L. N. Regis³ & R. S. Cavalcanti¹, ¹Empresa Pernambucana de Pesquisa Agropecuária - IPA, C.P. 1022, Recife, PE, Brasil; ²Universidade Federal de Pernambuco - UFPE, Av. Prof. Morais Rego, s/n, CEP 50.670-901, Recife, PE, Brasil; ³Centro de Pesquisas Aggeu Magalhãe - CPqAM/FIOCRUZ, Av. Prof. Morais Rego, s/n, CEP 50.670-420, Recife, PE, Brasil.

In the state of Pernambuco, Brazil, *Culex quinquefasciatus* has considerable medicinal and social importance, in the transmission of Bancroft's filariasis and because of the discomfort caused by the process of hematophagism. The entomopathogenic bacterium *Bacillus sphaericus*, because of its action against mosquitoes, is considered the main control agent of this culicide. The Laboratory of Bioproducts Production in Empresa Pernambucana de Pesquisas Agropecuárias - IPA, has been producing, since 1997, together with Departamento de Antibióticos in Universidade Federal de Pernambuco and Instituto de Pesquisas Aggeu Magalhães/CpqAM - FIOCRUZ, *Bacillus sphaericus* 2362 in the scale of 1000 liters. The biolarvicide has been distributed, in the form of fermented broth, since 1997, to the Health Bureau from many cities in Pernambuco State: Altinho, Araripina, Bonito, Brejo da Madre de Deus, Caruaru, Floresta, Olinda, Recife, Petrolina, Salgueiro, Santa Cruz do Capibaribe, Santa Maria da Boa Vista, São Caetano, São João, São Joaquim do Monte, Serra Talhada, Toritama, e Trindade. The percentage of control was situated between 80 and 100%, 48 hours after application. For the experiments, IPA distributed about 6500 liters of fermented broth, 24.3% from this volume for the Program of Filariasis Control in the city of Recife; the rest was applied in the others cities, with the aim of reducing *C. quinquefasciatus* and the discomfort caused by this insect.

Index terms: Culex quinquefasciatus, Bacillus sphaericus, vector insects, entomopathogenic bacteria.

[2151] LARVAL PARASITOIDS AND PATHOGENS OF SPODOPTERA FRUGIPERDA (LEPIDOPTERA: NOCTUIDAE) IN FOUR CITIES IN PARAÍBA

M.T.C. Silva¹, <u>I.A. Mezzomo¹</u>, F.R. Guimarães¹ & M.G.A. Lima², ¹Laboratory of Biological Control, Dept. of Pharmacy and Biology, Paraíba State Univ., Félix Araújo Square, 13B, 58101-450, Campina Grande, PB, Brazil, E-mail jamezzo@zaz.com.br; ²Dept. of Biology, Ceará State Univ., P.O. Box 1531, 60740-020, Fortaleza, CE, Brazil, E-mail goretti@uece.br

Among the pests that attack corn, the Spodoptera frugiperda stands out, considered the principal pest of this culture in Brazil, being able to cause great damage also to other important cultures like sorghum, rice and sugarcane. The biological control is an important tectic within the integrated management of this pest, controled principally with insecticides. Searching to know the parasitoids and pathogens that attack this noctuid in the larval phase, larvae were collected in corn plantations within the city limits of Campina Grande, Lagoa Seca, Alagoa Nova and São José da Lagoa Tapada, from May 1997 to July 1999. In the laboratory, the larvae were individualized in Petri dishes and fed on an artificial diet. Of the 3324 larvae collected, 710 (21,4%) were parasited, being 478 (14,4%) by Chelonus insularis (Hymenoptera: Braconidae), 111 (3,3%) by Archytas incertus (Diptera: Tachinidae), 96 (2,9%) by Winthemia trinitatis (Diptera: Tachinidae), 12 (0,4%) by Campoletis flavicincta (Hymenoptera: Ichneumonidae) and 2 (0,06%) by Cotesia sp. (Hymenoptera: Braconidae). A nematode of the genus Hexamernis killed 112 larvae (3,4%), while a non-identified protozoa caused the death of 12 larvae (0,4%). The death rate caused by all the biotic agents was 34,2% in A. Nova, specially by C. insularis (33,3%); 30,9% in SJ.L. Tapada, predominating Hexamernis sp. (25,7%); 24,7% in L. Seca, specially by C. insularis (14,4%); and 9,2% in C. Grande, predominating C. insularis (10,5%). In the surveyed places, with the exception of S.J.L. Tapada, C. insularis was the most frequent natural enemy and with the highest rate of parasitism, being the most promising to be used in the biological control of S. frugiperda. The nematode Hexamernis sp. was efficient in sp.J.L. Tapada, reaching 72,0% of parasitism in on of the collections, although its performance limits itself to the rainy season.

Index terms: Insecta, biological control, fall armyworm.

[2152] CLONING AND HETEROLOGOUS EXPRESSION OF A BACILLUS THURINGIENSIS PROTEIN TOXIC AGAINST THE FALL ARMYWORM

LO. Silva-Werneck¹, P.W. Inglis¹, S.M. Melo¹, R.G. Monnerat¹ & M.F.G. Sa¹, ¹Embrapa Recursos Genéticos e Biotecnologia, P. O. Box 02372, 70849-970, Brasília, DF, Brazil. E-mail: joseilde@cenargen.embrapa.br

Bacillus thuringiensis is an aerobic bacterium that synthesizes crystalline inclusions, during sporulation, that are composed of one or more proteins, known as \delta-endotoxins or Cry proteins. These proteins are toxic to a wide variety of agronomic, forestry, healthrelated insect pests and other invertebrates. Because of their high specificity and environmental safety, bioinsecticides based on B. thuringiensis have been successfully used for more than 50 years. The goals to this work was to express a Cry toxin from a Brazilian B. thuringiensis strain toxic to the fall armyworm (Spodoptera frugiperda), in order to evaluate its isolated activity to the former and other insect species, to study toxinreceptor affinity, to produce anti-body and to develop a heterologous expression methodology (*Pichia pastoris*) for *B. thuringiensis* toxins. The coding sequence of the cry1Ab gene from the strain S93 of B. thuringiensis subsp. kurstaki was cloned in pUC18 and amplified by PCR using Bam HI primers. The PCR product was cloned in a shuttle expression vector for the yeast P. pastoris and amplified in Escherichia coli cells. P. pastoris GS115 cells were transformed by electroporation and analised by Western blot. A clone was selected and induced for expression. Samples collected at different hours post-induction were analised by SDS-PAGE and Western blot, showing a better expression level at 72 hours.

Index terms: Spodoptera frugiperda, biological control, Cry protein

[2154] INTEGRATED SYSTEM TO SIMULATE THE IMPACT OF THE FUNGUS NOMURAEA RILEYI ON BRAZILIAN ANTICARSIA GEMMATALIS POPULATIONS

E. R. Suiii¹, D. R. Sosa-Gomez², V. A. M. de Carvalho¹ & M. S. Tigano¹, ¹Embrapa Recursos Geneticos e Biotecnologia, PqEB Final W3 Norte, C. Postal 02372, 70849.970 Brasilia, DF, Brazil, E-mail sujii@cenargen.embrapa.br; ²Embrapa Soja, C. P. 231, 86001.970 Londrina, PR, Brazil.

The fungus Nomuraea rileyi is known as an important biological agent of Anticarsia gemmatalis (Lepidoptera: Noctuidae), a key soybean pest in Brazil. N. rileyi can prevent A. gemmatalis populations from reaching economic threshold levels in soybean, and consequently avoid the use of chemical insecticide applications against this pest. Little is known about the evolution of this disease on A. gemmatalis population dynamics. An integrated system of mathematical models has been developed, using the software "STELLA version 5.0 Research", to simulate the pest population dynamics and the progress of the disease caused by N. rileyi. The system integrates a model of N. rileyila, gemmatalis dynamics, the precision of the system has been improved by the introduction of data related to infection and conditions, host population and soybean variety is required for simulations. The system generates a curve of A. gemmatalis caterpillars population based on the estimation of N. rileyi condition rates. The generated data compared to the field data shows that the system developed can mimicry the N. rileyi'A.gemmatalis interactions. However, further studies on environmental factors affecting migration rates of the insect, N. rileyi condidingenesis dynamics and considial survivorship, are still needed to improve the precision of the model for the use on A. gemmatalis management. Index terms: Biological control, pest management, population dynamics

[2153] BIOLOGICAL ACTIVITY OF NUCLEAR POLYHEDROSIS VIRUS ISOLATED FROM CELERY LOOPER (ANAGRAPHA FALCIFERA KIRBY) AGAINST NUN MOTH (LYMANTRIA MONACHA L.)

I. Skrzecz, B. Glowacka, Forest Research Inst. Bitwy Warszawskiej 1920 r. nr 3, Warsaw, 00-973, Poland, E-mail: skrzeczi@ibles.waw.pl.

Diseases caused by entomopathogenic viruses may play an important role in reducing population numbers of forest insect pests. Special attention has been focused on nuclear polyhedrosis viruses and granulosis viruses from the family Baculoviridae due to their essential selectivity and the lack of induced resistance to these viruses in infected insects. Research on insecticidal efficiency of insect pathogenic viruses for control economically important defoliators (Lymantria monacha, Lymantria dispar, Panolis flammea and Dendrolimus pini) is currently being conducted by the Forest Research Institute, Poland. This study was carried out in order to evaluate the insecticidal efficiency of virus isolated from caterpillars of Anagrapha falcifera (AfMNPV) against nun moth (L. monacha) - the most harmful defoliator in Polish (finite of definite the laboratory conditions, caterpillars of nun moth fed on artificial diet infected with 5 different doses of AfMNPV $(2\pi10^5-2\pi10^9 \text{ PIB/ml})$. The mortality of observed caterpillars was evaluated every day. The intensity of nun moth feeding was determined by faeces dry mass produced by an average caterpillar over a 24 h period. The results of the experiments indicated that AfMNPV was infectious for nun moth. The mortality of caterpillars that fed on infected diet was higher (16-45%) than mortality of control caterpillars (10%). Microscopic observations indicated numerous polyhedral bodies in dead caterpillars and pupae from the groups treated with virus. The pathogen was not observed in dead control caterpillars or pupae. All caterpillars that survived the treatment with infected diet pupated, although a high mortality (47-100%) of obtained pupae was observed within a few days after pupation. The intensity of feeding decreased in infected caterpillars after 20 days of treatment.

Index terms: Anagrapha falcifera, Lymantria monacha, AfMNPV, biological activity

[2155] SELECTION OF ENTOMOPATOGENIC FUNGI IN THE CONTROL OF LEPTOPHARSA HEVEAE

M.R.Tanzini^{1,2} & S.B.Alves¹, ¹Dept. of Entomology, Univ. of São Paulo, ESALQ, P.O. Box 9, Piracicaba, São Paulo 13418-900, Brasil, E-mail nutanzin@carpa.ciagri.usp.br; ²Scholarship from FAPESP.

The patogenicity of the one isolate of Aschersonia aleyrodis, 13 isolates of Beauveria spp., five of Hirsutella spp., 20 of Metarhizium anisopliae, two of Nomuraea rileyi, seven of Paecilomyces spp, seven of Sporothrix insectorum, one of Trichoderma sp. and four of Verticillium lecanii to nymphs of Leptopharsa heveae, a pest of rubber tree (Hevea brasiliensis, Euphorbiaceae) was evaluated under laboratory conditions. Conidial suspensions (1×10^8) of the isolates were applied with Potter tower to leaf disks of H. brasiliensis (0.2µl/cm²). Leaf disks were maintained under controlled conditions at 26±0.5°C; 80% RH and LD 12:12 for four days. H. thompsonii, A. aleyrodis and N. rileyi caused mortality between 23 and 50% and were considered of low virulence. For Beauveria spp., M. anisopliae, S. insectorum, Paecilomyces spp. and V. lecanii a great variation was observed in the patogenicity. The best isolates were Beauveria bassiana 1196 and 619 with 84 and 56% mortality after 3 days after inoculation, M. anisopliae 1144 and 1104 both with 90%, S. insectorum 1229 with 92%, V. lecanii 972 with 46% and P. fumosoroseus 1200 with 100% mortality. Trichoderma sp. a phytopathogenic fungus, caused 78% of mortality 4 days after inoculation. The high virulence of *M. anisopliae*, *S. insectorum* and *P. fumosoroseus* is an important and desirable characteristic for the development of a strategy of pest management in plantations of Heven with great potential for control of these insect. Index terms: Heteroptera, Tingidae, lace bug, Hevea brasiliensis, fungus, biological control

[2156] PHYLOGENY OF *PAECILOMYCES* SPECIES REVEALED BY ANALYSIS OF RIBOSOMAL RNA ITS SEQUENCES

<u>M. S. Tigano¹</u>, F. Driver², P. W. Inglis¹, J. W. H. Trueman³ & R. J. Milner², ¹Embrapa Recursos Genéticos e Biotecnologia (Cenargen), P. O. Box 02372, Brasília, DF 70770-900, Brazil, E-mail myrian@cenargen.embrapa.br; ²CSIRO Entomology, P. O. Box 1700, Canberra ACT 2601, Australia; ³Research School of Biological Sciences, Australian National University, Canberra ACT 2601, Australia.

The 5.8S rDNA and flanking internal transcribed spacers (ITS1 and ITS2) of the ribosomal RNA gene from Paecilomyces species were amplified using the polymerase chain reaction and sequenced. Sequences from P. amoeneroseus, P. carneus, P. farinosus, P. fumosoroseus, P. leycettanus, P. lilacinus, P. marquandii, P. penicillatus, P. tenuipes, P. variotti and P. viridis were compared to published sequences and phylogenetic trees were produced. The two observed major clusters agreed with the subdivision of *Paecilomyces* species, based on morphological criteria, into the sections *Paecilomyces* and *Isarioidea*. Section *Paecilomyces* included *P*. leycettanus and the type P. variotii and confirmed the relationship of these species to the teleomorph genera Talaromyces and Byssochlamys. Two clades were evident in this section, which also included Penicillium and Nomuraea anemonoides, which resemble *Paecilomyces* morphologically. These data agreed with other studies showing that the genus *Talaromyces* and *Penicillium* are not monophyletic. The relationship of *P. variotii* isolates with the two teleomorph genera indicate that it is probably a cryptic species. Section *Isarioidea* comprised three major clusters showing that this section too, is not monophyletic. One clade included *P. viridis*, *P. carneus* and isolates identified as *P. lilacinus* and *P. marguandii*, as well *N. rileyi*. Some other P. lilacinus and P. marquandii isolates were included in another clade along with Trichoderma. The clade containing the type for this section, P. farinosus, also included other entomogenous species, P. amoeneroseus, P. fumosoroseus and P. tenuipes. P. fumosoroseus was confirmed to contain a cryptic species, with one group of isolates closely related to P. tenuipes and another related to P. amoenoroseus. In this study, some prior mis-identifications were evident, proving that the ITS region can be useful to resolve the difficulties of classical taxonomy of these fungi. Our data suggest that Paecilomyces is a "form" genus only, and a major review is required, including the analysis of a more conserved gene region to clarify the phylogenetic relationships. Index terms: entomopathogenic fungi, rDNA, molecular taxonomy.

[2157] PHYLOGENY OF *PAECILOMYCES* SPECIES REVEALED BY ANALYSIS OF RIBOSOMAL RNA ITS SEQUENCES

M. S. Tigano¹, F. Driver², P. W. Inglis¹, J. W. H. Trueman³ & R. J. Milner², ¹Embrapa Recursos Genéticos e Bioteonologia (Cenargen), P. O. Box 02372, Brasília, DF 70770-900, Brazil, E-mail: myrian@cenargen.embrapa.br; ³CSIRO Entomology, P. O. Box 1700, Canberra ACT 2601, Australia; ³Research School of Biological Sciences, Australian National University, Canberra ACT 2601, Australia.

The 5.8S rDNA and flanking internal transcribed spacers (ITS1 and ITS2) of the ribosomal RNA gene from Paecilomyces species were amplified using the polymerase chain reaction and sequenced. Sequences from P. amoeneroseus, P. carneus, P. farinosus, P. fumosoroseus, P. leycettanus, P. lilacinus, P. marquandii, P. penicillatus, P. tenuipes, P. variotti and P. viridis were compared to published sequences and phylogenetic trees were produced. The two observed major clusters sequences and phylogenetic trees were produced. The two observed major clusters agreed with the subdivision of *Paecilomyces* species, based on morphological criteria, into the sections *Paecilomyces* and *Isarioidea*. Section *Paecilomyces* included *P*. *leycettanus* and the type *P. variotii* and confirmed the relationship of these species to address the subdivision of the section of the se the teleomorph genera Talaromyces and Byssochlamys. Two clades were evident in this section, which also included Penicillium and Nomuraea anemonoides, which resemble Paecilomyces morphologically. These data agreed with other studies showing that the genus *Talaromyces* and *Penicillium* are not monophyletic. The relationship of *P. variotii* isolates with the two teleomorph genera indicate that it is probably a cryptic species. Section Isarioidea comprised three major clusters showing that this section too, is not monophyletic. One clade included P. viridis, P. carneus and isolates identified as P. lilacinus and P. marquandii, as well N. rileyi. Some other P. lilacinus and P. marquandii isolates were included in another clade along with Trichoderma. The clade containing the type for this section, P. farinosus, also included other entomogenous species, P. amoeneroseus, P. fumosoroseus and P. tenuipes. P. fumosoroseus was confirmed to contain a cryptic species, with one group of isolates closely related to P. tenuipes and another related to P. amoenoroseus. In this study, some prior mis-identifications were evident, proving that the ITS region can be useful to resolve the difficulties of classical taxonomy of these fungi. Our data suggest that Paecilomyces is a "form" genus only, and a major review is required, including the analysis of a more conserved gene region to clarify the phylogenetic relationships. Index terms: entomopathogenic fungi, rDNA, molecular taxonomy.

Symposium and Poster Session

[2158] EFFECT OF TREATMENT TIMING OF BACULOVIRUS SPODOPTERA AND BACILLUS THURINGIENSIS ON SPODOPTERA FRUGIPERDA

F. H. Valicente¹, L. L. Loguercio¹, F. T. França¹, E. Paiva¹ & M. R. Barrreto1, CNPMS/EMBRAPA. C.P.151, 35700, Sete Lagoas, MG, Brasil. Email: fernando_valicente@entm.purdue.edu

The objective of this experiment was to test the effect of treatment timing of pathogens Baculovirus spodoptera (B.s) and Bacillus thuringiensis (B.t) on Spodoptera frugiperda larvae, used together but at different timing intervals. S. frugiperda larvae were 2 and 6 days old, using 48 larvae per treatment with 4 replicates. Treatments, for each age included Baculovirus and Bacillus provided in the same solution and at the same time, Baculovirus provided 24, 48 and 72 pathogens before Baculovirus was provided to the same insects. After exposure to both pathogens, contaminated larvae were transferred to artificial diet. Results showed that there was no difference in the mortality among the treatments, except when B.t was offered alone to 6-day old larvae. Mortality was high (above 89,25%) for all treatments. No difference was detected for larval and pupal development period among the treatments for both ages. Abnormalities among pupae and adults were not detected in any treatment. Index terms: insect pathology, pathogen interaction

[2159] BIOPESTICIDE PRODUCTS FOR MIGRATORY PESTS IN AFRICA: REGIONAL EFFORTS TO HARMONIZE REGISTRATION PROCEDURES

L.J Vaughan, Office of International Research and Development, Virginia Tech. 1060 Litton Reaves Hall. Blacksburg, VA 24061-0334 USA. E-mail larryjv@vt.edu

Migratory pests in Africa, such as locusts and armyworms, present a potentially large, but irregular and geographically fragmented market for biopesticides. Migratory pest control campaigns in Africa result in widespread application of broad-spectrum synthetic insecticides. By their nature, biopesticides are typically narrow-spectrum products. This narrow spectrum could be an environmental advantage for control campaigns. However, narrow specificity inherently limits the range of insects against which a biopesticide may be used, thereby restricting the market size. Another constraint not faced by synthetic pesticides is that biocontrol agents may be subject to importation restrictions as "exotic" species. Defining the "exotic" or "indigenous" status of a biocontrol agent is important for determining the geographic extent of markets, and has important consequences for the ability to use biopesticides in transborder control programs in Africa. In addition to several efforts on the part of individual African countries, there are two regional efforts being undertaken to promote and harmonize the registration of biopesticides in Africa. The Inter-State Committee Against Drought in the Sahel (CILSS) already has regional guidelines in place for registration of synthetic pesticides among its nine member countries. Through USAID's Africa Bureau-funded biopesticide project, managed by Virginia Polytechnic Institute and State University, CILSS is developing guidelines for harmonized registration of biopesticides across West Africa. By contrast, there is no regional organization in Eastern Africa with an equivalent mandate and intergovernmental structure to that of CLLSS. Therefore, regional harmonization in Eastern Africa must be approached with a different model. The Virginia Tech project is working through the Desert Locust Control Organization for Eastern Africa (DLCO-EA) - an organization with a narrow mandate for assisting its eight member countries with migratory pest control operations - to develop a consensus on a core set of items which will be common to national biopesticide guidelines as they are developed. Index terms: regulation, biological control, locusts, armyworms

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[2160] SCREENING FUNGAL PATHOGENS OF INSECTS FOR AMENABILITY TO LIQUID CULTURE SPORE PRODUCTION

F.E. Vega¹, G. Mercadier² & <u>M.A. Jackson³</u>, ¹USDA-ARS, Insect Biocontrol Lab, Bldg 011, BARC-West, Beltsville, MD, USA; USDA-ARS, ²European Biological Control Lab, Campus International de Baillarguet, Montferrier-sur-Lez, France; ³USDA-ARS, Nat. Ctr. for Agricultural Utilization Research, 1815 N. University St., Peoria, IL 61604, USA.

The potential to control insect pests with fungal pathogens has received considerable attention in recent years. Many fungal entomopathogens have been identified which actively infect and kill important insect pests. A major constraint to the commercial use of these biopesticides has been the lack of low-cost mass production methods that yield high concentrations of stable, infective propagules, ususally in the form of fungal spores. In order to assess the commercial potential of these pathogens, a screening protocol was developed to evaluate the amenability of these isolates to liquid culture spore production. Spore yields were measured for various fungal entomopathogens grown in six nutritionally different liquid media. Media with high and low carbon concentrations, 36 and 8 g/L, respectively, were tested at carbon-to-nitrogen (CN) ratios of 10:1, 30:1 and 50:1. In this study, six fungi were tested; two Beauveria bassiana strains, two Paecilomyces funosoroseus strains, one P. farinosus strain and one Metarhizium anisopliae strain. Spore yields were examined after 2, 4 or 7 days growth. In general, highest spore yields were obtained in media containing 36 g/L and a CN ratio of 10:1. After 4 days growth, highest spore yields were measured in the three *Paecilomyces* isolates $(8.3 - 22.9 \times 10^{4} \text{ spores/mL})$. Spore production by the *B*. bassiana isolates was variable with one isolate producing high spore yields (12.2 X 108 spores/mL) after 7 days growth. The *M. anisopliae* isolate produced low spore concentrations under all conditions tested. The ability of the *P. farinosus* strain (isolated from the coffee berry borer, Hypothenemus hamper) to rapidly produce high concentrations of spores (22.9 X 10^8 spores/mL in 4 days) prompted further testing to determine the desiccation tolerance of these spores. Liquid culture produced P. farinosus spores were mixed with diatomaceous earth, filtered to remove excess water and air-dried overnight at 23C with moist air (RH >60%). Germination assays showed that 80% of the spores survived the air-drying process. These results suggest that screening potential fungal biopesticides for amenability to liquid culture spore production can aid in the identification of commercially viable isolates. In this study, P. farinosus was shown to possess the production and stabilization attributes required for commercial development.

Index terms: Hypothenemus hampei, Biocontrol, Paecilomyces, Beauveria, Metarhizium

[2161] PROTOZOAN AND ENDOGENOUS CELLULASES FROM TERMITES OF THE GENUS COPTOTERMES

H. Watanabe¹, G. Tokuda², N. Lo³, M. Slaytor³ & H. Noda¹, ¹Nat. Inst. of Sericultural and Entomological Science, Tsukuba, Ibaraki, 305-8634, JAPAN, E-mail hinabe@affrc.go.jp; ²Bio-oriented Technology Research Advancement Institution, 1-40-2 Nisshin, Omiya, Saitama, 331-8537 JAPAN, ³Dept. of Biochemistry, The University of Sydney, NSW, 2000, AUSTRALIA.

Three discrete cellulase components were separated from extracts of the salivary glands (53.7kD), midgut (58.8kD) and hindgut protozoan fauna (64.3kD) of the Australian termite *Coptotermes lacteus*, on a Sephacryl S-200SF column (16/60; Pharmacia). The protozoan cellulase was further purified by SDS-PAGE, and its N-terminal amino acid sequence was determined. A set of degenerate primers was designed from this N-terminal sequence (ADHPKFTWQEVTG(C)GITNDN), and reverse transcription PCR was performed using the total mRNA of hindgut protozoans from the Japanese termite *C. formosanus*. Two distinct cDNAs showing similarity to the members of the glycoside hydrolase family (GHF) 7 cellulases were subsequently cloned from the individual protozoan species *Pseudotrychonympha grassii* and *Holomastidotoides hartmanni*. To clone endogenous cellulase cDNAs, a set of general primers for termite endogenous cellulases was designed from the sequence of the cellulase cDNAs from the salivary glands of the termite *Reticulitermes speratus* and from the nidgut to GHF9 members were cloned both from the salivary glands and the midgut tissue of *C. formosanus*.

Index terms: Coptotermes lacteus, Coptotermes formosanus, protist, glycosyl hydrolase family

[2162] NUCLEOPOLYHEDROVIRUS SPECIFIC TO FALL ARMYWORM

Symposium and Poster Session

M. A. Watanabe¹, A. de H. N. Maia¹, M. H. Romanini¹ & A. C. Barteli^{1 1}Laboratório de Entomologia, Embrapa Meio Ambiente, P. O. Box 69, 13820-000 Jaguariúna, SP, Brazil, E-mail watanabe@cnpma.embrapa.br.

Spodoptera frugiperda

The Spodoptera frugiperda nucleopolyhedrovirus (SFNPV) is an efficient pathogen for fall armyworm biological control. But its specificity is yet poorly known. Fall armyworm, velvetbean caterpillar and silkworm larvae in batches of 20 individuals of each species were fed on diets infected with 0,1 ml of a SfNPV suspension containing 1,0 x 10⁶ polyhedra/ml. The control group was formed by 20 insects of each species were treated with uninfected diet sprayed with distilled water. The fall armyworm and the velvetbean caterpillar were fed on artificial diets whereas the silkworm was fed on mulberry leaves. Daily evaluation of mortality was carried on until the larvae reached adult stage. 45% of the fall armyworm, 90% of velvetbean caterpillar and 55% of silkworm fed on infected diet reached adulthood. The survival rate of fall armyworm was significantly lower than that of velvetbean caterpillar ($\chi^2 = 6.27$, p = 0.0025) and than that of silkworm ($\chi^2 = 6.27$, p = 0.0123) indicating the specific action of SfNPV on the first species. No significant differences were observed between velvetbean caterpillar survival distribution and that of silkworm. After 7 days of treatment 25% of fall armyworm were dead; at 11.5 th day 50% were dead; the silkworm mortality reached 25% only after 20.5 days. The velvetbean caterpillar did not attain 25%, 90% of them reaching adult stage.

Index terms: Spodoptera frugiperda, Anticarsia gemmatalis, Bombix mori, Sf nucleopolyhedrovirus

[2163] BIOLOGICAL CONTROL OF SPRUCE CONE INSECTS USING BACILLUS THURINGIENSIS

I. Weslien¹ & C. Glynn¹, ¹The Forestry Research Inst. of Sweden (SkogForsk), SE-753 41 Uppsala, Sweden.

Experiments with *Bacillus thuringiensis* (Bt) were carried out on Norway spruce in seed orchards of Central Sweden. Spraying of young conclets was effective in reducing the damage by the spruce coneworn *Dioryctria abietella*.(Lep. Pyralidae). The treatment was most likely effective because larvae come in contact with Bt since oviposition in *D. abietella* occurs mainly on the surface of young spruce conelets. Biological control of cone-dwelling insects is, however, more difficult for those insect species that oviposit within strobil during flowering. Thus, Bt treatment of conelets had no effect on damage by *Cydia strobilella* (Lep. Torttricidae). Because larvae feed concealed within the cone the only occasion for introduction of Bt, for later contact with larvae, is during flowering before cone development. Therefore, we also tested the effect of Bt treatments of strobili during flowering. We assessed the treatment effects on insect mortality, seed yield and seed quality.

Symposium and Poster Session

[2164] COPING WITH CROWDS: THE EVOLUTION OF DENSITY-DEPENDENT RESISTANCE TO PATHOGENS

K. Wilson¹, A.F. Reeson², R.S. Hails², J.K. Pell³ & K.A.J. White⁴, ¹Institute of Biological Sciences, University of Stirling, Stirling FK9 4LA, UK, E-mail kw2@stir.ac.uk; ²Institute of Virology and Environmental Microbiology, Mansfield Road, Oxford OX1 3SR, UK; ³IACR - Rothamsted, Harpenden, Hertfordshire AL5 2JQ; ⁴Department of Mathematical Sciences, University of Bath, Bath BA2 7AY.

Many insects, most notably locusts, experience wide fluctuations in population density between successive generations. In low-density populations the risk of parasitism is usually iow, but as population density increases, so too does the rate of disease transmission. Life history theory predicts that if there is a cost to maintaining an effective inimune response, then this should be paid only when there is a significant risk of being parasitised. In other words, if the population density experienced early in development is a reliable predictor of the risk of parasitism then we would expect the allocation of resources to parasite resistance to increase in a positively densitydependent manner. We tested this prediction using caterpillars of the African armyworm moth, Spodoptera exempta and two pathogens (a nuclear polyhedrosis virus and an entomopathogenic fungus). As predicted, we found that pathogen resistance was substantially greater in insects reared in crowds than in isolation. This result was robust and replicated in both laboratory bioassays and field experiments, where twice as many solitary as crowded insects died. Our results suggest that the insect immune response is phenotypically plastic and that some species are capable of changing their allocation of resources to prophylactic resistance in accordance with the perceived threat of parasitism. We discuss the implications of these results for the population dynamics of the insects and their pathogens.

Index terms: Spodoptera exempta, SeNPV, baculovirus, phenotypic plasticity.

[2166] THE SPECIFICITY ANALYZE OF ENTOMOPATHOGENIC FUNGUS BEAUVERIA BRONGNIARTII

D. Yaginuma, II. Hiromori & M. Hatsukade, Department of Applied Entomology, Faculty of Agriculture, Shizuoka University, Ohya, Shizuoka 422-8529, Japan, E-mail t0930029@ipc.shizuoka.ac.jp.

The pathogenicity of entomopathogenic fungus, Beauveria brongniartii (Strain: PBbr-1) to Heptophylla picea larva indicates especially high. However the pathogenicity of PBbr-1 against other scrab grubs shows relatively low. We thought that the specificity of PBbr-1 derived from the interaction between immunity system of H. picea and PBbr-1. Insects are known to possess effective immunity system cuticle, celluluar and humoral defense against the penetration of fungi. The insect cuticle has the important role of physical barrier and chemical substances that inhibit the growth and adhesion to fungi. In case fungi penetrate the host cuticle, fungi undergo cellular and humoral defense response in the insect hemocoel. In this study, we investigated the immunity response of H. picea larva against B. brongniartii. Especially, we researched that hemocytes, phenoloxidase activity in hemolymph and adhesion of fungal conidia The total hemocytes of H. picea larva decreased after low on the cuticle. concentration PBbr-1 injection. Whereas the total hemocytes number of H. picea hemolymph was maintained control level after other conidial injection. The phenoloxidase activity of H. picea showed lower activity than control after injection of B. brongniarti and other fungus such as Metarhizium anisopliae. From these results, PBbr-1 was able to overcome the *H. picea* hemocytes, but other fungus was inhibited from hemocytes in the hemocoel. Furthermore, the adhesion and development of fungi were investigated under fluorescence and scanning electron microscopy. These microscope studies indicated that PBbr-1 conidia adhered the cuticle of H. picea larva compared with other fungus after treatment of same concentration. The difference of adhesive ability is another factor of specificity. In this study, we convinced that PBbr-1 efficiently adhered the cuticle and inhibited to the immunity system of H. picea larva. These abilities of PBbr-1 were the factor of pathogenicty specific to H. picea larva.

Index terms: Heptophylla picea, immunity system, hemocoel, hemocyte

[2165] MANIPULATION OF SPRAY PARAMETERS TO IMPROVE EFFICACY OF MYCOINSECTICIDES AGAINST INSECT PESTS OF FIELD CROPS

<u>S. P. Wraight¹</u>, M. E. Ramos¹ & C. A. Bradley², ¹USDA, ARS, U. S. Plant, Soil, and Nutrition Laboratory, Tower Road, Ithaca, NY 14853 USA, E-mail spw4@cornell.edu; ²Mycotech Corp., 2500 Continental Dr., Butte, MT 50702-4109, USA, E-mail cbradley@mycotech.com

Most entomopathogenic fungi establish infections by direct penetration of the host's exterior body wall. The infectious units must therefore be applied directly onto the target insect or onto substrata in the host habitat where inoculation can be effected indirectly during locomotion or feeding. This mode of dose acquisition puts these agents at a marked disadvantage compared to many synthetic chemical insecticides whose vapor activity or capacity for systemic or translaminar movement obviates the need for precisely targeted spray applications. This paper reviews and compares results of field studies designed to evaluate the effects of various spray application methods on the field efficacy of Beauveria basssiana against Bemisia argentifolii (silverleaf whitefly) infesting cucurbits and Leptinotarsa decemlineata (Colorado potato beetle) infesting potatoes. In whitefly trials, efficacy of B. bassiana applications from a hydraulic sprayer configured to spray straight downward from 20 cm above the crop canopy was significantly improved by lowering nozzles to within a few cm of the crop canopy, orienting them downward at a 45° angle, and increasing hydraulic spray pressure over the range of 3.5 to 28.1 kg/cm². Compared to overhead sprays, efficacy of applications against early-instar potato beetle larvae was increased by mounting nozzles on lateral drop tubes and directing them upward at a 45° angle. These configurations effectively targeted the abaxial leaf surfaces, where young insects were feeding in a microenvironment shielded from sporicidal solar radiation and with greater than ambient relative humidity. Unexpectedly, however, use of the drop-nozzle configuration to spray third-instar potato beetle larvae had little effect on efficacy. Parallel greenhouse studies suggested that secondary acquisition of conidia by potato beetle larvae feeding on contaminated foliage was limited and that direct inoculation of larvae with a high dose of conidia was necessary to achieve control. This work indicates considerable potential for improving efficacy of foliar applications of B. bussiana through manipulation of various spray parameters and underscores the importance of precise targeting of mycoinsecticide sprays. Index terms: Entomopathogenic fungi, Beauveria bassiana, Bemisia argentifolii, Leptinotarsa decemlineata, application technology, microbial control

[2167] MICRODIAL CONTROL OF APPLE INSECT PESTS WITH ENTOMOGENOUS FUNGI

K. Yaginuma, Apple Research Center, National Institute of Fruit Tree Science, Shimokuriyagawa, Morioka, Iwate, Japan, E-mail yaginuma@ringo.affrc.go.jp

The peach fruit moth, Carposina sasakii (=C. niponensis) and peach curculio, Rynchites heros directly feed on apple fruit. The former is a key pest of apple production and a serious pest of economic importance in Japan. Chemical insecticides have been used for control of insect pests because of low damage thresholds. However , mating disruption of lepidopterous pests has become recently accepted in insect pest management programs of apples and enhanced biological control of other pests. In pursuit of useful fungal pathogens for control of two insect pests, the pathogenicity to the pests were investigated in 97 strains of Beauveria bassiana, B. brongniartii, Metarhizium anisopliae, Paecilomyces amoeneroseus, P. cicadae, P. fumosoroseus and P. farinosus. Based on laboratory bioassays, P. fumosoroseus isolate FRP99 and M. anisopliae isolate FRM119 were chosen as agents for control of the moth and curculio larvae, respectively. Suspension of conidia were applied at 10¹¹ cfu/m² into soil of apple orchard because these pests pupate in soil and the survival in soil were monitored every 7 days for 4 months using two kinds of selective media. The isolates, FRP99 and FRM119 were detected in number of 4.5x106 and 8.3x106 cfu/1g of dried soil at 7days post-application, respectively. The number of FRP99 decreased sharply to one twentieth after 28 days. The number of FRM119 decreased gradually to one fourth at 42 days post application and lasted more than 106 for three months. The moth and curculio larvae were released to the soil samples collected from test plots and evaluated in the laboratory for morality. The average mortality of the moth larvae in soil samples treated with FRP99 was 83, 50 and 6% at 14, 28 and 49 days postapplication, respectively. With FRM119, the average mortality of the curculio larvae was more than 80% at two months post-application. The potential of entomogenous fungi for controlling two pests will be discussed in light of these result.

Index terms: Carposina sasakii, Rynchites heros, Paecilomyces fumosoroseus, Metarhizium anisopliae.

Session 11 – GENERAL AND APPLIED INSECT PATHOLOGY

[2168] MICROBIAL CONTROL OF IXODES SCAPULARIS

<u>E. Zhioua¹</u>, K. Heyer², H. S. Ginsberg³ & R. A. LeBrun², ¹Fisheries, Animal and Veterinary Science Dept., ²Dept. of Plant Science, ³USGS Patuxent Wildlife Research Center, Univ. of Rhode Island, 127 Woodward Hall, Kingston, RI 02881, USA, E-mail elzhioua@uri.edu.

Ixodes scapularis, is the principal vector of Borrelia burgdorferi, the etiologic agent of Lyme borreliosis, in the U.S. Steinernematid nematodes are pathogenic only to engorged female ticks, and thus have limited applicability. Recently, we have isolated entomopathogenic fungi from field-collected *l. scapularis*. Pathogenicity of these isolates is under study. We have shown that *Metarhizium anisopliae*, a commercially-available entomogenous fungus, is highly pathogenic to *l. scapularis* in the laboratory. We have also shown that *Bacillus thuringienis* is highly pathogenic to all stages of *l. scapularis*. Potential efficacy of a delivery system for entomopathogenic fungi and bacteria is currently being evaluated.

Index terms: Ixodes scapularis, Metarhizium anisopliae, Bacillus thuringiensis, pathogenicity

[2169] INSECT GUILDS GUIDE THE EVOLUTION OF MIMETISM

C. R. F. Brandão & R. Silvestre, Museu de Zoologia da Universidade de São Paulo, C.P. 42694, São Paulo, SP, 04299-970, Brazil, E-mails: crfbrand@usp.br; rogestre@usp.br.

In quantitative and qualitative surveys of the ant fauna, using different and complementary techniques in several cerrado (a tropical dry forest that once covered most of the Brazilian central plateau) localities (Silvestre et al. 1998), we recorded 331 ant species, selecting for the present analysis those taxa associated with field observation data. For this purposes the sample included 133 species, mostly recorded visiting sardine or honey baits. Gaps in our data were filled consulting the literature whenever the information is available. A cluster analysis with complete linkage revealed 13 well characterized functional groups (Bestelmeyer & Wiens, 1996, Andersen, 1997), involving species that share ecological characteristics as to foraging strategy combined with spatial utilization of the habitat (e.g. cryptic specialized predators). Some groups show a clear taxonomic identity (e.g. Cephalotini, Attini and Ecitonini). We have noticed that in different groups the ant species belonging to distant taxonomic positions share also the overall pattern in terms of external morphology, color and/or behavior, with one or a few in each group well equipped with efficient defense mechanisms and aposematic. For instance Pseudomyrmex termitarius (Pseudomyrmecinae) may have been the model for some Camponotus species of different subgenera (Formicinae) while Pseudomyrmex unicolor may have been the model for the mimetic Gigantiops destructor (also Formicinae). In both of these cases the pairs belong to the same functional group revealed by our analysis. Community structure are affected by the ecological relations and by the reciprocal evolutionary among its members.

Index terms: guilds, ant communities, cerrado.

[2170] GENETIC POLYMORPHISM IN PREY PREFERENCE AT A SMALL SPATIAL SCALE: A CASE STUDY OF SOIL PREDATORY MITES (HYPOASPIS ACULEIFER) AND TWO SPECIES OF ASTIGMATIC MITES AS PREY

I. Lesna & M. W. Sabelis, Section Population Biology, University of Amsterdam, Kruislaan 320, 1098 SM Amsterdam, The Netherlands, E-mail: sabelis@bio.uva.nl.

Arthropod predators usually feed on a variety of different prey types. At one extreme opulations consist of an ensemble of pure specialists for each prey type and at the other they are composed of generalists that indiscriminately seize any prey encountered. In between these extremes populations may be composed of generalist predators with learned or genetically fixed prey preferences. Whether mono- or polymorphism will evolve depends on various factors, such as the cost of flexibility for the generalist, the variability in supply of various prey species and the degree to which the population is homogeneously mixed with respect to mating. Population genetic models for well-mixed populations predict polymorphism in spatially and temporally heterogeneous environments, but only under a very restricted set of conditions, i.e. when heterozygote fitness is close to each of the homozygotes. To explore the robustness of these predictions these models need to be extended to include population dynamics and experimental tests are required. Here, we report on experimental evidence for genetic variation in a well mixed, local population. A sample of c. 150 individuals of the haplo-diploid predatory mite, Hypoaspis aculeifer, obtained from c. 0.25 m^2 sandy soil in a lily field (North-Holland), was collected and their offspring was subjected to two-way selection for prey choice, using two species of astigmatic mites as prey (Rhizoglyphus robini and Tyrophagus putrescentiae, further referred to as **R** and **T**). Individual female predators choosing exclusively **R** or exclusively T in three 10-minute dual-choice tests carried out at three-day intervals were set apart and reared (on T) as isofemale lines. Selection during four generations yielded three lines showing a high probability of choosing R and two lines choosing T. Cross-breeding in both directions resulted in hybrid females with intermediate preferences and the choices found in females from F1xParent backcrosses were best explained by assuming monogenic inheritance without dominance. Our selection and cross-breeding experiments demonstrate that polymorphism in prey preference can occur at a very small spatial scale within a local population. We discuss how such variability will alter the dynamics of otherwise monomorphic predator-prey models, and how the simple mode of inheritance of a preference trait can aid the evolution of ecotypes.

Index terms: Genetic polymorphism, hybrid advantage, genetic architecture, polyphagy, specialization, predators, prey preference

EVOLUTION INSECT-PLANT DIVERSITY AND OF [2171] INTERACTIONS

T. M. Lewinsohn, Lab. Interações Insetos-Plantas, Depto. Zoologia, Inst. Biologia, UNICAMP, C.P. 6109, CEP 13081-970, Campinas, SP, Brasil. E-mail: thomasl@unicamp.br

The diversity of phytophagous insect assemblages is set both by plant and insect attributes. Insect-plant evolution can accordingly be approached either from a phytocentric or from an entomocentric standpoint. Yet another alternative, which we pursue here, is to combine these two: that is, to study and analyze insect assemblages on plants ("plant faunas") and insect host ranges jointly. Questions that can be thus addressed include for instance: to what extent are processes that determine the size and composition of insect assemblages on particular hosts shared with, or reciprocate, those processes that set the insects' host ranges? do endemic plants tend to have exclusive assemblages of specialized endemic insects, or are their assemblages subsets of polyphagous insects on widespread plants? The joint analysis of variation of assemblages and realized host ranges on different spatial scales offer insights on the evolutionary inertia of host associations or, conversely, their ecological plasticity with local conditions. These questions are examined in an extensive data set of Asteraceae and their flowerhead-feeding insects sampled over a variety of localities, habitats and regions in southeastern and southern Brazil. Included hosts are mostly in the tribes Vernonicae and Eupatoricae, and main phytophagous groups are Tephritidae and Agromyzidae (Diptera) and Pterophoridae, Tortricidae and Pyralidae (Lepidoptera). The observed insect-plant associations are also contrasted with those from other continents, spanning scales from the local Funded by Fapesp (94/2837-2 and community to intercontinental contrasts. 98/05085-2) and CNPq (522251/96-0).

Index terms: Asteraceae; Tephritidae; community structure; biodiversity; interaction diversity.

[2172] SIMULATION OF THE TRI-TROPHIC SYSTEM COFFEE-BROCA-PARASITOIDS: POSSIBLE OUTCOMES FROM TWO DIFFERENT CLIMATIC REGIMES

J. R. Cure, Facultad de Ciencias. Departamento de Biologia Aplicada. Universidad Militar Nueva Granada.

As biologists we understand that life history traits affect the growth rates of populations. Numbers and size of the offspring, age distribution of reproduction and life span are all life history traits in which species differ (Futuyma, 1998). The problem has always been to have a consistent method that enables the practical use of this information, in terms of the useful application of laboratory data with field data and observations. When we talk about tri-trophic simulations we are referring to a very well structured system analysis for the simulation of ecological interactions and its outcomes. The system has been developed during the last 20 years, and although it has been extensively illustrated with biological control examples, it can also apply to basic ecology and applied biology in general (for a complete reference, see Gutierrez, 1996). Strengths of the system are: its ability to describe complex patterns using simple biological criteria as drivers of the models; the possibility of using available data to make initial assumptions; the capacity to incorporate new data as they are available; and its' modular approach, which permits the modification of functional relationships among variables as simulations suggest a new way for interpreting the data. In many countries of South America, coffee production is threatened by the introduced coffee berry borer, *Hypothenemus hampei* (Ferrari). There is a serious need to have a good method of control, which at the same time should be safe for the consumer. Several agencies in Latin America are currently looking for such a control and are introducing parasitoids and pathogens to deal with the problem (Hoyos and Aristizabal, 1996); however, there has not been a previous evaluation of the possible results of the introduced agents for the control of the borer. A tritrophic model was developed in order to have in advance, an estimate of the possible outcome of each parasitoid and their combination under different management strategies and climatic regimes (Gutierrez et al., 1998). Elements of behavior and life history of the borer and the parasitoids are incorporated into the model. The model is driven by climatic and management data (fertilization, pruning, etc.). What we are going to present is an example of the use of the approach to practical biological control. References:

[2173] MODELING THE IMPACT OF GLOBAL WARNING ON VECTOR-BORNE INFECTIONS

E. Massad

ABSTRACT NOT RECEIVED

[2175] SELF-ORGANIZED TOLERANCE TO STRESS IN TERMITES.

O. DeSouza¹ & O. Miramontes², ¹Depto. Biologia Animal, Univ. Fed. Viçosa, 36571-000 Viçosa MG, Brazil, Email: og.souza@mail.ufv.br, ²Depto. Sistemas Complejos, Instituto de Física, Univ. Nac. Autónoma de México, Apto. Postal 20-364, México, 01000 DF, México, Email: octavio@fenix.ifisicacu.unam.mx

Social insects present a notorious diversity of behaviours, ranging from very simple to extremely elaborated tasks. Contrary to general belief, many of these complex tasks are not a result of a blueprint "hardwired" into the nervous system of the insect. Rather, the concurrent action of simple individuals, performing simple local actions, may originate very complex group behaviour. Social behaviour thereby originated are not explicitly specified in the individuals' design or in their rules for interaction. Such an "spontaneous emergence of order" is generally called self-organization. Specifically for termites, most of the theoretical and practical studies on selforganization are devoted to the nest building process. It has been already shown that the complex architecture of a nest is self-organized, resulting from the action of termites that are guided by the work in progress, rather than by an internal map. We propose another class of self-organized behaviour in termites: tolerance to stress. Termites under serious stress, such as starvation or poisoning, are able to extend survival times, as long as they are confined in optimal group sizes. Apparently, the mechanism generating such an effect is the intensity and frequency of physical contact among group members, which seems to have no explicit relation to the survival of the individuals. This conclusion is supported by results from experiments performed with real termites as well as computer simulations.

Index terms: Isoptera, social facilitation, group effects, complex systems, celular automata

(2174) ASSORTATIVE MATING, SEXUAL SELECTION, HAPLODIPLOIDY AND THE EVOLUTION OF SOCIAL BEHAVIOR IN INSECTS

<u>K. Jaffe</u>, Departamento de Biología de Organismos. Universidad Simón Bolívar, Apartado 89000, Caracas 1080A, Venezuela, kjaffe@usb.ve

Computer simulations of sexual reproduction among haploid, diploid and haplodiploid organisms showed that strategies in which females produce males asexually are evolutionary stable, displacing pure sexual organisms in interbreeding populations. Haplo-diploidy seems to drives evolution with a different dynamics than pure diploidy. Haplo-diploidy allows for a faster adaptation to a rough fitness landscape than pure diploidy. Haplo-diplod organisms showed higher probabilities for fixing alleles coding for altruistic behavior than diploid ones, and so did organisms reproducing with assortative mating. The results allow to predict that during phylogenetic evolution of sexual organisms, diploidy will be replaced by haplo-diploidy when the appropriate mutations occur, but that the reverse is unlikely. For the study of the evolution of social behavior, a theoretical game was developed. It was based on the eventual evolution of social behavior through development of altruistic cooperative care of the offspring or extended parental care. Alleles coding for five different strategies were simulated: 1- No care: A parent invested nothing in the offspring. 2- Communal care: A parent invested in any offspring irrespective of it was his own. 3- Open care: A parent invested half its acre-energy in its own offspring and half in any other offspring. 4- Opportunistic care: A parent invested only in its own offspring but its offspring could receive care from open or communal parents. 5-Closed care: A parent invested only in its own offspring and its offspring could not receive care from any other adult. The results suggest that social behavior without social synergy is very unlikely. Social behavior should emerge in evolution when cooperation improves synergistically the corresponding egoistic behavior and when alleles coding for altruistic or social behavior can be rapidly fixed in the population, by strategies such as haplo-diploidy, assortative mating, and probably others. The main conclusion thus is that social behavior has to be economically more efficient than the corresponding solitary behavior. Data are presented showing that this prediction is supported by laboratory and field observations in ants, termites and wasps.

[2176] BIO-ECONOMICS OF FITNESS: EXAMINING GOD'S UTILITY FUNCTION

A. P. Gutierrez, Ecosystem Science, 151 Hilgard Hall, Univ. California, Berkeley, CA 9472020

"DNA neither cares nor knows. DNA just is, and we dance to its music." (Dawkins 1995). A multi-trophic population dynamics model that attempts to unify ecological and economic theory of sustainable renewable resource utilization is proposed. Analogies between the energy acquisition and allocation strategies of organisms (plant or animal) in nature and modern humans are developed, and used to formulate a general objective function "maximizing" individual utility of consumption (cf. Dawkins 1995). The well-known economic concept of consumption is understood to be that part of profits that do not contribute to growth. We posit that fitness is analogous to profit and hence consumption in biology is the reproductive surplus that does not contribute directly to population growth. The currency of nature is energy and that of economics is a monetary unit, and both systems are driven by uncertainty. In economics, the discount rate reflects the level of uncertainty, while in biology uncertainty is reflected in the reproductive rate selected to counter expected mortality. In biology, consumption reflects the constraints of top-down and bottomup factors that limit population growth, while in economics the discount rates is often not related to the renewable resource being managed. Energy acquisition and allocation strategies in nature are genetically based and change on an evolutionary time scale, while in human economics the strategies are decision-rule based and may occur on a short time horizons in response to economic forces. The utility of consumption of all individuals in the population is maximized, and the objective function is subject to the constraints of the physiologically - based population dynamics model of the species in a food chain. The model applies to all trophic levels including human harvesting of resource species (see Regev et al. 1998). Humans are viewed as the top predator in the system. Sensitivity analyses of the model are used to examine how changes in the biological discount rate and physiological and behavioral parameters as well as environmental carrying capacity affect consumer and resource steady state levels. The analysis explains the role of the biological discount rate on biological consumption in r- and K-selected species. Index terms: economic and ecological theory, optimal control, population dynamics, natural selection, fitness, adaptedness, energy flow, r and K selected species

Symposium and Poster Session

[2177] EVOLUTION ABOUT BEES EVOLUTION

W. E. Kerr

ABSTRACT NOT RECEIVED

[2178] PHYLOGEOGRAPHY OF APIS MELLIFERA: SUBSPECIFIC DIVERSITY AND THE IMPLICATION FOR INTRODUCED POPULATIONS

W. S. Sheppard, Dept. of Entomology, Washington State University. 166 FSHN Bldg., Pullman WA 99164-6382, USA, E-mail shepp@mail.wsu.edu

The natural range of the honey bee includes Europe, western Asia and ali of Africa. A high degree of morphological and behavioral differentiation occurs within the species across this area of endemism. The visible nature of morphological differences led to an early appreciation of genetic diversity within the species and the development of a triany appreciation of generic diversity within the species and the development of a triangular dissification of subspecies. At present 26 subspecies are recognized and morphological and molecular data support the existence of 3 or 4 main "branches" within the species - corresponding roughly to African (A), northern European (M), southern European (C) and western Asian (O) distributions. Recent advances in molecular methodology provide data to readdress issues of subspecies origins, dispersal and subsequent gene flow. Estimates of the time since cladogenesis of the species range from about one million to nine million years. Moreover, radiation of the extant subspecies appears to coincide with the more recent estimate of cladogenesis, based on both morphology and the extent of nucleotide sequence divergence. The relatively rapid diversification of the numerous subspecies within Apis mellifera permit us to examine recent evolutionary processes. Imperfect barriers to gene flow among some subspecies and subspecies lineages provide examples of natural introgression useful to study ongoing hybridization, ecological genetics and the consequences of ancient hybridization. Honey bees spread widely throughout the world due to human activity, introducing various combinations of subspecies from both temperate and tropical regions into distinct new territories. As a consequence, we have new opportunities to examine the genetics of hybridization and the effects of selection acting on adapted and non-adapted genotypes across ecological zones. One highly visible example of this is the successful expansion of a sub-Sahara African honey bee subspecies into the Americas and its interaction with other introduced subspecies. Overall, the worldwide spread of Apis mellifera in historical time, both inside and outside the range of other Apis species, provides possibilities to investigate the genetic consequences of introduction, ecological displacement, and host shifts of parasites

Index terms: Apis mellifera, phylogeography, introduced populations, subspecies

[2179] CONTRIBUTIONS OF MITOCHONDRIAL DNA ANALYSES TO MELIPONINI BIOLOGY AND EVOLUTION

<u>M. C. Arias</u>, Depto de Biologia - IB, Universidade de São Paulo, São Paulo, Brazil 05508-900, E-mail mearias@ib.usp.br

The mitochondrial DNA (mtDNA) analysis has been widely used adding more informations about biology, genetics and evolution of different organisms. This molecular tool has been successfully employed to solve questions concerning phylogeography, phylogeny and population structure of honey bees. The mtDNA analysis of stingless bees is still very scarce. This group of hees comprises hundreds of species and exhibits a pantropical distribution. The origin of those bees is reported to be ancient than the genus Apis and South America has been indicated as their center of origin and dispersion, since presents the greatest species diversity. However some authors are still questioning about center of origin, routes of dispersion, phylogeny and phylogeography. Most of the Meliponini studies are based on morphology and behavior. In an attempt to start Meliponini mtDNA analyses, our group are studying five species of *Plebeia*, six species of *Melipona* and *Schwarziana* quadripunctata. The initial idea is to have a characterization of the mtDNA molecule and further apply this knowledge to population and evolutionary studies. The molecular approach was to characterize the mtDNA genomes using restriction enzymes and determine genetic variability among species and populations. Restriction maps were determined for all the studied species and the data set generated by RFLP were used to perform phylogenetic analyses. At population level we were already able to characterize two different populations of *Plebeia remota*, one from Paraná state and another from São Paulo state. These two populations have distinct morphological traits however they are considered as same species. Each population showed distinct haplotypes suggesting a possible geographic isolation that may lead to speciation. The whole mtDNA genome of Melipona bicolor is being sequenced. This species was chosen because it is endemic of Southern Brazil and it is getting rare due to the devastation of our forest. Approximately 65% of the genome are already cloned and sequenced. Preliminary results showed that Meliponini mIDNA is around 2 kb larger than the mtDNA genome of Apis mellifera (the only Apidae sequenced so far). Nonetheless the most striking finding is that the gene order is not conserved between Apini and Meliponini. This characteristic can be used as a marker for further studies focusing evolution an biogeography of stingless bees. The mtDNA data have shown a great genetic variability among Meliponini species, higher than found among Apis species. Our results are encouraging us to continue using this kind of analysis to understand biology and evolution of stingless bees. Index terms: Melipona, Plebeia, mtDNA, RFLP, evolution

[2180] HYMENOPTERA DNA TELLS ALL, WELL, ALMOST ALL

D. L. J. Quicke¹ & N. M. Laurenne², ¹Center for Population Biology, Imperial College at Silwood Park, Ascot, Berkshire, SL5 7PY, UK; Unit of Parasitoid Systematics, CABI Bioscience UK Centre (Ascot), Dept of Biology, Imperial College at Silwood Park, Ascot, Berkshire, SL5 7PY, & Dept. of Entomology, The Natural History Museum, London SW7 5BD, UK, E-mail d.quicke@ic.ac.uk; ²Finnish Museum of Natural History, Zoological Museum, Entomological Division, P.O. Box 17, FIN-00014 Univ. Helsinki, Finland

The Hymenoptera are one of the largest groups of insects and most of that diversity exists among the parasitoid taxa. Not surpringly, given the diversity of the group and also to an extent, the fact that few amateurs have historically been willing or able to get into their study, there has been no shortage of problems that traditional techniques have failed to solve satisfactorily so far. Sequence and other molecular data are now being used to tackle evolutionary questions at all levels in the order, from higher level relationships of superfamilies to analysing species level questions such as determining the origins of asexual lineages, the nature of virulence genes and the recognition of cryptic species. Molecular phylogenies are actively being constructed in most major groups and being used to test hypotheses about a range of questions such as the origins of endoparasitism, of host location strategies and directions in the evolution of other life history strategies. Examples of these sorts of study will be used to illustrate the enormous potential of molecular techniques in this order. Finally, I will suggest that in the next few years, DNA sequencing will become the primary means of identifying species in many sorts of study, such as in determining the host associations of the vast number of parasitoids for which rearing has so far produced no data.

Index terms: Systematics, taxonomy, cryptic species, DNA.

[2181] APPLICATION OF MOLECULAR GENETIC TECHNIQUES FOR A BETTER UNDERSTANDING OF EVOLUTION IN THE SOCIAL INSECTS

R.N. Johnson¹, & R.H. Crozier¹, 1: Department of Tropical Biology, James Cook University, Townsville Qld, 4811, Australia: E-mail: rjohnson@bio.usyd.edu.au.

The social insects have long fascinated biologists with their extremely complex lifestyles and social organisation with many hypotheses put forth to qualify such altruistic' behaviours (eg. Darwin, 1859; Hamilton, 1963). With the advent of increasingly complex and informative molecular genetic techniques, sociabilologists have been able to answer questions that could only previously be speculated upon. Two broad areas have emerged; 1) detailed population genetic studies of individual species, and 2) the reconstruction of phylogenetic relationships that can be as specific as intra-genus or so broad as to encompass an entire order. Our research group has undertaken many projects that fall within these two categories and have made significant contuibutions towards a broader understanding of the area in general. Index terms: evolutionary genetics, social insects, molecular techniques

[2183] GENOMICS AND LARVAL DEVELOPMENT IN HONEY BEES

J. D. Evans, Bee Research Lab, USDA-ARS BARC-E, Bldg. 476 Beltsville, MD 20705 USA. Email: jevans@asrr.arsusda.gov ph: 301-504-5143 FAX: 301-504-8736.

Along with their importance as beneficial insects, honey bees (Apis mellifera) have played a central role in studies of insect development. This study focused on the isolation and description of genes expressed by larval honey bees. Through the use of subtractive libraries and gene-expression analyses using genetic arrays and Northern blois, numerous genes were characterized whose expression patterns vary with age, sex, and caste of developing honey bees. Overall expression patterns at 168 loci were most similar between members of the same caste, although some genes were expressed in an age-biased manner regardless of caste. Queens showed a strong down-regulation of many genes that were expressed in embryos and first-instar latvae, including several hexameric storage proteins, a putative heat-shock protein (70 kDa), and an ortholog to a Drosophila cytochrome p450 gene. These genes were strongly expressed by workers throughout larval development. Queens showed higher expression of two putative binding proteins and an ortholog to the mammalian sex-linked smc locus. Genes implicated in nutrient transfer and storage in developing larvae often showed changes in expression between castes and ages. disproportionate fraction of ribosomal proteins arose from the subtractive libraries. Assuming these proteins help modulate ribosome activity, they may be indicators of the developmental tempo of larvae, and could be useful for assessing the initiation of various developmental programs. Efforts are ongoing to more directly ascribe function to these differentially expressed genes, and to identify genes that can be used across other social insects as indicators of larval developmental stages, timing of caste determination, and larval health.

Index terms: Apis mellifera, gene expression, caste, eusocial insect

[2182] THE EVOLUTION OF ADAPTIVE POLYPHENISMS

H. F. Niihout¹ & D.E. Wheeler², ¹Department of Biology, Duke University, Durham, NC 27708, USA, e-mail hfn@duke.edu, ²Dept. of Entomology, Univ. of Arizona, Tucson, AZ 85721, USA.

Polyphenisms are discrete alternative phenotypes that develop in response to specific environmental cues such as temperature, photoperiod, pheromones, or nutrition. Often the alternative phenotypes are adaptations that allows an insect to escape from a deteriorating environment, or allow it to better utilize the resources of a changing environment. It is generally believed that environments that change gradually, or environments that contain much fine grained spatial variation, favor the evolution of continuous phenotypic plasticity (adaptive reaction norms), whereas environments that change rapidly, or that are coarse-grained in some other way, favor the evolution of discrete alternative phenotypes (adaptive polyphenism). A central problem in understanding the evolution of polyphenisms is that the environmental cues that regulate the developmental switch to an alternative phenotype are almost always token stimuli (such a photoperiod), and not the actual environmental variables to which the alternative phenotype is an adaptation. If we assume that a polyphenism evolves from an initially non-adaptive reaction norm, then it is not obvious how the switch to a token stimulus could be accomplished by gradualistic changes development. Alternative adult phenotypes must arise through developmental changes that accompany metamorphosis. We have developed a model, based on the known developmental physiology of metamorphosis, that demonstrates how discontinuous developmental variation can easily evolve gradualistically from continuous reaction norms. This models also suggests the steps by which the sensitivity of a reaction norm (and by extension a polyphenism) to an environmental stimulus can be transferred to a token stimulus. We apply this model to understanding the development and evolution of seasonal polyphenisms, caste polyphenisms, and diapause.

Index terms: evolution, polyphenism, reaction norm, photoperiod, diapause

[2184] GENE EXPRESSION AND CASTE POLYMORPHISM IN TERMITES

T. Miura, Dept. of Life Sciences, College of Arts and Sciences, Univ. of Tokyo, 3-8-1 Komaba, Tokyo 153-8902, Japan, E-mail cmiu@mail.ecc.u-tokyo.ac.jp

Although "polymorphic castes" in social insects are well-known as one of the most important phenomena of polyphenism, few studies of caste-specific gene expressions have been performed in social insects. To identify genes specifically expressed in the soldier caste of the Japanese damp-wood termite *Hodolermopsis japonica*, we first employed the differential display method using oligo-dT and arbitrary primers. comparing mRNA from the heads of mature soldier and pseudergates (worker caste). and identified a clone (PCR product) of 329 bp in length, termed SOLI. Northern blotting analysis showed that the SOLI mRNA is about 1.0 kb in length and is expressed specifically in mature soldiers, but not in pseudergates, even in the presoldier induction by juvenile hormone analogue (JHA), suggesting that the product is specific for terminally differentiated soldiers. By the method of 5'- and 3'-RACE (rapid amplification of cDNA ends), we isolated the full-length of SOLI cDNA, which contained an ORF with a putative signal peptide at the N-terminus. The sequence showed no significant homology with any other known protein sequences, suggesting that the gene encodes a novel protein. In situ hybridization analysis showed that this gene is expressed specifically in the mandibular glands. These results strongly suggest that the SOLI gene encodes a secretory protein specifically synthesized in the mandibular glands of the soldiers. Histological observations revealed that the gland actually develops during the differentiation into the soldier caste.

Index terms: termites, soldier caste, gene expression, mandibular glands.

Symposium and Poster Session

[2185] DEVELOPMENT AND THE EVOLUTION OF CASTES IN SOCIAL WASPS

J. H. Hunt, Dept. of Biology, Univ. of Missouri-St. Louis, St. Louis, MO 63121. Email jimhunt@umsl.edu.

Queen/worker difference in "highly social" insects such as honeybees, vespine wasps, and most ants incorporates morphological difference that can only reflect different developmental pathways as larvae. In "primitively social" insects such as paper wasps and some sweat bees, queens and workers do not differ in morphology. In these taxa, queen/worker differentiation is believed to occur among reproductively equi-potent adults. Data will be presented to test the validity of this supposition. Phylogenetic mapping of traits that are integral to sociality reveals that at the threshold of sociality in the wasp family Vespidae, key traits involve unequal distribution of nourishment among nestmates and the absence of mating opportunities for emerged females. Unequal distribution of nourishment is a plausible mechanism that can underlie developmental difference in caste. Morphometric studies of Polistine wasps reveal subtle but significant queen/worker dimorphism in at least some genera of Epiponini and Ropalidiini, which suggests that larval caste determination may occur closer to the sociality threshold than has previously been believed. Indeed, studies of storage proteins in various wasps reveals patterns of difference that coincide with the proposition that caste is determined during larval development. That is, Polistes paper wasp females that emerge early in a nesting cycle retain no storage protein following metamorphosis, whereas some of the females that emerge during the time when gynes are normally produced do retain storage protein following metamorphosis. This pattern reflects an underlying pattern of difference as a correlate of overall size in the solitary vespid Monobia quadridens. The pattern does not occur, however, in the yellowjacket Vespa maculifrons. Current research on storage proteins will be presented. Also to be presented are results to date on investigations intended to isolate genes differentially expressed during larval development by the yellowjacket Vespula maculifrons. Index terms: Polisies metricus, Monobia quadridens, Vespula maculifrons, storage

protein, gene expression

[2186] HORMONAL LINKS BETWEEN GENES AND PHENOTYPES IN SOCIAL WASPS

T. Giray¹ & M. J. West-Eberhard², ¹Dept. of Biology, Univ. of Vermont, Burlington, VT 05405, USA, E-mail tgiray@zoo.uvm.edu; ²Smithsonian Tropical Research Inst., c/o Escuela de Biologia, Universidad de Costa Rica, COSTA RICA.

Understanding the physiological mechanisms that link genes and phenotypes is a necessary complement to adaptive explanations for hypotheses regarding evolutionary transitions. Social insect colonies provide an extreme example of how the same genotype may lead to very different phenotypes, such as that of the reproductive queen and the more or less sterile workers. In addition, workers may also differ in their phenotypes due to changes in the social and other environmental conditions. The link between genes and phenotype in a particular environment is physiology; environmental conditions are sensed and particular sets of genes turned on or off, leading to different patterns of development. Hormonal mechanisms regulating queen reproduction and worker behavioral development have been identified in primitively and advanced cusocial insects, respectively. In three studies with the primitively cusocial wasp Polistes canadensis, we investigated how hormonal mechanisms regulating worker and queen phenotypes may have evolved. P. canadensis workers exhibit both age-related and age-independent division of labor. Aspects of worker division of labor are under juvenile hormone (JH) regulation. Queen reproduction is also associated with high JH hemolymph titers. In post-emergence nests, containing a queen and her worker progeny, the high-risk task of guarding was performed by older workers (>7 days of age), as in other social insects. Some workers foraged as young as 2 days of age, while others never foraged. Workers treated with a JH analog, methoprene, initiated guarding at significantly younger ages and in greater numbers than did control workers. There were no differences for ovary development of workers in the treatment and the control groups. There was a significantly higher JH titer in the guards in comparison to other workers. Reproductively active queens had the highest JH titers and ovary development. These results suggest the dual function of JH may have evolved from JH regulation of both reproduction and associated behaviors in a solitary ancestor. Index terms: Polistes canadensis, juvenile hormone, division of labor, polyphenism

[2187] DIFFERENTIAL DISPLAY PCR REVEALS ECDYSTEROID-RESPONSIVE GENES IN THE OVARY OF HONEY BEE WORKER LARVAE

C. Hepperle² & K. Hartfelder¹, ¹Zoologisches Institut, Universität Tübingen, D-72076 Tübingen, Germany; ²Depto. Biologia, FFCLRP, Universidade de São Paulo, Av. Bandeirantes 3900, 14040-901 Ribeirão Preto, SP, Brazil, E-mail: Av. Bandelrantes 5500, 14040501 Rules Theorem Bandelrantes 15500 Research and the test of the test of the test of the test of the test of the test of the test of the test of the test of the test of the test of the test of the test of t

Differential Display Reverse Transcription PCR (DDRT PCR) is a sensitive highresolution PCR strategy to detect differentially expressed genes under a variety of natural and experimental conditions. We employed this technique to investigate the responses of ovaries of last-instar honey bee workers to makisterone A. The competence of larval ovaries to respond to ecdysteroids in vitro has previously been demonstrated, mimicking the response to differences in endogenous ecdysteroid titers in queen and worker larvae. Differentially expressed gene products were detected in native sequencing gels, reamplified, cloned, and sequenced. The derived amino acid sequence of each cDNA fragment was compared to known sequences of the SwissProt databank using BLAST algorithms. As a general rule, the ecdysteroid response in the larval ovaries consisted of a down regulation in gene expression. The differentially expressed gene products could classified into (1) prospective regulatory genes, (2) genes coding for proteins involved in cell-cell interaction, and (3) genes coding for household proteins, mainly of the oxidative metabolism. The cDNA fragment D5/U14 490 exhibits sequence homology to the transcription factor FTZ-F1, a factor known to modulate the ecdysone response of many genes in last-instar Drosophila larvae. The cDNA fragment D3/U4 220 shows homology to CUT proteins, transcription factors known to stabilize states of tissue differentiation in vertebrates and invertebrates. The cDNA fragment D5/U10 217 appears to belong to the superfamily of immunoglobulin cell adhesion molecules with similarity to the Kekkon proteins of Drosophila. Four cDNA fragments exibit sequence homologies to proteins of the oxidative metabolism, being cytochrom b, NADH oxidoreductase, a short chain dehydrogenase, and a catalase. In summary, the results of this DDRT-PCR approach to investigate the mode of action of morphogenetic hormones in honey bee caste differentiation demonstrate the considerable complexity of the ecdysone response in a specific tissue. Using this powerful method it became clear to us that we are yet only scratching the surface of hormone-modulated gene expression patterns that will eventually generate the morphologically distinct castes observed in highly cusocial insects. Future studies will, thus, have to take into account stage- and caste-specific responses of different tissues to the different morphogenetic hormones. Index terms: Apis mellifera, ecdysone, gene expression, ovary, metamorphosis

[2188] CHANGES IN BRAIN EXPRESSION OF CGMP-DEPENDENT PROTEIN KINASE GENE AND DIVISION OF LABOR IN COLONIES OF THE HONEY BEE APIS MELLIFERA

V. Ben-Shahar^{1,2}, M. B. Sokolowski² & G. E. Robinson¹, ¹Dept. of Entomology, Univ. of Illinois, 320 Morrill Hall, 505 S. Goodwin Ave., Urbana, IL 61801, USA, E-mail yehudab@life.uiuc.edu; ² Biology Group, Erindale Campus, Univ. of Toronto, 3359 Mississauga Rd., Missisauga, ON L5L1C6, Canada.

Modulation of behavioral and neural response thresholds to task-related stimuli is thought to play a prominent role in the regulation of division of labor among workers in insect societies. This modulation is considered to be a dynamic process, sensitive to both changes in internal state and environmental conditions. As part of our interest in identifying neural and molecular mechanisms that regulate response threshold plasticity in the honey bee, Apis mellifera, we studied brain expression of the gene encoding cGMP-dependent protein kinase (PKG) during division of labor. cGMP/PKG signal transduction pathway has been implicated in the modulation of olfactory responses in both invertebrates and vertebrates, and many task-related stimuli in the beehive are olfactory. In addition, expression of the PKG gene in Drosophila melanogaster (dg2, aka foraging) is regulated in response to changes in nutritional state (unfed vs. well fed), and this in turn affects food search behavior. We cloned a honey bee ortholog of dg2 (AmG2) which showed significant homology to PKG genes from other organisms. Using real-time quantitative PCR, we measured mRNA levels in the brains of individual foragers and "nurse" bees that tend brood. Nurses work only in the hive and consequently obtain all of their food from other bees and from stores in the hive, while foragers collect nectar and pollen outside. AmG2 mRNA was significantly higher in the brains of foragers than nurses. Using a well established social manipulation to produce precocious foragers, we further showed that this difference in gene expression is associated more with behavioral state than with age. Precocious foragers had forager-like levels of AmG2 mRNA, significantly higher than nurse bees of the same age. AmG2 expression was also found to be sensitive to nutritonal state, but foragers had higher AmG2 brain expression, regardless of nutritional state. These correlative results suggest that modulation of AmG2 expression and perhaps other aspects of the cGMP/PKG pathway play a role in the regulation of division of labor. They also provide a hint of an evolutionary conserved mechanism for the modulation of food search behavior in flies and bees.

Index terms: Apis mellifera, behavioral plasticity, gene expression, PKG, Hymenoptera.

[2189] A DELETERIOUS GENETIC ELEMENT PROMOTES MULTIPLE-QUEEN ASSOCIATIONS IN THE FIRE ANT SOLENOPSIS INVICTA

M. C. Mescher & K.G. Ross, Dept. of Entomology, University of Georgia, Athens, Ga. 30602. Email: mcm@arches.uga.edu.

The fire and Solenopsis invicta exhibits distinct monogyne (single queen) and polygyne (multiple queen) social forms. Recent research has revealed that colony social form is determined by a simple mendelian element tightly linked to the locus Gp-9. The Gp-9^b allele confers the polygyne social phenotype on its bearers and is associated with numerous features of queen reproductive biology and worker behavior. Paradoxically, this allele remains at high frequency in wild populations despite acting as a recessive lethal. We discuss the role of $Gp-9^{k}$ in determining colony social form and present a conceptual model of social evolution by which a selfish genetic element linked to $Gp-9^b$ may spread within populations, despite deleterious effects on individual reproductive success, by promoting polygyne social strategies that are successful in competition with the monogyne form at the level of selection between colonies. By making polygyne social strategies obligate to carriers of the allele, Gp-9^b may also explain a second seemingly paradoxical feature of the social biology of S. invicta, the lack of relatedness among nestmate queens. We further discuss the possibility that the $Gp-9^b$ allele, which is entirely restricted to the polygyne form, may be involved in the evolution of a large group of linked alleles which represent a suite of adaptations to the polygyne social environment. It seems possible that selfish genetic elements like $Gp-9^b$ that are involved in conflicts across multiple levels of biological organization may play a general role in the evolution of social organization and other complex biological phenomena. Index terms: Solenopsis invicta, polygyny, selfish genes, social organization

[2190]PHENOTYPIC VARIATION IN LARVAL DEVELOPMENT AND EVOLUTION: POLYMORPHISM, POLYPHENISM, AND DEVELOPMENTAL REACTION NORMS

E. Greene

ABSTRACT NOT RECEIVED

[2191] COMPLEX PATTERNS OF DIFFERENTIATION IN FRAGMENTED HABITATS

F.M.Sene, Dept. of Genetics, FMRP, Univ.São Paulo, Ave.Bandeirantes, 3900, CEP 14049-900, Ribeirão Preto, SP, Brazil, email: famesene@usp.br

The actual distribution of cactus breeding populations and species of the genus Drosophila is mainly due to paleoclimatic events in the Quaternary period: South America became cold and dry in the glacial periods and hot and wet in the interglacial periods. There were at least 4 main cycles. The last cold-dry cycle period occurred about 18,000 and 13,000 years ago. During this period the vegetation adapted to dry conditions expanded its distribution and the *Drosophila* species associated to this vegetation followed its expansion becoming large populations. In the following hot-wet period, the same vegetation contracted its distribution and consequently, this situation caused population fragmentation, restricting the populations area in relicts or refugia. These relict areas have relief and soil features propitious for the relict survival and it is possible to affirm that relict areas observed today were also relictual in the previous cycles. Small populations, presenting fluctuation in the population size, have been compared to insular geographic isolated populations which makes this situation very promising for studying population differentiation. During the cold-dry period, if the populations came into contact, we can expect all possible kinds of consequences, depending on the differentiation level achieved during the geographical isolation, from reproductive isolation to population fusion. Since this habitat fragmentation presents a mosaic situation, several contact events might occur simultaneously at different areas and the consequences might be diverse in different regions. Only the extreme cases (fusion or reproductive isolation) make the consequences easier to be analyzed. The intermediary stages allow introgression creating complex situations since the introgression level depends on factors as genomic balance of populations, selection, and genetic drift. The phylogenetic relations inferred by one or several markers might be falsified by introgression of different parts of the genome. The refugia have been considered as areas where populations have been cyclic isolated, and the main question on this context is to investigate if the present observed differentiation is a consequence of the last isolation period or a previous one. Since each population has an independently evolutionary history and the number of populations is enormous, any attempt to establish general theories for a better understanding of the enormous biological diversity of the South American populations might not represent any biological meaning.

Index terms: Introgression, Drosophila, paleoevents, speciation, biodiversity.

[2192] BREEDING SITES AND SPECIATION IN THE DROSOPHILA REPLETA SPECIES GROUP

C. R. Vilela¹, ¹Departamento de Biologia, Instituto de Biociências, Universidade de São Paulo, Caixa Postal 11461, São Paulo – SP, 05422-970, Brazil. E-mail crvilela@ib.usp.br

The Drosophila repleta species group is endemic to the New World and includes 92 species which are mostly cactophilous at least during their larval stage. The geological and climatic events responsible for the desertification of several areas of the Americas may have allowed the burst of speciation in the Cactaceae (ca. 2000 species) and, accordingly, in the cactophilous section of the repleta group. Although much has to be discovered regarding to the specificity between the flies and their hosts, the orthodox model of allopatric speciation seems to have played an important role in the process. Several genetic markers analyzed for some cactophilic southamerican species, although not always congruent, revealed some differentiation correlated with the present patched distribution of their hosts. Paleoclimatic studies revealed an alternation of cold-dry and hot-humid climates at least four times during the pleistocene. These climate cycles have been considered a likely cause for the fragmentation, expansions and contractions of the distribution of the dry-adapted vegetation and, as a result, that of the associated flies. Different selective pressures in patched areas associated with low or complete absence of alele flow probably gave conditions for genetic differention and speciation to occur. On the other hand, one example which seems, at first sight, to be in favor of the sympatric model of speciation is that of one pair of species *D. nigrospiracula 1 D. mettleri*, which live in the Sonoran Desert in association with decaying saguaro, cardon and hecho cacti and the moist soil beneath them, saturated by fermenting juice from the necrotic tissues. The adults of the first Drosophila species prefer to feed on the rotting cacti while those of the latter are found both on the cacti and on the soil. Moreover, the first one has emerged only from decaying cacti while the latter, only from the moisted soil beneath them, thus indicating a distinct niche separation related to the same (sympatric) host plants. However, although morphologically very similar, and belonging to the same subgroup, the two species are not each other's closest relative. Moreover, some unexpected associations are known. The larvae of D. carcinophila, endemic to some Caribbean islands, live in the nephric groove of the land-crab Gecarcinus ruricola and pupariate glueing on the inner surface of the crab's third maxillipeds. D. eleonorae and two undescribed, and closely related species, are cavernicolous and depend on vampire guano to complete their larval stage, being apparently sympatric two by two. In both cases the excretory products provide an ideal medium for the culture of microorganisms upon which the larvae feed. Index terms: Drosophila eleonorae, Drosophila carcinophila, cacti, crabs, vampires.

ABSTRACT BOOK I - XXI-International Congress of Entomology, Brazil, August 20-26, 2000

[2193] GENETICAL AND MORPHOLOGICAL DIFFERENCES IN ANASTREPHA FRUIT FLIES: RACES OR SPECIES ?

D. Selivon, Depto. de Biologia, Univ. São Paulo, C.P.11461, São Paulo, SP, 04522-970, Brazil, E-mail dselivon@usp.br.

The basic question to understand the mode and process of speciation in natural populations is related to the knowledge of how gene flow is reduced between populations in such way that they became committed to different evolutionary paths. Hence, different models of speciation invoke distinct mechanisms of gene flow reduction, and when these models are applied to groups of organisms their specific and distinctive biological characteristics must be considered. There are species of tephritid fruit flies which are univoltines and monophagous frequently occurring in temperate regions while other species are multivoltines and polyphagous, generally from tropical and subtropical regions. Rhagoletis is an example of the first case, in which the host-races of R. pomonella are well known. The races present genetical differences related to the choice of host plants, eclosion time and other characteristics associated with the host phenology. These evidences were interpreted according to the model of sympatric speciation. Other species of Rhagoletis may also have evolved in the absence of geographic isolation. Sibling species are usually sympatric and speciation is accompained by host shifts, thus suggesting a sympatric mode of speciation. In the second case, is included the genus Anastrepha with species commonly showing a large geographic distribution in the tropical and subtropical regions of the American Continent. Taken as example A. fraterculus (lato sensu), which occur from southern USA to northern Argentina, two populations were found in a single non-commercial orchard showing different biological characteristics and using different host plants, guavas and oranges. However, detailed studies revealed that they are not host races, but indeed two cryptic species of the "Anastrepha fraterculus complex". Similar cases seem to exist in other species of Anastrepha. It is already known that variation in host plants exploitation by a species do exists, but this variability seems to be related to geographical and ecological parameters. Moreover, two species which are predominantly allopatric may use different host when in sympatry. The data so far obtained indicate that if polymorphisms associated to specific host plant do exist in Anastrepha, they must be rare since up to the moment they were not observed. Hence, the characteristics so far described for the species of Anastrepha, favour allopatry as the mode of speciation of this group of fruit flies. Index terms: sympatry, allopatry, speciation, host races, polymorphism

[2194] LAZY EVOLUTION: CRETACEOUS/TERTIARY BIOGEOGRAPHY IN THE NEOTROPICAL REGION

D. S. Amorim. Depto. de Biologia-FFCLRP, Universidade de São Paulo, Av. Bandeirantes 3900, 14.040-901 Ribeirão Preto SP, BRAZIL. E-mail: dsamorim@usp.br.

Since species ceased to be accepted as fixed, created entities to be ever-changing, splitting systems -mainly with Wallace and Darwin's contributions-, the question of speciation occupied a large amount of printed pages in the literature. This includes topics as modes of speciation (in a geographic sense), modes of isolation (in a geographical, cytological and behavioral perspective), areas of origin etc. The particular point of temporal scale of biological evolution has always been a difficult question. Physicists criticized Darwin last century because his theory demanded a too large span of time compared to the life of the sun... As noted by Lakatos, in the development of scientific theories, not all earlier ideas and misconceptions are automatically removed from the set of paradigms upon which new theories are based on. Early in the XIXth century, creationists suggested that life would have been created some few thousand years ago. Early evolutionists began to stretch out this time to many thousands years. Along this century, most evolutionists rejected that the main recent groups of animals and plants would be already present when continents were in contact, even when their distribution would strongly suggest it (e.g., with circumantarctic, transtropical, and holarctic distributions). A considerable number of recent evolutionary reconstructions associate great part of observable biogeographic patterns with Late Pleistocene paleoclimatic events. If groups originated quite recently, the speed of evolution to produce available biodiversity would be considerably high. However, not all interpretations point this way. Modern biogeographical methods showed that common, repeated biogeographical patterns have high probability of having been caused by geologic/geographic events with which they are corologically and cronologically congruent. Hence, the disjunctions seen in many intercontinental distribution patterns of vertebrates and invertebrates should be actually attributed to tectonic fragmentation -meaning Mesozoic origin of such groups. This brought up quite harsh reactions in the literature. Biogeographic reconstructions of Neotropical groups of mammals and insects using these methods showed detailed internal congruence, as well as congruence with Cretaceous/Early-Mid Tertiary geologic events. This points to a much older origin of many groups until recently supposed to be Pleistocene or Late Tertiary. Consequently, evolution would nuch slower than supposed by most evolutionists to date, so the complex biodiversity seen today would have been slowly constructed along the past many million years.

K. S. Brown. Ir.¹ & E. Suomalainen ^{2,3}, ¹Dept. de Zoologia and Museu de História Natural, Inst. de Biologia, Univ. Estadual de Campinas, C.P. 6109, Cidade Universitária, Campinas, SP, BRAZIL 13.083-970, E-mail: ksbrown@obelix.unicamp.br; ²Dept. of Genetics, Univ. of Helsinki, Arkadiankatu 7, Helsinki SF - 00100 FINLAND; ³Deceased 15 May, 1995. Financial support: CNPq

Broad examination of chromosome numbers (haploid n) as seen in spermatogenesis of Neotropical butterflies has given a general view of the patterns of variation found at different levels. The mode is n = 29.31 (normal in Lepidoptera), shown by a third of the 1100 species examined; 12% had n = 14-16, and only 12% had n > 31. Most Hesperidae and Papilionidae (primitive families) remained near n = 30; non-Coliadine Pieridae and Lycaenidae varied more, often tending towards the mid-20s, and a derived group (the genus Heliconius), though very constant at n = 21, suddenly radiates in its terminal branch through 33 and 37 to 56-62. Satyrinae and Ithomiinae (Nymphalidae) showed the most variable numbers. In Lycaenidae and Nymphalidae, varying numbers of microchromosomes are occasionally seen in different dividing cells of a single individual (such as in the Heliconiini genera Laparus and Neruda, 19-33 chromosomes, or the Ithomiinae Eutresis (30-40) and Scada batesi (31-43). Nymphalidae vary rarely within populations (conspecific individuals of Philaethria dido showed n = 21, 52, and 68), more frequently between geographical subspecies (in the Ithomiinae Melinaea ludovica, 17-24, or Hypothyris ninonia, 15-24), often between species in a genus (Ithomiinae, Forbestra with two species showing n = 9 + microchromosomes, the third with n = 60-65; Satyrinae, *Taygetis* with all numbers from 8 to 23, outliers at 26 and 31; *Pareuptychia* species, from 8 to 44), and usually between genera (advanced Nymphalidae usually show n=30-31, but Catonephele is stable at n = 15, also shown by the Amazonian genera Vila, Asterope and Baeotus; the Amazonian derivative of Catonephele (Nessaea) halves again to n = 7-8). Within the most advanced Ithomiine tribe (Godyridini), evolution can lead to great increase the most advanced thouman the (total) turns), evolution can react to great increase in number (Godyris, 24 to 120), decrease (Hypoleria, 45 to 8), or return to the mode (Pseudoscada and Heterosais, constant at n = 30-31). Occupation of a new adaptive zone, explosive species radiation, or formation of well-differentiated lineages do not necessarily lead to observable cytogenetic differences, but widespread lineages often show aneuploidy in the Amazonian and Andean members in relation to the Atlantic forest populations, suggesting ancient and effective interruption of gene flow. It is not yet possible to predict the direction, magnitude, or most probable lineage for chromosome change accompanying evolution of Neotropical butterflies

Index terms: Aneuploidy, Ithomiinae, Heliconiinae, Atlantic forests, Variation in n.

[2196] NEW APPROACHES TO LONG STANDING PROBLEMS IN THE CHROMOSOME INVERSION POLYMORPHISM OF *DROSOPHILA WILLISTONI*

V. L. S. Valente, Departamento de Genética, Instituto de Biociências, Universidade Federal do Rio Grande do Sul. Porto Alegre, BRAZIL, valente@if1.if.ufrgs.br. Financial support: CNPq, FAPERGS, FINEP and PROPESQ-UFRGS.

The traditional view on the genesis of paracentric inversions in *Drosophila* is that they are the result of two independent chromosomal breaks followed by re-connection of the broken parts of the chromosome in an inverted orientation in relation to neighboring areas. From this point of view, the multiple inversions found in many *Drosophila* species (that have served as a base for the construction of phylogenies) must have happened sequentially and not through the simultaneous occurrence of multiple breaks. Break-point coincidence in successive inversions has been attributed to events happening at different times, suggesting that each naturally segregating inversion is a consequence of a unique event and with all the copies of a specific inversion having a common origin, the resulting sequence being a reflection of a prior rearrangement in a specific individual. This traditional view have been revised in the last decades, based on the discovery of the potential of transposable elements (TEs) to induce chromosomal breaks and rearrangements. The apparent non-randomness of inversion break points is the strongest argument against the independent origin of these rearrangements, the existence of "hot spots" is either a consequence of chromosomal structural flaws or of an agent capable of producing changes at specific sites on the chromosome. "Hot spot" of inversion break points are conserved in natural populations by natural selection, probably because they occur at favorable positions on the chromosome. Few studies until now performed presented conclusive evidences of the involvement of TEs in the generation of chromosomal inversions segregating in natural populations. D. *willistori* is a Neotropical widely distributed species characterized by an enormous amount of chromosomal inversion polymorphism of D. *willistori*, we tried to contribute the knowledge of the role of TEs in the generation and evolution of the chromosomal aversion polymorphism of D. *willistori*, and analysed the cosincidence of the inversion b

[2195] CYTOGENETICS OF NEOTROPICAL BUTTERFLIES: PATTERNS OF EVOLUTIONARY DIVERSIFICATION IN CHROMOSOME NUMBERS

[2197] NATURAL SELECTION EFFECTS ON INVERSION SIZE IN DIPTERA

M. Cáceres, A. Barbadilla & <u>A. Ruiz</u>, Dept. de Genètica i de Microbiologia, Univ. Autònoma de Barcelona, 08193 Bellaterra (Barcelona), Spain.

Most species of the Drosophila genus and other Diptera are polymorphic for paracentric inversions. Despite many years of intensive research, very few general principles have been found, besides the notion that some kind of balancing selection is responsible for the maintenance of these polymorphisms. A common observation is that successful inversions are of intermediate size. This suggests that natural selection discriminates among inversions of different sizes, favoring those of intermediate physical length. We tested the hypothesis that the selected property is the recombination length of inversions, not their physical length. If this were the case, physical length of successful inversions should be negatively correlated with recombination rate across species. This prediction was tested by a comprehensive statistical analysis of inversion size and recombination map length in 12 Diptera species (ten Drosophila species and two Anopheles species) for which appropriate data are available. An a priori criterion, based on their geographical distribution and population frequency, was used to classify polymorphic inversions either as successful (82) or unsuccessful (125). Total recombination map length of each species was estimated from the published linkage map data. We have found that (1) there is a wide variation in recombination map length among species; (2) physical length of successful inversions varies greatly among species and is inversely correlated with the species recombination map length; and (3) neither the among-species variation in inversion length nor the correlation are observed in unsuccessful inversions. The contrasting results between successful and unsuccessful inversions rule out any mutational cause and point to natural selection as the most likely explanation for these results. Two opposite forces are presumably acting on inversion length. On one side, the selective advantage of an inversion due to its recombination-reducing effect increases with length. On the other side, its detrimental effect on fertility due to four-strand double crossovers also increases with length. The net result is an optimal recombination length which varies among species. Our analysis provides the strongest and most extensive evidence in favor of the notion that the adaptive value of inversions stems from their effect on recombination. Index terms: Diptera, inversion length, recombination, natural selection

[2198] MORPHOLOGICAL CORRELATES OF CHROMOSOME INVERSION GENOTYPES

L. B. Klaczko, W. N. Souza & L. M. Hatadani., Departamento de Genética e Evolução, Instituto de Biologia, Univ. Est. Campinas, UNICAMP, Cx. Postal 6801, Campinas 13083-970 SP, Brazil. E-mail: LBK@unicamp.br. Financial support: CNPq, CAPES, FAEP-UNICAMP, FAPESP.

For more than 10 years we have been engaged in the study of *Drosophila* mediopunctata as a model organism for Population Genetics. This species has 6 pairs of chromosomes: 5 acrocentrics and a dot (which does not undergo polytenisation). Chromosome II is highly polymorphic for inversions (Peixoto and Klaczko 1990). It can be didactically divided in two regions that do not overlap and which should allow recombination between them. In the distal region we found 9 inversions (*DA*, *DI* etc.). In the proximal region there are also 9 inversions of different 3 phylads (*PA*, *PB*, *PC*). There is a very strong linkage disequilibrium between distal and proximal inversions in spite of the possibility of recombination.

In a previous study (Bitner-Mathé et al. 1995) we analyzed males collected on three different occasions, looking at their chromosome inversion genotypes and taking body measurements. Using PCA we found that shape is affected by inversion genotypes and for size there is an interaction between genotype and collection date.

There are black spots in each of the last 3 tergites of *D. mediopunctata.* But, this character is variable: one finds flies with no spots, up to flies with three spots. We have carried out a genetic analysis finding that chromosomes II, III and V affect the character and the second has the largest effect. Through a series of back-crosses to a marker-strain, we transferred various second chromosomes to a single genetic background. They were then made autozygous and the flies, raised in standard conditions, observed for their phenotype. So far we have analyzed 5 strains *DA-PAO/DA-PAO* and 6 strains homozygous for inversions of the *PC* phylad. In the first set we found 4 strains with few spots and 1 with three spots. The opposite was found in the second masociation of the genetic factors conditioning the polycromatism and the inversions.

Index terms: Drosophila mediopunctata, polycromatism, linkage disequilibrium

[2199] INVERSION POLYMORPHISM AND EVOLUTIONARY RELATIONSHIPS OF DROSOPHILA SPECIES IN THE SALTANS SUBGROUP (SALTANS GROUP)

II. E. M. C. Bieudo, UNESP, Rua Cristóvão Colombo 2265, 15054-000, São José do Rio Preto, SP, Brazil. E-mail: bicudo@ bio,Ibilce.unesp.br.

The understanding of the evolutionary relationship between organisms is central in evolutionary biology. Several methods involving morphological traits, isozyme data, chromosomal variations, reproductive compatibility and molecular studies have been used for recovering evolutionary history of organisms. We will discuss evolutionary relationships in the saltans subgroup based on chromosomal polymorphism data. The saltans subgroup is one of the five subgroups included in the saltans group. Seven species are members of this subgroup: D. saltans, D. prosaltans, D. lusaltans, D. septentriosaltans, D. austrosaltans, D. nigrosaltans and D. pseudosaltans. They are exclusively found in the Nearctic and Neotropical regions, extending from Mexico to the South of Brazil and Paraguay, also including the Caribbean Islands. The seven species are morphologically very similar; for their correct classification spermatecae and male genitalia have to be examined. The metaphase plate configuration is the same for the seven species: two metacentric and one acrocentric chromosome pairs. Intraspecific analysis of inversion polymorphism studied in the salivary gland chromosomes of 49 strains of the seven species showed a total of 26 heterozygous inversions. D. prosaltans, the species with the largest distribution area presents the greatest chromosomal variability, 14 inversions, seven of them in the XL arm. The interspecific differentiation in the subgroup was studied by analysis of inversion configurations in hybrids and by comparison of the band pattern sequence with the standard sequence of D. prosaltans, chosen as the basic configuration. A considerable degree of sequential homology was observed, mainly for the chromosome III. Only three interspecific arrangements were found among the seven species showing that this was the most stable chromosome in the course of evolution within the subgroup. The opposite occurred with the X chromosome that was the chromosome subject to the greatest change. Considering together, intra and interspecific data suggested that *D. prosaltans* may be the stem population in the saltans subgroup. It could have originated first D. pseudosaltans. A second ancestor derived from *D. pseudosaltans* could give rise to the other five species. Because information on biochemical and morphological variability, reproductive compatibility, esterases and DNA sequence are also available they can be used for conclusions regarding the relationships of the seven species, reinforcing the idea that different sets of data reflect different aspects of the history of the same taxa. Index terms: Drosophila prosaltans, D. saltans, genetic divergence, phylogeny

[2200] CLINES, LEAPS, GAPS AND REVERSES IN INVERSION POLYMORPHISM

W. J. Etges¹, M. Levitan², ¹Dept. of Biological Sciences, Univ. of Arkansas, Fayetteville, AR 72701, USA, E-mail wetges@comp.uark.edu; ²Depts. of Cell Biology/Anatomy and Human Genetics, Mt. Sinai School of Medicine and the City Univ. of New York, New York, NY 10029, E-mail max.levitan@mssm.edu.

Drosophila inversion polymorphism has long provided understanding of the forces maintaining genetic variability in nature. Local inversion polymorphism can be shaped by both natural and sexual selection. Patterns of geographic variation and degree of population structuring, such as clines, are usually not caused by random events. Clines are, in some cases, apparent from only a few sampled populations. In a few species the number of studied populations has been expanded. These can strengthen the earlier noted clines, but they frequently reveal significant deviations from them. One of the most extensively studied in this regard is D. robusta. To date 132 populations, covering almost its entire range in North America east of the Rocky Mountains, have been sampled. Gene arrangement XL-1, representing a large inversion of the middle of the left arm of its metacentric X-chromosome, for instance, has been known to exhibit a north-south cline since the earliest reports by H. L. Carson and H. D. Stalker, being completely absent in the southernmost localities but reaching 100 percent in many of the northernmost ones. Placed on a latitudinal grid, however, some areas exhibit reverse clines, and many others deviate significantly from the frequencies expected from their geographic positions. Some populations that fit the predominant cline show unusual changes over very small distances. Similar mixed signals are found in the distributions of several autosomal arrangements with north-south clines and in XR-1, an arrangement with a predominant east-west cline. In other well-studied species such as cactophilic D. mojavensis and D. pachea, inversion polymorphisms exhibit steep clines overlaying significant population structure influenced by local adaptation and host cactus use. The data suggest strong ecological forces that modify or even reverse apparent clinal variation and shape fine-scale population structuring.

Index terms: Drosophila robusta, Drosophila mojavensis, inversion polymorphism

[2201] GENETIC DIVERSITY IN INVADING POPULATIONS

E. Villablanca.

ABSTRACT NOT RECEIVED

Symposium and Poster Session

[2203] POPULATION SPECIFIC MARKERS: THE POWER OF GENEALOGIES

<u>E. Villablanca.</u>

ABSTRACT NOT RECEIVED

[2202]IDENTIFYNG THE GEOGRAPHIC SOURCE OF INDIVIDUALS THROUGH MULTILOCUS GENOTYPES

N. Davies & K. G. Roderic.

ABSTRACT NOT RECEIVED

[2204] CONTRIBUTION OF MOLECULAR MARKERS IN BLOWFLIES

A.M.L. Azeredo Espin, Lab. Gen. e Biol. Mol. Animal, DGE/CBMEG, UNICAMP, P.O. Box 6109, Campinas, SP, Brasil, CEP 13083-970, e-mail: azeredo@obelix.unicamp.br. Financial Support: FAPESP, PADCT-CNPq.

The family Calliphoridae (blowflies) reponsible for myiasis can be divided into three functional groups based on their larval feeding habits: saprophages, facultative ectoparasites and obligate parasites. In Brazil, the screwworm fly Cochliomyia hominivorax is one of the most devastating insect pests, as it infest open wounds of man and warm-blooded vertebrates, causing great profit losses for cattle breeders. At the genetic level, investigations of natural populations have been conducted in some geographic populations of screwworm flies from South, Central and North America and Africa based on classical approaches and molecular markers. Investigations of natural populations of blowflies have been limited to the analysis of the population natural populations of blowflies have been limited to the analysis of the population dynamics and behavior of caliphorids, including *Chrysomya* species. These species are of considerable medical, forensic and sanitary importance. Until recently, *Chrysomya* flies were restricted to the Old World tropics. The introduction of four species of this genus, in the last two decades, in the Western Hemisphere, has been spectacularly successful. *C. megacephala*, *C. albiceps*, and *C. putoria* were introduced, around 1975, in Southern Brazil and since then they have spread rapidly in the transfer of the spread of the across South America. A fourth species, C. rufifacies, was collected in Costa Rica in 1978. Recently, the newly introduced Chrysomya species have been considered effective competitors of the widespread native saprophagous blowflies species. Remarkably little is known about the genetic structure of blowflies and intraspecific differentiation in Old World and Neotropical populations. Most genetic work on differentiation in insects species has focused on searching for genetic markers, such as mtDNA and nuclear DNA by RFLP, PCR, RAPD and sequencing approachs to recover the genetic information and geographic structure of populations. Because of its unique characteristics, mtDNA is a valuable tool for studying molecular evolution and phylogenetic relationships. This study provides the complete sequence of the mitochondrial genome of *C. hominivorax* and a population genetic analysis of *Cochliomyia* and *Chrysomya* species based on PCR-RFLP of mtDNA and sequences of specific genes and control region. Comparisons were made with the mtDNA of other insects including others blowflies species on the basis of genome size and organization, DNA and putative amino acid sequence data, nucleotide substitutions, codon usage and bias, and pattern of AT enrichment. The contribution of Calliphoridae mtDNA data will be discussed in terms of recover genetic and multiphoridae mtDNA data will be discussed in terms of recover genetic and evolutionary informations concerning the pattern of introduction, colonization and dispersion of blowflies in Brazil.

Symposium and Poster Session

[2205] MIGRATION OF RICE PESTS IN ASIA: GENETICS AND GIS

Y. Song, J. Mun & K. L. Heong.

ABSTRACT NOT RECEIVED

[2207] RETROTRANSPOSON MEDIATED HYBRID INSTABILITY IN DROSOPHILA

A. Fontdevila, Grup de Biologia Evolutiva, Departament de Genètica i Microbiologia, Universitat Autònoma de Barcelona, Bellaterra (Barcelona) Spain

Hybrid instability refers to the general condition of hybrids to undergo changes in mutation and recombination rates that may lead to a rapid genome repatterning. Conditions promoting this instability may be diverse and are still not well understood, but often they have been associated to transposition increase of mobile elements. Drosophila buzzatii and D. koepferae (Drosophilade, Diptera) are two cactophilic sibling species originating from the desserts of NW Argentina. Hybridization between D.buzzatii males and D.koepferae females yields fertile females and sterile males. Backcross hybrids show high chromosomal instability, evidenced by a high rate of new chromosomal rearrangement production. Osvaldo is a retrotransposon isolated from D.buzzatii. Its molecular structure has been reported and shows all the features of a retrovirus. Studies with backcross hybrids have shown that Osvaldo transposes at high rates in hybrids between D.buzzatii and D. koepferae. Since evidence is increasing that mobile element transposition induces many point mutations and chromosomal rearrangements, our results, in conjunction with other similar experiments with hybrids of other species, suggest that hybrid instability can be mediated by increasing rates of mobile element transposition. Recently, an increasing number of species originated by hybridisation is being described, so the possibility exists that transposon mediated hybrid instability represents the initial step to speciation.

[2206] HOST CONTROL OF COPIA RETROTRANSPOSITION RATE IN DROSOPHILA MELANOGASTER

S.V. Nuzhdin, S.G. Pardue, J.P. Gonzales & R. Ng, Dept Evolution & Ecology, Univ California at Davis, Davis, CA.

For most retrotransposons including *copia*, the average rate of transposition in natural populations is 10^{-5} - 10^{-4} per copy per generation. Among laboratory lines, however, the rate of *copia* transposition strongly varies. We are pursuing genetic analysis of the differences between two parental lines with transposition rate of zero (Oregon R) and 10^{-2} (2b). Previously, we constructed 98 recombinant inbred lines from these parental lines. Lines were scored for 126 molecular markers, *copia* transcript level, and *copia* transposition rate. *copia* transposition rate was controlled by interacting factors mapping to the region 27B-48D on the second and 61A-65A and 97D-100A on the third chromosomes. High *copia* transcript level was not required for transposition. Here, we report data on the level of reversly transcribed extrachromosomal *copia* DNA. We show that one of large-effect factors maps more precisely to near section 43 and accounts for a ten-fold difference in the level of *copia* reverse transcription. We further show that *copia* transpositions are not limited to a particular sequence variant, and reject the hypothesis of a master copy.

[2208] MOLECULAR AND EVOLUTIONARY ANALYSIS OF DIVERSE FAMILIES OF MOSQUITO TRANSPOSABLE ELEMENTS AND POTENTIAL APPLICATIONS

Z. Tu, Department of Biochemistry, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, USA

Transposable elements, or mobile genetic elements, proliferate by replicative transposition and can make up a large fraction of the genome. We have so far discovered many families of transposable elements in the yellow fever mosquito, *Aedes aegypti*. Many of these novel transposable elements are associated with genes and/or other repetitive elements. We are further analyzing the diversity, characteristics, and distribution of these elements. We are also comparing similar families of transposable elements in different mosquitoes to understand the evolution of these elements as well as the evolution of their host genomes. Finally, we are actively exploring the possibility to use some of the transposable elements as transformation tools or genetic markers.

Index terms: Aedes aegypti, genome, evolution, repeats

[2209] TRANSPOSABLE ELEMENT ABUNDANCE, DISTRIBUTION AND EVOLUTION IN TEPHRITID FLIES

L.M. Gomulski, C. Torti, A.R. Malacrida & <u>G. Gasperi</u>, Department of Animal Biology, University of Pavia, P.zza Botta 9, I-27100 Pavia, Italy, E-mail: gasperi@unipv.it

The fast colonizing species, Ceratitis capitata, can be considered a predictive model for studies of the effects of environmental factors on genetic stability and on the transfer efficiency of new genetic traits introduced by biotechnology. The medfly, C. capitata has over the last hundred years, greatly extended its range from its native source area, in S.E. Africa to include the Mediterranean basin, South and Central America and Australia. The very high genetic variability detected in the African native populations may reflect the genetic plasticity of this polyphagous species, that in a very short time has reached an almost cosmopolitan geographic distribution. Drift and bottleneck effects may have contributed to the genetic changes in the derived populations; a balance between drift and migration has not yet been reached in recently colonized areas. We cannot exclude that transposable elements (TEs) could help some populations to restore their genetic variability after a bottleneck and to adapt to changing environments. In *C. capitata* there is indirect evidence that endogenous families of transposable elements are still actively transposing as documented by hybrid dysgenesis phenomena and frequently occurring genomic instabilities. In this context we have isolated and determined the chromosomal distribution of hobo related sequences from C. capitata. Highly differentiated elements of the mariner and Tc1 superfamily are widespread in the medfly genome. The copy numbers of each of the elements are very different, but no significant differences were detectable between native, ancient and newly derived populations, indicating that the medfly's rapid colonization process has had little affect on their abundances. The distribution patterns of the elements vary greatly with respect to their euchromatic/heterochromatic localizations and they are distinctive and specific for each element. Based on our data on different mariner elements we propose a model in which the abundances and distributions of these elements are regulated primarily by selection against deleterious effects due to meiotic ectopic recombination, with genetic drift playing a minor role. The extension of these analyses to other related Tephritid species including Ceratitis rosa, Trirhithrum coffeae and Bactrocera spp. has permitted us to relate the evolution of transposable elements with the divergence of the host species.

Index terms: Ceratitis capitata, medfly, mariner, Hobo, Tc1.

[2210] TRANSPOSABLE ELEMENTS IN CULICINES MOSQUITO GENOMES : CLASSICAL AND ODD STRUCTURES, HIGH COPY NUMBER AND ROLE IN POPULATION POLYMORPHISM

<u>C. Feschotte</u>, C. Cagnon, S. Karama & C. Mouchès, Laboratoire Ecologie Moléculaire & Faculté Sciences et Techniques Côte-Basque, BP 1155, F64013 Pau -France Tel (33) (0)5 59 92 31 43 - Fax (33) (0)5 59 80 83 11 - e-mail claude.mouches@univ-pau.fr

Transposable elements characterized in Culex and Aedes mosquitoes belong to numerous families and contrast with those of other Diptera, as Drosophila or Anophelines, in being reiterated in high copy number. Moreover, several of these highly reiterated elements share original structures and/or belong to families rarely described among insects (e.g. MITEs, SINEs, 'gag only' retroelements, etc.). Insertion polymorphism analyses at the white locus suggest that recent massive transposition and retroposition events might play a major role in the processes that ensure the adaptative success of these vectors.

[2211] ZAM, A RETROVIRUS FROM DROSOPHILA MELANOGASTER

C. Vaury¹, S. Desset¹, C. Meignin¹, C. Conte¹ & P. Leblanc², ¹INSERM U384, Faculté de Médecine, 28 Place H. Dunant, 63000 Clermont-Ferrand, France, E-mail Chantal. VAURY@inserm.u-clermont1.fr; ²INSERM U412, 46 Allée d'Italie, 69364 Lyon Cedex 07, France.

ZAM is a new retroelement of *Drosophila melanogaster*. It was identified as a mutational insertion at the *white* locus. It displays all the structural features of a vertebrate retrovirus. Its three open reading frames encode predicted products resembling the products of the *gag*, *pol* and *env* genes of mammalian retroviruse. Its transcription gives rise to a 8.6kb full-length RNA and a 1.7 kb spliced message for the *env* gene. The latter encodes an envelope protein that is typical of elements having an extracellular phase of the life cycle. When tracing ZAM mobilization, we have shown that all components necessary to assemble ZAM particles, ie ZAM full length RNA, Gag and Env polypeptides are co-expressed in a small set of follicle cells surrounding the oocyte. In this somatic lineage of cells, ZAM particles have been detected by electron microscopy and found to leave the somatic cells and enter the closely apposed oocyte where genomic insertions take place. The potential ways a retrovirus may infect the germ line of its host will be discussed in light of our results. Index terms: *Drosophila melanogaster, Retrovirus, ZAM, retrotransposons*.

[2212] CODON USAGE OF TRANSPOSABLE ELEMENTS AND HOST GEMONE

E. Lerat^{1,2}, C. Biémont² & <u>P. Capy</u>¹, ¹Laboratoire Populations, Génétique et Evolution, Centre National de la Recherche Scientifique, 91198 Gif/Yvette Cedex, FRANCE, E-mail capy@pge.cnrs-gif.fr; ²Laboratoire Biométrie et Biologie évolutive, Centre National de la Recherche Scientifique, UMR 5558, Université de Lyon I, 69622 Villeurbanne Cedex – FRANCE.

Codon usage of transposable elements (transposons, LTR and non-LTR retrotransposons) were compared with those of genes of several hosts including *Drosophila melanogaster*, Caenorhabditis elegans *Saccharomyces cerevisiae*, *Escherichia coli*, *Homo sapiens sapiens*, *Arabidopsis thaliana*. Comparison was done from a multivariate statistics. We have shown that the codon usage of the host genes differ from those of transposable elements (TE) mainly in the third base of the codons. Transposable elements are generally AT-rich independently of the host genome and element class. A detailed analysis of the *P* element in several *Drosophila* transfers. Comparison of relative bias of TEs compared to those of the host genes could be useful to understand the dynamics (within a species) and evolution (between species) of TEs.

Index terms: Codon usage, ransposable elements, Drosophila melanogaster, host genes, correspondence analysis

[2213] TRANSPOSONS ARE IMPLICATED IN THE GENERATION OF NATURAL CHROMOSOMAL REARRANGEMENTS IN INSECTS

M. Cáceres, J. M. Ranz, A. Barbadilla & <u>A. Ruiz</u>, Dept. de Genètica i de Microbiologia, Univ. Autònoma de Barcelona, 08193 Bellaterra (Barcelona), Spain

Chromosomal changes are a common feature of insect evolution. Paracentric inversions are particularly abundant in the genus Drosophila both as intraspecific polymorphisms and fixed interspecific differences. The origin of such chromosomal rearrangements is uncertain. Transposable elements (TEs) were first shown to mediate chromosomal rearrangements in laboratory populations of Drosophila melanogaster and in situ hybridization studies provided circumstantial evidence of their presence around the breakpoints of some natural inversions. However, despite these observations, unequivocal evidence for the implication of TEs in the origin of natural chromosomal rearrangements has been until recently elusive. No association was found between middle repetitive sequences and inversion breakpoints in D. subobscura and D. pseudoobscura. Also, the first two studies which sequenced the breakpoints of natural inversions did not detect traces of TEs. We have cloned and sequenced the breakpoints of the most common inversion in the populations of D. buzzatii, named 2j. Both breakpoints of the sequenced 2j chromosome contain relatively large insertions of DNA, which are not present in the 2 standard chromosome (lacking the inversion). The insertion in the distal breakpoint (392 bp) represent a defective copy of a transposon named *Galileo*. That in the proximal breakpoint (4,319 bp) contains also a copy of *Galileo* plus another five copies belonging to three other TEs. Both DNA blocks are flanked by two pairs of 7 bp target site duplications which were presumably generated upon insertion and later exchanged during the inversion event. Therefore the inversion arose by ectopic recombination between the two copies of Galileo that were in opposite orientations. Characterization of the structural and nucleotide variability around the inversion breakpoints in a geographically diverse set of chromosomal lines has shown that all chromosomes carrying the 2j inversion are monophyletic, i.e. inversion 2j arose only once. It has also revealed a striking structural variability at the inversion breakpoints of the 2j chromosomes due chiefly to the presence of several TE insertions. Altogether, at least 20 different insertions representing 8 types of transpososons have been found. This suggests that the 2j inversion breakpoints are hotspots for transposon insertion.

Index terms: Drosophila buzzatii, transposons, chromosomal rearrangements.

[2214] MOLECULAR EVOLUTION AND GENETICS OF NEOTROPICAL ANOPHELINE MALARIA VECTORS

J.E. Conn, Dept. Biology, March Life Sciences Bldg., Univ. of Vermont, Burlington, VT, USA 05405-0086.

Systematics has been an important tool for clarifying the diversity and relationships of neotropical anophelines in the subgenus Nyssorhynchus. Anopheline mosquito taxa are known to include many species complexes, whose members differ in vectorial capacity, distribution and ecological requirements. The documentation of these differences and the evolutionary histories of members are a critical first step prior to testing evolutionary and ecological hypotheses about malaria transmission. Our work has examined and clarified the systematics of Anopheles darlingi, Anopheles aquasalis, Anopheles nuneztovari and reestablished both Anopheles trinkae and Anopheles dunhami as distinctive species. In addition, the molecular data set from our phylogenetic hypothesis of this important subgenus demonstrates that several additional taxa may not be monophyletic (Danoff-Burg and Conn, unpub. data). This underscores the need for further work on these taxa, some of which are important regional malaria vectors. At the population level, my main questions concern structure and gene flow. We have focused on three species with highly differentiated ecologies: A. aquasalis is primary coastal and is the only neotropical anopheline to tolerate high salinity breeding sites; A. nuneztovari generally breeds in sunlit pools and has a seemingly disjunct distribution (Amazonian Brazil vs. Venezuela and Colombia); A. darlingi is highly anthropophilic, very broadly distributed, and breeds in forested riverine environments as well as pools formed during road construction throughout the Amazon. We have found significant variance components both among populations within neotropical biomes and within populations (P < 0.001) for all three species. We have also hypothesized that the presence of highly divergent haplotypes in single populations (one of the contributing factors to significant intrapopulation structure) may be the result of historical waves of colonization by these vagile organisms, with subsequent selective extinction of some lineages. We have suggested that distinctive histories detected by mitochondrial DNA analysis may have influenced the different levels of gene flow in two closely related regional malaria vectors with partially overlapping distributions and similar ecologies . To elucidate the potential effect of population structure on malaria transmission, my laboratory has developed microsatellite primers (the first for a neotropical malaria vector). Using these powerful, highly variable, population-level molecular markers we are currently examining population structure and gene flow in A. darlingi in endemic malaria areas in Amazonian Brazil separated by the Amazon River.

[2215] CHROMOSOMAL POLYMORPHISM AND SPECIATION IN ANOPHELES GAMBIAE

G. C. Lanzaro¹, Y. T. Touré², F. Tripel¹ & C. E. Taylor³, ¹Center for Tropical Dis., Univ. Texas Med. Branch, 301 University Blvd., Galveston, TX; 77555-0609 USA; ¹Malaria Res. & Training Center, Fac. Médecine & de Pharmacie & d'Odonto-Stomatologie, Bamako, B.P. 1805, Mali; ³Dept. Organismic Biol., Ecol. & Evol., Univ. CA, Los Angeles, CA, 90095-1606 USA.

The population structure of Anopheles gambiac s.s. is unusual, with populations being composed of "chromosomal forms". The names BAMAKO (B), MOPTI (M) and SAVANNAH (S) have been applied to forms in West Africa. Studies of karyotype frequencies at sites where the 3 forms occur in sympatry revealed significant departures from the Hardy-Weinberg equilibrium. Specifically, heterokaryotypes representing hybrids between the S form and the other 2 were under-represented and B/M hybrids were never observed. This was inferred to result from partial reproductive isolation between S and the other forms and complete isolation between the B and M forms. Recently, the status of S hybrids has been questioned, so that in fact reproductive isolation between all 3 forms may be complete. However, hybridization experiments involving crosses between forms result in viable offspring indicating a lack of post-mating reproductive barriers between them, at least in the lab. Estimates of genetic distance and descriptions of population structure based on isozymes also suggest that deficiencies in the frequencies of certain karyotypes may not be the result of reproductive isolation. It should be emphasized that although these studies do not support reproductive isolation among forms, they do not disprove it. For example, pre-mating barriers may isolate subpopulations, even if post-mating mechanisms have not evolved, and isolation may be too recent to be detected by isozymes. It has been recently reported that RAPD and ribosomail RNA gene regions are diagnostic for the B and M forms, leading to the suggestion that these 2 represent species. We have recently completed studies to estimate levels of gene flow (N,m) among forms. These studies have included both "indirect" and "direct" methods. The indirect methods include mark-releaserecapture studies to estimate effective population size (N₄) and migration rate (m). In addition, we have made direct observations of mating among forms by genotyping sperm extracted from field collected fema

Index terms: population genetics, gene flow, microsatellite DNA

[2216]MOLECULAR PHYLOGENY OF THE BACTROCERA TAU SPECIES COMPLEX

S. Thanaphum, Department of Biology, Faculty of Science, Mahidol University, Rama VI, Rajdhavee, , Bangkok 10400, Thailand, E-mail testn@mahidol.ac.th

Tephritid fruit flies are important and very diverse pest of crops in Southeast-Asia. Although most tephritid species could potentially damage fruits, only several of them ruin major agricultural commodities. *Bactrocera tau* represents an example of an important tephritid pest. It shows a preference for attacking the fruits of Cucurbitaceae. The *B. tau* species identifications suggests that there may be a complex of widely distributed species. Biological understanding of systematics and evolution at the species complex level is fundamentally important to pest management programs as well as species concepts. The existence of a *B. tau* species complex status had initially been suggested by some biological differences such as host-plant preferences, karyotypes, and mophological studies. However, evolutionary genetic relationships among species in a complex could be better studied using DNA markers. Part of a heat shock cognate 70 kDa like gene (hsc70) was developed and used as a DNA marker. The hsc70 DNA sequences were used to reconstruct phylogenetic relationship of the *B. tau* at the level of species in the complex and/or populations. All molecular phylogenetic tree topologies show congruence results with high confidence when we use neighbor-joining, maximum parsimony, and maximum likelihood analyses. Thus, this part of hsc 70 may be a suitable phylogenetic marker for the study of *B. tau* species complex status.

Index Terms: Tephritid fruit fly, Bactrocera tau, heat shock 70 kDa gene, molecular phylogeny, species complex

[2217] HAT MEDIATED TRANSFORMATION OF INSECTS

D. A. O'Brochta¹, P. W. Atkinson², ¹Center for Agricultural Biotechnology, University of Maryland Biotechnology Institute, Plant Sciences Building, College Park, MD 20742, USA, E-mail obrochta@umbi.und.edu; ²Dept. of Entomology, Univ. of California, Riverside, CA 92521, USA.

The hobo, Ac, Tam3 (hAT) family of transposable elements has representatives in many organisms including vertebrates. Their widespread distribution is likely due in part to their ability to transpose when introduced into a new host. This property has also made them useful as gene vectors. The hAT element Hermes has received the most attention as a non-drosophilid insect gene vector and it continues to hold great promise as a versatile tool for creating transgenic insects. Hermes was originally isolated from the housefly, Musca domestica but has since been shown to be capable of undergoing transpositional recombination in approximately 10 species of insects from 3 orders. The limits of this element's host range remain undetermined. As with other elements, the rates of Hermes movement vary from species to species. In some strains of Drosophila melanogaster transformation rates of 100% have been found. Transformation rates of non-drosophilid insects with the same vector have been considerably lower. Aedes aegypti has consistently been transformed with Hermes at How the host influences integration rates is not rates of approximately 2%. understood but clearly this clement is capable of efficiently integrating into chromosomes. Some aspects of the behavior of Hermes are clearly host-independent. For example, this element consistently prefers to integrate into DNA of a particular sequence regardless of the host. The mechanism by which transposable elements integrate into a target molecule can proceed by a number of mechanisms. Hermes, like other elements of this type, appears to move via a cut-and-paste mechanism, whereby the element is excised from the donor site at positions defined by the terminal inverted repeats of the element. But many elements also have alternative mechanisms that can be used under certain conditions. Hermes appears to have at least two mechanisms by which it can transpose. In all insects tested Hermes undergoes cut-and-paste type movement. In mosquitoes a second mode of integration has also been detected that appears to be a form of replicative transposition. Finally, gene vectors constructed from transposable elements belonging to large element families have a chance to encounter one of their relatives present in the host insect being transformed. We have begun to explore the potential consequences of such an encounter and have found that in some cases the elements can interact in such a way as to destabilize each other. The interactions we have observed are not reciprocal. The significance of these observations will be discussed in relation to the planned uses of transgenic insects in the field.

[2218] THE *MINOS* TRANSPOSABLE ELEMENT AS A TOOL FOR INSECT TRANSFORMATION

C. Savakis, University of Crete and Institute of Molecular Biology and Biotechnology, Foundation for Research and Technology Hellas, Heraklion, Crete, Greece. E-mail: savakis@imbb.forth.gr

Minos, a Type 2 transposable element from Drosophila hydei, is transpositionally active in several insect species, including Diptera (Drosophila melanogaster, Drosophila virilis, Ceratitis capitata, Aedes aegypti, Anopheles gambiae and Anopheles stephensi) and Lepidoptera (Spodoptera frugiperda and Bombyx mori). Using established germ line transformation procedures, Minos vectors have been used for construction of stable transgenie D. melanogaster, C. capitata (the first non-Drosophilid insect for which mobile element-mediated transformation has been demonstrated) and, more recently, Anopheles stephensi. Expression of the white gene and of several constructs containing the Green Fluorescence Protein is routinely used to detect transformation. In jection of *in vitro*-synthesized Minos mRNA in preblastoderm embryos containing Minos transposon insertions results in high frequency mobilization of the transposon. In the Medfly, Ceratitis capitata, Minos-mediated transformation has been used to express genes in inducible, tisue-specific and sex specific manner. Applications of Minos-mediated transgenesis in the insect sciences and in applied entomology will be discussed. In addition to gene transfer, random chromosomal insertions of Minos vectors can be used to introduce mutations in diverse insect species. Possible applications of transposon-mediated mutagenesis for functional genome analysis in insects will be discussed. [2219] FRUIT FLY TRANSFORMATION WITH PIGGYBAC: PERSPECTIVES AND CONSIDERATIONS

A. M. Handler¹, S. D. McCombs² & R. A. Harrell¹, ¹Center for Medical, Agricultural, and Veterinary Entomology, USDA-ARS, Gainesville, FL 32608, USA, E-mail handler@nersp.nerdc.ufl.edu; ²Dept. of Entomology, University of Hawaii, Honolulu, HI 96822, USA

The ability to achieve efficient germline transformation in nondrosophilid insects has become feasible with the transposon-based vector system called piggyBac, originally isolated from the cabbage looper moth, *Trichoplusia ni. piggyBac* vectors were created by insertion of markers including white genes and a green fluorescent protein (g/p) gene, either individually or ln combination. With an hsp70-regulated helper transposase, the Mediterranean (*Ceratifis capitata*), Caribbean (*Anastrepha suspensa*), and oriental (*Bactrocera dorsalis*) fruit flies were transformed, in addition to *Drosophila melanogaster*. The ability of a moth vector system to function in several dipteran species is encouraging for its function in other dipterans, and possibly other insect orders. This is supported by the original transformations mediated by a self-regulated transposase helper, indicating that *piggyBac* retained autonomous function in another insect order. Subsequently, evidence from several groups showed *piggyBac*-inediated transformation of the oriental fruit fly, Southern DNA hybridization controls in non-transgenic strains showed that *jiggyBac* to closely related elements previously existed in this species, and this was the first detection of *piggyBac* present wild and mutant strains, with intact and defective elements. Analysis of 1.5 kb *piggyBac* PCR sequences in several *B. dorsalis* strains indicated a -95° nucleotid and amino acid sequence identify between the elements in *T. ni* and *B. dorsalis*. This was further supported by sequencing of genomic clones indicating the same inverted terminal repeats and TTAA insertion site. Further surveys by PCR and hybridization indicated that *piggyBac* exists throughout the *B. dorsalis* strans of distantiy related species is not surprising, and it is likely to have occurred by horizontal transmission. The apparent discontinuity of *piggyBac*, or related transpecies is range of function, and onignared to sinilarly active transposon vectors, the existence of *pig*

[2220] MARINER MOBILITY IN AEDES AEGYPTI

C. J. Contes¹, N. Jasinskiene² & A. A. James², ¹Dept. of Entomology, Texas A&M Univ., College Station, TX 77843-2475, E-mail: c-coates@tamu.edu; ²Dept. of Mol. Biol. & Biochem., Univ. of California, Irvine, CA 92697.

The Mosl mariner element from Drosophila mauritiana was used to produce germline transformants of the yellow fever mosquito, Aedes aegypti. A white eyed strain of Ae. aegypti, kh*, was used as the recipient strain. The D. melanogaster cinnabar gene was used as the transformation marker and was able to rescue the eye color mutation. Molecular analysis using Southern blot and Inverse Polymerase Chain Reaction (IPCR) techniques revealed that the integration events were occurring at TA nucleotides as expected. The transformation rate in this initial experiment was approximately 4%. This is significantly lower than comparable experiments performed in *D. melanogaster* with the *Mos1* transposable element system. In aneffort to improve the *Mos1*-mediated transformation rate in *Ae. aegypti*, experiments were performed with purified recombinant Mos1 transposase. The rate of germline transformation was increased by 2-fold and the number of transgenic G1 individuals that were produced in each transgenic family was increased 7.5-fold, when compared with the experiment using a helper plasmid as the source of transposase. However, Southern blot and IPCR data revealed that a number of the integration events mediated by the recombinant transposase, were not a result of an expected cut-and-paste transposition event. Experiments are in progress to produce variants of Mos1 that show increased transpositional activity following mutagenesis. It has been postulated that strains of mosquitoes that can no longer transmit certain pathogens could be genetically engineered and used to spread the refractory phenotype throughout a wild population. This will require a driving mechanism to spread the refractory gene. Experiments are in progress to assess the ability of a marked autonomous Mos1 element to spread through cage populations of Ae. aegypti. Index terms: Genetic transformation, Transposable Element, Transposition.

[2221] BACULOVIRUS-MEDIATED GENE TARGETING IN THE SILKWORM

11. Mori & M. Yamao, Department of Applied Biology, Kyoto Institute of Technology, Kyoto 606-8585, Japan, E-mail hmori@ipc.kit.ac.jp

Targeted disruption of an endogenous gene would permit analysis of gene function through the production of gene-knockouts in the silkworm, *Bombyx mori*. In addition, homologous recombination of a foreign gene downstream from a powerful promoter, such as the fibroin promoter, would allow large-scale and constitutive production of a useful protein in the silkworm. The green fluorescent protein (GFP) gene was inserted into fibroin light (L)-chain gene. The L-chain/GFP chimeric gene was used to replace with the polyhedrin gene of *Autographa californica* nucleopolyhedrovirus (AcNPV). This recombinant virus was used to target the L-chain/GFP gene to the L-chain region of the silkworm genome. Silkworm larvae were infected with the recombinant virus and genomic DNAs from their progenies were screened for the desired targeting event. This analysis demonstrated that the chimeric gene had been integrated into the L-chain gene on the genome by homologous recombination and stably transmitted through generations. The chimeric gene was expressed in the posterior silk gland and the gene product was spun into the cocoon layer. In order to produce several useful proteins in the silkworm, these genes were also inserted into L-chain gene and the polyhedrin gene of AcNPV was replaced with the chimeric genes. Screening of the desired gene targeting event and the useful protein-expressed silkworm under control of L-chain gene or as in progress.

Index terms: Bombyx mori, silkworm, gene targeting, Autographa californica nucleopolyhedrovirus.

[2222] INSECT TRANSCENESIS: BACULOVIRUSES MEET TRANSPOSONS FOR BENEFICIAL INVASIONS

J. P. Farrell¹, W. Wang¹, L. Swevers^{1,2}, Y. Hashimoto³ & <u>K. Iatrou^{1,2}</u>, ¹Department of Biochemistry and Molecular Biology, University of Calgary, 3330 Hospital Dr. NW, Calgary, AB T2N 4N1, Canada, E-mail iatrou@ucalgary.ca; ²Institute of Biology, National Centre for Scientific Research "Demokritos", PO Box 60228, 153 10 Aghia Paraskevi Attikis, Greece, E-mail iatrou@mail.demokritos.gr; ³Department of Applied Biology, Kyoto Institute of Technology, Matsugasaki, Sakyo-ku, Kyoto 606, Japan.

Using as model the domesticated silkmoth Bombyx mori, we are developing a new system that can be used for achieving easy and efficient transformation of a variety of lepidopteran insects. This system, termed Baculovirus Artificial Chromosome (BVAC), is based on the use of engineered baculoviruses (BmNPV in the case of Bombyx) that can infect and replicate into the host cells but cannot complete their infection cycle and kill the infected host because of a single virus gene deletion, that removes an important function required for the onset of late viral gene expression. BVACs and recombinant versions of them containing transgenes of choice placed under the control of relevant insect promoters, are propagated in insect cell cultures stably transformed with the missing viral function. When host insects are infected with recombinant BVACs by simple injection into late larval or pupal abdomens, the BVACs and associated transgene(s) are transmitted into essentially all the cells of the host including those of the gonad, which can transmit the BVACs to the next generation through mating of infected hosts with uninfected insects. To circumvent the inherent limitation of BVAC episomal inheritance (and loss upon transmission via repeated cell division), we are incorporating into BVACs a transposition system that can direct the integration of the transgene(s) into the genome of infected cells. Having demonstrated that the Mos1 Mariner transposase system of Drosophila mauritiana can direct efficient excision and transposition events in a silkmoth cell line (Wang, Swevers & Iatrou, Insect Mol. Biol., In Press), we are know attempting the insertion of this transposase system into the genome of our basic BVAC vector system. As it now stands, the BVAC system can be used for continuous high level expression of transgene products of interest in insect cell cultures in vitro and in live hosts in vivo. We anticipate that the incorporation of the transposition system into the basic BVAC vectors, will result in the generation of a major new transformation system that allows for efficient generation of transgenic lepidopteran insects with minimal effort.

Index terms: Bombyx mori, transformation, BmNPV, Mariner, expression system.

Symposium and Poster Session

[2223] THE INTEGRATED AREA-WIDE APPROACH TO INSECT PEST MANAGEMENT, PROSPECTS FOR ITS APPLICATION TO TSETSE

<u>J. Hendrichs</u>¹, U. Feldmann¹ & A. S. Robinson², ¹Joint FAO/IAEA Division, P.O. Box 100, A-1400 Vienna, Austria, E-mails: J.Hendrichs@iaea.org & U.Feldmann@iaea.org; ²FAO/IAEA Agriculture and Biotechnology Laboratory, A-2444 Seibersdorf, Austria, E-mail: A.Robinson@iaea.org

Conventional IPM is usually a localized and uncoordinated suppression response by individual farmers against a segment of an insect pest population that has exceeded an economic threshold level. As long as the farmer's neighbours do not join in the efforts, such farm-by-farm intervention will be of short lived effectiveness as pest insects will continue to re-invade the farm from the surroundings, resulting in the need for repeated control actions. However, when farmers in a given area apply coordinated IPM against the total population of a key pest, including non cultivated habitats and unmanaged properties, the control achieved will be much more effective. With this lower density of an entire pest population, more selective, preventative and less insecticide-reliant management tactics become feasible for the target key pest. To cope with current environmental, economic and global trade challenges, commercial producers are increasingly having to collaborate and to organize into associations, a trend which is strongly encouraging farmer participation in area-wide approaches to IPM. Tsetse flies, *Glossina* spp., vectors of African trypanosomoses, devastating diseases of man and livestock, representing a major obstacle to development in 38 African countries south of the Sahara. Research efforts to develop vaccines have been unsuccessful and have largely been abandoned. Current local control efforts are costly and are hampered by drug resistance in trypanosomes, side effects of continuous insecticide use, expansion of fly distribution into new agroecosystems, and lack of sustainability. In order to feed their growing human populations, Governments either have to continue expanding low-productive livestock/farming systems into wildlife areas or to promote intensified systems in existing agricultural areas and thus reduce the need of agricultural expansion into wildlife areas. The latter involves improved cattle breeds and requires tsetse management on an area-wide basis. An integrated, area-wide approach is highly appropriate in view of the transboundary nature of the problem and has been successfully demonstrated on Zanzibar. It involves vector suppression using insecticide on livestock or on attractive artificial targets, followed by the aerial release of sterile male tsetse. SIT, the final component of such an integrated areawide campaign, is environment-friendly and can lead to the creation of sustainable, tsetse free areas.

Index terms: Glossina spp., area-wide IPM, SIT.

[2224] ANALYSIS OF GENETIC VARIABILITY AND MATING BEHAVIOUR OF ANASTREPHA FRATERCULUS (DIPTERA, TEPHRITIDAE) WITHIN THE FRAME OF CONTROL PROGRAMS

J. C. Vilardi, Depto. Cs. Biológicas, Fac. Cs. Exactas y Naturales, Universidad de Buenos Aires, 1428 Buenos Aires, Argentina. E-mail vilardi@bg.fcen.uba.ar.

The neotropical tephritid genus Anastrepha includes many economical important species. A. fraterculus, the South American fruit fly is the most common and economically important pest for the fruit-bearing species of the neotropical region. Evidence from different sources, including variation in pest status, morphology, karyotypes, isoenzymes, mitochondrial DNA, and cuticular hydrocarbons, indicate that the nominal A. fraterculus comprises multiple cryptic species. Control strategies used for this species are mostly based on conventional insecticides. Developing genetic or biological control programs require a deeper knowledge of its taxonomy, behaviour and genetic diversity. The research conducted at our laboratory involves two main approaches, genetic variability and mating compatibility between natural populations of this species. Isozymal studies to asses the distribution of the genetic variability within a natural population (Yuto, Jujuy, Argentina) inidcated a significant substructuration evidenced by a remarkable homozygote excess. This result was related with the continuous host shifts undergone by this fly depending on fruit availability throughout the year. When seven populations belonging to different biogeographic provinces in Argentina were compared, genetic similarities ranged within values expected for conspecific populations. The phenogram obtained by UPGMA among populations were in rough agreement with the expected from geographic distribution. Experiments of sexual compatibility between two geographically isolated populations (Yuto in North West, and Concordia in East Argentina) were conducted under field cage conditions. The indices of reproductive isolation (ISI, RII, I) do not show behavioural incompatibility between them. Males from both populations show the same preferences respect to place and time for lekking, calling, and mating. The results from isozymal and behavioural studies indicate that the Argentinean populations of A. fraterculus so far studied would constitute a single biological species. However, the indices MRPI and FRPI indicate significant differences in mating propensity which may produce sexual selection. Males and females from Yuto mated 4 times as frequently as those from Concordia. These behavioural differences may be the consequence of genetic mechanisms that could affect the efficiency of laboratory strains selected for adaptation to mass rearing conditions.

Index terms: isozyme, mating compatibility, sexual selection.
[2225] SUCCESSFULLY MANAGING LEPIDOPTERAN PESTS WITH GENETIC METHODS: THE FUTURE IS NOW

S. Bloem¹, J. E. Carpenter², F. Marec³ & K. A. Bloem⁴, ¹USDA-APHIS-NBCI, at NFREC-Monticello, Univ. of Florida, Rt. 4, Box 4092, Monticello, FL 32344, USA; ²USDA-ARS-IBPMRL, P.O. Box 748, Tifton, GA 31793, USA; ³Institute of Entomology, Czech Academy of Sciences, Branisovska 31, CZ-37005 Ceske Budejovice, Czech Reability, USDA-APHIS-NBCI, at Florida A&M Univ., CESTA, Tallahassee, FL 32307, USA; E-mail: ^{1, 4}ksbloem@nettally.com; ²icarpent@tifton.cpes.peachnet.edu; ³marec@entu.cas.cz.

Genetic pest suppression is unique among biological control methods in that it involves the release of genetically modified insects to control the same species. These methods are unparalleled in their specificity and safety because only the targetspecies is affected. Lepidopterans are the most important pests of many major crops, forests and stored products. Safe and pest specific control tactics against these ubiquitous pests are constantly being sought. Three genetic methods have been developed and field-tested against Lepidoptera, and of these, radiation-induced inherited sterility (or F1 sterility) is considered to be the most promising. F1 sterility can be readily combined with other biological controls such as pheromone mating disruption and natural enemies. In the application of F1 sterility the radiation dose is lowered so that the released insects are partially sterile or adjusted so that the females are completely sterile and the males partially sterile. The radiation-induced deleterious effects are inherited for 1 or more generations. As such, releasing partially sterilized insects offers far greater suppressive potential than using fully sterile insects. The genetic basis of F1 sterility in Lepidoptera will be discussed and the advantages of this genetic control method will be illustrated using examples from both perennial (apples and dates) and annual (corn and cole crops) cropping systems. In the face of growing concerns surrounding the use of genetically modified crops, the presence of pesticide residues on exportable commodities, the development of pesticide resistance, the U.S. Food Quality and Protection Act, and environmental, ground water and worker safety issues we argue that now is the time to increase our commitment to the use of genetic methods in controlling Lepidoptera.

Index Terms: area-wide control, Helicoverpa zea, Cydia pomonella, Plutella xylostella, Ectomyelois ceratoniae.

(2226) GENETIC AND MOLECULAR APPROACHES IN SUPPORT OF THE STERILE INSECT TECHNIQUE

G. Franz & C. Caceres, IAEA, FAO/IAEA Agriculture and Biotechnology aboratory, A-2444 Seibersdorf, Austria, E-mail g.franz@iaea.org.

For several insect species, including the screwworm fly and the Mediterranean fruit fly, the Sterile Insect Technique is an established technology to eradicate or suppress pest populations. For other species the method has also been shown to work successfully (e.g. tsetse fly) and it can be expected that this technology will become the future method of choice. It is environmentally friendly and, especially in the medium and long term, more cost effective than the traditional application of insecticides. Unlike the latter strategy, the Sterile Insect Technique is applied also outside of the area of direct commercial interest, i.e. the entire pest population is targeted. At its heart the Sterile Insect Technique is a genetic method as it relies on radiation induction of dominant lethal mutations that are introduced into the target population via the release of large numbers of irradiated insects. Mass rearing of insects is also subject to genetic effects, e.g. inbreeding, which can lead to the production of non-competitive insects. Other components of the Sterile Insect Technique are subject to genetic/molecular investigation or modification. These include the molecular analysis of the target populations and the development of maleonly strains. These genetic and molecular approaches to improve the Sterile Insect Technique will be reviewed.

Index terms: Ceratitis capitata, Sterile Insect Technique, area wide, genetics, molecular biology

[2227] RAPD MARKERS FOR GENETIC POPULATIONS STUDIES IN AEDES

C. F. J. Ayres, <u>M. A. V. Melo</u>, L. Régis & A. F. Furtado, Dept. de Entomologia, Centro de Pesquisas Aggeu Magalhães/FIOCRUZ, Av. Moraes Rego, CEP-50670-420, Recife, PE/Brasil, e-mail: tans@cpqam.fiocruz.br. Supported by CNPg/FIOCRUZ.

The genus Aedes contains many species, which are implicated in the transmission of diseases of public health importance, as yellow fever, dengue and haemorrhagic dengue fever. Historically, dengue has been controlled mainly by the use of measures against its vectors. Nowadays it has been shown that new weapons must be employed. The understanding of the patterns of vectorial dispersion, gene flow and the molecular basis of the genomic flexibility of vectors and consequently the mechanism ensuring the population diversity is important for the development of effective mosquito control strategies. A study on the genetic variability and structure of Aedes aegypti population from Brazil (Amazonas, Pernambuco and Alagoas), Ae. albopictus population (Rio de Janeiro) and Ae. taeniorrhynchus population (Pernambuco) was conducted using Random Amplified Polymorphic DNA (RAPD). Ten arbitrary primers were tested and 4 were reproducible, 3 of which were abele to differentiate populations of *Ae. aegypti* based on diagnostic bands. The intrapopulation similarity index (F) and polymorphism (P) was F=0,80; P=73% for *Ae. aegypti* populations and F= 0,81; P = 76% and F= 0,68; P = 93% for *Ae. taenirrhynchus* and *Ae. albopictus* populations, respectively. The results demonstrate that RAPD markers are an important tool to detect population differences, what is of fundamental importance in epidemiology studies of relationship between geographic populations and vectors dispersal. Index terms: Aedes, polymorphism, RAPD-PCR, genetic variability

[2228] ABOUT GENETICAL VARIABILITY OF CODLING MOTH POPULATIONS INHABITING IN DIFFERENT CONDITION

A.A. Azizyan ,A.S. Akopyan & A.R. Ter-Hovhanessyan, Institute of Zoology NAS Armenia , Mchitar Heratsi 89,ap.6,Yerevan,375025,Armenia

The quantitative dependence of duration of the periods of development poikilotherm organisms from complex changes of ecological parameters is known. Life cycle of codling moth in conditions of a climate of various geographical zones is determined in basic two parameter: being provided with warmth and duration of light day. According to the standard technique of prognosis the phenoecology of insects, the reactivate them begins at set in of steady temperature of air 10° C. of insects, the reactivate them begins at set in or steady temperatures of all 10 ce. The amount of warnth necessary for passage of separate stages the onlogeny of codling moth, is characterized by the following sizes of the sum of effective temperatures (SET): a beginning the fly of the butterflies – 90-110° C, mass fly of butterflies - 150-190° C. The aim of this work was the comparative study of phenoecology of different populations of codling moth in valley and mountain zones depending on the ecological factors. The received results have shown significant of a deviation of settlement dates from actual for a mountain zone, Development of codling moth generation after diapause in a mountain zone start in the period, when daily average temperature of air was kept at a level 7-8° C. The beginning of pupa formation is characterized SET - in mountain zone 6-12°C, and in valley - 45-55°C, the beginning of butterflies fly - in mountain zone -60-80° C, in valley-110-130° C. The received distinctions in actual phenology dates of development of two different populations depending on SET, have shown, that the development of an insect depends not only on a complex of the ecological factors, but also from genetically predetermined of phenology peculiarities of each population. The phenology peculiarities of development of a mountain population of codling moth as against to prognosis it is possible to consider as the hereditary adapted reaction to low temperatures in a mountain zone.

[2229] OPTICAL PROPERTIES OF *MORPHO TYPE* SCALES. MULTILAYER AND GRATING MODEL

<u>S. Berthier⁽¹⁾ & P. Lalanne⁽²⁾, (1) Laboratoire d'Optique des Solides, Univ. P. et M. Curie, case 80, 4 place Jussieu, F75252 Paris cedex 05, France. E-mail: berthier@ccr.jussieu.fr, (2) Inst. d'Optique, Univ. Paris 11, bat. 503, BP 147, 91403 Orsay cedex, France.</u>

Butterfly scale ultrastructures leading to iridescent effects are numerous : thin films and multilayers give rise to interferences, grating to diffraction, and small particles to diffusion. Although some butterfly pigmentary colours appear bright and highly visible, their absolute visibility is substantially inferior to those wing colours generated by optical interferences or grating diffraction and they generally lead to poor iridescent and polarisation effects. If both optical interference and grating diffraction lead to sheer brightness, the spatial dispersion of the light, necessary to enhance the viewing angle over witch they are visible, is very different. When the origin is purely interferential (*Uraniidae* are common examples : the upper membrane of the scale acts as a quasi continuous dielectric multilayer, or Bragg mitror) the reflection is high but specular and it severely restricts the solid angle over witch the light is reflected. Long range communication would be limited in this case. The spatial dispersion of the light is then generally assumed by the convexity of the scales about their transversal (*Christridia*) or longitudinal (*Procris statice*) axis. The situation is quite different for the *Morpidae* where the multilayer structure lies in the ridge of the generally plane basal scales. Depending of the species, the spacing between ridges lies in the range 0.5 to 1 µm, each ridge acting as a Bragg mirror. The whole scale acts now as a grating inscribed in a Bragg mirror, giving rise to a wavelength selective grating. The dispersion is now assumed by diffraction and some time by diffusion by the upper transparent cover scales. The modellastion of this structure is much more complicated and most of the authors neglect the grating effect and only deal with the multilayer model. SEM and TEM images of *Morpho menelaus* are first presented and the optical structure model deduced. We then present hemispherical reflectivity can be modelised by both the multilayer and the grating models. Modelisation

Index terms : Interferences, diffraction, polarisation effects, Morpho, Uraniidae,

[2230] POLYMORPHIC MICROSATELLITE MARKERS TO ASSESS THE GENETIC VARIABILITY IN THE MEDITERRANEAN FRUIT FLY, CERATITIS CAPITATA, SPECIES RANGE

M. Bonizzoni¹, L. Zheng¹, F. Sebastiani¹, C.R. Guglielmino³, L.M. Gomulski¹, G. Gasperi¹ & <u>A.R. Malacrida</u>¹, ¹Dept. of Animal Biology, University of Pavia, 27100 Pavia, Italy, ²Dept. of Epidemiology and Public Health, Yale Univ., New Haven, CT 06520, USA, ³Dept. of Genetics and Microbiology, Univ. of Pavia, 27100 Pavia, Italy

Polymorphism at 16 simple sequence repeat (SSR) markers was investigated in 122 C. capitata flies from 4 regions throughout the species range: Africa (Kenya and Reunion), extra-Mediterranean island (Madeira), Mediterranean basin (South Italy and Greece) and Latin America (Peru). The number of alleles per locus, the variance in repeats count, the gene diversity and the Rst values were not homogeneously distributed over the 16 loci, indicating that different genomic regions contributed differently to the differentiation among populations. The degree of genetic variability in the medfly species range was assessed by measuring the number of effective and actual alleles and the heterozygosity at these 16 loci. The greatest number of SSR alieles and the highest levels of heterozygosity were found in the native African region; furthermore a large number of Kenyan and Reunion variants appeared to be private or rare. The decrease in genetic variation, at the microsatellite loci analyzed, found in the derived populations (Madeira, South Italy, Greece and Peru) appeared to be consistent with their demographic history. Similar results were obtained both with allozyme, sigle-copy DNA and RAPD markers. Given their high degree of polymorphism, SSR markers appear to be the ideal tools to detect population differentiation on a small geographic scale and of recent infestation events of the Mediterranean fruit fly.

Index terms: Medfly, Ceratitis capitata, microsatellite polymorphism, colonization

[2231] PREDATION AS A POST-MATING ISOLATION MECHANISM IN IELICONIUS CYDNO AND H.MELPOMENE

Y.I.Bull & J.L.B. Mallet, Galton Laboratory, Department of Biology, University College London, 4 Stephenson Way, London NWI 2HE, UK. E-mail bullv@naos.si.edu

Speciation is thought to be driven by a range of pre and post-mating isolation mechanisms acting as barriers to gene flow. A number of studies have used the broadly sympatric Müllerian mimic species, *Heliconius cydno* and *H.melpomene* which hybridise in the wild at a frequency of around 1:1000. These studies aimed to determine the relative importance of ecological divergence, assortative mating and sterility in keeping the two species distinct (Jiggins & Naisbit, unpublished). However, the major selective factor thought to control *Heliconius* hybrid numbers is strong frequency-dependent selection on colour patterns (McMillan *et al* 1997, Chai 1986), a hypothesis which has thus far remained untested. It is thought that novel colour patterns arising in hybrids will be at a frequency-dependent disadvantage when they are found alongside commoner forms, and will therefore be selected against, as predators fail to recognise novel patterns as unpalatable (Greenwood *et al* 1989). A field study aimed at testing this theory was conducted by Mallet and Barton (1989), however the fate of the butterflies was not directly observed, so that direct evidence for preferential selection by colour pattern is lacking. We present the results of experiments conducted using caged birds to assess the relative importance of predation as a post-mating isolation mechanism in *H.cydno* and *H.melpomene*. Index terms: speciation, hybridisation, frequency-dependent selection.

[2232] GENETIC CONSTRAINTS IN THE SPECIALIZATION PATTERN OF AN APHID

P.P. Caballero, C.C. Ramírez & H.M. Niemeyer, Laboratorio de Química Ecológica, Departamento de Ciencias Ecológicas, Universidad de Chile, P.O. Box 653, Santiago, Chile. E-mail paulac@abulafia.ciencias.uchile.cl

Aphids (Homoptera, Aphididae) have an important degree of specialization, which is frequently related with a higher performance on the host in which they are specialized (established host) than on other host plants (novel host). Nevertheless, considerable evidence of changes in host use after experience (i.e. during ontogenetic development) on novel hosts suggests experience as a mechanism able to modify the specialization degree. The aim of this work was to study the effect of experience on a novel host on the specialization pattern of the aphid Rhopalosiphum maidis. R. maidis commonly occurs in Chile on johnsongrass (Sorghum halepense) but rarely on wheat (Triticum durum) despite the proximity of these two species. Intrinsic rate of population increase of 23 PCR-identified clones of R. maidis from johnsongrass, was evaluated on johnsongrass (established host) and on wheat (novel host), before and after experience for 20 generations on wheat. The pre-reproductive period and the fecundity of these 23 clones were also evaluated. Before the period of experience on wheat there was a negative correlation between fecundities on both host plants. Differential survival of clones was also evidenced: only 8 of 23 initial clones survived 20 generations on wheat. After the period of experience on wheat survival on wheat increased while performance was no affected, and performance on johnsongrass increased while survival was no affected. It is suggested that both genetic constraints and experience affect host use capacity and specialization pattern. Index terms: Rhopalosiphum maidis, specialization pattern, experience

[2233] GENETIC MARKERS IN CONGENERIC HERBIVORES: FINE-SCALE POPULATION STRUCTURE

<u>A. Caldas¹</u>, **D. Hawthorne¹**, & P. Barbosa¹, ¹Dept. of Entomology, Univ. of Maryland, College Park, MD 20742-4454, USA, E-mail: ac182@umail.umd.edu

We are investigating the population structure and patterns of relatedness among individuals of the noctuid moths Zale galbanata and Zale lunata using microsatellite markers. These two species co-occur in our two study sites at Patuxent Wildlife Research Center in southern Maryland. Although Z galbanata is a maple specialist, at our sites it only uses box elder (Acer negundo) despite the presence of other maple species. Preliminary laboratory experiments show that larvae die when offered leaves from other maples, which suggests population differentiation. Zale lunata, on the other hand, feeds on a variety of plants, including maples, but in our study sites it was never found on box elder in 8 years, but rather on black willow (Salix nigra). Larvae from these two species were collected from numbered trees of box elder and black willow at the two sites, approximately 3 km apart. Nine microsatellite markers have been isolated from a partial genomic library, and at least six of them are polymorphic to various degrees. These loci are being used to characterize variation of individuals within and between localities and levels of genetic relatedness among individuals obtained from the same tree. These data will be used to evaluate the influence of population structure and genetic relatedness on the rates of parasitism observed in these moths. Further studies with individuals from other localities will enable us to identify population processes responsible for this apparent host plant specialization. Index terms: Zale galbanata, Zale lunata, Noctuidae, parasitism, relatedness.

Symposium and Poster Session

[2235] POLYTENE CHROMOSOMES OF CULEX QUINQUEFASCIATUS (DIPTERA: CULICIDAE)

J. Campos¹, C.F.S.Andrade¹ & S.M. Recco-Pimentel², ¹Dept. of Zoologia, Iust. of Biology, State Univ. Campinas, P.O. Box. 6109, Campinas, SP CEP 13083-970, Brazil, E-mail jairocag@unicamp.br; ²Dept. of Celular Biology, Inst. of Biology, State Univ. Campinas, Campinas, SP CEP 13083-970, Brazil.

Dipteran polytene chromosomes are an excellent material for detailed approaches in species complex determination as well as structural and functional cytogenetics. Such material has become presently available for gene location in relation to insecticide resistance in *Culex* molecular cytogenetics studies. The species status in the *Culex pipiens* complex has been controversial and the use of polytene chromosomes for cytogenetic analysis has been difficult for the Culicinae subfamily because of methodological problems. The pupal Malpighian tubule polytene chromosomes maps were obtained for *Cx. quinquefasciatus* collected and maintained at the University of Campinas campus. The chromosome maps for this species were constructed and compared with published data for *Cx. pipiens* pipiens and *Cx. p. quinquefasciatus*. Although the banding patterns are conserved among species, analysis of structural variations for bands and interbands showed differences apparently related to their physiological stages. Configurations for the centrometric regions occurring among larval and pupal chromosomes showed more similarities than those between pupal and adult chromosomes. The Malpighian tubule polytene chromosomes of 20 to 48 hours old pupae provided the best cytogenetic analysis. Their use for *in situ* hybridization of vectorial competence probes is discussed. Index terms: cytogenetics, *Culex pipiens*, mosquitoes

[2234] PROTEIN PURIFICATION AND CONA CLONING OF SALIVARY GLANDS COMPONENTS OF ANOPHELES DARLINGI

E. Calvo, P. M. Ribolla, S. Daffre & O. Marinotti, Department of Parasitology, Institute of Biomedical Sciences. University of São Paulo. Av. Lineu Prestes 1374, Cidade Universitaria. CEP 05508-900, São Paulo, Brazil . E-mail: ccalvo@lineu.icb.usp.br. Finantial support: FAPESP, UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases.

Malaria remains the most prevalent and devastating insect-borne parasitic disease of humans, with more than 300 million cases worldwide reported yearly. The mosquito *Anopheles darlingi*, is the principal vector of human malaria in Brazil, where the number of cases has grown dramatically in the last 30 years. Four to five hundred thousand cases per years have been reported this decade. Salivary glands homogenates of the adult female *Anopheles darlingi* mosquitoes were fractinated using reverse-phase high performance liquid chromatography column. Four fractions were purified to homogeneity and their anino acid sequences determined by Edman degradation. Fragments with high degree of similarity with D-7 related proteins and gVAG allergen form *Anopheles gambiae*; and a metallothionein-like proteins were specific primer for 3'-RACE amplification of salivary glands cDMAs. A PCR amplified fragment (750 bp) from *Anopheles darlingi* was cloned and partially sequenced, showing high degree of homology with a D-7 related protein 2 from *Anopheles gambiae*; conhology with a D-7 related protein 2 from *Anopheles gambiae*; by protein, is specifically expressed in salivary glands. A PCR aregulated the constrained the protein was cloned and partially sequenced, showing high degree of homology with a D-7 related protein 2 from *Anopheles gambiae*; cDNA. This D-7-like protein, is specifically expressed in salivary glands of *Aedes aegypti* and *Culex quinquefasciatus* mosquitos. The presence of D-7 like genes expressed in different species of hacmatophagous mosquitoes, suggest that D-7 protein would play some essential role in the salivary gland functions, probably related with blood feeding.

[2236] MALE COURTSHIP SONG PATTERN OF THE *DROSOPHILA* SERIDO AND *DROSOPHILA* SP D (*REPLETA* GROUP) IN A HYBRID ZONE AREA

A.M.Cansian¹ & <u>F.M.Sene²</u>, ¹Dept. of Biology, FFCLRP, Univ. of São Paulo, Ave. dos Bandeirantes 3900, CEP: 14040-901, Ribeirão Preto, SP, Brazil Email: marfisa@rgm.fmrp.usp.br; ²Dept. of Genetics, FMRP, Univ. São Paulo, Ave. Bandeirantes, 3900, CEP 14049-900, Ribeirão Preto, SP, Brazil. Financial Support: CNPq, FAPESP, FINEP, CAPES and USP

The species Drosophila serido and Drosophila sp D belong to the buzzatii cluster of the repleta group endemic to South America. They are distributed in a zone of xerophytic vegetation and show a close association with some cactus species. The species distribution reflects the fragmentary distribution of its host plants, which appears to be in accordance with the climatic history of South America. Data from polytene inversions and multivariate acdeagus analysis showed the existence of a zone of secondary contact between Drosophila serido and Drosophila sp D in the Atlantic coast of Santa Catarina and Rio Grande do Sul states. This natural zone of hybridization is promising for studying evolutionary changes and speciation through the evolution of pre-mating barriers. In order to get more information on this situation, six populations were analysed based on the male courtship song pattern. The analysis cover the Atlantic coast populations of the state Santa Catarina and Rio Grande do Sul included at the zone of secondary contact. The male courtship song parameters analysed were: - intrapulse interval (PI); - interpulse interval (IPI); parameters analysed were: - intrapulse interval (PI); - interpolae interval (NI), intrapulse frequency (IF). Statistical comparisons among the populations showed significant differences concerning the three analysed parameters. The IPI was the most differentiated parameter among the species (ANOVA p<0.01), suggesting its importance for the female discrimination. The IPI parameter between Drosophila sp D and populations from contact area are also significantly different (ANOVA p<0.001). In addition, the low intraespecific variability on both PI (ANOVA p=0.682) and IPI (ANOVA p=0.348) showed in the two species was also observed in others species subgroups and it could be explained by strong selection acting on the song parameters. The relationship among morphology, inversion, male courtship and speciation are sometimes difficult to evaluate in a hybrid zone context, and the present study shed more light to elucidate the species differentiation process. Index terms: zone of secondary contact, speciation, cactus breeding species.

[2237] MOLECULAR STUDIES OF SEX-SPECIFIC GENES IN THE INSECTS C. CAPITATA AND BACTROCERA OLEAE

G. Christophides¹, D. Lagos¹, E. Zakynthinos¹, C. Savakis² & <u>K. Komitopoulou</u>¹, ¹Univ. of Athens, School of Biology, Dept. of Genetics and Biotechnology, Greece. ²Institute of Molecular Biology and Biotechnology, Foundation of Research and Technology, Crete. E-mail:akomitop@biology.db.uoa.gr.

A multigene family encoding Male Specific Serum Polypeptides (MSSPs) was characterized in the medfly C. capitata. The family comprises seven members classified, according to sequence similarity, in three subgroups, MSSP- α , MSSP- β and MSSP-y. Sequence analysis data and secondary structure predictions showed that these genes belong to the Odorant Binding Protein family of insects. Expression pattern analysis showed that certain MSSP genes appear to be expressed in distinct sex- and tissue-specific manner. Transformation analysis of the regulatory elements of the gene MSSP-02 was performed using two overlapping fragments fused to the lacZ reporter gene. A functional dissection of the promoter was identified. Sequences located between +37 and -283 are responsible for a basic male fat body expression pattern, although a temporal shift to later period was observed, compared to the endogenous synthesis of MSSP polypeptides. The region from -283 to -522 causes a five-fold increase to the transgene expression predicting the presence of enhancing regulatory elements. Moreover, this region corrects the temporal profile possibly due to the existence of early activating elements. The MSSP-a2 promoter may prove to be a useful tool for the controlled expression of selectable genes, such as the Adh gene. The -283/+37 promoter fragment was used to drive the basic male fat body expression of Drosophila Adh gene in medfly transgenic flies established after Minos germline transformation. It was demonstrated that the enzyme is active in the transgenic flies, leading to an approximately two-fold increase of the total ADH enzyme activity in males compared to the females. These results suggest that the long promoter fragment,-485/+37 should be able to confer a ten-fold expression of the Adh gene in transgenic strains. We have extended our studies in sex-determining genes, in a very related species of economic importance, B. oleae. We have isolated by PCR and RT-PCR, using the appropriate synthetic oligonucleotides, three gene fragments. Two of them, after subcloning and sequencing, were found to be homologous to the double-sex gene, while the third, is homologous to the sex-lethal. One embryonic and two adult cDNA libraries, a male specific and a female specific are under construction for the purpose of the isolation of the complete cDNA clones corresponding to these genes.

[2238] IDENTIFICATION OF *TRICHOGRAMMA* BASED ON THE SEQUENCE OF THE ITS2 REGION OF THE rDNA, WITH A NEW RECORD FROM RRAZIL

<u>A. LCiociola Jr¹</u>, R. B. Querino¹, R.A. Zucchi¹ & R. Stouthamer ², Departmento de Entomologia, Fitopatologia e Zoologia Agrícola. Caixa Postal 9, CEP:13.418-900, ESALQ/USP, Piracicaba-SP, Brazil. E-mail: ciociola@carpa. ciagri.usp.br;
 ²Department of Plant Sciences, Laboratory of Entomology, Wageningen-UR Centre, P.O Box 8031, 6700EH Wageningen, The Netherlands.

Historically the identification of *Trichogramma* has been very difficult. Specialists after 1970, used the male genitalia to identify different species, which was a major improvement in the identification of these minute wasps. However, the preparation for correct identification is time consuming. For a quick and routine identification of *Trichogramma* species we used a new molecular technique. The sequence of the ITS2 (internal transcribed spacer 2) region of the rDNA is useful to distinguish between some species from Brazil. Using the sequence of this region together with taxonomic identification is that it's quick and with some lab routine we can use it without problems. The specific primers used for *Trichogramma* spp. in this study amplified the DNA of 5 of the Brazilian recorded species of *Trichogramma*. This technique can also be used to check possible contaminations in lab rearings. Based on this technique we are discussing a new record of *Trichogramma* species in Brazil. Index terms: Trichogrammatidae, molecular technique, biological control.

[2239] RIBOSOMAL DNA VARIATION IN NATURAL POPULATIONS OF DICHROPLUS ELONGATUS (ORTHOPTERA: ACRIDIDAE)

M. Clemente, <u>M. I. Remis</u> & J. C.Vilardi, Lab. Genética de Poblaciones, Depto. Cs. Biológicas, Fac. Cs. Exactas y Naturales, Pabellón II, Ciudad Universitaria, Buenos Aires, 1428, Argentina. E-mail: mariar@bg.fcen.uba.ar.

Dichroplus elongatus is a phytophagous South American grasshopper widely distributed in Argentina which exhibits parallel polymorphisms for B chromosome and supernumerary segments. In the last years, the analysis of restriction fragment length polymorphisms (RFLP) of mitochondrial DNA (mtDNA) showed that the distribution patterns of haplotipic variation in chromosomally polymorphic populations may be explained by ecogeographic factors. In the present work, we reported a RFLP analysis of ribosomal DNA (rDNA) variation in the same populations. In this study we analyzed the genetic relationship among populations and the relative importance of different evolutionary forces and concerted evolution in the genetic differentiation of an intergenic spacer region (IGS). The study involved 156 individuals from 13 populations of *D. elongatus* belonging to three biogeographic provinces from Argentina (Las Yungas, El Espinal and Pampeana) were analyzed. The 0.8kb cloned sequence from a 26s intergenic spacer region from the Caledia captiva rDNA was used as probe. A total of 21 restriction fragments were obtained by simple digestion with five enzymes (BamHI, EcoRI, Pstl, HindIII and XbaI). All the enzymes but BamHI exhibit intra and interpopulation variation. The average number of length variants produced per individual was from 13.8 to 8.6. The populations of "Las Yungas" exhibited the higher value of average number of variants per individual (11.6) in comparison with Espinal (10.1) and Pampeana (9.6) provinces. The intra and interpopulation variation was analyzed by two distance indices: i) Lynch (1990), based on presence and absence of bands, and ii) Hedrich (1983) that takes into account differences in band intensities. The highest values of intraindividual and intrapopulation variability were observed in populations of Las Yungas. The Neighbor-Joining trees based on Lynch and Hedick distances were very similar showing high genetic distance between the two northwestern populations of Las Yungas. Both populations are also highly differentiated from the remaining ones. Regression analysis of band frequencies on geographic and climatic variables employing the stepwise selection procedure revealed that the average number of length variants produced per individual is significantly associated with altitude and the frequency of some restriction variants show a significant regression on altitude and temperature. The high level of intraindividual, intra and interpopulation variation would imply that concerted evolution are not efficient in this species. The disagreement between rDNA and mtDNA distribution patterns, suggests that adaptive factors may affect the rDNA variation limiting the effects of stochastic factors.

[2240] SEXUAL SELECTION ON MORPHOMETRIC AND CHROMOSOME VARIABLES IN *LEPTYSMA ARGENTINA* (ORTHOPTERA)

P. C. Colombo, S. M. Pensel & <u>M. I. Remis</u>, Depto Cs. Biologicas, Fac. Cs. Exactas y Naturales, Universidad de Buenos Aires, 1428 Buenos Aires, Argentina, E-mail: mariar@bg.fcen.uba.ar.

The South-American species Leptysma argentina carries a polymorphism for a centric fusion between chromosomal pairs 3 and 6 of the basic complement (fusion 3/6) that has been found throughout most of the species' distribution area. Simultaneous cytogenetic and morphological studies revealed that fusion 3/6 significantly increases morphometric variables in males. A study of selection components showed that the fusion is positively selected for longevity, the actual target being a morphometric variable, namely thorax height. In the present study both the effect of fusion on morphometrical variables in females as well as the effect of body size and karyotype on mating success in both sexes were analysed. The experimental design consisted in placing a number of wild caught males and females (usually 10 of each) in mating cages during a period of time; when a match was formed they were taken out and assigned absolute fitness 1, and the other individuals were assigned fitness 0. Cytological preparations were made by squashing some testicular follicles (in males) or gastric caeca (in females) in acetic haematoxylin. Both males and females were measured with a binocular microscope for length from the fastigium to the third coxa (L), third femur length (FL), third tibia length (TiL), thorax length (TxL), thorax height (TH) and total length (TL). First, exomorphological effects of the fusion in females were examined. The MANOVA and individual ANOVAs revealed that there were significant differences between karyotypes for FL, TiL, TxL and TL. The influence of the fusion in females, as had been detected for males, leads to a significant and additive increase in body size. Secondly, the morphometric variables and the fusion were examined with respect to their effect on male choice selection. The analysis of standardised selection differentials (S') -assessed through the correlation of each trait along with relative fitness- showed that directional selection operated significantly and positively on FL. TiL, TxL, TxH and TL. The analysis of the selection gradient (D') -which estimates direct and indirect effects of directional selection- showed a significant effect of selection on FL, TxL and TL. Our results indicate therefore that the differences in those traits have the greatest contribution to fitness variation in males, the selective effects on the other morphometric traits being indirect ones. Thirdly, a similar analysis of mating success in females revealed only indirect effects for TxL and TL. In conclusion, it can be said that differences in some body size related traits could be due to the karyotype both in males and in females, and that FL, TxL and TL were detected as targets of sexual selection in males.

[2241] ORIGIN AND DISPERSAL OF THE COTTON BOLL WEEVIL (COLEOPTERA: CURCULIONIDAE) IN SOUTH AMERICA: A miDNA PHYLOGEOGRAPHIC STUDY

V. A. Confalonieri¹, M. A. Scataglini¹ & <u>A. A. Lanteri²</u>, ¹Dep. Cs. Biol., Fac. Cs. Exactas y Naturales, Univ. de Bs. As., Ciudad Universitaria, 1428 Buenos Aires, Argentina; ²Dep. Cient. Entomol., Museo de la Plata, UNLP, 1900 La Plata, Argentina.

The boll weevil Anthonomus grandis Boheman, is the most harmful insect pest of cotton in America. Since its first report damaging that culture, there have been considerable efforts to address the question of its place of origin, original hosts and pathways of dispersal. Most authors proposed that the boll weevil was indigenous to tropical lowlands of Mexico, and reached its present distribution by extending its range northward, to Southern United States, and southward, to Brazil, Paraguay and Argentina. The hypothesis of north american dispersal is well supported by data on host plants and geographic variation of morphological characters, and would have taken place, in both, prehistoric and historic times. On the contrary, the presence of would have taken place, in boar, premisions and mistoric times. On the contrary, the presence of the boll weevil in South America would be associated to cotton cultivation, and the insect would have been introduced from Southeastern USA. Our results of RAPD's analyses on populations from Argentina, Brazil and Paraguay, compared with samples from the USA and Mexico, made us to proposed that some south american populations from none cultivated areas, are more related to mexican samples than to those on cotton cultures from its own geographic region. The main goal of the present contribution is to test the hypothesis on the origin of South American boll weevil populations, by means of a phylogeographic analysis using sequences of the mitochondrial gene Cytochrome Oxidase I (COI). We analyzed 30 individuals of five natural populations from Tecomán (Colima, Mexico), Lubbock (Texas, USA), Londrina (Paraná, Brazil), Caacupé (Cordillera, Paraguay), and Puerto Iguazi (Misiones, Argentina). All samples were collected on cotton cultures, except the latter, occurring on native plants. COI sequences correspond to bp 1720-2020 (numbers according to *Drosophila yakuba*) and were aligned using CLUSTAL W 1.6. The genetic relationships of the 17 haplotypes found, were inferred by cladistic analysis, using exhaustive search of PAUP 4.0 (Beta 4a). Tecomfan and Pto. Iguazd display the highest number of haplotypes and sequence divergence, typical of boll weevils from cotton areas of Brazil and Paraguay were introduced from USA. On the other hand, weevils collected on native plants from Pto. Iguazá would correspond to an ancestral population, established prior to cotton cultivation. Index terms: Cytochrome Oxidase I, DNA Sequencing, Anthonomus grandis.

[2242] CHARACTERIZATION OF MOLECULAR MARKERS ON CHRYSOMYA ALBICEPS BY PCR-RFLP OF MITOCHONDRIAL DNA

F. F. Conte, A. C. Lessinger, A. C. M. Junqueira & A. M. L. Azeredo-Espin, Lab. Genética Animal, DGE/CBMEG, Univ. Estadual de Campinas, P.O. Box 6010, Campinas, SP, Brasil, CEP 13083-970. E-mail: azeredo@unicamp.br. Financial support: Fapesp, Capes, PADCT-CNPq.

The species Chrysomya albiceps, one of the most abundant and economically important blowfly from Africa, was probably introduced into Brazil around 1975 with refugees from Angola and Moçambique. The adults of C. albiceps feed and breed in carrion, feces, urban garbage and carcasses and have a medical-veterinary importance due to its synanthropic and endophilic behavior, acting as potentially important mechanical vector of pathogens. C. albiceps, such as Chrysomya putoria and Chrysomya megacephala, is an effective competitor and has a considerable autonomous dispersal ability that could be causing the displacement of the Brazilian native populations of blowflies that share the same ecological niche. Due to these characteristics the study of C. albiceps evolutionary dinamics is a very important subject. The analysis of specific regions of the mitochondrial DNA (mtDNA) provides an efficient approach in order to identify informative molecular markers for evolutionary studies. The aim of this work is to characterize the mtDNA of C. albiceps using the PCR-RFLP technique. The specific mDNA regions analyzed were the control region (A+T rich region) and the subunits I and II of the cytochrome oxidase c (COI/II). The amplification of COI/II region and the control region resulted in 2200 bp and 320 bp PCR products, respectively. Preliminary results for COI/II region using EcoRI and Sau3AI have shown two restriction sites for Sau3AI (fragments with 1000bp, 600bp and 500bp). The A+T rich region was digested with DraI and SspI, resulting in the identification of one site for SspI that provides the 180 bp and 110 bp restriction fragments. The importance of this work concern the characterization of diagnostic molecular markers useful for species-specific identification of C. albiceps, improving the analysis of forensic fauna, contributing in the resolution of taxonomic conflicts with Chrysomya rufifacies, and for understanding the evolutionary context of introduction.

Index terms: Chrysomya albiceps, blowflies, mtDNA, PCR-RFLP, molecular markers.

[2243] THE IDENTIFICATION OF TRANSPOSABLE ELEMENTS IN THE GENOME OF THE MALARIA VECTOR, ANOPHELES GAMBIAE

J. M. Crampton^{1,2}, R. J. Parkes¹, J. M. Kirk¹ & A. M. Warren¹, 'Liverpool School of Tropical Medicine, Pembroke Place, Liverpool, L3 5QA, UK. ²School of Biological Sciences, Univ of Liverpool, Crown St., Liverpool, L69 7ZB, UK.

The focus of our research is to identify endogenous transposable elements in mosquito vector genomes, with a particular emphasis on the major malaria vector Anopheles gambiae. Our interest in these elements is twofold. First, we are interested in their potential as DNA vectors for the genome manipulation of this insect. Second, such elements represent a potentially important source of genetic variation in these insects, which will have relevance to their evolution and their ability to act as vectors of malaria. We have used a PCR based approach to identify and characterise two classes of transposable element in *An. gambiae*. The first is *Salto*, a *Ty-copia* element closely related to copia and 1731 from D. melanogaster. The element is actively transcribed, and present in variable copy number and location in An.gambiae strains. The second element is Frisky, a Tc1-like element. This transposable element is bounded by 27bp inverted terminal repeats and has a single open reading frame with the potential to encode a 331 amino acid protein showing similarity to other Tc1-like transposases. It is present in low copy number in a number of species within the An. gambiae species complex. The structural features of both elements will be described and discussed in the context of the evolution of such elements and their potential as DNA vectors for genome manipulation.

index terms: Ty-copia transposable elements; Tc1 transposable elements; genome manipulation

[2244] EXPRESSION OF PAIRED GROUP III GENES AND THE EVOLUTION OF SEGMENTATION

G. K. Davis¹, C. A. Jaramillo¹, & N. H. Patel^{1,2}, Committee on Developmental Biology, ²HHMI and Dept. of Organismal Biology and Anatomy, University of Chicago, 5841 S. Maryland Ave. MC1028, IL 60637, USA., E-mail npatel@midway.uchicago.edu

The Drosophila Pax genes paired, gooseberry, and gooseberry-neuro encode a family of transcription factors, each containing both a DNA-binding paired domain and a paired-type homeodomain. paired acts as one of several pair-rule genes to define the boundaries of future segments via the activation of segment polarity genes, including gooseberry. gooseberry-neuro is a gene of yet undefined function expressed later in the developing nervous system. The protein products of these genes are both similar in sequence and functionally equivalent, as the coding regions have been shown to be functionally interchangeable between the different cisregulatory regions (Xue and Noll, EMBO, 15, 3722-3731, 1996). Because of their importance in segmentation and the potential for using these genes to address questions regarding the evolution of pair-rule function and the homology of segmentation, we have begun to study the expression of these genes in several insects, including the grasshopper, Schistocerca americana, and the beetle, Tribolium castaneum. We have used degenerate PCR to clone members of this family from Schistocerca, and have developed a cross-reactive antisera to study expression in a number of different arthropods. We will present expression data from a number of animals and discuss the implication of these results for understanding the evolution of segmentation.

Index terms: Drosophila melanogaster, Tribolium castaneum, Schistocerca americana, paired, gooseberry.

[2245] ABSENCE OF GENIC VARIABILITY FOR SIX ENZYME SYSTEMS IN MYCETOPHYLAX SP. (HYMENOPTERA, FORMICIDAE)

<u>E. Dichl-Fleig</u> & Ed. Dichl-Fleig, Lab. de Genética: Setor de Insetos Sociais, C.C. da Saúde, Univ. do Vale do Rio dos Sinos. C.P. 275 São Leopoldo 93001-970 RS – Brasil, E-mail: ediehl@cirrus.unisinos.br.

The tribe Attini, which belongs to the subfamily Myrmicinae, is restricted to the Americas comprising thirteen genera of fungus grower ants. Amongst those Atta and Acromyrmex are noticeable for their phylogenetic position as the higher attine and for being recognized as serious economic pest. Mycetophylax, another attine genus, in turn is included among the lower attines using plant material in decomposition, insect remains and excrements as substratum for growing its fungus. It is mainly found in sandy areas of low vegetation such as the north seacoast of Rio Grande do Sul state. As part of a greater project which aims at describing the isoenzyme genic variability and the social structure of the attines, workers (153), gynes (32) and queens (10) from 39 Mycetophylax sp. colonies were all analyzed for the enzyme systems Malate dehydrogenase (MDH) and Superoxid dismutase (SOD). From those same colonies, 18 were analyzed for α -Glycerophosphate dehydrogenase (α -GPDH) and 19 for Aldehyde oxidase (AO), Alcohol dehydrogenase (ADH) and Octanol dehydrogenase (ODH). To analyze α -GPDH, ADH and ODH 6% polyacrylamide gels were used with Roose & Gottlieb (1976) buffers; for AO, MDH e SOD, 8% polyacrylamide gels with Poulik (1957) buffers. Enzymes were run at 4°C, at 10 V/cm until the front line reached 8 cm from the application point. Staining techniques followed Ayala et al. (1972) for AO, ADH, ODH, α-GPDH and MDH; white light was used for SOD. All six systems showed to be monomorphic, excluding the possibilities to determine the colony mating structure. In one of the 39 evaluated colonies, two queens were found which indicates that polygyny may be true for Mycetophylax sp. This data differ from what is known for Atta and Acromymnex which present isoenzyme polymorphism, especially for the systems α -GPDH and MDH, besides the high frequency of polygynic colonies of Acroinymex. Both the isoenzyme analyses and the bioecological studies shall be extended to other Attini genera giving support for a phylogenetic analysis of this tribe.

Index terms: Myrmicinae, Attini, isoenzyme polymorphism, mating structure

[2246] THE EVOLUTION OF HOST PLANT BREADTH IN DIABROTICITES (COLEOPTERA : CHRYSOMELIDAE)

A. Eben & A. Espinosa de los Monteros, Instituto de Ecología, A.C., Km 2.5 Antigua carretera a Coatepec, 91000 Xalapa, Veracruz, Mexico, E-mail: astrid@ecologia.edu.mx

Specialization toward a limited range of host plants has been viewed as evolutionary dead end in herbivorous insects. Beetles of the subtribe Diabroticites (Chrysomelidae : Galerucinae) are found to have a variable number of host plants. Several species are oligophagous on Cucurbitaceae or Graminaceae, whereas others are polyphagous. The association of Diabroticites with bitter Cucurbitaceae was interpreted as an example for chemically mediated plant-insect coevolution. This hypothesis is based on experiments with a limited number of species distributed in the USA, where they were introduced from Mexico and Mesoamerica together with corn and squash. We recovered a maximum parsimony phylogeny of 19 Mexican Diabroticite species from 6 different genera based on 472 bp of COI and 45 external Our results corroborate the current taxonomical morphological characters. arrangement. The evolutionary scenario depicted from this phylogeny allows to conclude that the genus Acalymma speciated after the specialization of ancestral Diabroticites on Cucurbitaceae. An ancestor which was specialized on Cucurbitaceae gave rise to the polyphagous genus *Diabrotica*. Within this genus, the basal species have a host range from polyphagous to narrow, feeding on Graminaceae, Leguminosae or a few other families. The species in the virgifera group have a host plant range restricted to Graminaceae. Nevertheless, all species feed on bitter cucurbits in the wild. Our data corroborate the hypothesis, that the kairomonal response to secondary compounds in Cucurbitaceae is a relic of the ancestral host plant association. Furthermore, specialization is not a dead end in the evolution of Diabroticites. Instead, host plant range became restricted and broadened several times within the evolution of the subtribe.

Index terms: Acalymma, Amphelasma, Diabrotica, Gynandrobrotica, Paratriarius

[2247] RAPID GENOME SHUFFLING BY TRANSPOSABLE ELEMENTS: WHAT CAN WE LEARN FROM CULEX PIPIENS MOSQUITOES?

<u>C. Feschotte</u>, C. Cagnon, I. Desmons, S. Karama & C. Mouchès, Laboratoire Ecologie Moléculaire, Université de Pau, BP 1155, 64 013 PAU, France, E-mail: cedric.feschotte@univ-pau.fr.

The genome of C. pipiens is larger than those of some more extensively studied diptera, such as Drosophila or Anopheline mosquitoes. This difference is due to higher amount of repetitive DNA, which is organized in a short interspersion pattern. However, little is known about the molecular processes involved in the shaping of the C. pipiens genome. The only sizeable genomic data available for C. pipiens was the previous characterization of a DNA region (25-kb) which is amplified in an organophosphate insecticide resistant population. This region contains the esterase B1 gene (2.8-kb) and also a high density of transposable elements (TEs) in its flanking regions. As TEs make up most of the dispersed fraction of the repetitive DNA, our working hypothesis is that TE amplification and mobility can promote rapid and extensive reshuffling of the C. pipiens genome. Two families of elements, Juan and CM-gag, were first characterized. Both are found in high copy number in the C. pipiens genome and were recently amplified by retroposition, a process which was already shown to play a major role in the evolution and plasticity of vertebrate genomes. Recently, we have cloned a 15-kb region encompassing the white gene of C. pipiens and found that insertions of various and numerous TEs have occurred in introns 1 and 2, leading to a spectacular enlargement of these regions compared to the Drosophila and Anopheline homologues. Some of these TEs belong to large families of retroelements (LINEs and SINEs) whereas others are non-autonomous elements with inverted-repeats that share structural similarity to MITEs, a novel class of ubiquitous and highly abundant elements in plant genomes. Culex MITEs are found in high copy-number and some families have a recent amplification history (1). Despite evidence for recent mobility of these MITEs, no element has been found to encode a protein; therefore, we do not know how they have transposed and have spread in the genome. Structural analysis indicate that some of these mosquito MITEs may have originated from pogo-like DNA transposons, as it was previously demonstrated for a plant MITE family (2). (1) Feschotte C. & Mouchès C. Recent amplification of Miniature Inverted-repeat Transposable Elements in the genome of the vector mosquito Culex pipiens: characterization of the Mimo family. Submitted to Gene. (2) Feschotte C. & Mouchès C. (2000) Evidence that a family of Miniature Inverted-repeat Transposable Elements (MITEs) from the Arabidopsis thaliana genome has arisen from a pogo-like DNA transposon. Mol Biol Evol 17 (4) in press.

[2248] ECOLOGICAL FACTORS VERSUS MACRO-EVOLUTIONARY FORCES: A CASE STUDY OF THE BUTTERFLIES OF THE GENUS ACTINOTE (LEPIDOPTERA: NYMPHALIDAE) IN SOUTHEASTERN BAZIL

R.B.Francini, Museu de História Natural, FAFIS, Univ. Católica de Santos, Rua Euclides da Cunha, 247, 11065-902, Santos, SP, Brasil, E-Mail francini@unisantos.com.br, Financial support: BIOTA-SP (FAPESP)

The data from a phylogenetic analysis of 58 characters of the larvae and imagines of 17 species of *Actinote*, using *A.manita* as the functional out-group was compared with 46 ecological and ethological characters. The plant genus *Mikania* was the most used as larval food plant (with 14 species used by *Actinote*) followed by *Eupatorium; Trichogonia*, Erigeron, and Senecio contributed only one species each. Nearly all Actinote species used Engreta, and seneric contributed only one species each. Nearly an Activity species used only one genus of larval food plant, but the species with wide geographic distribution can use more than 3 genera. Many of these plants are more widespread than the Activities species that use them. Most of the hostplants are common in secondary successional environments, but a few grow inside the forest or in swamps. Some species in the genus Actinote are useful as ecological indicators but in a limited fashion. A.zikani indicates environments with constant water supply (rain, fog, or swamp areas). Another two species, *Actinote* ca. *terpsinoe* and *A.morio*, indicate environments with greater water deficit and lower precipitation, including savanna (Cerrado) and semi-deciduous montane forest. Based on MRR data of *A. pellenea pellenea* (Parque Estadual Xixová-Japui, São Vicente, SP) and *A. zikani* (Paranapiacaba, Sto. André, SP), a potential "explosive" capacity was showed, allowing that even the rarest species in areas of variable relief and unstable appear to be the demographic pattern of all Actinote populations. These include populations occupying relatively small areas (usually less than 1 ha) and characterized by a rapid initial growth of adult numbers (usually < 10 days). The assemblages in high (between 1200-2000 m) and cold (mean annual temperature < 18° C, with possibility of frost) areas have short adult generations (usually < 20 days) with a larger peak in the summer (December, when all the univoltine species are on the wing), and another small peak in autumn (April-May). In these places, the species populations of the orange-red and black-iridescent mimetic groups are residents (based on at least 3 years of observations) while the species of the other mimetic groups appear only in lower density, represented usually by solitary females. Because all *Actinote* species are considered unpalatable (they are cyanogenic), these taxocenes condition the learning patterns of potential butterfly predators. The population features combined with the slow larval development of most species, suggest that *Actinote* have a demographic pattern resembling that of butterflies of the temperate regions.

Index terms: food-plants, explosive populations, demographic patterns

[2249]PHYLOGENETIC RELATIONSHIP AMONG STINGLESS BEE SPECIES INFERRED BY MITOCHONDRIAL DNA RESTRICTION FRAGMENT LENGTH POLYMORPHISM

F. O. Francisco, R. Weinlich, D. Silvestre, D. R. Cunha & <u>M. C. Arias</u>, Dept. de Biologia, Inst. de Biociências, Univ. de São Paulo, Caixa Postal 11461, São Paulo, SP, 05422-970, Brasil, E-mail: Igea@ib.usp.br.

The systematic and phylogenetic relationship among stingless bees is still a controversial subject. Only few phylogenetic studies have been published and are based on morphological characters. Molecular techniques have been recently used trying to solve phylogenetic and population dynamics questions of several organisms. The mitochondrial DNA (mtDNA) is one of the most used molecular tools and its analysis has already proved its potential to solve genetic and phylogenetic issues among species and subspecies of Apis. One characteristic of the mtDNA is to have, in the same molecule, some conserved regions and others that accumulate rapidly base substitutions. The RFLP (Restriction Fragment Length Polymorphism) technique allows to approach this molecule as a whole, including the variable and conserved regions. Thus, in the present work we used RFLP technique to analyze the mtDNA of five species of Plebeia, six of Melipona and one of Schwarziana; Apis mellifera was used as outgroup. The mtDNA of these species was extracted and then digested with seventeen restriction enzymes. Using the results of single and double digestions, restriction maps were constructed. This was a crucial step to be assured that we were comparing the same sites, according to their positions. Approximately twenty restriction sites per species were located and as a result of these comparisons a binary matrix was built. The genetic distances between pairs of species were calculated. As expected, the distances among species of the same genus were smaller than the ones among species of different genera. The binary matrix was also used to infer phylogenetic relationship by using the softwares PAUP Star (version 4.0b3) and RESTSITE (version 1.1). Trees were generated by parsimony and genetic distance methods. The results of this work revealed the potential of mtDNA RFLP analysis to infer the relationship among stingless bee species. The inclusion of other species of these genera will undoubtedly strengthen the phylogenetic relations of this group and improve our comprehension about its evolution and biogeography. Index terms: Meliponinae, phylogeny, RFLP, mtDNA, evolution

[2250] MITOCHONDRIAL DNA SEQUENCES OF TRIATOMINAE (HEMIPTERA: REDUVIDAE): PHYLOGENETIC RELATIONSHIPS

<u>B. A. García¹</u>, E. N. Moriyama² & J. R. Powell², ¹Cátedra de Química Biológica, Facultad de Ciencias Médicas, Universidad Nacional de Córdoba, C.C. 35, Suc. 16, 5016 Córdoba, Argentina, E-mail: bgarcía@biomed.uncor.edu; ²Department of Ecology and Evolutionary Biology, Yale University, New Haven, Connecticut 06520-8106, USA.

The phylogenetic relationships among fifteen species of the genus *Triatoma* were inferred based on the mitochondrial DNA sequences. The species included eleven belonging to the infestans complex (T. infestans, T. guasayana, T. sordida, T. platensis, T. brasiliensis, T. rubrovaria, T. vitticeps, T. delpontei, T. maculata, T. patagonica, and T. matogrossensis) and other four of the same genus but of different complexes (T. circummaculata, T. protracta, T. dimidiata, and T. mazzottii). We also used three species of other genera as possible outgroups (Mepraia spinolai, Panstrongylus megistus, and Rhodnius prolixus). We have sequenced both strands of mtDNA fragments of the 12S and 16S ribosomal RNA genes (342 and 509 bp, respectively) from each of the eighteen species, and of the cytochrome oxidase I (COI) protein coding gene (1,447 bp) from nine of the species studied. The sequences were obtained from two individuals per species in all cases. Interspecific distances (maximum likelihood, Felsenstein 1981) varied from 0.00 to 18.79% for 12S, 0.20 to 21,95% for 16S, and 0.30 to 20.60% for COI. Phylogenetic trees were inferred from aligned sequences by the neighbor-joining (Saitou & Nei 1987) and maximum parsimony (Swofford 1993) methods. The 12S, 16S, and COI gene sequences were studied individually, and combined as follows: 12S+16S, and 12S+16S+COI. All the phylogenetic trees inferred from the molecular sequence data had a cluster of *T. infestans, T. platensis*, and *T. delpontei* supported by high bootstrap values, as well as *T. sordida* with *T. matogrossensis*. Other well supported nodes, in the trees obtained from both combined data sets, are those clustering: (i) T. guasayana, T. circummaculata, T. rubrovaria, and T. patagonica, (ii) the ((infestansplatensis) delpontei) clade and the other species of Triatoma analyzed (except T. vitticeps, T. dimidiata, T. mazzottii, and T. protracta), (iii) T. vitticeps as the sister taxon of the clade that contains all the other species belonging to the infestans complex studied plus T. circummaculata, and (iiii) T. dimidiata and T. mazzottii. Index terms: Phylogeny, 12S, 16S, cytochrome oxidase I.

[2251] CYTOGENETIC STUDIES OF POLYTENE CHROMOSOMES IN THE TSETSE FLIES GLOSSINA AUSTENI AND GLOSSINA PALLIDIPES

A. Gariou-Papalexiou, G. Yannopoulos & <u>A. Zacharopoulou</u>, Dept. of Biology, Division of Genetics, Cell and Developmental Biology, University of Patras, Greece. E-mail: zacharop@upatras.gr. *This work is being supported by FAO/IAEA Joint*.

Polytene chromosome analysis has application both to formal and population genetics. In many insect vectors of diseases the analysis of polytene chromosomes has provided the key tool to unravel many important epidemiological and speciesrelated questions, particularly mapping and isolating of any endogenous gene(s) involved in their vectoring capacity. In addition, polytene chromosomes have been proved essential for elucidating phylogenetic relationships among taxa, based on their chromosome structure. Polytene chromosomes in two tsetse species, Glossina austeni and Glossina pallidipes have been analysed and chromosome maps have been constructed, with the aid of Photoshop software package. The three long polytene elements, representing the X and the two autosomes, L1 and L2, were numbered into 100 divisions. In accordance with the system in Drosophila, the divisions were numbered from the telomere of the left arm of the X chromosome to the telomere of the right arm of L2. Characteristic features of each chromosome are described. Chromosomal homology between G. austeni and G. pallidipes has been determined by comparing chromosome banding pattern. Extensive similarities exist, especially in the tips of the chromosomes, indicating that they must share a common ancestor. In addition numerous chromosome rearrangements have been observed which should have occurred since the separation of the two species. Furthermore, in situ hybridization technique, which allows the accurate localization of any cloned DNA sequence, has been applied on tsetse polytene chromosomes. Several cloned tsetse genes provided to us, have been tested by in situ and their cytological position will be given

[2252] A NOVEL GENE UP-REGULATED DURING RECOVERY FROM COLD-SHOCK IN DROSOPHILA

S. G. Goto, C. O. Masahito & T. Kimura, Graduate School of Environmental Earth Science, Hokkaido University, Sapporo, Hokkaido 060-0810, JAPAN, E-mail goto@ees.hokudai.ac.jp

Cold tolerance has been extensively studied in insects mainly focusing on accumulation of cryoprotectants and maintenance of the fluidity of cellular membranes. However, the mechanisms of cold tolerance still remain unclear in Drosophila. Recently, expression of stress proteins has been received attention as a mechanism to rescue proteins or cells from cold injury. However, our previous results showed that the relation between the expression of *HSP70* mRNA and cold tolerance was not so rigid in some *Drosophila* species. Here I report an attempt to find genes that are specifically expressed after cold-shock in *Drosophila melanogaster* using subtraction and differential screening techniques. Experimental flies were reared at 25 °C (continuous light) from the egg stage to the 7-day adult stage, exposed to cold (0 °C) for 8 h, and thereafter allowed to recover at 25 °C for 2 h. mRNA was extracted from these flies and then subjected to subtraction and differential screening using mRNA extracted from flies without cold treatment as a control. As a result, four gene fragments were obtained. By Northern hybridization, at least a gene was shown to be considerably up-regulated at the transcription level during recovery from cold-shock. cDNA of this gene was 1,151 bp in length with an ORF of 834 bp, which encodes 278 amino acids. The nucleotide and amino acid sequences shared low homology to other genes and proteins so far known. The molecular weight of the deduced polypeptide was 29.4 kDa and the estimated p/ was 3.85. The protein had several motifs concerning post-translational modification. In addition, a proline rich region that has been reported to be involved in protein-protein interactions was also observed. Moreover, there was a signal peptide in N-terminus and therefore the protein would be secret to the extracellular fluid or hemolymph. We will discuss the function of the gene in relation to the acquisition of cold tolerance.

Index terms: Drosophila melanogaster, cold-shock, cold tolerance, subtraction, differential screening.

[2253] POSSIBILITIES OF HOST ADAPTATION IN THE CABBAGE APHID, *BREVICORYNE BRASSICAE*

E.C. Greatorex & <u>G.M. Tatchell</u>, Entomological Sciences Dept., Horticulture Research International, Wellesbourne, Warwick, CV35 9EF, UK, E-mail mark.tatchell@hri.ac.uk

Adaptation to host plant species has been reported widely in phytophagous insects. However, the extent to which these adaptations are due to the genetics of the herbivore and its genetic environment (i.e. the plant genotype) or are a response to true environmental effects (i.e. seasonal weather effects on both herbivore and plant) require elucidation. The Brassicaceae and Brevicoryne brassicae system was selected as a model system to test the hypothesis that adaptation to heterogeneity in their environment in asexually reproducing plant herbivores is driven by host plant diversity. Closely related Brassica crop plant species, with similar morphology but different genome organisations, were planted in replicated plots at two locations in the UK shortly before colonisation by B. brassicae would be expected. Samples of B. brassicae were collected from each plant genotype at intervals throughout the growing season and individuals were genotyped using a suite of microsatellite markers to determine the variation in the population due to abiotic environmental factors. Correlations between the presence of particular aphid genotypes and particular host plants were investigated to determine whether there are host plant adapted genotypes of aphid. Potentially host-adapted clones of B. brassicae were established from the different plant genotypes at the end of the season and were genotyped. These clones were used in controlled laboratory experiments in which they were switched between plant genotypes to determine the relative intrinsic rate of increase, r_m , a measure of their fitness. These experiments have determined the effect of host plant genotype on the herbivore and support the findings from the field experiments. The implications of these findings to the deployment of plant varieties resistant to insects, either through genetic modification or conventional breeding, are discussed.

Index terms: Aphididae, microsatellites, Brassicaceae, genotype

[2254]CYTOTAXONOMY AND HOMOSEQUENTIAL SPECIES OF THE Simulium perflavum SPECIES GROUP (DIPTERA: SIMULIIDAE) FROM BRAZIL AND VENEZUELA

N. Hamada¹, P. H. Adler² & M. E. Grillet³, ¹Inst. Nac. Pesquisas da Amazônia/CPEN, Caixa Postal 478, 69011-970 Manaus, AM, Brazil, E-mail nhannada@inpa.gov.br.; ²Clemson Univ., Dept. of Entomology, Clemson, SC, 29634 USA; ³Inst. Zoología Tropical, Univ. Central de Venezuela; Ap. 47058, Caracas 1041-A,Venezuela.

The Simulium perflavum species group includes Simulium maroniense, Simulium rorotaense, Simulium kabanayense, Simulium suarezi, Simulium trombetense, Simulium perflavum and Simulium ignacioi. The objective of this study is to examine cytologically all of the known species in the S. perflavum species group, to provide new information on geographical distribution, and to re-evaluate at the cytological and morphological levels the specific status of S. ignacioi, which was formerly considered synonymous with S. rorotaense. The black fly specimens were collected in Brazil and Venezuela. In Venezuela, the species S. maroniense, S. suarezi, S. kabanayense and S. ignacioi were collected in Bolivar state (Oct. 1996, Feb. 1998, Oct. 1998), and S. maroniense was collected in Amazonas state (Oct. 1996). In Brazil, the species S. trombetense was collected (Oct. 1998) in one stream in Serra do Cachimbo, state of Pará; S. rorotaense was collected (Aug. 1998) in Oriximiná County, Pará state and Apuí County (July 1998), Amazonas state, and S. maroniense was collected in Apui County, southern portion of Amazonas state, (July 1998) and in São Gabriel da Cachoeira County, northern portion of Amazonas state, (Nov. 1998, Nov. 1999). Larvae were fixed in Carnoy fixative and larval chromosomes were stained using the Feulgen process. The species in this species group have few polymorphisms, the most polymorphic species being S. maroniense. Simulium rorotaense, S. kabanayense and S. suarezi are chromossomally homosequential, although they can be distinguished by conventional morphological characters, such as gill filament number and shape. Simulium ignacioi has a fixed inversion on chromosome arm IIL that distinguishes it from S. rorotaense, besides the fact that it has a lower number of gill filaments (mean number = 16) than S. rorotaense (mean number = 20). Chromosomal rearrangements, such as inversions, are believed to be important in the speciation of black flies; however, because three species in the S. perflavum group are homosequential, rearrangements appear not to have been a driving force in speciation for some members of this species group.

Index terms: aquatic insects, Canaima National Park, cytogenetics, taxonomy

[2255] HOST GENETICS AND THE CONTROL OF LIFE HISTORY TRAITS IN THE YELLOW FEVER MOSQUITO AEDES AEGYPTT INFECTED WITH NOSEMA ALGERAE MICROSPORIDIA

M. H. H. Hansen¹ & J. C. Koella², ¹Dep. of Zoology, Univ. of Aarhus, Universitetsparken B135, DK-8000 Aarhus C, Denmark; ²Laboratoire d'Ecologie, Univ. Pierre & Marie Curie, CC237, 7 Quai St. Bernard, 75252 Paris Cedex 5, France.

Virulence, defined as a parasite mediated reduction in host fitness, results from changes in the host life history caused by the parasite. Thus, understanding how parasites affect host life history is crucial to understanding the evolution of virulence. The phenotypic characters of hosts infected by parasites may be viewed as extended phenotypes influenced by both host and parasite genes. Since host life history affects the lifetime reproductive success of both host and parasite, conflicting selection pressures acting on the two genotypes will lead to a coevolutionary conflict of interests over the control of host traits. The ecology and life histories of both host and parasite influence the outcome of this conflict. Using the yellow fever mosquito Aedes aegypti and its microsporidian parasite Nosema algerae, we investigated the genetic basis of host control of life history traits. We compared groups of infected and uninfected half-sibs, performing a quantitative genetic analysis of traits of importance to both host and parasite life history. Furthermore, we investigated the effect of demographic and environmental factors on correlated host life history traits in infected versus uninfected hosts, providing an impression of the interacting selective forces operating in this host-parasite system.

[2256] EXPLORING THE MITOCHONDRIAL GENOME OF ANASTREPHA SUSPENSA

M.A. Heath, R.J. Schnell & Cecile Olano, USDA, ARS, SHRS, 13601 Old Cutler Rd., Miami, FL 33157, USA.

DNA sequences from the mitochondrial genome of Anastrepha suspensa for regions of the cytochrome c oxidase I, II and III genes, the large-subunit rRNA gene, the small-subunit rRNA gene, the cytochrome B gene, the tRNA leucine 2 gene, the tRNA lysine gene, and the NADH dehydrogenase subunit I gene have been obtained. These sequences have been mapped to restriction fragments. Comparisons of the DNA sequences and the restriction map from Anastrepha suspensa to those known from other tephritid fruit flies are also presented.

key words: Caribbean fruit fly; mitochondrial DNA; restriction maps

[2257] MORPHOLOGY AND GENETICS OF THE NEWLY DISCOVERED INTERSEX IN THE SILKWORM, *BOMBYX MORI*

M. Hirokawa, H. Tanaka & A. Shimazaki, Lab. of Genetic Resources, Natl. Inst. Seric. Entomol. Sci., 6585 Kobuchisawa, Kitakoma, Yamanashi, 408-0044, Japan, Emailhirok@nises.affrc.go.jp.

As a sexually abnormal individual with both sexual characteristics, sex mosaic and intersex are known in some species of insects. However, in Bombyx mori, only the sex mosaic had been reported. Morphology and genetics of the intersex newly discovered in *Bombyx mori* were investigated. The number of abdominal segments with the scales of a normal moth is seven in female and eight in male. Whereas, in the intersex moths, the eighth abdominal segment with the scales varied in manifestation from undetectable traces on their back to the complete structure. In the external sexual organs, both female and male organs were mixed. In the internal sexual organs, most of them had ovaries and many of them had a seminal vesicle of the male organ. Since the fertile moths as female were found in the intersex, the sexuality of the offspring from the cross intersex x male was examined. Intersex and male appeared at a ratio of approximately 1:1. When the males from this cross were crossed with normal females, the sex ratio of male and female was 1:1 and no intersex was observed in the offspring. To confirm the sex chromosome constitution of each individual, the intersex was crossed with the male carrying the recessive sex-linked translucent larval skin gene, od. In the offspring of the cross intersex (Z+W) x male (Z^{od}Z^{od}), translucent skin larvae (Z^{od}W) became intersex moths, and normal skin larvae (Z⁺Z^{od}) became male moths. If the "intersex" is a sex mosaic genetically constructed from two synkaryons, the sex mosaic larvae constructed from two kinds of the cells with the genotypes both $Z^{\alpha d}W$ and $Z^{\dagger}Z^{\alpha d}$ should appear. But such a mosaic individual had never appeared. Since nearly all the ZW individuals became intersex and all the ZZ individuals became male without carrying any sexually transforming genes, the existence of the interesex was confirmed in Bombyx mori, moreover, the intersexuality gene, Isx, was confirmed to be located on the W chromosome of the intersex, too.

Index term: sex mosaic, W chromosome

[2258] DIFFERENTIATION AND IDENTIFICATION OF *AEDES AEGYPTI* POPULATIONS IN TAIWAN

C. M. IIo¹, C. Y. Chang¹, Y.C. Su² & E. L. Hsu², ¹Dept. of Parasitology, Natl. Yang-Ming Univ., 115 Sec. 2, Li-Nung St., Shih-Pai, Taipei (112), Taiwan, ROC, Email vector@ym.edu.tw, ² Dept of Entomology, Natl. Taiwan Univ. Taipei, Taiwan, ROC.

The abdominal scaling pattern of the adult mosquito, Aedes aegypti is highly variable. Hartberg et al. (1986) proposed a simplified system of classification based on the McClelland' 30 groups and designated as CKM. In this system, only the number of tergites with additional white scaling is considered. The extent of white scaling on the tergites is distegarded. This allows for classification using eight different classes, ranging from 0 to 7. In this study, scale patterns of the abdominal tergites in adults were identified and ranked by CKM system for 8 populations of Ae. acgypti collected from southern and southeastern parts of Taiwan. We did not find any individual with the scale at CKM 0 in these natural populations. In general, there were 75% of these adults ranked at CKM 1and 25% or less of the individuals ranked at CKM 2 to CKM 7. However, in the population from Taitung County, we found that the scale patterns were more diverse than that of other areas. They were 47%males and 37% females having the white scale at CKM 2 to CKM 7. Cluster analyses revealed that there were two major groups existing in the natural populations. But, differences of scale pattern were not detected from the individuals collected peri-domestically and domestically. In the meanwhile, five laboratory colonies were compared with the natural populations, we found that colonies from Kenya and Gambia had 11% and 26% individuals at CKM 0, respectively. However, colonies from Puerto Rico and small Liu-Chiu Isle. Which locating in Pintung County had a similar scale pattern as that of Kaohsiung, population, and colony from Hainan Isle where is near Mainland China was similar to that of Taitung population. Moreover, a technique, random amplified polymorphic DNA (EAPD) developed by William et al (1990), was also used to detect the genetic variability for Kaohsiung population and the laboratory colonies. Genetic distance dendrograms were constructed based on the unweighted pair-group mean of the percent of match using the total set of fragments. Our results revealed that colony from Gambia and Puerto Rico was a sister group, population from Kaohsung was closer to this sister group, than that of colony from Kenya or Heinan.

Index terms: Aedes aegypti, abdominal scale pattern, RAPD.

[2259] MOLECULAR CLONING OF NEUROPARSIN PRECURSOR CDNAS IN THE DESERT LOCUST SCHISTOCERCA GREGARIA

T. Janssen, L Claeys, G. Simonet, A. De Loof & <u>J. Vanden Broeck</u> Lab. for Developmental Physiology and Molecular Biology, Zoological Institute K.U.Leuven, Naamsestraat 59, B-3000 Leuven, Belgium.

The pars intercerebralis (PI) is one of the brain regions that contain perikarya of neurosecretory cells. The neurosecretory material is stored in the corpora cardiaca (CC) until it is released into the hemolymph. Peptidic factors originating from the PI and released at the CC are called "parsins". Neuroparsin A (NPA) and neuroparsin B (NPB) are two 8 kDa neurohormones that were initially isolated from the corpora cardiaca (CC) of the migratory locust, Locusta migratoria (Girardie et al., 1987). NPA is an 83-residue polypeptide that co-exists with several N-terminally truncated isoforms in CC-extracts. DNA sequencing revealed that both neuroparsins are cleavage products of a 107-aa precursor polypeptide. This precursor consists of a secretory signal peptide and NPA. NPB is the result of a partial metabolic conversion (enzymatic proteolytic cleavage) of NPA. In Locusta migratoria, these purified neuroparsins exhibit anti-juvenile, antidiuretic, hyperglycemic, hyperlipemic and neurotopic activities. Recently, Girardie et al. (1998) also determined the amino acid sequence of NPA (NPB) in the desert locust, Schistocerca gregaria. The sequences of Locusta and Schistocerca neuroparsins are similar. Based on this sequence information, we have cloned the neuroparsin precursor cDNA of Schistocerca gregaria. Interestingly, a combined approach of PCR and RACE has led to the identification of additional cDNA sequences encoding different neuroparsin-related precursors (NPP). The deduced amino acid sequences of the NPPs range in length between 103 and 111 residues. All Schistocerca NPPs share the same secretory signal sequence and contain 11-12 cystein residues at conserved amino acid positions. For each precursor, specific cDNA probes were generated and the tissue- and stage-dependent (larval stages, moulting cycle and reproduction cycle) distribution of the distinct NPP-transcripts was analyzed by northern blot experiments. The results show that some NPP transcripts are exclusively expressed in the brain, whereas others also occur in a variety of other tissues, including the fat body and the testes. Furthermore, the level of NPP-transcripts generally was higher in males than in females.

Index terms: gene expression, gonad, neurohormone, parsin

[2269] EVOLUTION OF LARVIFORM MALES IN THE INBREEDING BARK BEETLE OZOPEMON: FIERCE FIGHTERS OR JUST WEIRD?

B. H. Jordal^{1,3}, R. A. Beaver², B. B. Normark³ & B. D. Farrell³, ¹Dept. Zoology, University of Bergen, Allegt. 41, N-5007 Bergen, Norway, E-mail: bjarte.jordal@zoo.uib.no; ²161/2 Mu 5, Soi Wat Pranon, T. Donkaew, A. Maerim, Chiangmai, S0180, Thailand; Museum of Comparative Zoology, Harvard University, 26 Oxford St., Cambridge 02138 MA, USA.

Bark and timber beetles of the weevil subfamily Scolytinae exhibit a wide range of different mating and genetic systems, as well as different courtship behaviors and use many different woody substrates for breeding. Perhaps the most successful clade (among the 5800 species described) includes almost 1400 species of regular inbreeders with female biased sex ratios, and where haplodiploidy is the only known genetic system. Basal to, or nested basally within this clade, is the remarkable bark beetle genus Ozopemon, for which an earlier designation of males had been discarded, and some entomologists even believed that males did not exist. A strange creature with fully developed aedeagus, strongly modified pronotum and head, and larviform abdomen, was first described as the male of O. brownei, by Francis Browne; this suggestion was later set aside by Roy Crowson who assigned the weird looking male to the Histeridae, based on a single morphological character. With the evidence provided here, the long standing controversy over the assessment of these enigmatic males has come to a solution. Based on recently obtained DNA sequence data, as well as detailed examination of genital and proventricular characters, we have shown that these strange and fierce-looking creatures are indeed males which have sisters with normal adult bark beetle morphology. Here, we report on two more species, now three in total, having males assigned to the females. The larviform males show a gradual character transformation in the head region, from the adult-like antennae and labium in O. obanus, to the larviform homologs in the two other species. The unique modification of these males is one the most dramatic ontogenetic transformation known for any adult male insect, and extends the range of known modifications of males in inbreeding bark beetles. Moreover, the modification of Ozopemon males is the most extreme example of what WD Hamilton defined as adaptations to an ideal extreme biofacies of inbreeding and arrhenotoky. Also, the rather unique combination of fighting characteristics (e.g. enlarged mandibles) and neoteny, makes sense in the light of similar seraglio situations observed for other insects in confined habitats, where precocity, winglessness and fighting are advantageous in the males. We summarize the most obvious alternative explanations for the evolution of larviform males in this genus, and compare these males to other male forms of related hapiodiploid species. Index terms: haplodiploidy, inbreeding

[2261] RECOVERY OF MITOCHONDRIAL DNA SEQUENCES FROM MUSEUM SPECIMENS: METHODS AND EVOLUTIONARY PERSPECTIVES

A.C.M. Junqueira, A. C. Lessinger & A. M. L. Azeredo-Espin, Lab. Genética Animal, DGE/CBMEG, Universidade Estadual de Campinas, P.O. Box 6109, Campinas, SP, Brasil, CEP 13087-970. E-mail: anacmj@aol.com. Financial support: FAPESP, PADCT/CNPq.

Recent advances in molecular biology have allowed the extraction and analysis of DNA from well preserved museum specimens. The optimization of DNA extraction methodologies is crucial to recover the genetic information preserved in the tissues due to the fractionation and degradation of DNA over the time. The efficient amplification by PCR provides a direct recovery of short intact DNA sequences, and the mitochondrial DNA (mtDNA) increases the chances for amplification due to its high copy number. The comparison of three techniques for DNA extraction have shown that the DNAzol reagent was the most efficient in retrieval of DNA from museum specimens, although the Chelex extraction procedure has been currently the most frequently approach reported. We have successfully amplified mtDNA sequences from eight species of mylases-causing-flies: Cochliomyla hominivorax, Cockliomyia macellaria, Lucilia eximia, Hemilucilia segmentaria, Chrysomya putoria, Chrysomya megacephala, Chrysomya albiceps (Diptera: Calliphoridae) and Dermatobia hominis (Diptera: Oestridae). Dried pinned and alcohol preserved specimens ranged in age from 10 to 53 years. Total Genomic DNA was used to amplify specific regions of mtDNA genes: 137, 160 and 310 bp of Cytochrome oxidase subunit II (CO II), 194bp of Cytochrome oxidase subunit I (CO I), 330bp of a sequence including the rRNA 16S and NADH subunit I, and 345bp of Cytochrome b (Cyt b). These fragments have been cloned in pUC 18 / Sma I and the sequences were obtained by automated sequencing. Preliminary results based on BLAST analyses have shown that amplified fragments have high sequence identity with the homologous regions of ntDNA of other species of mylases-causing flies, an indication that contamination has been efficiently avoided. The D. hominis COII 160bp fragment presents sequence identity with Lucilia illustris (89%), Lucilia sericata (86%), Phormia regina (86%), Chrysomya albiceps (85%), and Chrysomya rufifacies (84%). The cloning and sequence analyses are allowing the characterization of amplified mtDNA regions from museum specimens, in order to compare data from different species, providing a picture of genetic changes and elucidating evolutionary questions

Index terms: intDNA, myjases, PCR, DNA extraction, museum specimens, diptera.

[2262] HEAT SHOCK RESPONSE IN THE MEDITERRANEAN FRUIT FLY: GENES, PROMOTERS AND THERMOTOLERANCE

K. Kalosaka , G. Kokolakis , M. Theodoraki , G. Chrysanthis , A. Zacharopoulou & <u>A. Mintzas.</u> Dept. of Biology, Univ. of Patras, Patras 26 500, Greece. E-mail mintzas@upatras.gr.

The response of cells or organisms to heat shock and other environmental stresses is connected to the induction or enhancement of the synthesis of a number of proteins, called heat shock proteins (HSPs). HSPs, via their chaperoning effects on proteins, protect cells from many forms of stress-induced cell damage. Members of the HSP families play also central roles in a constantly increasing number of cellular activities under non-stress conditions. We are interested to investigate the relationship between hsp gene expression and thermotolerance in the Mediterranean fruit fly (medily), a major agricultural pest, and to assess the efficacy of the promoters of the hsp genes as drivers for conditional and constitutive expression of any transgene in this species. Eight heat-inducible puffs have been identified on the medfly larval salivary gland polytene chromosomes and several *hsp* genes (*hsp* 83, *hsp* 70 and two small *hsp* genes) have been cloned and characterized. The medfly *hsp* genes exhibit maximum expression between 36-39 °C, approximately 2-3 °C higher than the optimum temperature of their D. melanogaster homologs. Structural analysis revealed a number of heat shock elements (HSEs) in the 5' flanking region of these genes. The function of the hsp70 promoter was studied in vivo, in transiently transformed medfly embryos, using the chloramphenicol acetyl transferase gene as a reporter. Our transient expression data indicated that a 106 bp region of the hsp70 promoter that includes two HSEs is necessary for the function of the medfly hsp70 promoter and that additional sequences upstream of the HSEs are required for maximum activity. Furthermore, our data indicated that the efficiency of the medfly hsp70 promoter for driving constitutive and heat-inducible gene expression in the medfly is higher than the efficiency of the heterologous D. melanogaster promoter. To complement these results, stable transformants are currently being generated by germline transformation. To test whether the expression of the hsp genes is related to the development of thermotolerance, the heat shock protein and RNA levels are being compared to the survival of the medfly under various stress conditions in embryos, larvae and adults. Results from these experiments are going to be presented. Index terms: Ceratitis capitata, hsp gene expression, hsp promoters.

[2263] CONCENTRATED EXPRESSION OF THE GENES FOR PROTEINS INVOLVED IN CALCIUM SIGNALING IN THE MUSHROOM BODIES OF THE BRAIN OF THE WORKER HONEYBEE APIS MELLIFERA L

<u>A. Kamikouchi¹, H. Takeuchi¹, S. Natori², K. Sekimizu¹ & T. Kubo¹, ¹Grad. Sch.</u> Pharmaceu. Sci., Univ. of Tokyo, Bunkyo-ku, Tokyo, 113-0033, Japan; and ²Natori Special Lab., RIKEN, Wako-shi, Saitama, 351-0198, Japan.

The honeybee is a social insect and various exquisite social behaviors are performed by their colony members. To analyze the molecular basis of such social behaviors of the honeybee, we searched for genes that are expressed selectively in the paired mushroom bodies, putative memory and sensory integration centers of the insect brain, of the honeybee. As results, we found that genes for three proteins involved in the intracellular Ca²⁺ signaling pathway, inositol 1,4,5-trisphosphate receptor, Ca³⁺/calmodulin-dependent protein kinase II (CaMKII) and protein kinase C (PKC), were expressed selectively in the mushroom bodies of the honeybee brains.^(1,2) We also found that specific activities of CaMKII and PKC are higher in the mushroom bodies than in those of the optic and antennal lobes of the worker bee brain⁽²⁾. The intracellular Ca²⁺ signaling pathway is reported to be involved in neuronal plasticity in various higher organisms. Taken together, our results suggest that the function of the intracellular Ca²⁺ signaling pathway and thus the synaptic plasticity of the intrinsic neurons of the mushroom bodies (the Kenyon cells) are enhanced in comparison with other neuronal cell types in the honeybee brain.

Index terms: social insect, gene expression, specific activity, synaptic plasticity

[2264] MOLECULAR IDENTIFICATION OF THE ANOPHELES FUNESTUS GROUP IN SOUTHERN AFRICA

L.L. Kockemper¹ & R.H. Hunt¹ & M. Coetzee¹, ¹Department of Medical Entomology, SA Inst. for Medical Research, P.O. Box 1038, Johannesburg, 2000, South Africa. E-mail: entosafr@global.co.za

Three main vectors transmit malaria in Africa. Two of these belong to the Anopheles gambiae complex, An. gambiae s.s and An. arabiensis. The third main vector is An. funestus. Anopheles funestus belongs to the An. funestus group of species and is less well studied than the An. gambiae complex due the major problems experienced in identifying members within the group. Eight species are recognized within the An. funestus group based on morphological differences in the immature stages. Historically identification of wild females of the An. functus group necessitated obtaining eggs and rearing the progeny in the laboratory. This process is time consuming and success rates are limited. The use of banding arrangements on the giant polytene chromosomes proved to be very successful and more rapid than rearing progeny. Polytene chromosomes, however, have the disadvantage of being limited to female mosquitoes at a specific stage of their gonotrophic cycle. Another disadvantage is the presence of homosequential chromosome arrangements existing between two species in the group, An. funestus and An. vaneedeni. Using available molecular methods we developed an molecular assay able to distinguish between the members of the An. funestus group most commonly found in southern Africa, An. funestus, An. vaneedeni, An. rivulorum, An. leesoni and An. parensis. This assay does not depend on age or sex of the specimen and does not require specialized preservation methods. The SSCP-PCR assay distinguished between An. funestus, An. vaneedeni, An. rivulorum and An. leesoni. A variable domain in the 28S gene, D3, was amplified and due to sequence differences present between the species resulted in different mobilities during electrophoresis. This assay however could not distinguish between An. vaneedeni and An. parensis. The second PCR assay used primers amplifying the ITS2 region which produced a product that differed in size between the two species. Studies are underway to determine the reason for the size difference, but it is likely to be the addition of a repeat sequence within the region. Previous research on An. funestus group collected indoors automatically assumed them to be An. funestus s.s. However, vectorial studies on An. funestus in Senegal, showed that within this species there might be other populations present not contributing equally towards malaria transmission. Using these molecular tools we are now able to monitor the An. funestus group within the malarious areas of South Africa and determine if any members of the group apart from An. funestus play a role in malaria transmission.

Index terms: mosquitoes. PCR-SSCP, malaria

[2265] CLONING OF THE ACIDIC RIBOSOMAL P-PROTEINS IN THE SILKMOTH BOMBYX MORI

S. Kouyanou-Koutsoukou¹, A. Zaniou¹, P. Athanasakis¹ & M. E. Gagou², ¹University of Athens, Department of Biology, Division of Genetics and Biotechnology, Panepistimiopolis, Athens, Greece. ²Institute of Molecular Biology and Biotechnology, Foundation of Research and Technology, Crete, Greece. E-mail: skougian@biology.db,uoa.gr

The eucaryotic ribosomes contain a family of acidic phosphoproteins P1 and P2 that form the lateral stalk of the large subunit with the ribosomal phosphoprotein P0, similarly to L7/L12 and L10 proteins of Escherichia coli. The ribosomal stalk is involved in the interaction of the elongation factors with the ribosome and the GTP hydrolysis during protein synthesis. We have cloned the P-proteins, CcP1, CcP2 and CcP0 of the medfly Ceratitis capitata and showed that they can complement P-protein defficient strains of the yeast Saccharomyces cerevisiae, forming an heterogenous ribosomal stalk. To perform an in vivo functional analysis of the Pproteins in another insect of economical importance, we isolated genomic and cDNA clones of the genes of the ribosomal proteins P1, P2 and P0 of the silkmoth Bombyx mori, using homologous probes, prepared by PCR. We used as template genomic DNA of B. mori and primers of synthetic oligonucleotides, similar to the conservative regions of the ribosomal P-protein genes of C. capitata, most Drosophila melanogaster and other eucaryotic organisms. Three PCR products of 151 bp, 313 bp and 500 bp were synthesized for the P1, P2 and P0 genes of B. mori, respectively. Sequencing analysis and determination of their predicted amino acid sequence showed that they code for open reading frames, while comparison with the homologue P-proteins genes of C. capitata and D. melanogaster showed great similarity. The homologous probes were used for the screening of a genomic and a Agt11 cDNA library of B. mori, that led to the isolation of one recombinant genomic clone for the P2 gene and two recombinant cDNA clones, for the P1 and P0 genes, respectively. Sequence analysis and alignment of the nucleotide sequences of the P1, P2 and P0 genes and of the deduced amino acid sequences of the proteins with published sequences of *C. capitala*, *D. melanogaster* and other eucaryotic organisms showed considerable similarity. The P2 gene is introlless, while the characteristic structural domains of the hinge and carboxy-terminal regions have been well conserved in all proteins. All three genes were cloned in expression vectors pT7/7 and expressed in Escherichia coli BL21(DE3) strains. Their products, with MW of 18 kD (P1), 15 kD (P2) and 34 kD (P0) were subjected to Western blot analysis with specific polyclonal and monoclonal antibodies.

[2266] DROSOPHILA BUZZATH EVOLUTION IN BRAZIL REVISITED: HIGH SATELLITE DNA HOMOGENEITY AMONG POPULATIONS

<u>G.C.S. Kuhn</u> & F.M.Sene, Dept. of Genetics, Univ. of São Paulo, Ave. dos Bandeirantes, 3900, CEP 14049-900, Ribeirão Preto, SP, Brazil, E-mail: gcskuhn@rgm.fmrp.usp.br. Financial support: FAPESP, CNPq, FINEP, CAPES and USP

Drosophila buzzatii is a world-wide cactus-breeding species probably originated in the Argentinean Chaco. In South America, outside Chaco, D.buzzatii populations have been found in Bolivia and Brazil. D.buzzatii reached Brazil most probably in two ways: in an ancient one, D.buzzatii followed the expansions of the distribution of the xerophytic formations within paleoclimatic cycles during the Quaternary Period; the recent one was a consequence of the anthropogenous dispersal of the Opuntia host plants, which is also believed to be the way D.buzzatii colonized the Old World. In literature only limited data sets are available about the evolutionary relationships among Brazilian populations. Some allozyme and chromosomal data showed that at least two Brazilian populations (i.e. Northeastern and South-coast populations) present differentiation which is in accordance with the ancient way of colonization. satellite DNA sequences often show rapid turnover between even closely related species. For that reason, satDNA sequences seems to be a suitable fast-evolving marker for discriminating populations. In order to get additional information on the evolution of D.buzzatii in Brazil, we compared a previously described D.buzzatii satellite DNA sequence, named pBuM189, among 6 populations which cover D.buzzatii known Brazilian geographical distribution. In addition, one population from Argentina was included in the sample. The pBuM189 satDNA consists of repetition units 189bp long which are tandemly arranged with a high copy number in the genome of D.buzzatii. The nucleotide sequences of 32 selected clones (representing 32 repeat units independently obtained) showed a high degree of sequence similarity among the 7 analyzed populations (95% on average). The observed variability is mainly due to nucleotide substitutions. No specific population feature was observed after the sequence alignment. Genetic distances among the 32 pBuM189 satDNA clones were calculated according to Kimura's "two-parameter method" and used to construct UPGMA and Neighbor-Joining dendograms. No specific clustering of any group of sequences was observed. The absence of specific populations features was specially surprising in the Northeastern and South-coast populations, since they would be somehow expected from allozyme and chromosomal data. However, one Argentinean repeat unit (of four sequenced repeats) shows a remarkable variability compared to the other repeats (25% on average). This result makes it interesting to include more Argentinean populations samples into these studies.

[2267] INCOMPLETE DOMINANCE OF SOME MORPHOLOGICAL CHARACTERS IN HYBRIDS OF DROSOPHILA VIRILIS GROUP

<u>A.M.Kulikov¹</u>, A.I.Mel'nikov¹, N.G.Gornostnev² & V.G.Mitrofanov¹, ¹Institute of Developmental Biology, Moscow, 117334 Russia, E-mail: alex@ibrran.msk.su; ²Institute of Ecology and Evolution, Moscow, 117071, Russia.

We studied two morphological characters of male genitalia of sibling species of *Drosophila virilis* group: the shape of apical claw of aedeagus and absence/presence of hairs on dorsal surface of aedeagus. It was found that the claw of *virilis* phylad species is distinctly more narrow than in *montana* phylad where it is massive and broad with the exception of *D.ezoana* having no claw. The shape of claw of *D.virilis* Sturt. is intermediate between two phylads. The hairs on dorsal surface of aedeagus lack in species of *virilis* phylad except of *D.lummei* where they are rare; these hairs are dense in species of *montana* phylad. The heritability of both characters was studied in hybrids F1 of *D.virilis* x *D.lummei* and the shape of claw also in hybrids of *D.virilis* x *D.novamexicana*. We found that the shape of the claw was intermediate in F1 hybrids and expression of presence of the dorsal hairs also showed incomplete dominance with 50% penetrance in hybrids.

Index terms: Drosophilidae, male genitalia, heritability.

[2268] A MOLECULAR PHYLOGENY OF NOTONECTIDAE (HETEROPTERA) USING 16S RNA

E. C. Larsen, BSLC, University of Chicago, 924 E. 57th St., Chicago, IL 60637, USA, E-mail eclarsen@midway.uchicago.edu.

There is no modern phylogeny for the backswimmers, a cosmopolitan group of predaceous aquatic insects. The accepted taxonomy of this family is two subfamilies and eight genera. Notonectinae is comprised of Notonecta, Enithares, Nychia, and Martarega, and Anisopinae is comprised of Paranisops, Walambianisops, Anisops, and Buenoa. Hungerford (1933) proposed a phylogenetic arrangement with the following sister taxa: Notonecta and Enithares, Martarega and Nychia, Anisops and Buenoa. There has been no cladistic treatment of morphology or DNA to test this arrangement. Species groups have been proposed in Buenoa (Truxal 1953) and Anisops (Brooks 1951), but no relationships of these groups to the rest of the respective genera were proposed. I have sequenced a portion (ca. 600 bp) of the mitochondrial gene for 16s RNA from 29 species of Notonectidae from 4 of the 8 genera. An additional 12 individuals from 9 related families have also been sequenced for use as outgroups. The sequence data were analyzed with PAUP 4.0, using bootstrapping and branch and bound algorithms. Notonectidae is not monophyletic as Enithares falls in a clade with the Naucoridae. The most parsimonious tree does not support the subgenera of Notonecta, but that tree is not dramatically shorter than a topology consistent with existing subgenera. One of Truxal's species groups within Buenoa is supported (margaritacea, scimitra, albida, and uhleri), but it appears derived rather than "primitive" as supposed by Truxal. More species are needed to examine the other six species groups and their relationships to each other. More taxa and sequence data from another gene are required for a more complete and rigorous phylogeny of this family. Index terms: systematics, backswimmers, Buenoa, Notonecta

[2269] GRAM-NEGATIVE BACTERIA BINDING PROTEIN, A PATTERN **RECOGNITION RECEPTOR FOR LIPOPOLYSACCHARIDE AND II-1,3-**GLUCAN, WHICH MEDIATES THE SIGNALING FOR THE INDUCTION OF INNATE IMMUNE GENES IN DROSOPHILA MELANOGASTER CELLS

W. J. Lee¹, P. T. Brey², B. Lemaitre³, K.-B. Nam¹, K.-H. Choi¹, S.-J. Han², J.-H. Ryu¹Y.-S. Kim¹, ¹Lab. of Immunology, BK21 Center for Medical Science and Medical Research Center, College of Medicine, Yonsei Univ., CPO Box 8044, Seoul, South Korea, E-mail wijeel@yumc.yonsei.ac.kr; ²Laboratoire de Biochimie et Biologie Moléculaire des Insectes, Institut Pasteur, 25, rue du Dr. Roux, 75724 Paris, France, and ³Centre de Génétique Moléculaire, Centre National de la Recherche Scientifique, 91198 Gif-sur-Yvette, France.

Pattern recognition receptors, non-clonal immune proteins recognizing common nucrobial components, are critical for non-self recognition and the subsequent induction of Rel/NF-DB-controlled innate immune genes. However, the molecular identities of such receptors are still obscure. Here, we present data showing that Drosophila possesses at least three cDNAs encoding members of the Gram-negative bacteria binding proteins (DGNBPs) family, and one of which, DGNBP-1, has been characterized. Western blot analysis, flow cytometric analysis and confocal laser nicroscopic analysis demonstrate that DGNBP-1 exists in both a soluble and a glycosylphosphatidylinositol-anchored membrane form in culture medium supernatant and on Drosophila immunocompetent cells, respectively, DGNBP-1 has a high affinity to microbial immune elicitors such as lipopolysaccharide (LPS) and □-1,3-glucan whereas no binding affinity is detected with peptidoglycan, □-1,4glucan or chitin. Importantly, the overexpression of DGNBP-1 in *Drosophila* immunocompetent cells enhances LPS- and \Box -1,3-glucan-induced innate immune gene (NF-DB-dependent antimicrobial peptide genes) expression, which can be specifically blocked by pretreatment with anti-GNBP-1 attibody. These results suggest that DGNBP-1 functions as a pattern recognition receptor for LPS from Gram-negative bacteria and -1,3-glucan from fungi, and plays an important role in non-self recognition and the subsequent immune signal transmission for the induction of antimicrobial peptide genes in Drosophila innate immune system. Index terms: Drosophila, GNBP, innate immunity, Pattern Recognition.

[2270] CHRYSOMYA (CALLIPHORIDAE) MITOCHONDRIAL DNA CONTROL REGION: CHARACTERIZATION OF C. MEGACEPHALA IRNA REPEAT

A. C. Lessinger, A. C. M. Junqueira, F. F. Conte & A. M. L. Azeredo-Espin, Lab. Genética Animal, DGE/CBMEG, Univ. Estadual de Campinas, P.O. Box 6010, Campinas, SP, Brasil, CEP 13083-970. E-mail: lessinge@unicamp.br. Financial support: CAPES, FAPESP, PADCT/CNPg

The mtDNA control region (or A+T-rich region) of the blowfly C. megacephala have been previously characterized, resulting in a total size of 986 base pairs (bp). However, a revised analysis of this data provided the identification of $tRNA^{le}$ complete sequence inside the control region B domain. This tRNA-sequence secms to represent a second copy of this gene, since the partial 5' end of the original tRNA was assigned adjacent to the A domain, as characterized for other Calliphoridae species. Comparative analysis provided 100% of sequence similarity between the two tRNA genes from C. megacephala and approximately 95% of sequence similarity when compared with C. hominivorax $tRNA^{le}$ gene. Secondary structure prediction were performed using the tRNAscan-SE software in order to characterize tRNA structural loops (D loop, anti-codon loop, variable loop, and TwC loop). This analysis resulted in a typical "cover-leaf" configuration (cove score = 21.68), with the identification of the same anti-codon (GAT) assigned for *C. hominivorax* tRNA^{lle} gene. Differences between the tRNA^{lle} genes of *C. megacephala* (repeat) and *C.* hominivorax, refer to two transitions $(A \rightarrow G)$ and one insertion (A) that occurred: 1in the D loop arm, 2- between the D loop and the anti-codon loop, and 3- between the $T\psi C$ loop and the anti-codon loop, respectively. None of this mutational events seem to affect the secondary structures configuration and this tRNA^{1k} repeat may represent a functional copy. There were two PCR amplified products for C. megacephala mtDNA control region, one of which were initially interpreted as PCR non-specific band. However, preliminary sequence data from this "non-specific" 300 bp PCR product recovered from *C. megacephala* control region amplification, provide the accurate identification of partial tRNA^{the} sequences, however this could be due to the annealing of PCR primers in the second tRNA copy. The occurrence of this tRNA repeat could be responsible for technical difficulties in amplifying *Chrysomya* mtDNA control region, especially with primers anchored in the tRNA^{the} sequences. Preliminary results based on the characterization of the mtDNA control region of C. albiceps and C. putoria have provided an amplified product of approximately 300 bp, how this results are related to the C. megacephala control region evolution is under investigation.

SCREWWORM FLY

CALLIPHORIDAE)

lessinge@unicamp.br

This study provides the complete sequence of the mitochondrial genome of Cochliomyia hominivorax (Diptera: Calliphoridae), which presents 16.022 bp in size, a typical Brachycera gene content of 13 protein-coding genes, 2 rRNA genes, 22 tRNAs and a major non-coding region (A+T rich region), organized as reported for Drosophila mtDNA. Intergenic non-coding regions and overlapping sequences account for a total of 138 and 37 nucleotides, respectively. Non-optimal codon usage patterns are commonly observed for C. hominivorax mitochondrial genes, as frequently reported for other metazoan mtDNA. The biased composition of C. hominivorax mitochondrial genome (77% AT-rich) may contribute for the observed codon usage pattern by providing a high proportion of AT-rich codons. Special features include a Serine start codon for cytochrome oxidase subunit I (COI) and incomplete stop codons for CO II, NADH 5 and NADH 4 genes. In addition to its general importance as a livestock ectoparasite, C. hominivorax mtDNA is particularly interesting as a source of sequence information useful for general dipteran molecular approaches. The contribution of screwworm mtDNA data will be discussed in terms of improving primer selection for Calliphoridae species, optimizing PCR-RFLP essays and providing phylogenetic informative sequence data for understanding dipteran evolution, especially from a Calyptratae perspective.

Index terms: Cochliomyia hominivorax, myiasis, mtDNA, molecular evolution.

[2272] BEMISIA TABACI POPULATIONS IN BRAZIL: GENETIC **DIVERSITY REVEALED BY RAPD MARKERS.**

L. H. C. Lima¹, L. Campos¹, M. C. Moretzsohn¹, D. Návia¹ & M. R. V. Oliveira¹, ¹Embrapa Recursos Genéticos e Biotecnologia, P. O. Box 02372, Brasília, DF 70.849-970, Brazil. E-mail: luzia@embrapa.cenargen.br

Bemisia tabaci is probably, one of the most damaging whitefly pest in agricultural systems worldwide, vectoring over 60 different plant viruses. In the last years, biological differences among Bemisia tabaci populations have led to the suggestion that some members of this taxon are separate species or are representative of a species complex. The taxonomic identity of B. tabaci is problematic as it is highly polymorphic with extreme plasticity in key with morphological characters that vary according to the host. Up to 1990, in Brazil, *B. tabaci* was considered a secondary pest, although a very efficient vector of geminivirus in beans and soybeans. However, in 1991, a new biotype, known as the poinsettia strain or silverleaf whitefly or B. tabaci biotype B (= B argentifolii) was detected in Brazil causing phytotoxic disorder in cucurbits and attacking weeds. After molecular analysis of the brazilian'whitefly population, it was determined that two biotypes existed in our agroecosystems: B. tabaci being nominated as biotype BR and biotype B. The purpose of this study was to evaluate the genetic diversity of 100 samples collected in 10 different localities on 5 cultivated plants, cabbage, pumpkin, melon, cotton, and soybean. We used the random amplified polymorphic DNA (RAPD) technique in search for genetic markers which would enable the identification of genetic variants within Brazilian populations of B. tabaci. Results showed a high genetic variability of B. tabaci population. An average Jaccard similarity of 0.67 was observed between all individuals. Cluster analysis demonstrated that populations from the same region tend to group together. AMOVA showed that most of the total genetic variation is found within populations (55,3%).

Index terms: Whitefly, Bemisia tabaci, genetic diversity, RAPD.

HOMINIVORAX

(DIPTERA:

[2271] THE COMPLETE MITOCHONDRIAL GENOME OF THE PRIMARY

A. C. Lessinger¹, A. C. M. Junqueira¹, T. A. Lemos¹, E. L. Kemper², F. R. da Silva², A. L. V. Oliveira², P. A. Arruda² & A. M. L. Azeredo-Espin¹, Lab. Genética Animal, DGE/CBMEG, Univ. Estadual de Campinas, P. O. Box 6109, Campinas, SP, Brasil, CEP 13083-970¹; Lab. Genoma, CBMEG, Univ. Estadual de

Campinas, P. O. Box 6109, Campinas, SP, Brasil, CEP 13083-970², E-mail:

The study of mitochondrial genomes have been subject of increasing research interests, especially due to the ease of recovering genetic and evolutionary

information useful for the investigation of both molecular and organismal evolution.

Complete sequenced mitochondrial DNA (mtDNA) are currently available in

GenBank for five dipteran species representing the Brachycera (Drosophila and

Ceratitis) and the Nematocera (Anopheles) sub-orders. Calliphoridae species address

approximately 50% of all calypterate sequences published, mainly reported as

molecular markers for species-specific identification and phylogenetic reconstruction.

COCHLIOMYIA

Index terms: Chrysomya megacephala, mtDNA, A+T-rich, molecular evolution.

Symposium and Poster Session

[2273] CLONING AND THE EXPRESSION OF A CIRCADIAN CLOCK GENE PERIOD IN THE GERMAN COCKROACH, BLATTELLA GERMANICA

K. H. Lin¹, R. F. Liou² & H. J. Lee¹, 'Dept of Entomology, National Taiwan University, Taipei 106, Taiwan, E-mail m480@ccms.ntu.edu.tw., ²Dept of Plant Pathology, National Taiwan University, Taipei 106, Taiwan.

The circadian expression of *period* gene (*per*) is an important indicator of a functional endogenous clock. We use the RT-PCR and RACE strategies to clone the *per* homolog in the German cockroach, *Blattella germanica*. The cDNA of *per* homolog from *B. germanica* encodes a protein which shows 72% identity with the *per* protein of the American cockroach, *Periplaneta americana*. Comparing the peptide sequences among *B. germanica*, *P. americana*, and *Drosophila melanogaster*, we found that stretches of high identity were in the amino terminus and the PAS domain region. Unlike the *per* protein sequence of *P. americana*, the *per* homolog protein of *B. germanica* shows high identity with the *per* protein of *D. melanogaster* in the carboxyl terminus. With the RNase Protection Assays(RPA) method, the expression of *per* mRNA in the male adult was shown in circadian rhythm which is coinside with the locomotor circadian thythm. Although the female adult German cockroach doesn't show circadian thythm in locomotion, we could use RPA to examine whether the female's endogenous clock works properly or not. Index term: *Blattella germanica*, circadian thythm. *Per*.

[2274] MOLECULAR ANALYSIS OF THE EVOLUTIONARY DYNAMICS OF THE AFRICAN QUEEN BUTTERFLY DANAUS CHRYSIPPUS

<u>G. Lushai¹</u>, J.A. Allen¹, N. Maclean¹, D. Goulson¹ & D.A.S. Smith², ¹Sch. Biological Sciences, Univ. of Southampton, Bassett Crescent East, Southampton, SO16 7PX, UK, E-mail gl1@soton.ac.uk; ²Natural History Museum, Eton College, Windsor, Berkshire, SL4 6EW, UK.

The African queen butterfly, Danaus anosia chrysippus is a tropical butterfly with six subspecies currently recognised. Five of these are spread through tropical Asia, Australasia and Oceania and are allopatric and monomorphic. Under this scenario, all African forms are referred to as a single subspecies, *argyptius*, which is supposedly monomorphic for different forms in each of five geographical areas. In central and east Africa the situation is more complex, with the five regional forms (and others) coexisting sympatrically. The traditional view is that selection drives populations to monomorphism over much of the range of the single African subspecies and maintains polymorphism in east and central Africa. We propose that Danaus is a complex of five monomorphic subspecies which overlap sympatrically in northern and central eastern Africa. Using suitable mitochondrial (12s rRNA) and nuclear markers, i.e. the distal end of the 18s ribosomal gene, we have revealed that one of the supposed geographical races (dorippus) is probably a sister species. This finding is relevant to the dynamics of the species complex in northern and central parts of Africa. We have also studied the phylogenetics of the three sub-genera of Danaus together with most of the genera in the Danainae to determine more fully the status of the proposed sister species and to challenge the existing phylogeny of this family. Further findings support the hypothesis that a geographically extensive 'hybrid zone' is in operation over much of the African continent.

Index terms: Danainae, lepidoptera, sympatric, phylogenetics, hybrid zone

[2275] THE ORIGIN AND MOLECULAR EVOLUTION OF MOSQUITO NON-LTR RETROTRANSPOSONS BELONGING TO THE CR1 AND JOCKEY CLADES

C.A. Malcolm¹, J.L. Crainey¹ & C.F. Garvey^{1,2}, 1. Queen Mary & Westfield College, Univ. of London, Sch. of Biol. Sciences, Mile End Road, London E1 4NS, UK. 2. Current address: MRC-LMB Hill's Road, Cambridge CB2 2QH.

Phylogenies of non-LTR retrotransposable elements (retroposons), based on protein sequences inferred from the reverse transcriptase domain in ORF2, identify at least eleven distinct clades. This study focused on two sister clades: CR1 and Jockey. CR1 contains retroposons from blood fluke, nematode, turtle, chicken, puffer fish and also includes Q and T1 from Anopheles gambiae. Jockey, in contrast, contains only insect host species and includes the Juan elements from Culex pipiens and Aedes aegypti. To look for evidence of horizontal transfer and pre-requisite to an evaluation of retroposon contribution to mosquito evolution, a systematic survey was made by PCR, cloning and extensive database searches on mosquitoes from four genera, for retroposons belonging to the CR1 and Jockey clades. Previously, Anopheles stephensi was shown to contain multiple, highly divergent, families of retroposons falling into both clades, suggesting an ancient origin and a high probability that related retroposons are ubiquitous in mosquitoes. This has now been confirmed. Q/II and Juan related elements were found in multiple distinct families within all species analysed. Within the Jockey clade, a second lineage of mosquito retroposons more closely related to Chironomid NCR1Cth was discovered. A new retroposon closely related to Q/T1 was found in Drosophila melanogaster, thus ending the position of mosquitoes as the only insect hosts in the CR1 clade. It has been proposed that retroposons are not capable of horizontal transfer (Malik et al 1999, Mol Biol Evol 16:793-805). The make-up of the CR1 clade provided scope for the antithesis. Our discovery of two new families of retroposons in *Caenorhabiditus elegans* belonging to the CR1 clade and sharing the distinctive structured 3' untranslated regions of the Q/T/elements offered even more scope. However, overall, the current data for insects can easily be explained by vertical evolution; any horizontal transfer to insects within the CRI clade, has to date back prior to the divergence of the mosquito and Drosophila lineages. The origin of the Jockey clade predates the divergence of Lepidoptera and Diptera.

[2276] THE PRESENCE OF THE TRANSPOSABLE ELEMENTS R1 AND R2 IS ASSOCIATED TO MITOTIC CROSSING OVER IN SEVERAL APHID SPECIES

M. Mandrioli, N. Tarozzi, D. Bizzaro, G.C. Manicardi, <u>R. Crema</u>, A.M. Pagliai & U. Bianchi, Dipartimento di Biologia Animale, Università di Modena, Via Campi, 41100 Modena, Italy. E-mail: mandriol@unimo.it

The analysis of metaphase chromosomes obtained from parthenogenetic females of the aphid Megoura viciae, Acyrthosiphon pisum, Myzus persicae and Schizaphis graminum, after silver and chromomycin A3 (CMA3) staining as well as after fluorescent in situ hybridization (FISH) with a 28S rDNA probe evidenced the presence of inter- and intra-individual heteromorphism in NORs size which are localized in a telomeric region of the two X chromosomes. Since silver staining is a marker for ribosomal gene activity, the heteromorphism shown with AgNO3 could be considered as a consequence of different transcriptional activities between NORs and not as an indicator of variation in ribosomal gene numbers. The presence of such an heteromorphism even after CMA3 staining and FISH argues against this hypothesis and strongly indicate the existence of an heteromorphism in gene number. Moreover intra-individual differences in NORs size suggests that events of mitotic crossing over could be responsible for such an unequal distribution of the rDNA genes between the two X chromosomes. A comparison between slides obtained from aphids belonging to the four species analysed, evidenced that NOR heteromorphism was particularly strong in A. pisum and progressively lower in M. vicine, M. persicae and S. graminum. Molecular analysis of 28S rDNA carried out in order to go in depth in understanding the mechanism involved in the origin of NOR heteromorphism evidenced that all the aphid species analysed possess two different and independent retro-transposons called R1 and R2 in view of their specific and highly conserved localization into the rDNA array. Dot blot experiments, performed in order to quantify the number of R1 and R2 into the four aphid species, revealed that the number of R1 and R2 was particularly high in A. pisum and progressively lower in M. viciae, M. persicae and S. graminum. This data are in agreement with the observed frequency of NOR heteromorphism and suggest us that the number of R1 and R2 elements could be related to the frequency of NOR heteromorphism. In view of such data we suggest that R1 and R2 could be responsible for the mitotic crossing over implicated in the origin of such an heterotorphism. The implication of transposable elements in the origin of mitotic crossing over has been already described in other organisms but it is particularly important in aphids in view of their peculiar strategy of reproduction. Transposons could in fact represent a source of genetic recombination during parthenogenetic generations, when it is generally believed that no recombination occurs.

[2277] MITOCHONDRIAL DNA ANALYSIS IN SPECIES OF DREYFUSIA IN ITALY

B. Mantovani¹, V. Francardi², A. Binazzi ²& A. Leccese ², ¹Univ. of Bologna, Dept. of Exper. Evol. Biology, via Selmi n.3, 40126, Bologna, I, E-mail Barman@alma.unibo.it; 2 Exper. Inst. of Agric. Zoology, Forest Entomology Section, via di Lanciola 12A, Cascine del Riccio, 50125 Firenze, I, E-mail isza@fi.flashnet.it, ahinazzi@dada.it.

The genetic differentiation of five entities of the genus Dreyfusia Börner living on Abies in Italy has been evaluated through the molecular characterization of mitochondrial DNA genes. The aim of these molecular analyses was to better define the taxonomic position of these Dreyfusia taxa. Further, their real capability in colonizing firs was investigated: they are, in fact, able to reach high population levels, wherever host trees are stressed or decaying, so that they become pests to their host firs. The analysed species are the endemic D. piceae (Ratzeburg) with its "aggressive form", widespread in our country, and the exotic D. nordmannianae (Eckstein), D. merkeri Eichhorn, and D. prelli Grosmann whose recording areas are more reduced. Mt genes 16S (506 pb), cytocrome b (435 pb) and ND4 (426 pb) of each of the above mentioned species were amplified and sequenced. Main results are: an overall low degree of genetic differentiation among analyzed taxa, especially for 16S sequences; the absence of genetic divergence between the so far analysed specimens of *D. piceae*; an high affinity between *D. nordmannianae* and *D. merkeri* and a closer relationship between D. prelli and D. piceae. On the other hand the traditional morphometric analysis evidences divergent characters between D. piceae and D. piceae "aggressive form", as well as among the other species, even if it recognizes the same affinities between D. nordmannianae and D. merkeri, one side, and between D. prelli and D. piceae, the other. Mt DNA analysis is the first attempt to the molecular characterization of Dreyfusia species; other genetic analyses, such as RAPD, are going to be carried out to get more information about the degree of differentiation among the analysed entities of Dreyfusia.

Index terms: adelgidae, taxonomic positions.

[2278] USING PRIMERS DESIGNED FOR AMPLIFICATION OF FLIES'S MITOCHONDRIAL DNA TO AMPLIFY MITOCHONDRIAL DNA FROM TERMITES, WITH PHYLOGENETIC PURPOSE

V.G. Martins^{1,2} & M. Bacci Jr.², ¹Departamento de Fonoaudiologia, Univ. Estadual Paulista-UNESP, Ave. Hygino Muzzi Filho, 737, Marília, São Paulo, 17.525-900, Brazil, E-mail martv@uol.com.br; ²Centro de Estudos de Insetos Sociais, UNESP, Rio Claro, São Paulo, Ave. 24-A, 1515, 13.500-900, Brazil.

The C1-J-2792 (George) and TK-N-3772 (Eva) primers (Bogdanowicz et. al., 1993) designed early to amplify a mitochondrial DNA fragment from flies of approximately 1kb were used to amplify the same segment for Termites species from the Neotropical region. Those primers amplifies part of the Citocrome oxidase I (COI), the whole transfer RNA for Leucina (tRNALeu) and Citocrome oxidase I (COII) genes. So, amplifications by PCR were performed for eight species from three of the four Neotropical Isoptera families occurring in Brazil. Three of the studied species belong to Kalotermitidae, one to Rhinotermitidae and four to the Termitidae. Electrophoresis on agarosis gel of PCR products proved that the desired 1kb pairs of DNA fragment was amplified. Those DNA fragments were sequenced in a Perkin Elmer 377 Sequencer for three of the species. Early analyses performed for these sequences showed that some characters used for molecular phylogenetic studies were present in our DNA fragments and allowed us to infer that both primers will be useful for phylogenetic studies that are our main goal. These results are in accordance to previous studies for two species of the Termitidae (Cornitermes bequaerti and C. cumulans) which had the same segment amplified and sequenced, including pseudogenes for three populations of C. bequaerti, according to Martins et al. (Mol. Biol. and Evol. submitted).

Index terms: Citocrome oxidase, Isoptera, Phylogeny.

[2279] ODYSSEUS, A NOVEL TRANSPOSON INVOLVED IN THE GENERATION OF CHROMOSOMAL INVERSIONS IN THE MALARIA MOSQUITO ANOPHELES ARABIENSIS

K.D. Mathiopoulos¹, F Santolamazza², A della Torre², V Petrarca^{2,3} & M Coluzzi², ¹Dept of Biology, Univ of Patras, Greece, e-mail: kmath@upatras.gr; ²Inst of Parasitology, Pasteur-Cenci Bolognetti Foundation; ³Dept of Genetics & Molecular Biology. Univ "La Sapienza", Rome, Italy.

The Anopheles gambiae complex is comprised of six sibling species, each one characterized by the presence of fixed paracentric inversions on their chromosomes. Two of these, An. gambiae s.s. and An. arabiensis, are the most important vectors of human malaria and are subdivided into discrete subpopulations, each carrying a unique set of polymorphic chromosomal inversions. Some of these inversion polymorphisms are associated with differences in seasonality of breeding, adaptation to natural vs. human-disturbed habitats, microhabitat selection, and host preference. The origin of inversions in nature is uncertain. There is indirect cytological evidence that hobo may be implicated in the generation of certain endemic inversions of natural D. melanogaster populations. However, direct molecular support for this event in natural populations has been elusive. We have cloned the breakpoints of the naturally occurring polymorphic inversion 2Rd' of the malaria vector Anopheles arabiensis. A cDNA clone that cytologically mapped on the proximal breakpoint was the starting material for the isolation of a cosmid clone that spanned the breakpoint. Analysis of the surrounding sequences demonstrated that adjacent to the distal breakpoint lies a transposable element that we called *Odysseus*. This element is distributed on all five chromosomal arms of the An. gambiae complex. Analysis of its cytological distribution in different An. gambiae strains indicates a relative recent activity of Odysseus. It seems specific to An. gambiae since an Odysseus probe does activity of Odysseus. It seems specific to An. gamonae since an Odysseus probe does not hybridize with DNA from the North American An. freeborni, the East Asian An. stephensi, or with Acdes aegypti mosquitoes. We have analyzed several additional copies of Odysseus from different insertion sites in the chromosomes in order to define the full-length transposable element as well as to obtain data on its variability. Analysis of the insertion site also sheds light on the mechanism of transposition and the mechanism by which Odysseus may have generated the 2Rd' inversion. It is theorized that Odysseus creates inversions by ectopic recombination between two copies of the transposon that are in opposite orientation.

[2280] IDENTIFICATION OF TEPHRITID FRUIT FLIES USING rRNA GENES

L. Mckenzie, <u>F. Driver</u>, L. Dransfield & J. Curran, CSIRO, Entomology, P. O. Box 1700, Canberra, ACT 2601, Australia, E-mail feliced@ento.csiro.au.

Surveillance and early detection of exotic pest incursions is vital to protecting Australian agriculture and Australia's unique environment. To assist in the identification of exotic and endemic fruit flies, we have designed a kit to provide a rapid molecular diagnostic system for larval and adult fruit flies that is suitable for non-specialist laboratories. Based on our initial analyses, restriction fragment length polymorphisms (RFLP) within the internal transcribed spacer (ITS) regions of the ribosomal RNA genes were used as the molecular markers. To date we have screened 79 species of fruit fly belonging to four genera; Bactrocera, Dacus, Certatitis, and Anastrepha. In addition we have developed sets of species-group specific PCR-primers to rapidly target unidentified specimens to a major taxonomic cluster. These techniques have been successfully applied to distinguish the majority of species of interest to Australia, however not all species clusters can be resolved by RFLP analysis of the ITS region. In some cases highly specific PCR-primers may be useful. An analysis of sequence data from rRNA gene regions reflects the complexity of some endemic and exotic species groups in Australia and raises issues about phylogenetic relationships.

Index terms: Tephritid fruit flies, Bactrocera, Dacus, Ceratitis, Anastrepha, rDNA

[2281] THE MEDITERRANEAN FRUIT FLY IN THE US: POPULATION STRUCTURE INFERRED FROM MITOCHONDRIAL DNA AND MICROSATELLITE ANALYSES

M. D. Meixner^{1,3}, J. G. Silva², B. A. McPheron² & W. S. Sheppard¹, 1) Dept. of Entomology, Washington State Univ., Pullman, WA 99164, USA, 2) Dept. of Entomology, Pennsylvania State Univ., College Park, PA16802, USA, 3) Inst. fuer Zoologie, Martin-Luther-Univ. Halle-Wittenberg, 06120 Halle, Germany

The Mediterranean fruit fly, Ceratitis capitata, is one of the most widespread and economically important agricultural pests worldwide. From a presumably sub-Saharan origin, it colonized the Mediterranean region, South and Central America, Australia and Hawaii within the past 150 years, reaching the continental US for the first time in 1929 and again in subsequent years. Because of their high economic impact, introductions of Mediterranean fruit fly result in costly measures for monitoring and eradication and also impose restrictions on export of fruits produced in infested regions. We report here the genetic structure of medfly populations from areas with established populations and recent introductions using mitochondrial DNA and microsatellites as genetic markers.

MtDNA of C. capitata samples was analyzed using PCR-RFLP for determining haplotype profiles with the enzymes XbaI, EcoRV and MnII. To improve the resolution of questions surrounding the introduction and eradication of medfly populations in the US, we also analyzed variation at two microsatellite loci, MF 106 and MF 113. Over 400 flies caught on monitoring traps from 1992 to 1998 in both California and Florida were analyzed. Composite genotypes obtained with analysis of mtDNA and microsatellites indicate several independent introductions of medflies into California between 1992 and 1998. While the majority of specimens displayed a single mtDNA haplotype (AAA), variation of microsatellite alleles among these flies suggests at least one additional introduction in 1993 into southern California. In contrast to earlier infestations, a few specimens caught in southern California in 1993 and again in 1998 showed both mtDNA and microsatellite patterns consistent with a Hawaiian origin. Flies displaying the AAB haplotype sampled in 1992 both in northern and southern California shared alleles absent in AAA flies while lacking others commonly found in AAA specimens, thus supporting the hypothesis of an independent introduction of these flies from a different source. In recent outbreaks in Florida, two different mtDNA haplotypes (AAB and AAC) were found in 1997, while AAB only was detected in 1998. Microsatellite analysis of the AAB specimens does not contradict the hypothesis that they persisted through the winter and later spread by human-mediated dispersal.

Index terms: Ceratitis capitata, mtDNA, PCR-RFLP, microsatellites.

[2282] A PARTHENOGENETIC NEW SPECIES OF THE GRYLLACRIDID GENUS APOTETAMENUS

A. Mesa & M. M. Levada, Dept. de Biologia, Instituto de Biociências, Univ. Estadual Paulista (UNESP), Av. 24A 1515, 13506900, Rio Claro, SP, BRAZIL. Email: alejomesa@linkway.com.br

Orthopteran insects are normally bisexual. Facultative parthenogenesis sometime occurs in cave crickets but reproduction by true parthenogenesis is definitely rare. In the case here reported the species was reproduced in the lab for several generations without the presence of males and the opposite sex was never collected in nature. The number of chromosomes in the species is 2n=11 (an unusual odd number for females) and the chromosomes are different from each other in such a way that no pairs can be formed. Two theories are advanced to explain that karyotype: 1) That the species is an haploid. 2) That the species is an hybrid between an 11 (male) – 12 (female) species and another 9 (male) – 10 (female), resulting from the union of a 5+X and a 4+X gamete. The putative parental species have not been yet collected. Index terms: Gryllacridoidea, Henicidae, parthenogenesis, chromosomes.

[2283] A X-AUTOSOME TANDEM FUSION IN AN UNDESCRIBED SPECIES OF THE FAMILY PODOSCIRTIDAE

A. Mesa & P. C. García, Dept. de Biologia, Instituto de Biociências, Univ. Estadual Paulista (UNESP), Av. 24A 1515, 13506900, Rio Claro, SP, BRAZIL. E-mail: alejomesa@linkway.com.br

In ortopteran insects, changes from XO to neo XY sex chromosome mechanisms take place in the majority of cases by means of X-autosome centric fusions. A single case of incorporation of an autosome to the X by means of tandem translocation has been reported in the literature for an eumastacid. The consequence of that incorporation results in the change of a reductional meiotic first division of the sex chromosomes to an equational one and viceversa for the second division. Illustrations of male and female of the undescribed species drawing of the male concealed genitalia sclerites and photograph of the meiotic process are provided. Index terms: Sex chromosomes, tandem fusion, cricket,

[2284] DOES AN X-AUTOSOME CENTRIC FUSION IN ACRIDOIDEA CONDEMN THE SPECIES TO EXTINTION?

A. Mesa, C. Fontanetti & P. C. García, Dept. de Biologia, Instituto de Biociências, Univ. Estadual Paulista (UNESP), Av. 24A 1515, 13506900, Rio Claro, SP, BRAZIL. E-mail: alejomesa@linkway.com.br

Neotropical actidids show an unusual high percentage of species with neo XY chromosomes sex determining mechanisms. Approximately 10% of nearly 500 species studied have this kind of X-autosome fusion. Once this mechanism is established it start a slow and gradative process that change the structure and behavior of the neo XY pair during first prophase male meiosis. During this period the ex-autosome pair gradually reduce the extension of pairing and the crossing-over to the tip chromosome end while Y becomes more and more condensed. At the beginning of the process, the ex homologous fused with X (neo XR arm) and Y remain euchromatic but towards its end, both X and Y appears wholly heterochromatic. Among fifty neo XY species analyzed, five are in the beginning of the process, with XR and Y pairing and showing crossing over along their entire length. Another five species are at the end of the process with neo X and Y including XR entirely heterochromatic, while the remaining 40 species show several intermediate stages. Species at the end of the process show a peculiar chromosome structure during first prophase, with bivalents pressing unusually large loops. The following assumptions follow: 1) The whole process needs to be relatively short in time since in many cases, species with old neo XY mechanisms coexist with XO species within the same genus. 2) If the process ends with the whole heterochromatinization of the neo XY pair, an accumulation of species with old mechanisms should be observed while this is not the case. 3) If species with old neo XY mechanisms survive during a long period of time and speciate, whole taxa as genera, tribus and subfamilies should be present in acridids with all their species showing old neo XY mechanisms. Since the second and third inferences are not observed, the only reasonably conclusion is that the species with old neo XY mechanism do not survive and are extinct. The meiotic structure changes observed in the bivalents during male first prophase could be a symptom of meiotic disorders that will finally conduce the species to a deficit in the generation of male gametes starting the consequent species decay. The early condensation of XR arm in male first meiotic prophase compromising the genetic control of a normal meiotic process could be the origin of troubles that conduces the species to extinction. Index terms: grasshopper, sex chromosomes, neoX-Y mechanism

[2285] NON MENDELIAN BEHAVIOR IN MALE MEIOSIS ASYNAPTICAL MULTIPLE SEX CHROMOSOMES IN CRICKETS

A. Mesa & P. C. García, Dept. de Biologia, Instituto de Biociências, Univ. Estadual Paulista (UNESP), Av. 24A 1515, 13506900, Rio Claro, SP, BRAZIL. E-mail: alejomesa@linkway.com.br

The majority of ortopteran species have XO males and XX female's sex determining mechanisms. Some species have however changed this simple and primitive condition to another more complex by mean of one or several centric or tandem fusions with autosomes. The male first prophase pairing of X's and Y's and the correct arrangement of them at first metaphase, assures that they go to opposites poles during first anaphase. The absence of such pairing should however liberate the sex chromosomes to behave freely in a Mendelian way joining each of them randomly to the poles. A single case was mentioned in the literature where the absence of pairing is the rule, in the cricket *Eneoptera surinamensis*. The unpaired sex chromosomes behave however in a non-mendelian way going always X1 and X2 to a pole and Y to the opposite pole. Four new cases with complex sex mechanisms in cricket species are reported in the present paper. They are as follows: 1) A similar case to E. surinamensis occurs in a still unidentified species of Mogoplistidae. 2) Another Mogoplistidae species have two X's and not Y and the unpaired X's go independently to the same pole during first anaphase. 3) In an undescribed species belonging to the family Podoscirtidae the mechanism is X_1X_2Y in males with Y and X_1 pairing normally and the unpaired X_2 going always to the same pole than X. 4) The most unusual case occurs in another undescribed species of Podoscirtidae, with four Xs and one Y. the Y chromosome pairs with X1, but X2, X3 and X4 remain unpaired during the whole male prophase but then go to the same pole than X1 during first anaphase. Studies aiming to solve the reasons of such unusual not Mendelian chromosome behavior are cogitated.

Index terms: Grylloidea, cytogenetic, multiple sex mechanism.

[2286]MARKER-ASSISTED SELECTION AS A STRATEGY FOR SELECTING INSECT RESISTANT BREEDING LINES WITH IMPROVED EFFICIENCY

<u>S. Mohankumar</u>^{1,2}, P.Shanmugasundaram² & M. A. Saghai Maroof¹, ¹ CSES Dept., Virginia Tech, Blacksburg, VA24061,USA, ²Center for Plant Molecular Biology, TamilNadu Agricultural Univ., Coimbatore-641003,INDIA. Enail:smk65@hotmail.com

Host plant resistance is the most desirable means of pest management resulting in positive environmental and economic benefits in crop production. Breeding of high yielding insect resistant varieties is one of the top priority areas of research in national and international crop breeding programs. Selection of plants based on DNA markers holds promise for accelerating the rate of development of crop plants resistant or tolerant to insects. DNA marker- based technology is being increasingly used to overcome some difficulties of plant breeding based on phenotypic characters (field and greenhouse screening). The greater number of DNA markers, independent of plant physiology and coincidence of crop and insect seasons made the breeders to merge pedigree analysis with DNA markers. Molecular breeding approaches facilitate the early and efficient selection for resistance genes even in areas where the insect is not known to occur. It is most appropriate for intersubspecific and interspecific transfer of insect resistance that have been difficult to improve using conventional methods. It also paves the way for selecting the target gene based on DNA marker with a predictable rate of accuracy. Marker-assisted selection will also be useful for pyramiding resistance genes into a single line from all resistance sources. Molecular marker-assisted selection techniques have been discussed widely in the current breeding approaches but there are few practical examples of utilization. When compared to genes for resistance to diseases, there are relatively few reports describing the mapping of insect resistance loci in crop plants. Molecular markers have been used to identify insect resistance loci in rice, barley, wheat, maize, cowpea, mungbean, soybean, potato, tomato and apple. In this presentation, the basic requirements to develop molecular markers and their potential application for selecting insect resistant crop varieties will be addressed. Data from phenotypic and genotypic evaluations of rice mapping populations screened for reaction to brown planthopper, white-backed planthopper, stemborer and leaffolder will be presented. Index terms: DNA markers, mapping populations, rice pests

[2287] MOLECULAR CHARACTERIZATION OF RICE BROWN PLANTHOPPER POPULATION

S. Mohankumar^{1,2}, N.SenthilKumar¹, J. Souframanien¹, P. Nagarajan¹, P. Shanmugasundaram¹, S. Sadasivam¹ & M. B. Cohen³, ^{1,2} CSES DEPT., VIRGINIA TECH, BLACKSBURG, VA24061, USA, ²Center for Plant Molecular Biology, TamilNadu Agricultural Univ., Coimbatore- 641 003, India, ³International Rice Research Institute, Philippines.

Brown plant hopper, Nilaparvata lugens (Stal.) is a persistent pest in rice fields throughout tropical Asia. Since 1970, IRRI has been maintaining green house colonies of three brown plant hopper biotypes, which differ in ability to survive on and injure various rice cultivars containing single genes for resistance. These biotypes are still used today for screening germplasm for resistance to the brown plant hopper. Indian brown planthopper population differed from the above biotypes and designated as biotype 4. The present study aims to characterize Indian BPH population in comparison with other biotypes through molecular markers. Genetic fingerprints of four biotypes were developed using random amplified polymorphic DNA-polymerase chain reaction (RAPD-PCR). Variation within biotype 4 was also analysed using seven populations collected from diverse agro-climatic zones. About one hundred random primers (OPERON) were screened and polymorphic primers were recorded. Each gel was scored for the presence (1) and absence (0) of a specific band, was worked out. A data matrix was generated to calculate genetic similarity index, analysed using NTSYS program and a dendrogram was constructed by using UPGMA. Two clusters were observed and first cluster consists of the biotype 1,2,3 and the second cluster with biotype 4 alone. The biotype 2 and 3 are closely related within the first cluster. Among the seven populations of biotype 4, the population collected from Raipur, Madhyapradesh is distinctly separated from others. Index terms: Rice, Nilaparvata lugens, biotypes, RAPD-PCR

[2288] ISOLATION, CLONING, AND CHARACTERIZATION OF G PROTEIN-COUPLED RECEPTOR GENES, FROM THE AFRICAN MIGRATORY LOCUST, *LOCUSTA MIGRATORIA*

<u>G. Molaei¹</u>, W.G. Bendena² & A. B. Lange¹, ¹Dept. of Zoology, Univ. of Toronto at Mississauga, 3359 Mississauga Rd., Mississauga, ON., L5L 1C6, Canada. ²Dept. of Biology, Queen's Univ., Kingston, ON., K7L 3N6, Canada.

G protein-coupled receptors (GPCRs) are involved in the transduction of specific extracellular signals across the lipid bilayer of the cell and the linkage of those signals to an intracellular second messenger pathway. This family of receptors responds to a wide range of chemical messengers, including biogenic amines, amino acids and peptides. An extensive amount of research has been carried out on the stimulatory and inhibitory effects of different peptides on visceral muscle contraction of the oviducts of the African migratory locust, *Locusta migratoria*. Molecular cloning studies are very valuable in characterizing the receptors for these peptides and in elucidating the related signaling pathways. In the search for GPCR genes, mRNA was isolated from the midgut and oviduct tissues and was converted to complimentary DNA using oligo (dT). Two primers corresponding to DNA sequences within the conserved regions of transmembrane domains of GPCRs were employed to amplify midgut and oviduct specific GPCR cDNAs by the Polymerase Chain Reaction (PCR). Cloning of the PCR products and further sequencing revealed that at least seven partial cDNAs demonstrate strong sequence homology with known GPCRs. To obtain the complete sequence of our positive PCR generated cDNA, a lambdaphage L. migratoria cDNA library was screened by PCR. This was accomplished by designing specific sense and antisense primers to the partial cDNA sequences and the lambda phage arms. The PCR generated fragments were subcloned into a pCR 2.1(Invitrogen) cloning vector. Experimentation is underway to complete the sequence and characterize these clones. The full-length cDNA clones will be employed to conduct expression studies using a suitable expression system and to perform *in situ* hybridization to localize the expression of the receptors, thereby identifying target tissues. Binding assays, and pharmacological studies will be performed to confirm the second messenger systems utilized by the various receptor types.

Index terms: signal transduction, complementary DNA, PCR, cloning vector

[2289] SEX-BIASED PARASITISM IN INSECTS

<u>S.L. Moore¹</u>, R.S. Hails² & K. Wilson¹, 1 Institute of Biological Sciences, University of Stirling, Stirling FK9 4LA, UK, e-mail: s.l.moore@stir.ac.uk: 2 Institute of Virology and Environmental Microbiology, Mansfield Road, Oxford OX1 3SR, UK;

Male-biased parasitism has been observed in a number of vertebrate taxa, including mammals and birds. One hypothesis to explain the greater susceptibility of males to parasites is the innuncocompetence haudicap (ICH) hypothesis, which proposes that the male immune system is suppressed by the sex-steroid, testosterone. In order to determine if this hypothesis could be a universal explanation for male-biased parasitism, I reviewed the evidence for a similar bias in the invertebrates, which do not produce sex hormones. Currently there are very few data on sex-differences in parasitism rates in invertebrates. However, significant sex-biases in parasitism have been reported and I will use meta-analysis methods to determine if there is a consistent trend across all of the studies.

Index terms: sex-biased parasitism, immunocompetence handicap (ICH) hypothesis, meta-analysis

[2291] DIAPAUSE HORMONE AND PHEROMONE BIOSYNTHESIS ACTIVATING NEUROPEPTIDE (DH-PBAN) GENE EXPRESSION IN THE EMBRYO OF THE SILK WORM, BOMBYX MORI

A. Morita, F. Niimi & O. Yamashita, Grad. Sch. Bioagric. Sci., Nagoya Univ., Chikusa, Nagoya, 464-8601 Japan. E-mail: amorita@agr.nagoya-u.ac.jp

The scenario leading to embryonic diapause of the silkworm, Bombyx mori, starts at the embryonic stage of maternal generation, when the environment serves as the initial signal to develop neuroendocrine system for diapause hormone synthesis. In this study, we focused on the maternal embryos to examine when the neuroendocrine system is established functionally to recognize the environmental stimuli for regulation. From the results of the quantitative RT-PCR, the diapause hormonepheromone biosynthesis activating neuropeptide (DH-PBAN) gene expression is shown to start in the late embryonic stage regardless environmental conditions. By using anti-FXPRLamide antibody, immunoreactive somata were observed in the subesophageal ganglion of both embryos at 15 and 25°C. Furthermore, when the caudal part of the embryo incubated at 15 or 25°C was implanted into pupae, all recipients laid nondiapause eggs. Thus, that the DH-PBAN gene expresses and its products are translated and secreted in the late embryonic stage. Therefore, we concluded that in the late embryonic stage, the neuroendocrine system for diapause hormone-synthesis and -secretion is completed, but this system functions independently of environmental conditions.

Index term: Bombyx mori, diapause hormone, embryo of the maternal generation

[2290] STUDY OF HYBRID ZONE AMONG DROSOPHILA SERIDO AND DROSOPHILA SP D, SPECIES OF THE CLUSTER BUZZATH

A.C.Morales¹; M.H.Manfrin¹ & F.M.Sene², ¹Deptorde Biologia, FFCLRP, Univ. de São Paulo. Av. dos Bandeirantes, 3900. CEP 14040-901, Ribeirão Preto, SP, Brazil. Email: morales@rgm.fmrp.usp.br.² Depto. de Genética da FMRP, Univ. de São Paulo. Av. dos Bandeirantes 3900. CEP 14049-901, Ribeirão Preto, SP, Brazil. Financial Support: FAPESP, CNPq, FINEP, CAPES and USP.

The buzzatii "cluster", endemic of South America, is composed by seven cactus breeding species: Drosophila buzzaiii, D. borborema, D. koepferae, D. seriema, D. serido, Drosophila. sp B e Drosophila sp D, distributed in different vegetation formations of South America. Drosophila/cacti associations make that differentiation processes inside of this group are related with the successive expansions and retractions of the South American xerophytic vegetation due to paleoclimatic fluctuations, that provoked an asynchronism of historical connections among the populations. A hybrid zone among Drosophila sp D and D. serido was described in the coast of the Santa Catarina and Rio Grande do Sul, Brazil. The objective this work was characterize through isoenzymes the populations of Florianopolis, SC (D. serido), Santiago, RS (Drosophila sp D) and the contact area populations of Arroio Teixeira, RS; Cornélio, RS; Osório, RS and Tramandaí, RS. The technique used was starch gel (14%), horizontal electrophoresis. Thirteen loci were used for the characterization of the genetic structure of these populations: alcohol dehydrogenase (ADH-1 and ADH-2), esterase (EST-1 and EST-2), 1-glicerophosphate dehydrogenase (a-GPDH), hexokinase (Hk-2 and Hk-3), isocitrate dehydrogenase (IDH), leucine aminopeptidase (LAP), malate dehydrogenase (MDH), malic enzyme (ME), peptidase (PEP), phosphoglucomutase (PGM). The distance estimative and the construction of phylogenetics trees were accomplished through the method of Neighbor-Joining using the DISPAN software. The phylogenetic relationships obtained show two main branches: one composed by the Santa Catarina (D. serido), the Arroio Teixeira and Osório populations (hybrid zone), and another branch composed by the Santiago (D. sp D), Cornélio and Tramandal populations (hybrid composed by the balance (D, sp D), content and Hamman populations (D, sp D) was located. The data obtained at the moment, do not support the hypothesis of the structure of the hybrid zone described for the area, however should be considered that enzymes in many cases are under selection, which might do not diagnose historical events of populations. Some populations are in Hardy-Weinberg equilibrium, others are not.

Index terms: allozyme, genetic structure, contact area.

[2292] GENETICS ACROSS THE SPECIES BOUNDARY: HOST PLANT PREFERENCE AND COLOUR PATTERN IN HELICONIUS CYDNO AND H. MELPOMENE

<u>R.E. Naisbit</u> & J.I.B. Mallet, Galton Laboratory, Department of Biology, University College London, 4 Stephenson Way, London NW1 2HE, UK. E-mail r.naisbit@ucl.ac.uk

Sympatric species that are able to hybridise offer an opportunity to study the genetic basis of traits which currently maintain species distinctness, and which may have contributed to speciation. The butterflies *Heliconius cydno* and *H. melpomene* are sympatric across much of Central and Andean South America and retain the ability to hybridise, although hybrids are thought to form less tan 0.1% of wild populations. They occupy different Müllerian minicry rings and have diverged in host plant and habitat use, all of which will act to reduce gene flow between the two. In Panama, *H. melpomene* specializes on *Passiflora menispermifolia* in secondary growth, while *H. cydno* oviposits on most of the available *Passiflora* species in the understory. These preferences are retained in the insectary and are autosomally inherited, with dominance of the preference of *H. melpomene*. Oviposition differences will act as a barrier to gene flow between the two species, since caterpillars pupate close to the host plant and males patrol the plants and mate with newly emerged females. Colour pattern differences are controlled by several loci of major effect, together with many modifier loci. This divergence will contribute to assortative mating since initial attraction is on the basis of colour, and also lead to selection against the nonmimetic colour pattern of hybrids by preductry birds.

Index terms: speciation, Müllerian mimicry, assortative mating.

[2293] MULTIPLE PARTIAL BARRIERS TO GENE FLOW BETWEEN HELICONIUS CYDNO AND H. MELPOMENE

R.E. Naisbit, C.D. Jiggins & J.L.B. Mallet, Galton Laboratory, Department of Biology, University College London, 4 Stephenson Way, London NW1 2HE, UK. Email r.naisbit@ucl.ac.uk

A growing number of studies have shown that closely related sympatric species are separated by multiple, incomplete barriers to gene flow. These are often a direct result of ecological divergence, generating assortative mating in conjunction with some form of selection against hybrids. This will have consequences for the way we view the species boundary, and how we study speciation. The butterflies *Heliconius* cydno and *H. melpomene* retain the ability to hybridise, but in their sympatric range across much of Central and Andean South America hybrids are thought to form less than 0.1% of wild populations. Speciation has accompanied shifts in both Müllerian mimicry ring and habitat use. Barriers to gene flow between the two currently take the form of assortative mating, differentiation in habitat use, sterility of female hybrids, and selection by predators acting against the novel colouration of hybrids. We present data from mate choice experiments which show very strong assortative mating between the two species, and weaker discrimination against F1 hybrids. Oviposition sites and adult capture data show habitat segregation along a transect from open habitat to closed forest, reducing but not eliminating the possibility of encounter and hybridisation. Data will also be presented on sterility of female hybrids (following Haldane's Rule), with complete sterility in the FI generation and segregation of the trait in backcross broods.

Index terms: speciation, assortative mating, Haldane's Rule, habitat segregation.

[2294] A MOLECULAR VIEW OF TRYPSIN SYNTHESIS IN AEDES AEGYPTI

F.G. Noriega^{1,2}, K.Edgar^{1,2} & M.A. Wells^{1,2}, ¹Dept. of Biochemistry, Univ. of Arizona, BSW 440, Tucson, AZ 857, USA, E-mail fnoriega@u.arizona.edu; ² Center for Insect Science, Univ. of AZ.

Ingestion of a blood meal induces two phases of trypsin synthesis in the mideut of Aedes aegypti females. The first phase, which encompasses the first 4-6 hours following a blood meal, is characterized by the presence of small amounts of early trypsin. The second phase, which occurs between 8 and 36 hours after blood feeding, is characterized by the presence of large amounts of late trypsin. A specific form of regulation of trypsin synthesis characterizes each phase: early trypsin synthesis is regulated at the translational level, while late trypsin synthesis is regulated at the transcriptional level. The enzymatic activity of early trypsin plays a unique and critical role in the regulation of late trypsin synthesis. Early trypsin acts like a "sensor". It carries out limited proteolysis of the ingested proteins and, somehow, the products of this limited proteolysis induce synthesis of late trypsin, which is the protease responsible for the majority of the endoproteolytic cleavage of the meal proteins. Transcription of the early trypsin gene starts a few hours after adult emergence and is under control of juvenile hormone. However, the early trypsin mRNA is stored in the midgut epithelium and remains untranslated until a blood meal is taken. The exact mechanism responsible for initiating translation is presently unknown, but an increase in the size of the amino acid pool in the midgut is sufficient to activate translation of early trypsin mRNA. The transcription of the late trypsin gene is regulated by uncharacterized proteolysis products generated by the action of early trypsin on the blood meal proteins. Once transcription has been activated, the rate of transcription of the late trypsin gene is proportional to the amount of protein present in the meal. In addition, the amount of late trypsin protein translation is controlled by the amount of amino acid released during digestion. Regulation at both transcriptional and translational levels allows the midgut to adjust the amount of late trypsin with remarkable flexibility in response to a particular meal.

[2295] A HOMOLOGUE OF THE DROSOPHILA MELANOGASTER SEX-DETERMINING GENE DOUBLESEX IS TRANSCRIBED INTO SEX-SPECIFIC ISOFORMES IN THE SILK WORM, BOMBYX MORI

F. Ohbayashi¹, M. G. Suzuki¹, K. Mita², K. Okano³, T. Sugasaki^{1,4} & T. Shimada¹, ¹Dept. of Agric. Environ. Biol., Univ. of Tokyo, Yayoi, Bunkyo-ku, Tokyo 113-8657, Japan. E-mail aa77005@mail.ecc.u-tokyo.ac.jp; ²Natl. Inst. of Radiol. Sci., Anagawa 4-9-1, Inage-ku, Chiba City, Japan; ³Lab of Mol. Entomol. and Baculovirol., RIKEN, Hirosawa 2-1 Wako, Saitama, Japan; ⁴Kitamoto High School, Kitamoto, Saitama, Japan

The doublesex (dsx) gene is known as the final gene of the sex-determining cascade in Drosophila melanoguster. We have isolated a homologue of dsx from a pheromone gland and testis CDNA library of silkworm, Bombyx mori, which has an epistatic feminizing gene located on the W chromosome, by using the expressed sequence tags (EST) database. RT-PCR analysis indicated that the size of the amplified products of Bombyx mori dsx (Bmdsx) showed sexual differences in all the examined tissues. Northern blot hybridization revealed that transcriptional level of Bmdsx is higher in ganads and pheromone gland and the Bmdsx probe detected a band with a sexspecific size difference. The female-specific Bmdsx mRNA isoform was approximately 10.6kb in length and the male-specific one was approximately 10.4kb. The male-specific cDNA was skipped over the sequence between 713 and 961nt of the female-specific cDNA. As the result of RNase protection assay it was confirmed that this sequence was male-specifically removed from the *Bmdsx* pre-mRNA. A Southern blot analysis and bacterial artificial chromosome (BAC) library hybridization showed that the Bmdsx is present at single copy in the genome. Linkage analysis by using hybrid resulting from the backcross between Bombyx mori and Bombyx mandarina revealed that the Bmdsx is located on the 25th chromosome of Bombyx mori. These results strongly suggested that the Bmdsx gene is alternatively spliced to yield male- and female-specific mRNA isoforms. These sex-specific isoforms encoded polypeptides with a common amino terminal sequence but sexspecific carboxyl termini. The largest ORF of female cDNA is 795nt and encode 265 amino acids. On the other hand, the largest ORF of male cDNA is 801nt and encode 267 amino acids. The level of identity of the sex-specific DSX proteins of Bombyx mori with Drosophila melanogaster DSX proteins, across the region corresponding to the DNA binding domain (DM domain), is 80%. These results suggest the possibility that the dsx homologue in Bombyx mori would also regulate sexual differentiation like the Drosophila ds. gene.

Index terms: Bombyx mori, doublesex, sex determination, alternative splicing

[2296] MORPHOLOGICAL AND MOLECULAR IDENTIFICATION OF WHITEFLIES SPECIES IN BRAZIL

M.R.V. Oliveira', L. Campos', K.R. Vilarinho', W.N.M. Lago' & L.H.C. Lima¹, Embrapa Recursos Genéticos e Biotecnologia, P. O. Box 02372, Brasília, DF 70.849-970, Brazil. E-mail: vilarin@cenargen.embrapa.br.

Whiteflies have been described in Brazil for more than 100 years but never caused severe problems in agricultural ecosystems, excepted for *Bemisia tabaci* as a vector of phytovirus, in beans and soybeans crops. This situation changed 1992 onwards when *B. tabaci* outbreaks as a pest was described in São Paulo State. During the past three years we have received 223 samples of whiteflies from investigators all over Brazil and from Paraguay. These represents collections made in 47 different host plants, among them, melon, cotton, squash, watermelon, tomato, soybean and weeds. Morphological characters of the pupal case were examined by sterescopic microscopy. For *B. tabaci* biotypes, DNA was extracted from individuals and subjected to RAPD-PCR (randomly amplified polymorphic DNA polymerase chain reaction) analysis. RAPD-PCR, using fresh or alcohol preserved material, enables the B biotype to be distinguished from a tange of other biotypes a well as other species. The most common whiteflies found among the samples analyzed were: papaya and coffee (*Tetraleurodes sp.*), cashew (*Aleurodicus cociss*), green cabbage (*Trialeurodes abutiloneus*), citrus (*Aleurothrixus floccosus*) and *Brosinum gaudichadii* (*Aleurodicus dugesii*). *B. tabaci* biotype BR was found in 15,92% samples and biotype B, in 70,40%. The results also showed that for the first time, biotype B of *B. tabaci* is found feeding on cassava crops in Brazil. Index terms: Whitefly, *Bernisia tabaci*, genetic diversity, RAPD.

[2297] GENETIC VARIABILITY OF CACOPHONY GENE IN LUTZOMYIA LONGIPALPIS POPULATIONS

<u>S. G. Oliveira</u>¹, N. A. Souza², C. P. Kyriacou³ & A. A. Peixoto¹, ¹Department of Biochemistry and Molecular Biology, Inst. Oswaldo Cruz, Aven. Brasil 4365,21045-900, Brazil, E-mail: sigomes@gene.dbbm.fiocruz.br; ² Department of Entomology, Inst. Oswaldo Cruz; ³Department of Genetics, Univ. of Leicester

Lutzomyia longipalpis is a phlebotomine that is considered as the major vector of visceral leishmaniasis in New World. Several studies confirm its widely distribution in Brazil and suggest that L. longipalpis could be a complex of cryptic species. In this work we utilized a DNA fragment of L. longipalpis correspondent to cacophony (cac) gene of Drosophila melanogaster to analyse the genetic variability in this complex of species, cac (Dmca1A) gene is a mutantion that encodes the al subunit of a voltage sensitive calcium channel in Drosophila melanogaster. This gene promoves variations in courtship song produced by vibrations of wings of males. The ritm of this love song depends of length of IPI (inter pulses intervals) and the number of the cycles. The love song produced by cac mutants have increased IPI and the number of cycles in each pulse. In some species of Drosophila these variations reflects disturbious in choice of male by females to mating, due it cac could have a important role in speciation process. The sexual behaviour of L. longipalpis suggests that the same process could be happen in this complex cryptic species. At this moment were analysed 57 individuals of three populations: Natal/ RN, Gruta da Lapinha/MG and Jacobina/BA. To obtain and amplify this fragment we utilized specific primers of L. logipalpis using PCR technics. The DNA fragments obtained were cloned and each one was sequenced automaticaly. The sequences were alinged and polimorfism observed in the intron of these DNA fragments were analysed. The polimorfism in intron finded were increased in Natal and Lapinha populations than Jacobina population. Inumerous alleles were find in three populations, some of they were frequents in Natal and Lapinha populations, but some other were finded only in one population. Some of these results suggest that could be happend introgression process in these populations. Others studies are been realized to confirm this suggestion. Index terms: Lutzomyia longipalpis, cacophony, genetic, polimorfism

[2298] ANALYSIS OF GENETIC STRUCTURE CHANGES WITH POPULATION DENSITY IN PANONYCHUS CITRI IN A SMALL HABITAT USING AN ESTERASE LOCUS

Mh. Osakabe¹ & S. Komazaki², ¹Dept. of Plant Protection, National Agriculture Research Center, 3-1-1 Kannondai, Tsukuba, Ibaraki 305-8666, Japan, E-mail mhosaka@narc.affrc.go.jp; ²Persimmon and Grape Research Center, National Inst. of Fruit Tree Science, Toyota, Hiroshima 729-2494, Japan, E-mail koma@akt.affrc.go.jp.

Several instances of proof of restricted dispersion ability have been reported in spider mites. If the dispersion rate is very low, the size of their breeding colonies is small, causing a genetic differentiation among trees or branches. The resulting genetic structure is assumed to affect preservation and dispersion of an acaricide-resistance gene. In the early stages of acaricide resistance development, a few individuals generally survive in parts of the orchard after spraying. In this study, to learn the genetic structure in a small habitat, the spatial distribution of *Panonychus citri* and the change of the inbreeding coefficient with population density on citrus seedlings were analyzed using an esterase locus as a genetic marker. Genotype frequencies in F₁ females after mating in various population densities suggested that P. citri mated randomly. Adult P. citri females were introduced to small sour orange seedlings, and the spatial distribution of eggs laid on leaves and the offspring were observed. Introduced adult females laid most eggs on the leaves on which they were set and most of the offspring grew on the leaves where they hatched. In the next experiment, females with different homo genotypes were separately introduced on leaves at the top and the bottom of the three sour orange seedlings. The inbreeding coefficient of the developing population was kept high for at least a month in all seedlings although it gradually decreased with the population increase. A linear relationship was found between the density of adult females and the inbreeding coefficient. From these results, the genetic structure in a small habitat can be explained as follows. The relatively aggregated egg production, the low dispersion rate in the immature stage, the precopulatory mate-guarding behavior of the male and ineffectiveness of the second mating may increase the frequency of sibmating. These traits force a delay in hybridization among the breeding colonies at low density. With an increase in population density, distances among the colonies established by different immigrants or survivors are closer. This increases the opportunity for an adult male to meet quiescent females of different colonies. Consequently, the inbreeding coefficient will gradually decrease with coefficient population development and probably converge at Symposium and Poster Session

[2299] STRUCTURE AND EVOLUTION OF THE WING ARTICULATION AND PLEURITES OF THE PSYLLOIDEA (HEMIPTERA, STERNORRHYNCHA)

<u>D. Ouvrard</u>, Mus. nat. d'Hist. nat. Lab. d'Entomologie & ESA 8043 CNRS. 45 rue Buffon. 75005 Paris. FRANCE. E-mail: ouvrard@cimrs1.mnhn.fr.

The characters of the thorax have been rarely used for the taxonomy of the Psylloidea. Reasons for this are probably linked to the jumping aptitude of these insects which has led to the particular development of the metathoracic internal furcae on one hand and of the meron of the coxa on the other hand. This has led to the apparent disappearance of some structures (pleural suture, wing process) and to a difficulty in interpreting (in terms of homology) thoracic sclerites. This lack of discernible homology has led psyllid systematists to focus on head, wing and genitalia characters, or only on the prothoracic pleurites. The dissections of 25 genera representative of the current taxonomic arrangement in psyllids and several species with striking thorax features (Apsylla cistellata, Trichochermes magna, Rhegmoza tinctoria, Diclidophlebia eastopi, Notophyllura cataphracta) have led to a topographical and connective definition of the mesopleurites, to the evolutionary hypothesis concerning the metathoracic pleural suture, to the understanding of the endopleurites in relation with the sternal apophyses, and to the description of peculiar features in the arrangement of the sclerites of the forewing base articulation. As previously claimed by other authors, the propleurites show interesting variations, but the exact primary homology of the antero-ventral angle of the proepisternum varies with the taxa: it is a real trochantin in some species, but a precoxal bridge (i. e. the catepisternum + basisternum) in other species. The metathoracic pleural suture in not the secondary structure designated by several authors, but clearly the incomplete suture indicated by the fossa of the deep pleural apophysis. An internal apodeme at the ventral part of the mesepisternum is reported for the first time, and its serial homologous apodeme is also found in the metathorax, and used as an important landmark. Finally, the metathoracic pleural suture appears to be pressed to the ventral edge of the metepimeron, as it has been shown in the mesothorax of some species. when the meron of the mesocoxa is also developed (Caillardia inedita). The study of the wing articulation shows special trends in the evolution of sternorrhynchal third axillary sclerite in relation to the proximal medial plate (what consequences for the flight of these insects ?). These new interpretations and the discovery of new internal apodemes are useful to assess the primary homology of structures for phylogenetic studies in progress. A glossary of terms used standardizes the nomenclature within the Hemiptera non-Heteroptera taking into account the most recent specialized work and older major works on the thorax of insects.

Index terms: forewing base structure, insect flight, pleurites, pleural suture, thorax, morphology, phylogeny

[2300] SEX CHROMOSOME VARIATION AMONG MUSCOIDEA FLIES

P.P. Parise-Maltempi¹, R.M.P.Avancini² & <u>G. Tirone¹</u>, ¹Dept. of Cell Biology, ²Dept. of Parasitology, Inst. of Biology/ State Univ. of Campinas P. O. Box 6109 Cep 13083-970 Campinas, São Paulo, Brazil.

The chromosome modal number in Muscoidea Diptera is 2n=12: five pairs of autosomes and one sex chromosome pair. Nevertheless, some species with 2n=10 chromosomes have been described, all of them from the Muscidae family. We analyzed the karyotype of some species of Muscidae, Calliphoridae and Sarcophagidae, for the presence or absence of heteromorphic chromosomes. Besides, once there is a relation between NOR(s) and heterochromatin with sex chromosomes, we also investigated these regions through FISH for NOR and C banding for heterochromatin localization. Sex chromosomes are present in the Muscidae species: Ophyra chalcogaster, Synthesiomyia nudiseta and Musca domestica; in the Calliphoridae flies: Chrysomya putoria and C. megacephala; and in the Sarcophagidae Pattonella intermutans. Muscina stabulans and Haematobia irritans are exceptions among Muscidae, since they lack sex chromosomes. There is a considerable variation on the length of sex chromosomes among the different species. Sex chromosomes are very short in O. chalcogaster, medium-size in M. domestica and Chrysomya species and very long in S. nudiseta and P. intermutans. NOR is located on pair II of M. stabulans and M. domestica, on pair III of S. nudiseta, on pair IV of P. intermutans and on sex chromosomes of C. putoria and C. megacephala. Usually in Diptera NORs are associated with sex chromosomes, therefore NORs located in autosomes may suggest an intermediary step in the chromosome evolution of that group where some sequences of the genome, such as NOR(s), could be moved from sex to autosome chromosomes, avoiding serious damage to the genome if parts of sex chromosomes are lost. The Muscidae species apparently are in a more advanced stage in the evolution of sex chromosome. Moreover, in all the Muscidae investigated that presented sex chromosomes these chromosomes are heterochromatic and NOR(s) are located in the autosomes. Pattonella intermutans has long sex chromosomes, that are totally heterochromatic and NOR is also located in the autosomes. The Calliphoridae species studied in this work, seem to be in an intermediate stage, with NOR located in the sex chromosomes, which are not totally heterochromatic.

Index terms: Panonychus citri, citrus, esterase, inbreeding

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[2301] MOLECULAR PHYLOGENY, CHROMOSOMES, AND HOST PLANT AFFILIATION IN CHRYSOLINA AND OREINA (COLEOPTERA, CHRYSOMELIDAE)

E. Petitpierre, C.F. Garín, B. De Astorza, C. Juan & I. Garnería, Lab. Genètica, Dept. Biologia, UIB, 07071 Palma de Mallorca (Spain), e-mail: dbaepv@clust.uib.es.

A segment of 510 bp length of rDNA from mitochondrial genome has been sequenced in forty-one species of Chrysolina and five of Oreina, belonging to twenty-four and three current subgenera, respectively. A maximum parsimony tree was built where some subgenera or groupings of them are clearly established by supported nodes. Thus, among the Lamiaceae feeders having 2n = 24 chromosomes, at least four clades are shown: 1) Maenadochrysa + C. (Colaphosoma) sturmi, 2) Taeniochrysa + Chrysolinopsis + Rhyssoloma, 3) Fastuolina + Chrysomorpha, 4) Methastriella + Melasomoptera + Erythrochrysa. A quite polyphagous clade feeding on Lamiaceae, Plantaginaceae, Asteraceae and Ranunculaceae, joins Chrysolina s.str. + C. (Colaphoptera) rufa, the latter feeding on Lamiaceae and Asteraceae, and sharing also 2n = 23 chromosomes. The *Chalcoidea*, Asteraceae feeders with 2n = 40chromosomes, are a highly supported clade as well as the Hypericia + Sphaeromela, on Clusiaceae and with 2n = 38 and 32 chromosomes, respectively. The Stichoptera are also clustered despite their distinct choices, on Scrophulariaceae or Lamiaceae, and their chromosomal heterogeneity, while the Threnosoma agree with their feeding on Apiaceae and with their 2n = 47 chromosomes. Finally, five Oreina appear in two allied branches: Chrysochloa and Oreina s.str. + Protorina. The separation of Chrysolina respect to Oreina needs additional analyses by using more conserved genetic markers. Conversely, Chrysolina-Oreina diverges strikingly from other enera of Chrysomelinae.

Index terms: 16S rDNA, genetic interrelationships, trophic selection

[2303] THE ECOLOGO-KARYOTYPICAL APPROACH TO THE ANALYSIS OF SIBLING-SPECIES GENUS CHIRONOMUS MEIG. (CHIRONOMIDAE, DIPTERA)

N.V. Polukonova, Saratov Medical Univ. Russia, 410710, Saratov, Bolshaja Kzachja St., 112

The ecologo-karyotypical approach to the analysis of chromosomal polymorphism of sibling species allows to reveal the common tendencies in the formation of karyofunds of evolutionary young species and to trace the influence of external environment on karyotypical structure of hydrobionts taxocenosises. The study represent of simpatrical living sibling species seems to be most convenient. The natural populations of *Chironomus* gr. *plumosus* species of Volga river basin reservoirs of the Saratov region (Lower Volga) were investigated. On analysis the following ecologo-karyotypic parameters were taken into account, which, in our opinion, could reflect karyotype connection with external environment: 1 - quantity of heterozygotic inversions in a species, 2 - chromosome arms with inversions (only common for all species of taxocenosis), 3 - chromosome segments, included in heterosygotic inversions (only common for all species of taxocenosis), 4 - segments chromosome where break off forming inversions (only common for all species of taxocenosis). The analysis we carried out, has revealed certain, optimale for the given ecological conditions the set of the inverted chromosome segments, which is maintained by selection as selectively favourable. General set of such segments for different species of group plumosus once again indicates their evolutionary youth. On the other hand, it is obvious, that a set of the inverted segments, number of heterozygotic inversions and chromosomal arms with inversions can vary in this or that direction depending on conditions of a definite reservoir.

Index terms: karyotype, polytenic chromosomes, heterotopic insects, midges.

[2302] CHROMOSOMAL AND MORPHOLOGICAL DIVERGENCE SPECIES OF A GENUS CHIRONOMUS MEIG. (CHIRONOMUDAE, DIPTERA)

<u>N.V. Polukonova</u>, Saratov Medical State Univ. Russia, Saratov, 410710, Saratov, Bolshaja Kazachja St., 112

Researches of closely related species of a genus Chironomus Meig. have shown, that during chironomids evolutionary divergence distinction between species revealed with the help of the karyotypic analysis, it is not necessary correlated with distinctions between them to morphological signs. So, C. curabilis, C. nuditarsis and C. behningi with chromosomal figure of disks close to C. plumosus, do not belong to group *plumosus* following morphological signs of larva - absence of serration in the anterior edge of a ventromental plate, and in *C. behningi* also by the presence of 4-5 bladed premandibule (instead of 2-bladed). However, C. behningi has in the G arm identical chromosomal sequence with C. usenicus (sibling species C. plumosus). Identity in the sequence of disks in a G arm in different species is rare case in Chironomus genus. The species of thummi cytocomplex (AB, CD, EF and G) form groups of closely related species inside it. But these groups can include species of others cytocomplexes, for example, *C. nudiventris* of group *lumosus*, from the cytocomplex *staegeri*, with 2n = 6 (AB, CD, GEF). There are representatives from listed cytocomplexes in others subgenus's - Baeotendipes (C. valkanovi from a staegeri-complex), Lobochironomus (C. globulus from a thummi-complex) etc. Species subgenus Camptochironomus - C. tentans and C. pallidivittatus, belong to a genus Chironomus following morphology larva, but they have "their own" cytocomplex camptochironomus (AB, CF, DE and G). Species Chironomus of North - C. fraternus and C. fundatus - C. wulkeri, clearly different karyologically, can have weak morphological differences (Filinkova, 1995 in Russian). Dendrogramms of species similarity in group's plumosus and obtusidens, formed on morphological and karyotypical signs do not correspond in a sequence of species and their relative The discrepancies between morphological and cytogenetical arrangement. differentiation are found out and in other groups of animals (Yegorov, 1983; Giljova, 1990 all in Russian). Apparently, the karyotype structural transformations do not contribute significantly to evolutionary transformation of external morphological signs, and the processes of chromosomal and morphological differentiation, at least, at early stages of evolutionary divergence, go independently.

Index terms: evolution, kariosystematic, karyotype, heterotopic insects, midges.

[2304] PATTERNS OF RDNA LOCALIZATION IN TIGER BEETLES (COLEOPTERA: CICINDELIDAE)

<u>S. J. R. Proenca</u>¹, A. R. M. Serrano¹ & J. Galián², ¹Depto Zoologia e Antropologia and Centro de Biologia Ambiental, Fac. Ciências, Univ. Lisboa, Campo Grande, Bloco C2 - 3º Piso, 1700 Lisboa, Portugal, E-mail soniajr@fcu.um.es; ²Depto Biologia Animal, Fac. Veterinaria, Univ. Múrcia, 30071 Múrcia, Spain.

Tiger beetles are Coleoptera belonging to the family Cicindelidae, which are characterised by the presence of multiple sex chromosomes of the type XnY (males) XnXn (females) that form a non-chiasmatic multivalent during meiosis. With the exception of the chromosome number and sex chromosome mechanism, little is known about their nuclear genome organisation. The localization pattern of conserved genes such as ribosomal DNA is of particular interest in phylogenetic and evolutionary studies. The ribosomal clusters were localized on meiotic and mitotic chromosomes and in interphase nuclei of nine Paleartic taxa belonging to the genus Cicindela (s.l.) by fluorescence in situ hybridization (FISH), using a PCR-amplified 18S rDNA fragment as a probe. The Cicindela species studied (C. hispanica, C. maura, C. deserticoloides, C. circumdata, C. trisignata, C. littoralis littoralis, C. littoralis nemoralis, C. flexuosa and C. paludosa) show variation regarding to the number of chromosomes with ribosomal genes, which varies from 2 to 4, as well as their localization within the genome. Polymorphism between populations and between subspecies has also been observed. Four new patterns of rDNA localization can be added to the one previously described corresponding to two fluorescent signals in two of the heterosomes (XY). These four patterns are: 1) two fluorescent signals located in an autosomal pair; 2) three fluorescent signals located in an autosomal pair and in one of the heterosomes (X); 3) three fluorescent signals located in three of the heterosomes (XXY) and 4) four fluorescent signals in an autosomal pair and in two of the heterosomes (apparently XY). These results show that ribosomal cistrons have changed their localization between autosomes, from autosomes to heterosomes, from heterosomes to autosomes and between heterosomes during the evolution of the genus Cicindela, showing a dynamic rather than a conservative pattern. The polarity of these changes is discussed. A mechanism that involves transposable elements that jump from one localization in the genome to another, in some cases leaving copies in the original localization is proposed to explain these dynamics.

Index terms: Cicindela, ribosomal genes, FISH.

[2305] CHARACTERIZATION OF GENOMIC GENE ENCODING KYNURENINE 3-MONOOXYGENASE IN THE SILKWORM BOMEYX MORI

G. X. Quan¹, L. Kim², T. Shimada², T. Kômoto¹, K. Yukuhiro¹, T. Kanda¹, K. Mita³, M. Kobayashi² & T. Tamura¹, ¹Dept. of Insect Genetics and Breeding, National Institute of Sericultural and Entomological Science, Owashi 1-2, Tsukuba, Ibaraki 305, JAPAN; ²Dept. of Agricult., University of Tokyo, Hongo, Bunkyo-ku, Tokyo 113, JAPAN; ³Nat. Inst. of Radiological Sciences, Anagawa4, Inage, Chiba 263, JAPAN.

To develop a efficient system for the transgenesis in the silkworm, it is important to use a visible dominant marker gene which possesses very high sensitivity and expresses at early developmental stage of the embryogenesis. In the silkworm, many white egg color mutants were known and preserve in NISES and Kyusyu University. One of the mutant called w1 is knows its egg color is white and caused by the deficiency of kynurenine 3-monooxigenase (KMO). The mutant cannot accumulate ommochrome pigments in the serosal membrane cells of the embryos. Recently, cDNA homologue of Drosophila KMO gene was cloned by Kim et al. (1998). We performed further analysis related to the genomic gene structure of the wild type and the w1 mutant. Southern blot analysis showed that the Bombyx KMO gene is present as a single copy gene in the silkworm genome. The clones covered the entire region of KMO gene was isolated from the BAC library. The sequencing of the whole region of the gene showed that the silkworm KMO gene consist of 10 exons and its total size is about 16kb. The DNA sequences associated with CREBP(cAMPresponse element binding protein) and CEBP (CAAT/enhancer binding protein) consensus were found in the 5'upstream region of the gene. The highly reiterated sequences were found at the introns. Especially, the large insertion was found in the third introns. Comparison of the DNA sequences of KMO genes between the Bombyx and Drosophila showed that the second to eighth exons of the silkworm gene correspond to the second exon of Drosophila KMO gene and the ninth to tenth exons were equivalent to the third exon of Drosophila. No consensus sequences were identified in 5'upstream regions between the two genes. Although the expression of KMO gene in the mutant was much lower than the wild, the comparison of the sequences of 5' upstream region appeared only minor difference in the mutant and wild type genes.

Index tems: lepidoptera, white egg, w1, ommochrome, transgenic.

[2306] CLONING FULL-LENGTH CDNAS ENCODING TWO NOVEL INSECT HYPERACTIVE ANTIFREEZE PROTEIN ISOFORMS FROM SPRUCE BUDWORM

<u>M. Rahavard</u>, Department of Anatomy, Univ. of Medical Sciences, P. O. Box 19735-183, Tehran, 19735, Iran, E-mail mRahavard@hotmail.com

Spruce budworm (Choristoneura fumiferana) employ antifreeze proteins (AFPs) and other cryoprotectants as part of their freezing avoidance overwinteing strategey. The second instar, 1mm larvae overwinter successfully in hibernaculae attached unprotected to the tips of conifer branches, exposed to frequent-30° C and lower. The pest destroys millions of hectares of North American forests in peridic outbraeks. AFPs bind to the microscopic seed ice crystal via surface adsorption-inhibition mechanism and inhibit ice crystal growth. This function is resulted in lowering body fluids freezing point, non-colligatively, bellow the melting point which is defined as thermal hysteresis (TH). On a molar basis the TH obtained from this insect is 10 to 30 times higher than that of the fishes'. Based on the 9kDa, hyperactive, antifreeze protein sequences, which previously obtained, oligonucleotide degenerate primers (sense and antisense) were designed for cloning AFP cDNA via polymerase chain reaction (PCR). As the template for the reaction, first strand cDNA was prepared via reverse transcription, using poly (A⁺)-enriched mRNA isolated from second instar larvae. The PCR, amplified a 120 -bp DNA fragment which subsequently was used as a hybridization probe for screening the second instar larval cDNA library. Sequencing of some of the isolated positive clones revealed full-length AFP cDNAs. Conceptual translation of the DNA sequences to their encoded proteins, produced two novel 107 and 108 amino acid AFP isofrms, which contained all previously obtained protein sequences confirming identity of the clones. Alignment of the two AFP isoforms showed 77.6 % identity. Results showed that at least two cDNAs are encoding the spruce budworm AFPs. In addition, preliminary Northern analysis showed that AFP cDNA hybridizes to three functional AFP mRNA transcripts. This also suggests that more than one gene or a close family of genes is encoding spruce budworm AFP isoforms. Potentially, spruce budworm AFP gene can be a preferred candidate to be over or/ under expressd in producing frost resistant or/suceptible transgenic plants and animals, respectively. Frost suceptible transgenic pests may help integrated pest control strategies. Other applications of the AFP in cryomedicine, cryopreservation of frozen food and in biotechnology in general may be also invaluble.

Indexterms: Choristoneura fumiferana, Antifreeze protein, cryprotection

Symposium and Poster Session

[2307] COMPARATIVE CYTOGENETICS IN ARGENTINE SPECIES OF PENTATOMINAE (PENTATOMIDAE, HETEROPTERA)

P.J. Rebagliati, L. M. Mola & A. G. Papeschi, Lab. de Citogenética y Evolución, Depto. de Ciencias Biológicas, FCEN, Universidad de Buenos Aires, C.P.A.: C1428BGA, Argentina. E-mail: gchu@bg.fcen.uba.ar.

Species of Pentatominae are generally phytophagous, feeding on a wide range of weeds and cultivated plants, and causing great economic losses. Cytogenetic analysis is one of the tools employed in the species characterization. The Pentatominae, as is the rule in Heteroptera, have holokinetic chromosomes and a particular meiotic development: bivalents present only one chiasma and arrange in a circle at metaphase plates; sex chromosomes are achiasmatic and lie at the center of the autosomal ring at these stages. The analysis of more than 200 species of the subfamily reveals a diploid chromosome number ranging from 2n=6 to 27, with a mode in 14 (86%) and a sex chromosome determining system XY/XX (male/female). Adult males of Loxa deducta, Macropygium reticulare, Piezodorus guildinii, Edessa meditabunda, Edessa rufomarginata, Proxys albopunctatus, Dinocoris prolineatus and Dichelops furcatus from different localities have been cytogenetically analyzed. Specimens were fixed in 3:1 (absolute ethanol: glacial acetic acid), gonads were dissected out and slides were performed by the squash method in iron propionic haematoxylin; DAPI banding was also carried out in both Edessa species. All the species present 2u=14, n=6+XY, except D. furcatus with 2n=12, n=5+XY, and meiosis proceeds as usual in Heteroptera. Despite the great constancy in chromosome number, the species show differences in karyotype and meiotic behaviour. D. furcatus shows a reduced chromosome number due to an autosomal fusioa, while E. meditabunda, E. rufomarginata, P. albopunctatus and L. deducta have a large autosomal bivalent which can present two chiasmata. Sex chromosomes are also diagnostic: in P. albopunctatus and P. guildinii the X and Y are strikingly unequal in size; in E. meditabunda and E. rufomarginata the smaller sex chromosome is DAPI negative and iso-DAPI, respectively, from metaphase I onwards. Besides, the larger sex chromosome of *E. meditabunda* is frequently part of the ring of autoscmes at metaphase I. Finally, *L. deducta, M. reticulare* and *D. prolineatus* show a highly irregular meiosis in one testis lobe ("hariequin lobe"), a feature already described in only 23 species of Pentatominae belonging to 3 different tribes, Pentatomini, Halyini and Discocephalini.

Index terms: Edessa meditabunda, Dinocoris prolineatus, Dichelops furcatus, Macropigium reticulare, meiosis.

[2308] MOLECULAR GENETIC MAPPING IN THE HESSIAN FLY

S. D. Rider Jr.¹, W. Sun¹, F. H. Valicente¹ & J. J. Stuart¹, ¹Dept.of Entomology, Purdue Univ., West Lafayette, IN,47907, USA. Email: jeff_stuart@entm.purdue.edu

The Hessian fly, Mayetiola destructor (Say), is one of the most destructive insect pests of wheat in the United States and is the most important pest of wheat worldwide. The most effective method of control of the Hessian fly to date depends on the development and deployment of wheats that carry genes that provide resistance to this pest. Over time, Hessian fly populations evolve into new virulent biotypes' against which these genes are not effective. Our objectives are to understand the mechanism of virulence by mapping and cloning the genes conditioning avirulence/virulence in this insect. Bulked segregant analysis was used to identify molecular genetic markers associated with Hessian fly genes conditioning avirulence to the H5, H6, H9, H7/H8 and H13 wheat resistance genes. An AFLPbased genetic linkage map of the Hessian fly genome was created to facilitate the acquisition of flanking markers for each avirulence gene. The map shown was generated using 84 polymorphic loci and a backcross mating design. The map covers approximately 580 Kosambi centimorgans which translates to an average of less than 170 kb per centimorgan of recombination. In conjunction with a large insert BAC or cosmid library, positional cloning of avirulence loci is feasible. We are also focusing on the locus controlling sex determination in the Hessian fly. Fine-scale mapping and positional cloning one avirulence gene, vH13, has been initiated.

Index terms: host plant resistance, Cecidomyiidae, avirulence, bulked segregant analysis.

[2309] CYTOGENETIC HETEROGENEITY IN COMMON ARGENTINE HAPLOGINE SPIDERS

S. G. Rodríguez Gil¹, L.M. Mola¹, A. G. Papeschi¹ & C. L. Scioscia^{1,2}, ¹Lab. de Citogenética y Evolución, Depto. de Ciencias Biológicas, FCEN. Univ. de Buenos Aires, CPA: C1423BGA, Argentina, E-mail Errol Indicador não definido.. ²Museo Argentino de Ciencias Naturales "B. Rivadavia", Buenos Aires, Argentina.

During the last decade phylogenetic knowledge of the higher systematics of Araneae has increased. Cladistic evidence suggests that although classical Haploginae were originally defined on the basis of a plesiomorphy, they form a monophyletic group. This paper had its origin as an attempt to bring cytogenetic data that can be used as new evidences for a better understanding of the relationships in this conflictive group. Araneae comprises 108 families and more than 3000 described genera; just a little more than 100 genera and 300 species have been cytogenetically analized and only 7% of the species are haploginae. Most spiders present monocentric chromosomes (acro or telocentric), a diploid chromosome number ranging from 2n=22 to 28, chiasmatic meiosis and a sex chromosome determining system X1X20/X1X1X2X2 (male/female). Spermatogenesis of Dysdera crocota (Dysderidae), Ariadna bocsenbergii (Segestriidae), Pholcus phalangioides (Pholcidae), Kukulkania hibernalis (Filistatidae) and Scytodes maculata (Scytodidae) has been analyzed in immature and adults. Specimens were fixed in 3:1 (absolute ethanol: glacial acetic acid), testes were dissected out and slides were performed by the squash method in iron propionic haematoxylin. The chromosomes of D. crocota (2n=11, n=5+X0) lack a primary constriction (holokinetic chromosomes), and meiosis is achiasmatic; the sex univalent chromatids separate at anaphase 1 (post-reductional division); A. boesenbergii (2n=9, n=4+X0) also presents holokinetic chromosomes. P. phalangioides (2n=24, n=11+X1X20) possess monocentric chromosomes of very small size, making difficult their morphological characterization; K. hibernalis $(2n=24, n=11+X_1X_20)$ and S. maculata (2n=13, n=6+X0) have metacentric autosomes. In all these 4 species meiosis is chiasmatic and the sex chromosomes divide pre-reductionally: both X_1 and X_2 , or both chromatids of the unique X, migrate together to one pole at anaphase I. Cytogenetic studies in species of Segestriidae and Dysderidae reveal a low diploid chromosome number, and the presence of holokinetic chromosomes, contrasting with the generality of spiders; ail the species of Pholeidae characterize by the presence of very small sized chromosomes. Finally, S. maculata and K. hibernalis are the only species cytogenetically analyzed until present in Scytodidae and Filistatidze, and they show an uncommon chromosome morphology (metacentric chromosomes). Cytogenetic data in haplogine spiders far from being homogeneous show strong differences from generality, a fact also encountered in many other characters in the group.

[2310] MITOCHONDRIAL DNA "A+T RICH" REGION AS A GENETIC MARKER IN AEDES AEGYPTI POPULATION STUDIES

J. C. Rondan Dueiias¹, G. Panzetta-Duttari² & <u>C. N. Gardenal</u>¹, ¹Cátedra de Química Biológica, Facultad de Ciencias Médicas; ²Departamento de Bioquímica Clínica, Facultad de Ciencias Químicas, Universidad Nacional de Córdoba, Casilla de Correo 35, Sucursal. 16, 5016 Córdoba, Argentina. E-mail: ngardenal@biomed.fcm.unc.edu.ar;

Because of its maternal inheritance, non recombinant nature and high levels of polymorphism, nutochondrial (mt) DNA has been extensively used as genetic marker in animal population genetics. Among the few noncoding segments of mt DNA, the control region comprising the replication origin is usually long and hypervariable, being potentially suitable for studies at the intraspecific level. In insects, this fragment is called A+T rich region, because of its particularly high content of adenine and thymine. The usefulness of this region, because of its particularly man content of adcanne and thymine. The usefulness of this region as a tool for the study of population structure has not been investigated in mosquitees. We present here a survey of length and restriction fragment diversity in the A+T rich region in natural populations of *Aedes aegypti*, the main urban vector of yellow lever and dengue. Samples were obtained from five cities of Argentina (Orán, Salta, Posadas, Córdoba, Villa María and Buenos Aires) and from San Juan de Puerto Rico. DNA of 8 to 16 individual adult mosquitoes from each locality was extracted by standard phenol-chloroform procedure. Universal primers were used for amplification by the polymerase chain reaction (PCR). Aliquots of amplification products were digested with 7 restrictases, according to the manufacturer's protocols. The PCR product varied in length (2.1, 2.3 and 2.5 kb) among individuals and populations, and was used as one of the variables to define haplotypes. Four out of the seven restrictases employed (Ssp I, Dra I, Apo I and Pac I) originated patterns revealing intrapopulation restriction fragment length polymorphism (RFLP). A total of nine different haplotypes could be defined in Argentina; haplotype 2 had the highest frequency and was present in four out of five populations . The sample from Salta was the most polymorphic, showing 6 haplotypes. In individuals from Puerto Rico, three different haplotypes were observed, none of them found in Argentina. Our results demonstrate that the A+T rich region of Ae. aegypti offers good levels of polymorphism to allow intrapopulation discrimination, being a suitable genetic marker for the study of population structure.

Index terms: mosquitoes, population structure, RFLP, haplotypes.

[2311] GENETIC VARIATION OF EUROPEAN CORN BORER (OSTRINIA NUBILALIS) POPULATIONS IN NEBRASKA DETECTED BY RANDOM AMPLIFIED POLYMORPHIC DNA (RAPD)

L. A. Saldanha¹, S. Skoda², S. S. Quisenberry³ & J. E. Foster¹, ¹Dept. of Entomology, 202 Plant Industry Building, University of Nebraska-Lincoln, Nebraska, USA 68583-0816, ²USDA-ARS Midwest Livestock Insects Research Laboratory, Department of Entomology University of Nebraska, Lincoln, USA 68583-0938, ³Montana State University, College of Agriculture 202 Linfield Hall, Bozeman, MT 59717-2860

The European corn borer, Ostrinia nubilalis (Lepidoptera: Crambidae) an introduced pest of maize (Zea mays), is common to maize growing areas throughout North America. European corn borer is a polyphagous species that causes about US\$ 1 billion damage annually. It exists in three morphologically similar ecotypes. Despite the importance of this pest, limited information is available concerning the nature and extent of genetic diversity of the European corn borer in the United States. Because there is a need to understand the genetic structure of the European corn borer, we used random amplified polymorphic DNA-Polymerase chain reaction (RAPD-PCR) to examine ecotype variation in European corn borer from five sites in Nebraska. After initially screening 120 RAPD primers we selected 10 for further studies. RAPD-PCR of European corn borer DNA, resulted in the amplification of a series of DNA fragments of varying length. We use only fragments that were consistently present and reliable. The results showed that the European corn borer from Nebraska constituted a broad genetic group. We found the genetic population structure to consist of 35.5% univoltine, 44.5% bivoltine, and 20% multivoltine ecotypes. More research along these lines will give a better understanding of the ecotype distribution of European corn borer and may be useful in developing pest control strategies.

Index terms: DNA polymorphism, population genetics, PCR, randomly amplified polymorphic DNA, molecular markers

[2312] REPRODUCTIVE ISOLATION AND GENETIC DIFFERENTIATION IN JAPANESE SPECIES OF ADOXOPHYES (LEPIDOPTERA: TORTORICIDAE)

<u>Y, Sato</u>, Lab. of Entomology, National Research Institute of Vegetables, Ornamental Plants and Tea. 2769, Kanaya, Shizuoka 428-8501, Japan, E-mail lucifer@tea.affrc.go.jp

The smaller tea tortrix, Adoxophyes honmai and its sibling species, A. dubia are important pests of tea plants, and the summer fruits tortrix, A. orana has been known to attack various fruit trees in Japan. These three Japanese Adoxophyes species have been recognized based on larval host, adult pheromone, or some morphological differences, but no consistent genetic differences have been reported. To clarify their genetic relationships, I surveyed mitochondrial DNA (mtDNA) and allozyme variations of these species. Most specimens were sequenced over an 832-bp segment of the ND5 region. At the molecular level, these three species were very similar; especially A. honmai and A. dubia were most closely related species. The crossbreeds between A. honmai and A. dubia didn't lose their fertility alone. Viable and fertile interspecific hybrids can be obtained in the laboratory, thus permitting a genetic study of some of these traits. However, these results don't confirm the allozyme survey, which found that A. dubia was the most genetically distinct species. These closely related tortrcid moths have been found in sympatry in southern part of Japan, and habitat isolations among these species by their host plant preference are incomplete. Therefore, I also examined the degree of reproductive isolation among these species. The sexual isolation was confirmed by mating choice experiments in the laboratory. Most mating of A. honmai were conspecific. A.dubia and A. orana also showed a tendency to the conspecific matings, although the mating activity of these species was restrained under the experimental conditions. The presence of other Adoxophyes females seemed to suppress the mating activity of A. dubia and A. orana. Observations at 22°C, under a 14:10 LD-cycle mating times of A.dubia revealed two hours earlier than these of A. honmai and A. orana. These data suggest that the Japanese Adoxophyes species differ by 1) ecological preferences, 2) some morphological features, 3) the relative amounts of the two main components of the female pheromonal blend, 4) the temporal pattern of sexual behavior, and 5) the genetic differentiations

Index terms:. Adoxophyes, A. dubia, A. orana, reproductive isolation, mt-DNA

Symposium and Poster Session

[2313] MITOCHONDRIAL DNA COI SEQUENCES DIFFERENTIATE TWO CLOSELY-RELATED SPECIES, ANOPHELES DUNHAMI AND ANOPHELES NUNEZTOVARI (DIPTERA: CULICIDAE)

Y. M. Scarpassa¹ & J. E. Conn², ¹ Lab. de Vetores da Malária, Inst. Nac. Pesquisas Amazônia, Avenida André Araujo, 1756, Manaus, Amazonas, 69011-970, Brazil. ² Dept. Biology, Univ. of Vermont, Burlington, VT, USA 05405-0086

The known geographic distribution of Anopheles dunhami Causey is restricted, including only Tefé (type locality) and Tabatinga, on the Solimões River, in Amazonas State, Brazil. This species was a synonym of Anopheles nuñeztovari Gabaldón, and in recent publications A. dunhami was resurrected as a distinct species; and Anopheles trinkae Faran regarded as the senior synonym of A. dunhami based on isomorphic genitalia. Currently, A. dunhami, A. nuñeztovari and A. trinkae are considered as separate species based on differences in egg ultrastructure, accessory gland volume, the ITS2 region of ribosomal DNA, RAPD sequences and polytene chromosomes. In the present study, we determined one new locality for A. dunhami, Coari, which is situated on the Solimões River, in Amazonas State. Anopheles dunhami from Coari was identified using 873 base pairs of DNA from the mitochondrial cytochrome oxidase subunit I (COI) and the results were compared with the sequences of A. dunhami from Tefé, the sequences of 16 populations of the sister-taxon A. nuñeztovari from South America, and the sequences of the outgroup, Anopheles darlingi Root. The uncorrected pairwise divergence between the two populations of A. dunhami ranged from 0.6% to 0.9%, while the divergences between A. dunhami and A. nuñeztovari were 1.6% to 3.2%. Among the sequences of A. dunhami, the matrix presented 9 variable sites (1.0%) and 0 (0%) informative sites, while the data matrix showed 10 (1.1%) phylogenetically informative sites between the two species. The strict consensus tree, using maximum parsimony, supported A. dunhami and A. nuñeztovari, morphologically indistinguishable as wild-caught females, as distinct species with 85% bootstrap support (1000 replications). These results demonstrate the utility of mtDNA COI sequences to separate the human malaria vector A. nuñeztovari and A. dunhami, especially in areas where they are sympatric. This research was supported by INPA/PPI-3190 and NIH AI 40116 to

Index terms: Anopheles dunhami, Anopheles nuñeztovari, Mitochondrial DNA, COI gene, maximum parsimony

[2314] INVASION GENETICS OF THE PEA LEAFMINER LIRIOMYZA HUIDOBRENSIS (DIPTERA: AGROMYZIDAE): CRYPTIC SPECIES AND GEOGRAPHIC ORIGINS OF PEST POPULATIONS

<u>S. J. Scheffer^L</u>, ¹Systematic Entomology Laboratory, USDA-ARS, Bld 005, Rm. 137, BARC-W, 10300 Baltimore Ave., Beltsville, MD, USA, sscheffe@sel.barc.usda.gov.

Liriomyza huidobrensis is currently a major worldwide pest of many vegetable and flower crops. Originally known from the western United States and South America, this polyphagous leafmining fly has recently been introduced into many locations around the world, giving rise to new outbreak populations that are currently causing substantial economic losses. Phylogenetic relationships among populations of the L. huidobrensis were investigated using mitochondrial cytochrome oxidase sequence data. Results show that L. huidobrensis contains two well-defined monophyletic groups, one comprised of specimens from California and Hawaii and one comprised of specimens from South and Central America. The differentiation between the two clades within L. huidobrensis is equivalent to that seen between other agromyzid species, suggesting that L. huidobrensis as currently defined contains two cryptic species. This finding is consistent with reports of field observations of differences in pest status and insecticide resistance between L. huidobrensis populations from these different regions. Introduced populations, sampled to date, of L. huidobrensis present in other regions of the world all belong to the South and Central American clade. The potential of nuclear DNA markers to further identify geographic origins of introduced pest populations will be addressed. Until additional studies are complete, no changes has been addressed with the proposed. However, researchers and quarantine officials may wish to consider the findings of the present study in designing research, pest management, and quarantine programs for L. huidobrensis.

Index terms: phylogeography, molecular systematics.

[2315] FROM SEVEN CRYPTIC SPECIES OF THE CULICOIDES IMICOLA COMPLEX (DIPTERA: CERATOPOGONIDAE)

F. Sebastiani¹, **R.** Meiswinke¹², **P.** Mellor³, **L.** M. Gomulski¹ & <u>G. Gasperi¹</u>, 1Dept. of Animal Biology, Univ. of Pavia, 27100 Pavia, Italy; 20nderstepoort Veterinary Inst., Onderstepoort, Republic of South Africa; 3Inst. for Animal Health, Pirbright Laboratory, Pirbright, UK

The Culicoides imicola complex is represented by seven morphological described species (Meiswinkel, Onderstepoort J. Vet. Res., 1989; 1991; 1992; 1995). The taxonomic rank of species assigned on morphological basis has been already validated by the use of the molecular technique AP-PCR (Sebastiani et al., VII Congr. Europ. Soc. Evol. Biol., 1999). In the Old World C. imicola ss and C. Congr. Europ. Soc. Evol. Biol., 1999). In the Old World C. Imicola ss and C. bolitinos represent the only verified vectors of African Horse Sickness Virus (AHSV) and Blue Tongue Virus (BTV) (Meiswinkel, et al. 1994 - Vectors: Culicoides spp. In Infectious Diseases of Livestock, with special reference to southern Africa, pp. 68-89 [J. A. W. Coetzer, G. R. Thomson & R. C. Tustin. Eds.] Cape Town, Oxford Univ. Press). The morphological discrimination between the seven cryptic species is very difficult but essential for preventive and epidemiological studies of virus transmission. For this purpose we have developed an approach based on diagnostic PCR and restriction enzyme analyses. The second internal transcribed spacer (ITS2) of the ribosomal DNA was considered to discriminate the seven cryptic species of the Culicoides imicola complex from Southern Africa. After amplification and sequencing of ITS2 of all seven C. inicola species, the length of the ITS2 was in the range of 350 and 395bp among species. The variation in the length of the ITS2 is due to indels in simple repeats and in species-specific sequences. Differences in the presence of restriction sites may be useful for the identification of the species of the C. imicola complex. Besides, primers can be constructed for species-specific PCR amplification of midges DNA based on differences in their nucleotide sequences. Index terms: Culicoides inticola, species complex, ITS2 polymorphism, PCR assays.

[2316] SPECIES DIAGNOSTIC DIFFERENCES IN RIBOSOMAL DNA INTERNAL TRANSCRIBED SPACER 2 FROM SEVEN CRYPTIC SPECIES OF TILE CULICOIDES IMICOLA COMPLEX (DIPTERA: CERATOPOGONIDAE)

F. Sebastinni, **R. Meiswinke**², **P. Mellor**³, **L. M. Gomulski**¹ & **G. Gasperi**¹, ¹Dept. of Animal Biology, Univ. of Pavia, 27100 Pavia, Italy; ²Onderstepoort Veterinary Inst., Onderstepoort, Republic of South Africa; ³Inst. for Animal Health, Pirbright Laboratory, Pirbright, UK

The Culicoides inicola complex is represented by seven morphological described species (Meiswinkel, Onderstepoort J. Vet. Res., 1989; 1991; 1992; 1995). The taxonomic rank of species assigned on morphological basis has been already validated by the use of the molecular technique AP-PCR (Sebastiani et al., VII Congr. Europ. Soc. Evol. Biol., 1999). In the Old World C. imicola ss and C. bolitinos represent the only verified vectors of African Horse Sickness Virus (AHSV) and Blue Tongue Virus (BTV) (Meiswinkel, et al. 1994 - Vectors: Culicoides spp. In Infectious Diseases of Livestock, with special reference to southern Africa, pp. 68-89 [J. A. W. Coetzer, G. R. Thomson & R. C. Tustin. Eds.] Cape Town, Oxford Univ. Press). The morphological discrimination between the seven cryptic species is very difficult but essential for preventive and epidemiological studies of virus transmission. For this purpose we have developed an approach based on diagnostic PCR and restriction enzyme analyses. The second internal transcribed spacer (ITS2) of the ribosomal DNA was considered to discriminate the seven cryptic species of the Culicoides imicola complex from Southern Africa. After amplification and sequencing of ITS2 of all seven C. imicola species, the length of the ITS2 was in the range of 350 and 395bp among species. The variation in the length of the ITS2 is due to indels in simple repeats and in species-specific sequences. Differences in the presence of restriction sites may be useful for the identification of the species of the C. imicola complex. Besides, primers can be constructed for species-specific PCR amplification of midges DNA based on differences in their nucleotide sequences

Index terms: Culicoides imicola, species complex, ITS2 polymorphism, PCR assays.

[2317] CHARACTERIZATION OF CRYPTIC SPECIES OF THE ANASTREPHA FRATERCULUS COMPLEX

D. Selivon, Depto. de Biologia, Univ. São Paulo, C.P.11461, São Paulo, SP, 04522-970, Brazil, E-mail dselivon@usp.br.

Since the 40's it is known that the nominal species Anastrepha fraterculus presents a large variability in the wing pattern. In the last decades analysis of isolate biological attributes, as karyotype, isozymes, mt DNA, lead to the suggestion that the species could indeed harbour a complex of cryptic species, the "A. fraterculus complex". However, no limits among the species were determined. Recently, using combined studies of several characteristics (chromosomes, isozymes, morphometric parameters and crossing), followed by analysis of eggshell morphology and embryonic developmental patterns, two species were found and provisorily named Anastrepha sp 1 aff. fraterculus and A. sp 2 aff. fraterculus (appearing in previous publications as A. fraterculus type 1 and type 2 or sp 1 and sp 2). Here we describe characteristics of individuals of A. fraterculus collected in two localities, one in the southeast coast of Brazil, and the other in the coast of Ecuador. In both, the karyotypes present 12 chromosomes similarly to Anastrepha sp 1 and sp 2. However, conspicuous differences were found in the sex chromosomes mainly in relation to the presence and size of blocks of heterochromatin (C-bands). Differences in the ornamentation of the eggshell allow discrimination of the four populations. The mesonotum and wing patterns are somewhat variable within populations but the differences among populations are larger, specially in individuals from the brazilian coast where the distinctive yellowish stripes of the mesonotum are not found. In this population, the proximal portion of the wings is clearly distinctive from the other ones. The results so far obtained indicates that the southeastern brazilian and the ecuadorian populations can be distinguished one from the other as well as they can be differentiate from the described Anastrepha sp 1 and sp2. Although more studies are necessary with the two populations here described, the data suggest that they may represent two other biological entities in the "Anastrepha fraterculus complex" Index terms: fruit flies, chromosomes, eggshell, morphology

[2318] RESTORATION OF CIRCADIAN BEHAVIORAL RHYTHM OF DROSOPHILA DOUBLE-TIME MUTANTS BY GENE TRANFER

<u>M. Shimoda¹</u>, M. W. Young² & L. Saez², ¹Dept. of Insect Genetics, Inst. of Sericul. Entomol. Sci. Ohwashi1-2, Tsukuba, Ibaraki 305-8634, Japan; ²Lab. of Genetics, and NSF Science and Technology Center for Biological Timing, The Rockefeller Univ., 1230 York Avenue, New York, NY 10021, USA

double-time (dbt) is a casein kinase gene involved in cell survival and circadian rhythms in the fruitfly, *Drosophila melanogaster*. Mutant alleles of *dbt* shorten or lengthen the period of circadian rhythms and the null allele causes lethality during early development. The effect of the expression of *dbt* on the lethality and locomotor activity rhythm of *dbt* mutants were studied. Using a *gal4-UAS* gene expression system, *dbt* expression from the *armadillo* promoter averted lethality caused by the

strongly hypomorphic mutant dbt . Many rescued flies showed abnormal wing

revVIII angle and lost the flight activity. dbt flies carrying a full-length dbt transgene showed ~24 hrs locomotor activity rhythm, indicating that a functional Drosophila clock can be restored entirely in the null mutation through dbt expression. Furthermore, dbt over-expression never shortened the locomotor rhythm of both dbt mutants and wild-type fly below the normal period (~24hrs), indicating that the DBT activity was saturated in wild-type flies. The ability of the kinase domain of dbt and the mammalian homologue of dbt, casein kinase I epsilon (hckle), to rescue the lethality and locomotor activity rhythm caused by dbt mutant was also tested. Under the same condition in which full length dbt rescued the null allele, neither the kinase domain of dbt nor the heterologous kinase could rescue the dbt mutant phenotype. These observations suggest that CKIe can not replace dbt activity in flies and that the C-terminal region of dbt appears to be indispensable for their regulatory activity. Index terms: circadian clock, locomotor activity, casein kinase I, dbt [2319] BIOCHEMICAL CHARACTERIZATION AND GENOMIC ORGANIZATION OF H. CUNEA LECTIN

<u>S. W. Shin</u>, D. S. Park & H.-Y. Park, Insect Resources Laboratory, Korea Research Institute of Bioscience and Biotechnology, 52 Eoun-dong, Yusong, Taejon, 305-600, Korea, E-mail hypark@mail.kribb.re.kr.

We previously identified a novel lectin cDNA from the fall webworm (Shin et al., 1998), which encodes two carbohydrate recognition domains (CRD-N and CRD-C) and is up-regulated following bacterial challenge. The lipopolysaccharide binding activities of the recombinant CRD-N and CRD-C (rCRD-N and rCRD-C) were investigated by enzyme-linked immunosorbent assay. The lipopolysaccharide binding of rCRD-N and rCRD-C was pH-dependent: at pH below 6.0, they show higher binding ability to lipopolysaccharide. The binding of the recombinant CRD-N was inhibited by both D-mannose and N-acetyl-D-glucosamine, whereas the binding of both rCRD-C was inhibited only by D-mannose. The binding of both rCRD-C was inhibited only by D-mannose. The binding of both rCRD-N and rCRD-C to *E. coli* was mainly mediated through the O-specific chain. The result of Southern analysis suggested the existence of several genes similar to *H. cunea* lectin in the genome. Several different genonic clones of H. cunea lectin were isolated and sequenced. The characteristics of these clones will be discussed. Index terms: carbohydrate recognition domain, CRD-N, CRD-C

[2320] CYTOGENETICS OF SOME SPECIES OF PARASITIC WASPS OF THE FAMILIES PTEROMALIDAE AND EULOPHIDAE

J. C. Silva-Junior¹, S. G. Pompolo¹ & L. A. O. Campos¹, ¹ Depto. de Biologia Geral, Universidade Federal de Viçosa - UFV, 36571-000. Viçosa - MG, Brasil. Email: juvenaljr@bol.com.br

The parasitoid insects are organisms that develop on or inside a host that represents the food source necessary to complete their development and represent a intermediary life style between predators and parasites. Several cytogenetic studies of parasitic wasps have been performed on the last years. However, a few of them provide information about localization of constitutive heterochromatin regions or NORs. The aim of this work was to characterize cytogenetically five species of Eulophidae (Emersonella sp., Palmistichus eloeisis, Melittobia hawaiiensis, Melittobia australica e Trichospilus diatraeae) and two species of Pteromalidae (Spalangia endius and Muscidifurax uniraptor), determining the number and the morphology of the chromosomes, distribution of constitutive heterochromatin, NOR-bands and localization of AT- or CG-rich regions. Data were obtained using techniques of standard staining, C-band, NOR-band and the fluorochromes DAPI/CMA3. From the total species of Eulophidae, four showed 2n=12 chromosomes. The only exception was T. diatracae with 2n=14 chromosomes. Among the Pteromalidae, M. uniraptor showed 2n=10 and S. endius, 2n=12. C-banding data demonstrated that the majority of species showed small heterochromatics blocks randomly dispersed in the chromosomes. The only exception was S. endius which showed a distinct pattern of pericentromeric heterochromatic blocks. In all species, NORs were only found in one chromosome pair and two regions in the interphasic nucleus. The results obtained with fluorochromes pointed small DAPI bands in P. eloeisis and CMA₃ in M. hawaiiensis. In M. hawaiiensis there was a correspondence between NOR and CMA3 bands. S. endius showed coincident bands of DAPI, CMA3 and C-band. The results obtained with giernsa pointed a great uniformity of size, type of chromosome and number of karyotypes in all studied species. Considering the modal theory of karyotype evolution, we could propose that Eulophidae present six as a modal number, so the chromosomic number 2n=14 observed in T. diatraeae could be resulted of a fission in a metacentric pair in the ancestral karyotype, resulting in two new acrocentric pairs. In the Pteromalidae the modal number is five, so the karyotype of S. endius could be resulted of a centric fission in a metacentric pair. Index terms: chromosomes, karyotype evolution, hymenoptera, parasitoid

[2321] THE 4-KDA PROTEASE INHIBITOR FAMILY IN THE DESERT LOCUST SCHISTOCERCA GREGARIA: MOLECULAR CLONING AND ANALYSIS OF TISSUE- AND STAGE-DEPENDENT EXPRESSION

G. Simonet, I. Claeys, R. Maes, T. Janssen, A. De Loof & <u>J. Vanden Broeck</u> Lab. for Developmental Physiology and Molecular Biology, Zoological Institute K.U.Leuven, Naamsestraat 59, B-3000 Leuven, Belgium

Serine proteases and their corresponding inhibitors play a crucial role in the regulation of a large variety of physiological processes, such as food digestion, blood clotting, embryogenesis, tissue reorganization, defense mechanisms and immune responses. Based on their structural characteristics, serine protease inhibitors were initially classified in twelve distinct families (Laskowski and Kato, 1980). Recently, members of a novel peptide family (the 4-kDa protease inhibitor family) were discovered in invertebrates. Boigegrain et al. (1992) and Nakakura et al. (1992) independently reported the identification of two serine protease inhibitors (PMP-D2 and PMP-C) from the migratory locust, Locusta migratoria. Kromer et al. (1994) showed that both peptides were derived from a single precursor polypeptide. A third related peptide (HI) was identified by Kellenberger et al. (1995) and by means of NMR spectroscopy the solution structures of PMP-D₂ and PMP-C were analyzed (Mer et al. 1994, 1996). More recently, five additional members, designated as SGPI-1-5, were isolated (Hamdaoui et al., 1998) from another locust species, namely Schistocerca gregaria. Although they were initially isolated from the ovaries, further studies revealed the presence of these peptides in different tissues (fat body and gonads). In addition, the cDNAs encoding the precursors for SGPI-1-3 have been cloned and stage- and hormone-dependence of gene expression has been studied in different locust tissues (Vanden Broeck et al., 1998). Based on the available sequence data we have also determined the complete cDNA sequence of the precursors for SGPI-4 and SGPI-5. Interestingly, these two precursors contain three additional peptides that display significant sequence similarities to the other 4-kDa Furthermore, northern blot analysis revealed important tissue-dependent inhibitors. differences in the expression of both precursors.

Index terms: gene expression, ovary, peptide, serine protease

[2322] FROM GENE OF HONEYBEE (APIS MELLIFERA) TO MOLECULAR PROPERTIES AND FUNCTION OF MAJOR PROTEINS OF ROYAL JELLY

J. Simuth, B. Malecova, K. Bilikova, S. Albert, J. Klaudiny, J. Schmitzova & II. Lehrach, Laboratory for Genetic Engineering, Institute of Chemistry, Slovak Academy of Sciences, Dubravska 9, SK-842 38 Bratislava, Slovak Republic; ¹Max-Planck-Institute for Molecular Genetics, Ihnestrasse 72, D-14195 Berlin, Germany

We started a targeted study of RJ proteins at molecular level by characterisation of the main RJ protein, designated as MRJP1 (1). Sequential characterisation of the MRJP1 gene and its regulation region by the methods used in mapping of human genome showed that it was composed from 5 introns and 6 exons. It was found (2) that MRJP1 was expressed in the brain of an adult honeybee at the sites where the learning and memory centres are located. The MRJP1 was characterised as a member of protein family of major proteins of RJ (MRJP1, MRJP2, MRJP3, MRJP4, MRJP5) represent about 82% of total protein of RJ (3). The obtained sequential data of MRJP3s showed that their C-terminal fragment is composed of multiple, repeating five-membered sequential repeat XQNXX. With this finding is connected also the polymorphous nature of MRJP3s found by DNA analysis of individual honeybees using PCR (4). Also MRJP5 posses repeat region containing 58 repeats of DRF motif (5). This length polymorphism at the level of the nutritional proteins brings a new view on qualitative evaluation of RJ as a substance composed of secretions of various honeybees with different genetical background. It points also to genetical determination of variability in a honeybee colony from the point of view of production of RJ proteins and larval nutrition by individual honeybees. The MRJP family is related to yellow proteins of D. mellanogaster and has no relatives in other non-insect metazoan species. One characteristic feature of RJPs, apparently absent in the Yellow proteins is the presence of repetitive region at their C-terminal (5). The bioactivity of RJ-proteins is not fully evaluated. We prepared these proteins in recombined forms for studies of their structures and their testing as ingredients of larval diet and functional food.

[2323] THE USE OF PHENOBARBITAL IN STUDIES OF *AEDES AEGYPTI* RESISTANCE TO INSECTICIDES

R. C. Sousa & H. E. M. C. Bicudo, IBILCE/UNESP. Rua Cristóvão Colombo, 2265, CEP. 15054-000, São José do Rio Preto-SP-Brasil.

Increased detoxification for resistance to organophosphorous (OP) insecticides has been described in some insects. In Culex pipiens such a mechanism results from overproduction of esterase-A and -B due to gene amplification. A-esterases are organophosphate hydrolyzing serine containing enzymes, such as carboxylesterase, that also inactivates organophosphates. They protect cholinesterases by binding Ops themselves. Phenobarbital (PB) is considered an enzyme inductor able to lower organophosphorous toxicity. Pretreatment with phenobarbital increased the LD₅₀values of several organophosphorous insecticides by 1 to 12 fold for rats and by 1 to 3-fold for mice. PB increased carboxylesterase activity in serum and liver of mice by about 50% and possibly the same amount of plasma cholinesterase activities. The mentioned results suggested the present study on PB effects in changes of esterase patterns of Aedes aegypti, followed by the study of its effect on resistance increase. Two kinds of treatment were performed: (1) a continuous treatment in which Aedes aegypti eggs were put to eclode in 0.10% PB and remained in that medium till adult stage and (2) a descontinuous treatment in which larvae, pupae and adults were treated during 30 hours in medium containing 0.15% of PB before freezing. The frozen fourth instar larvae, pupae and adults were individually used for sample preparations analyzed in polyacrilamyde gels. Esterase activity was visualized in gels by using the α and β naphtyl acetates as substrates. Gels from individuals submitted to continuous and descontinuous treatments compared to the controls showed activity increase or decrease of different bands. These changes of pattern were indicated by the staining degree and thickness of the bands and were supported by profile graphs obtained using an image analysis program. The use of inhibitors in gel preparations allowed to classify biochemically the esterase bands, indicating that the band that exhibited the greatest degree of activity increase is a cholinesterase and the two bands that showed activity decrease are carboxylesterases. As mentioned, cholinesterases as also carboxylesterases are involved in resistance and thus the results already obtained are very promising for the continuing studies. (FAPESP) Index terms: esterases, disease vector, population control

[2324] SEX-SPECIFIC ALTERNATIVE SPLICING OF THE LEPIDOPTERAN HOMOLOGS OF THE DROSOPHILA MELANOGASTER SEX DETERMINING GENE DOUBLESEX

M. G. Suzuki¹, F. Ohbayashi¹, T. Kamiya¹, K. Mita², Y. Koike^{1,2} & T. Shimada¹, ¹Dept. of Agricultural and Environmental Biology, Univ. of Tokyo, Yayoi, Bunkyoku, Tokyo 113-8657, Japan, E-mail gakyo@ss.ab.a.u-tokyo.ac.jp; ²Natl. Inst. of Radiological Science, Anagawa 4-9-1, Inage-ku, Chiba City, Chiba 263-8555, Japan.

A homologue of the bifunctional sex-determining gene, doublesex (dsx), has been identified in the silkworm, Bombyx mori, and has been found to be expressed in a sex-specific manner. We revealed that this homologue, Bmdsx, was transcribed to produce a common primary transcript that is alternatively spliced to yield male- and female specific mRNAs. These sex-specific mRNAs shared a common 5' end. Unlike the dsx gene, sex-specific exon was only one (exon 3, female-specific), and the remaining exons were shared between both sexes. However, in female, the exon 4 was transcribed as a 3' UTR because female-specific stop codon was found in the exon 3, resulting that the amino acid sequence encoded by the exon 4 was malespecific while this exon was transcribed in both sexes. Thus, sex-specific mRNAs encoded polypeptides with a common amino-terminal sequence but sex-specific carboxyl termini. The female-specific acceptor, which is a weak acceptor in dsx, was appeared to be a normal acceptor in Bmdsx because that had the same number of pyrimidines in comparison with the other splice acceptor sites in Bmdsx. This suggests that a splicing enhancer like TRA and TRA-2, which activates a weak dsx female-specific acceptor to promote processing of the dsx pre-mRNA into the femalespecific form, is not required to induce female-specific splicing of Bmdsx pre-mRNA. This idea was supported by the fact that no TRA/TRA-2 binding site could be identified in the female-specific exon of the Bmdsx gene. These results suggest that the sex-specific alternative splicing of the Bmdsx pre-mRNA is regulated by the different mechanisms from those observed in the case of the dsx gene. The dsx homologous genes were also found in the other lepidopteran insects, Bombyx mandarina, Antheraea pernyi, Samia cynthia ricini, and were appeared to be expressed in a sex-specific manner. The level of identity of the sex-specific DSX proteins of these insects with D. melanogaster DSX proteins, across the region corresponding to the DNA binding domain and the oligomerization domain, is greater than 50%. These results suggest the possibility that the dsx homologue in lepidopteran insects would also be transcribed into sex-specific mRNA isoforms and regulate sexual differentiation like the Drosophila dsx gene.

Index terms: Bombyx mori, doublesex, sex determination, alternative splicing, antibody

[2325] COSTS AND BENEFITS OF MULTIPLE MATING IN A BEETLE

T. J. B. Taylor¹ & R. H. Smith², ¹²Univ. of Leicester, Univ. Road, Leicester, UK, LEI 7RH. E-mail: tjt3@le.ac.uk

Two geographical strains of Callosobruchus maculatus beetles with contrasting life histories were compared. Female Callosobruchus maculatus beetles were manipulated to experience four different mating treatments. Multiple mating in the Brazil strain increased fecundity but decreased longevity of females. Multiple mating by parents also reduced the longevity of their singly mated offspring. In contrast, multiple mating in the South India strain had no effect on longevity or fecundity of female parents or their singly mated offspring. These differences are interpreted in relation to the trade-off between longevity and fecundity in the two strains. Index terms: Callosobruchus maculatus, fecundity, longevity.

[2326] MOLECULAR PHYLOGENETIC INSIGHTS INTO THE ORIGIN OF TERMITE WORKERS

G.J. Thompson¹, O. Kitade², N. Lo³ & R.II. Crozier¹, ¹School of Tropical Biology, James Cook Univ.Townsville, QLD Australia 4811; ²Faculty of Science, Ibaraki Univ. 2-1-1 Bunkyo, Mito, Ibaraki, 310-8512 Japan; ³Department of Biochemistry, Univ. of Sydney, NSW Australia 2006.

Phylogenetic analysis based on sequence variation in mitochondrial large-subunit rRNA and COII genes was used to investigate the evolutionary relationships among termite families. Maximum likelihood and parsimony analyses of a combined nucleotide data set yielded a single well-supported topology, which is: (((((Termitidae, Rhinotermitidae), Serritermitidae), Kalotermitidae), (Hodotermitidae, Termopsidae)), Mastotermitidae). While some aspects of this topology are consistent with previous schemes, overall it differs from any published. Optimization of 'true' workers onto the tree suggests that this caste originated once, early in the history of the lineage and has been lost secondarily twice. This scenario differs from the more widely accepted notion that workers are derived and of polyphyletic origin, and that extant pseudergates, or 'false' workers, are their developmentally unspecialized ancestor caste. We found that worker gains and losses co-vary directly in number and direction with shifts in 'ecological life type'. A phylogenetically-corrected test for correlated evolution indicates that this pattern is of biological significance and suggests that the variable occurrence of a worker caste in termites has ecological determinants, apparently linked to differences in feeding and nesting habits. Isoptera, mitochondrial-DNA, social-evolution, concentrated-changes-test

[3227] LIFE CYCLE, MORPHOLOGICAL AND GENETIC VARIATION IN CLONES OF MYZUS PERSICAE (HOMOPTERA: APHIDIDAE)

J. A. Tsitsipis¹, J. T. Margaritopoulos¹, R. L. Blackman³, L. Sannino⁴, K. Zitoudi¹, T. E. Kephalogianni¹, Z. Mamuris² & S. Goudoudaki¹, ¹Lab. of Entomology and Agricultural Zoology, ³Lab. of Biology and Chemistry, Univ. of Thessaly, P. O. Box 38334, Pedion Areos, Volos, Greece, E-mail tsitsipi@mail.uth.gr, ³The Natural History Museum, Cromwell Road, London SW7 5BD, UK, ⁴Istit. Sperimentale per il Tabacco, Biology Central Section, P. O. Box 84018, Via Vitiello 66, Scafati, Italy.

During years 1995-1999 life cycle variation of 2,774 Myzus persicae clones, collected from primary and various secondary hosts from different regions of Greece and Southern Italy (Caserta) was studied. Morphological and genetic variation of 166 and 95 clones respectively was examined using canonical variate analysis and random amplified polymorphic DNA (RAPD) analysis. Four life cycle categories were found: holocyclic, androcyclic, anholocyclic and intermediates. Ninety four % of peach originating clones were holocyclic. In peach-growing regions of Greece proportion of holocyclic clones was above 40% reaching up to 100%. Further south proportion of holocyclic clones was above 40% reaching up to 100% reaching the form of holocyclic sound in Greece and Caserta (near Naples), where peach is not common, holocyclic clones ranged between 0 and 30%. Fifty seven % of examined anholocyclic clones produced males under short day conditions. Intermediate clones were sampled from all host-plants but at low frequencies (3.4% of total examined clones or 6.5% of non-holocyclic clones). Red clones were predominant in regions where aphids overwinter parthenogeneticaly on weeds or winter crops. However, almost all clones from primary host were green. Scores of first two canonical variates generally separated tobacco-feeding clones from those of other secondary host-plants. In tobacco areas tobacco-feeding form predominated on peach in spring populations and was sometimes found on other secondary hosts. By cluster analysis tobacco clones from Caserta showed a relatively large phenotypic distance from Greek clones. Clonal phenotypes were affected both by host plant on which clones were reared and by long-term parthenogenetic rearing. In spite of these effects, tobacco form was distinguishable from aphids originating from other hosts. Despite genetic variability found between samples no specific RAPD marker was detected discriminating the different populations. Aphids from peach and pepper, collected far from tobacco regions, showed a genetic divergence from the tobacco-feeding clones. Holocyclic clones from tobacco showed higher level of estimated heterozygosity than anholocyclic (anholocyclic, androcyclic, intermediate) ones.-Observed genetic variation could be associated with different colour of examined clones, since most of anholocyclic clones were red and almost all of holocyclic ones green. Index terms: Myzus persicae, tobacco, peach

[2328] A POPULATION GENETIC COMPARISON OF ISOLATED POPULATIONS OF THE PHYTOPHAGOUS FOREST BEE PHYLLOTRETA TETRASTIGMA (COLEOPTERA: CHRYSOMELIDAE) BEETLE

P. Verdyck^{1,2} & K. Desender¹, ¹Dept. Entomology, RBINSc, Vautierstr. 29, B-1000 Brussels, Belgium, E-mail: verdyck@kbinirsnb.be; ²Dept. of Biology, Univ. of Antwerp, RUCA, Groenenborgerlaan 171, B-2020 Antwerpen.

In Flanders the remaining natural habitats are very fragmented, and this is especially the case for forests. For nature conservation purposes we studied several woodland beetle species. As most of these species are poor dispersers, fragmentation can easily lead to genetic differentiation. Also reduction of habitat can lead to reduction in population size and loss of genetic variation. Here we focus on the relatively rare cruciferous flea beetle Phyllotreta tetrastigma, a species which is restricted to very wet forests, as both larvae and adults only live on the plants Cardamine amara and C. flexuosa. In total 1080 individuals from twelve localities were studied genetically by means of cellulose acetate gel electrophoresis. For several of these localities populations from different years were analysed. Genetic variability was detected at five loci (PGM-1, AAT-1, IDH-1, ME-3 and PEP-Z). All populations were in Hardy-Weinberg equilibrium at all loci. There is no linkage between the different loci. No genetic differences were detected between populations from the same locality but from different years. Although not significant there is a tendency towards more genetic diversity in larger populations. There is significant genetic differentiation between localities, but there is no geographical pattern, probably meaning that even populations that are relatively close to each other are already genetically isolated and differentiated.

Index terms: flea beetle, nature conservation, allozyme electrophoresis.

[2329] GENETIC PATTERNS IN PHYTOPHAGOUS BEETLES OF THE GALÁPAGOS ARCHIPELAGO

P. Verdyck^{1,2}, K. Desender¹ & Dhuyvetter, II.^{2, 1} Dept. Entomology, RBINSc, Vautierstr. 29, B-1000 Brussels, Belgium, E-mail: verdyck@kbinirsnb.be; ² Dept. of Biology, Univ. of Antwerp, RUCA, Groenenborgerlaan 171, B-2020 Antwerpen

The Galápagos islands lie in the Pacific Ocean about 1000 km from the South American coast and straddling the Equator. There are 13 large volcanic islands, 6 smaller ones and 107 islets and rocks, with a total land area of about 8000 square kilometes. 97% of their land area was designated national park, and the islands are also recognised internationally as a Man and the Biosphere Reserve and a Unesco World Heritage Site. The Galápagos are also known as a living laboratory for the study of evolution because they are home to many examples of radiated endemic groups (e.g. Darwin finches, giant tortoises, mockingbirds, Opuntia cacti, Lava lizards). Also the most biodiverse group of organisms, the insects, show several cases of radiated genera, but these have been studied to a much lesser extent. Here we compare results of population genetic and evolutionary studies on a variety of phytophagous beetle genera from the families Chrysomelidae, Oedemeridae and Curculionidae, and with special emphasis on the flea beetles beetles (Alticinae, Chrysomelidae). The techniques used are allozyme electrophoresis, RAPD's and mtDNA sequencing. One of the more striking results is the detection of a metapopulation structure with recurrent extinctions and recolonisations in the endemic chrysomelid beetle Nesaecrepida darwini.

Index terms: Coleoptera, population genetics, evolution, islands

[2330] A MOLECULAR PHYLOGENY OF COLEOPTERA FROM 18S rRNA SEQUENCES

A. P. Vogler^{1,2}, V. L. Shull¹, L Ribera^{1,2}, M. S. Caterino¹ & P. M. Hammond¹, ¹Department of Entomology, The Natural History Museum, Cromwell Road, London, SW7 5BD, ²Department of Biology, Imperial College at Silwood Park, Ascot, Berks SL5 7PY, UK

The Colcoptera (beetles) are traditionally separated into four suborders (Adephaga, Polyphaga, Myxophaga, Archestomata), of which the largest, Polyphaga, is further subdivided into five Series containing the nearly 150 families of the suborder. No formal phylogenetic analysis for the entirety of the coleopteran relationships has been attempted, mostly due to the lack of a consistent character set applicable to all major groups. We used full-length 18S ribosomal RNA sequences to infer relationships of major groups within the Coleoptera. A thorough taxon sampling included exemplar taxa for all suborders and superfamilies, including nearly all families and numerous of the larger subfamilies. In total, some 500 sequences were generated, of which approximately half were selected for formal cladistic analysis. Those excluded mostly exhibited extreme length variation in the expansions segments of the molecule, and/or they were highly divergent from their relatives. The main results support the monophyly of the two large suborders Adephaga and Polyphaga, they support a major split of the terrestrial Geadephaga and aquatic Hydradephaga, and polyphagan relationships broadly agree with accepted ideas. Both the Staphyliniformia and Cucujiformia are recovered as monophyletic. The monophyly of the remaining Series, however, appears questionable. The Elateriformia in particular, appears to be a polyphyletic mix of very basal (Scirtoidea) and derived lineages.

Index: sequence alignment; expansion segments; species richness; rate variation; cladistics.

[2331] THE EVOLUTION OF HOST PLANT USE IN MELITAEINE BUTTERFLIES: A PHYLOGENETIC ANALYSIS

<u>N. Wahlberg¹</u>. ¹Metapopulation Research Group, Dept. of Ecology and Systematics, Div. of Population Biology, FIN-00014 University of Helsinki, Finland, E-mail niklas.wahlberg@helsinki.fi

Plant chemistry is a major determinant of host plant use in phytophagous insects, often dictating the availability of possible host plants. I have investigated the evolutionary history of host plant use in Melitaeini butterflies (Lepidoptera: Nymphalidae). There are four species genera in the melitaeines, with a total of about 250 species. Many species are mono- or oligophagous on species of plant belonging to twelve families of plants. Of these Antirrhinaceae, Orobanchaceae, Acanthaceae and Asteraceae are the most important. Eleven of the plant families utilized by melitaeines contain iridoid compounds, on which many of the butterflies apparently specialize. Plant species in Asteraceae do not contain iridoids. Using a molecular phylogeny of 64 species, I have attempted to elucidate the patterns of evolution of host plant family use in the melitaeines and then studied the effect of host plant chemistry on this pattern. My results show that host plant chemistry has been the driving force behind the evolution of host plant utilization in the melitaeines. There have been possibly five independent colonizations of Asteraceae, the only major host plant anily without tridoids.

Index terms: Euphydryas, Chlosyne, Phyciodes, Melitaea, plant-insect interactions

[2332] OCCURRENCE OF TWO DELTA-ENDOTOXIN GENES, THE CRY9DA AND A NOVEL ALLIED GENE, IN JAPANESE BACILLUS THURINGIENSIS ENVIRONMENTAL ISOLATES THAT PRODUCE SPHERICAL PARASPORAL INCLUSIONS WITH LEPIDOPTERA-SPECIFIC TOXICITY

N. Wasano¹, M. Ohba¹ & K. Miyamoto², ¹Division of Biorescurce and Bioenvironmental Sciences, Graduate School, Kyushu University, Fukuoka 812-8581, Japan, E-mail wasano@grt.kyushu-u.ac.jp; ²National Institute of Sericultural and Entomological Science, Tsukuba, 305-0851, Japan

Six Lepidoptera-specific Bacillus thuringiensis isolates, that belong to the four H serovars (sotto, fukuokaensis, canadensis, and galleriae) and produce spherical parasporal inclusions, were examined for assignment of the classes of the deltaendotoxin genes. Gene analysis was conducted by PCR technique using primers designed to probe the genes cry9Ca and cry9Da. The data revealed that the deltaendotoxin of the serovar canadensis isolate is encoded by the gene cry9Da, while those of the five other strains are encoded by an undescribed delta-endotoxin gene. DNA fragments from the five strains had an identical 1917-bp nucleotide sequence, covering the four conserved regions and a partial sequence of the block 5 region. The deduced amino acid sequence exibited a 70.6% homology to that of the corresponding region of the Cry9Ea delta-endotoxin protein active on the order Lepidoptera, and a 63.1% homology to the Cry9Ca protein highly toxic to the noctuid The results showed that Japanese isolates of B. thuringiensis lepidopterans. producing spherical parasporal inclusions with Lepidoptera-specific activity are categorized into two groups; one produces the class Cry9Da protein and the another a novel delta-endotoxin allied to the class Cry9. It also appeared that heterogeneous multiple H serovars are involved in each group.

Index terms: Novel cry gene, the class cry9, Lepidoptera specificity.

[2333] GENE EXPRESSION AND THE EVOLUTION OF INSECT POLYPHENISMS: INTRODUCTION

<u>D.E. Wheeler</u>¹, J.D. Evans², ¹Dept. of Entomology, Univ. of Arizona, Tucson, AZ 85721-0036, USA, E-mail: dewsants@ag.arizona.edu; ²Bee Research Lab, USDA-ARS BARC-E, Bldg. 476 Beltsville, MD 20705 E-mail: jevans@astr.arsusda.gov

Insects seem to have a special evolvability in regard to plasticities and polyphenisms. In many species, environmental variation during larval development leads to a continuum of variation in one or a few morphological traits. In polyphenic taxa, distinct sets of characters respond together, producing more profound differences between forms. Recent advances in molecular genetics, and their successful transfer from model to outlaw systems, portend rapid progress in understanding the developmental basis of a diversity of insect polyphenisms. Questions that can now be addressed include (1) the functional and evolutionary relationship between reactions norms and polyphenisms, (2) the developmental relationships between multiple morphs in complex systems such as aphids, (3) the relationship between mechanisms mediating allelic and polyphenic differences among the same characters, and (4) the role of hormones in coordinating the expression of alternative polyphenisms. Success of molecular genetics tools in tackling polyphenisms will have no greater impact than in our understanding of social insects. Previous studies aimed at the mechanisms behind social insect polyphenisms were slowed by the fact that no social insect species have been developed into a model genetic system. This barrier has fallen on several counts. First, new techniques for isolating differentially expressed genes, including cDNA subtraction and differential-display techniques, are being used to screen social insect genomes for genes involved with both regulatory and downstream steps on the route toward polyphenisms. Second, genome-wide studies of expression in other insects, including *Drosophila*, provide a rich source of potential homologues that can be screened in social insects. As one example, juvenile hormone-responsive genes isolated from Drosophila might be involved in similar ways in reproductive caste determination and development in social insects. Further, gene-expression studies of metamorphosis and other major developmental events in Drosophila will almost certainly clarify processes important for the evolution of phenotypic variation in polyphenic species. Finally, the honey bee, Apis mellifera, has emerged as a bona fide genetic organism, thanks to a fairly complete physical map, available DNA and cDNA gridded libraries, and an abundance of data on the genetic components of behavior and physiology. While this system lacks attributes that will push it into the realm of established genetic systems, including a demonstration of transgenesis or a viable tissue-culture protocol, honey bees show traits such as male haploidy and an efficient method for artificial insemination that make them unique among insects for studies of genetic mechanisms.

[2334] WEAK EXPRESSION OF EGFP IN TRANSGENIC AEDES AEGYPTI AND STOMOXYS CALCITRANS DESPITE THE PRESENCE OF MULTIPLE COPIES OF THE TRANSGENE

R.Wilson¹, M. J. Lehane², P. W. Atkinson³ & D. A. O'Brochts¹, ¹Center for Agricul. Biotech., Plant Sci. Bldg., Univ. of Maryland, MD 20742, USA. ²School of Biol. Sci., Univ. of Wales, Bangor, Gwynedd, LL57 2DG, UK. ³Dept. of Entomology, Univ. California, Riverside, CA 92521, USA.

Transgenic Aedes aegypti and Stomoxys calcitrans were created by embyonic injection of Hermes elements containing the EGFP gene, under the control of the actin5C promoter. Transgenic lines were identified by the presence of expressed EGFP in the G₁ progeny. All of the lines identified, one in Aedes and four in Stomoxys, exhibited an unexpectedly weak expression of EGFP. In the Stomoxys inset the expression of EGFP was limited to a few distinct, small spots of fluorescence, while the Aedes line EGFP expression was only visible in the pupae as a very weak, diffuse glow throughout the head and thoracic regions. No EGFP-specific fluorescence was detectable in either the larvae or adults of Aedes. All of the lines were shown to be transgenic by both PCR and Southern blot analysis of genomic DNA, and each contained at least two copies of the Hermes element. These results suggest that the actin5C promoter might not be ideal for use as a promoter for transgenic markers in these species.

Index terms: Hennes, mosquito, Stable fly.

Symposium and Poster Session

[2335] EVOLUTIONARY TRENDS ON MALE GENITAL STRUCTURES OF CHALCOSIINAE (LEPIDOPTERA: ZYGAENIDAE)

S. II. Yen¹, D. L. Quicke^{1, 2}, & G. S. Robinson², ¹Dept. of Biology, Imperial College at Silwood Park, Ascot, Berkshire, SL5 7PY UK, E-mail s.yen@ic.ac.uk; ²Dept. of Entomology, British Museum (Natural History), Cromwell Rd., SW4 5BD, London, UK.

The evolutionary trends of male genital structures with the associated 8th abdominal segments of Chalcosiinae (Zygaenidae) are examined. In our preferred cladogram, two major lineages are recognized. The first lineage, comprising of Agalopini + Aglaopini + Cyclosiini + Heteropanini assemblage, has typical lepidopterous genital and abdominal structures without any modification. However, the second lineage, comprising of Chalcosiini sensu lato, has the valva (=clasper) and uncus greatly reduced or rudimentary and morphologically and functionally replaced by the 8th tergite and sternite. A complicated structure formed by fusion of an extension of the tegumen, interior apodemes and juxta is newly recognized in Chalcosiinae sensu lato. The homology of sclerites of the male genitalia, the possible sister-group, the monophyly, tribe and genus-level systematics of this subfamily are also discussed.

[2336] DENTIFICATION AND CHARACTERIZATION OF THE KS-1 GENE, WHICH IS EXPRESSED PREFERENTIALLY IN THE SMALL TYPE-KENYON CELLS OF THE HONEYBEE BRAIN.

D. Yoshino¹, M. Sawata¹, H. Takeuchi¹, A. Kamikouchi¹, K. Sekimizu¹, S. Natori² & <u>T. Kubo</u>^{1, 1}Grad. Sch. Pharm.Sci., Univ. Tokyo, Bunkyo-ku, Tokyo, 113-0033 Japan; and ²Natori Special Lab. RIKEN, Wako-shi, Saitama, 351-0198, Japan

The honeybee Apis mellifera L. is a social insect, and various exquisite social behaviors are performed by their colony members. To analyze the molecular basis of their social behaviors, we have searched for genes that are expressed selectively in the mushroom bodies, putative sensory integration centers of the honeybee brain. The honeybee mushroom bodies consist of two types of intrinsic neurons, large and small-types of Kenyon cells. By the differential display method, we first identified a gene (Ks-1) which was expressed selectively in the small type-Kenyon cells of the mushroom bodies. Possibly, the function of the Ks-1 gene product is specifically needed for the small type-Kenyon cells. To determine the nucleotide sequence of the full length Ks-1 cDNA, we performed cDNA walking and identified a consensus Ks-1 cDNA sequences of 17.3kbp in length. We also isolated a genomic clone and identified a putative transcription initiation site of the Ks-1 gene by the primer extension method. Unexpectedly, many termination codons appeared all over the nucleotide sequence of the Ks-1 cDNA and no ORF longer than 300bp was contained in the sequence, suggesting that the Ks-1 transcript encodes no proteins and functions as an untranslated RNA. The analysis of the biological function of the Ks-1 transcript would be an important cue to understand the molecular basis of the division of the function of the Ks-1 transcript encodes no proteins and functions.

Index, Social insect, Apis mellifera L., Mushroom body, Differential Display, cDNA

[2337] TRACKING AUSTRALIAN FRUIT FLIES USING MICROSATELLITES

H. Yu¹, M. Frommer¹, <u>M.K. Robson¹</u>, B. Dominiak², A. Meats¹ & J.A. Sved¹, ¹ Fruit Fly Research Centre, School of Biological Sciences A12, The University of Sydney. 2006. AUSTRALIA¹² New South Wales Department of Agriculture, Locked Bag 21, Orange 2800. AUSTRALIA.

Microsatellites are variable repeated segments of DNA that are proving extremely useful in population analoyses. A six year survey of endemic regions of the major Australian fruit fly pest, *Bactrocera tryoni*, using microsatellites will be presented. The results indicate a surprising stability over time for the sub-regions of this fly. The major export fruit growing area of mainland Australia is within the Fruit Fly Exclusion Zone (FFEZ). This is an area of 180,000 square kilometres covering the borders of three states, New South Wales, Victoria and South Australia, and its management is covered by the 'TriState Agreement'. Any infestation occurring within the FFEZ results in suspension of exports from crops within a 30-80 km radius (and a lesser radius for domestic markets). In the past 3-4 years, exceptionally mild and wet weather has been associated with many severe breaches of the zone. The identification by the Fruit Fly Research Centre of characteristic patterns of microsatellites in the DNA of fruit flies trapped by the New South Wales Department of Agriculture has provided strong evidence that: (a) fruit flies causing infestation within the FFEZ come from the small towns surrounding the zone. (b) fly populations in these towns are distinct and do not receive a substantial number of immigrants from capital cities or the coast. This research by the Fruit Fly Research Centre has been supported by Woldworths Supermarkets through the Horticultural Research & Development Corporation.

Index terms: Bactrocera tryoni, fruit fly, population analysis, microsatellite

ABSTRACT BOOK I - XXI-International Congress of Entomology, Brazil, August 20-26, 2000

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