SHIFT

Project ENV 52

Soil Fauna and Litter decomposition in Primary and Secondary Forests and a Mixed Culture System in Amazonia

BMBF No. 0339675
CNPq Process No. 690007/96-5

Staatliches Museum für Naturkunde Karlsruhe (SMNK)
Empresa Brasileira de Pesquisa Agropecuaria - Centro de Pesquisa Agroflorestal da Amazônia Ocidental (Embrapa-CPAA), Manaus
Insituto Nacional de Pesquisas da Amazônia (INPA), Manaus
II. Zoological Institute of University of Göttingen
ECT Oekotoxikologie GmbH, Flörsheim

Annual Report 1997

D:\MyFiles\SHIFT\relatorios\ANUREP.97 for CNPq only text.wpd

Resumo

Os primeiros meses do ano foram dedicados a trabalho preparativo na Alemanha e no Brasil. Equipamento e material preparado para o transporte maritimo saiu de Karlsruhe no final de fevereiro e chegou em Manaus em junho. Laboratorios e escritórios em Manaus foram preparados entre maio e junho. Reuniões entre os membros brasileiros e alemães do projeto foram organizadas para discutir o arranjo final do desenho experimental. As áreas de estudo para a realização do programa central de coletas foram selecionadas e demarcadas. Equipamentos para medidas de longo prazo foram construídos e expostos nas áreas de coleta (coletores de liteira, medidores de temperatura e umidade).

Em julho terminamos a instalação - inesperadamente demorada e cara - do gerador e sistema no-break para manutenção do funcionamento do equipamento de extração e análise (extratores de fauna Berlese e Kempson, analisador de carbono/nitrogênio e analizador de dióxido de carbono IRGA) durante os muito frequentes black-outs de energia elétrica nos laboratórios da Embrapa em Manaus.

Em 23/24 de julho testamos com sucesso o programa comum "central" de coletas de macro- e mesofauna, oligochaeta e microflora, que inclui trabalho de campo e de laboratório. Estes dados são usados como a primeira data do programa central de coletas. Duas outras coletas centrais foram efetuadas conforme do cronograma em setembro e dezembro.

Em 27 de outubro a primeira série de sacos de liteira (litter bags) foi distribuída nas áreas de coleta, contendo folhas secas ao ar de *Vismia*, para avaliação de taxas de decomposição específicas dos locais. A retirada destes sacos de posições randomizadas iniciou-se 4 semanas depois e foi continuada até agora. Junto com os litter bags, uma série de barras de mini-containers foi distribuida no campo como um segundo método para determinar taxas de decomposição O sistema de mini-containers está sendo testado como alternativa aos litter bags. Um outro método de avaliação rápida, lâminas-iscas (bait lamina) que determina uma atividade geral não especificada da fauna de solo foi testado em julho; seu uso regular iniciou-se em dezembro. Neste relatório, primeiros dados são apresentados.

Abstract

The first months of the year were dedicated to preparatory work in Germany and in Brazil. The equipment and material prepared for the oversea transport left Karlsruhe at the end of February and arrived in Manaus in June. Laboratories and offices in Manaus were prepared from May to June. Meetings of Brazilian and German project members were organized to discuss the final set up of the study design. The study areas for the realization of the central sampling program were selected and marked. Long-term measuring devices were built and exposed in the study sites (litter-sampler, temperature and humidity-logger).

In July we finished the unexpectedly time- and cost-intensive installation of a generator and no-break system to maintain the functioning of extraction- and analyzing- equipment (Kempson and Berlese-extractors, C/N-analyzer and Infra-Red-Gasanalyzer IRGA) during the very frequent breakdowns of the power supply in the laboratory of the EMBRAPA institute.

On 23/24 July the joint "central" sampling program of macro- and mesofauna, oligochaeta and microflora which includes field and laboratory work was successfully tested. The data are used as the first sampling date of the central sampling program. Two other sampling events have been carried out on schedule in September and December.

On 27 October the first litterbag series with 1008 litterbags containing air-dried *Vismia*-litter to evaluate site-specific decomposition rates was distributed in the study sites. The retrieval of the bags from randomized positions started 4 weeks later and has gone on since then. Together with the litterbags a series of minicontainer bars was distributed in the field as a second method to measure decomposition rates. The minicontainer system is tested as an alternative to the litterbags. Another short-assessment method, bait lamina which measure general unspecified soil fauna feeding activity, was tested in July; its regular use started in December. In this report, first data are presented.

Introduction

Our project is embedded in the principal study design of all projects working in the same experimental area at EMBRAPA station in Manaus, all studying the regeneration and better use of former degraded areas, to diminish the human impact on primary rain forest in Amazonia.

Our basic hypothesis is that soil fauna and microflora communities are extremely important for the maintenance of functional nutrient cycles in the systems. We expect that biotic and abiotic factors may be manipulated to optimize the composition of the soil biota, to guarantee the efficient recycling of nutrients and their conservation in the system. Parameters like the quantity and quality of the litter produced in the systems, the decomposition rates, and the abundance, biomass and respiration of microorganisms and soil animals will be simultaneously and comparatively studied in primary and secondary forest and one of the mixed culture systems. The studied polyculture is a silvicultural plantation of four tree species, planted in rows, between which growth of secondary vegetation has been tolerated. Today, six years after initiating the plantation the silvicultural system is still in an early stage of development and the secondary vegetation between the tree rows clearly dominates the site (regarding plant cover and especially litter production).

Our aim is to obtain data on the specific contribution of the microflora and soil fauna to the decomposition of the organic matter, and on the importance of these processes for the nutrient supply to the plants. In particular, we will focus on studies on the interaction between microflora and soil fauna, an aspect that, up to now, has been poorly studied in the tropics.

Introduction

Our project is embedded in the principal study design of all projects working in the same experimental area at EMBRAPA station in Manaus, all studying the regeneration and better use of former degraded areas, to diminish the human impact on primary rain forest in Amazonia.

Our basic hypothesis is that soil fauna and microflora communities are extremely important for the maintenance of functional nutrient cycles in the systems. We expect that biotic and abiotic factors may be manipulated to optimize the composition of the soil biota, to guarantee the efficient recycling of nutrients and their conservation in the system. Parameters like the quantity and quality of the litter produced in the systems, the decomposition rates, and the abundance, biomass and respiration of microorganisms and soil animals will be simultaneously and comparatively studied in primary and secondary forest and one of the mixed culture systems. The studied polyculture is a silvicultural plantation of four tree species, planted in rows, between which growth of secondary vegetation has been tolerated. Today, six years after initiating the plantation the silvicultural system is still in an early stage of development and the secondary vegetation between the tree rows clearly dominates the site (regarding plant cover and especially litter production).

Our aim is to obtain data on the specific contribution of the microflora and soil fauna to the decomposition of the organic matter, and on the importance of these processes for the nutrient supply to the plants. In particular, we will focus on studies on the interaction between microflora and soil fauna, an aspect that, up to now, has been poorly studied in the tropics.

The research group

Prof. Dr. Ludwig Beck	SMNK	German project leader
Dr. Christopher Martius	SMNK	German project coordinator, termite studies, laboratory analyses, decomposition rates
Dr. Hubert Höfer	ZooGö	German project coordinator, macrofauna, predator impact, decomposition rates
Dr. Luadir Gasparotto	EMBRAPA-CPAA	Brazilian project coordinator
M.Sc. Marcos B. Garcia	EMBRAPA-CPAA	Brazilian project coordinator, macrofauna, ants
Dr. Bernhard Förster	ECT	IRGA-installation, respiration measures
Dr. Elizabeth Franklin	INPA	coordination of post-graduate activities, oribatid fauna, litterbag-experiment
Dr. Thierry Gasnier	University Manaus	cockroaches
Dr. Ana Harada	Museu Goeldi	ants
Dr. Flavio Luizão	INPA	litterbag-experiment, chemical analyses
Dr. Regina Luizão	INPA	microbial biomass, chemical analyses
Dr. José W. de Morais	INPA	wood litter stock
Dr. Elisiana Oliveira	INPA	collembolan fauna
Dr. Jörg Römbke	ECT	oligochaeta fauna
Dipl. Biol. Cäcilia Hanne	Uni Frankfurt	Termites, respiration of soil fauna
Dipl. Biol. Michael Meller [left the project in August]	SMNK Karlsruhe	Oligochaeta
M.Sc. Ricardo Ott	INPA	experimental study of predator impact
M.Sc. Edjuly M. Rísquez	INPA	experimental study of microbial biomass and decomposition
M.Sc. Maristela Farias	CNPq fellow	microbial biomass (IRGA)
Rosa Nubia V. de Moura	CNPq fellow	laboratory technician: C/N analyzer
Gessiene Do N. Pereira	SHIFT/Embrapa	laboratory technician, animal sorting, general lab work
Valdinez Montoia	SHIFT/Embrapa	laboratory technician, animal sorting, general lab work
Francisco Aragão	SHIFT/Embrapa	field and laboratory worker

Visiting scientists

Dr. Jörg Römbke, ECT GmbH, 26.5. - 23.6.97, 24.7. - 18.8.97

Dr. Bernhard Förster, ECT GmbH, 30.6. - 14.8.97

Dr. Ana Harada, Museu Goeldi, 24.12 - 30.12.97

M.Sc. Alexander Feijoo, CIAT, Programa de Laderas, Cali, Colombia, 27.11. - 4.12.97

Project activities in 1997

Overview

January - April	Purchase of project equipment and material in Germany (H. Höfer, C. Martius)
March/April	Organization of the transport of equipment by ship and airplane to Manaus (H. Höfer, C. Martius)
March	Training in C/N-analysis and technical services on the analyzer Vario EL (Firma Elementar in Hanau, C. Martius, H. Höfer)
Mai - June	Discussion of the final study and sampling design and selection of study sites (all project members)
June	Marking of the 4 sites (H. Höfer, M. Garcia and technicians)
May - July	Custom release of equipment from the transports in Manaus (M. Garcia)
June - July	installation of the laboratory at EMRAPA-CPAA in Manaus (M. Garcia, H. Höfer, M. Meller, C. Martius)
July	Field installation of permanent measuring devices; start of weekly litterfall sampling and monthly sampling of litter stocks (M. Garcia, H. Höfer, C. Martius)
July	Test of the bait lamina method (J. Römbke)
23./24. July	Successful test of the central sampling program for soil fauna and microbial biomass (all project members)
since July	Regular measures of soil respiration and microbial biomass with the IRGA (M. Farias, B. Förster)
	Extraction, sorting and identification of the soil fauna samples (resp. scientists and laboratory technicians)
since August	Start of special programs for termites (bait traps, respiration measures: C. Hanne, C. Martius) and ants (mapping of "ant gardens": M. Garcia)
9./10. September	Second regular sampling of the central sampling program and subsequent laboratory work (all project members)
October	Start of the first litterbag series with 1008 litterbags and 90 mini-containers for the measurement of decomposition rates (F. Luizão, E. Franklin, H. Höfer, C. Martius, M. Garcia, technicians)
November	Mapping of dead wood stocks in the study sites (J.W. de Morais)
	Start of an experimental study of increased litter quantity (Edejuly Rísquez, R. Luizão)
	Start of experiments on spider fauna (R.Ott)
2./3. Dezember	Third regular sampling of the central sampling program (all project members)
3-7 December	Bait lamina series (C.Martius, R.Ott)

(cf. Table 1: Overview of project activities and available data)

Basic study design

Study sites

We comparatively study soil fauna and litter decomposition in three different vegetation systems on sites within and close to the experimental 17-ha area of the Embrapa-CPAA at km 29 on the road Manaus-Itacoatiara:

- the polyculture system 4, a silvicultural plantation of four different tree species, planted in 1992, with secondary vegetation admitted between the tree rows;
- a secondary forest, growing since 1992 on the same ground as the whole experimental plantation, which formerly was an abandoned rubber tree monoculture;
- a primary forest, in close neighbourhood of the experimental plantation.

Within the experimental plantation of 17 ha, System 4 is laid out in 5 replications within the block design of the whole experiment. Preliminary studies (Presinger et al. 1994), however, have shown that two blocks strongly differ from the other three in important characteristics like vegetation cover, previous intensity of land use, water drainage.

Practical problems of the sampling design

The number of samples that can be taken at one time in our project is limited by the number of places in the extraction apparatus (e.g.; Berlese and Kempson extractors) and pricnipally by the time needed to sort and determine the collected animals. In view of the fact that few comprehensive studies of soil fauna in the tropics exist and that the high diversity and variability of tropical areas requires a large number of samples to be taken at each time, we decided to collect large numbers of samples instead of sampling many replicates of the systems. Also, several subsites in a highly diverse primary rain forest would hardly represent realistic replicates of a "treatment" and replicates of System 4 were not available in sufficient number (see above). Therefore, a generalization of the conclusions of our data will not be based on a statistical evaluation of the treatment effect, but rather on quantitative modelling of all soil fauna parameters of three systems based on reliable means (high sample numbers) and a good functional knowledge of the links.

The single plantation sites are rather limited in size (32 x 48 meters) and the litter layer in the rows (in fact, paths) below the planted trees is strongly disturbed. Consequently, the area necessary to sample the parameters of our program during a one year period could only be obtained by using two sites of the polyculture plantation (System 4), the one in block A (named POA) and the other in block C (POC). In each of the secondary (SEC) and primary forest (FLO) sites, one area of 40 x 40 m was marked.

These tree plantations of System 4 were found to be so strongly dominated by the secondary vegetation growing between the tree rows that the system could also be regarded as a young secondary forest rather than a tree plantation. Therefore, in fact, we are investigating soil fauna and microflora of a young secondary forest in comparison with an elder secondary forest and a primary forest.

A comparison of rows with inter-rows regarding nutrients and mesofauna and microbiological activities will be made.

Methods

Methodology

The basic sampling program was successfully established. For many methods that are used as pedobiological standards in studies in temperate regions however, adjustments had to be made for the tropical conditions of the site (see Abstracts of posters in Appendix). Some examples should be mentioned, e.g.; the adequate exposure time of bait lamina which measure general feeding activites of soil fauna turned out to be much shorter than in extratropical studies where 14 days are generally used. In the test made in July, 80% of all holes were open within 19 days (Fig. 1). Four days already allowed an evaluation of the frequency of empty holes caused by faunal feeding in December 1997 (Fig. 2).

On the other hand, the litter bag program initially designed to last 6 months was extended to 1 year in view of the low decomposition rates of the litter of *Vismia guianensis* used as a standard in this study. *Vismia* was chosen because it represents a litter type that is present in all three forest types.

The sampling program for large Oligochaeta was defined in cooperation with Dr. Jörg Römbke, on the basis of numerous pre-trials. The method used now, which consists in expelling large earthworms from a 4-m^2-area with 80 litres of a 0.25% formol solution applied over 30 minutes, is superior to hand sorting which is generally recommended in the literature. The final procedure for the extraction of Enchytraeidae was also established.

Termite baits for comparative studies of the termite populations of the sites, and which also are used for the supply of soil termites for respiration measurements, were successfully established in the second part of the year. An overall acceptance of 40% was recently recorded (in contrast to older findings in which only 10% of the baits were accepted). The methods for the sampling of the ant fauna were established during a visit of Dr. Ana Harada.

The established sampling methods together with work plans and detailed step-by-step instructions for many procedures have been compiled into a "handbook", accessible via internet from our homepage (from the end of March 1998 onwards): **http://www.cenargen.embrapa/~mgarcia/shift**. Up to now, manuals for the study of soil biology are available only in German and for temperate regions (e.g.; Dunger & Fiedler 1997), or the methods described for the study of the soil fauna are, in our view, not sufficient (e.g.; Anderson & Alexander 1993).

Results

A the end of 1997, first results are available from 2 events of the "central sampling program" and the additional experiments (litter bags, mini container, etc.) and data collections of litter production and quantity etc. These are shortly presented here.

Climate

Monthly rainfall at the study sites (Estação Agrometeorológica da EMBRAPA) was much below the 10-year mean in the months May, June, July, September and October 1997. Monthly air temperature means were higher than the 10-year means in all months since August 1996 and very high in September and October 1997. Relative air humidity was very low in July, September and October 1997, and monthly evaporation means very high from June to October 1997, when compared with the long-term means.

Subjectively, even to those accustomed to the climate of Manaus, the impression of extraordinarily dry and hot weather was very strong during the first months of field work in Manaus. For the whole region of central Amazonia, effects of a suspected El Niño were discussed in 1997.

Therefore, the data collected in 1997 may well represent an untypical, extraordinarily dry year. In view of the data to be gathered in 1998, we will have to decide later whether the 1997 data are effectively biased by these climatic conditions.

Litter production and litter stocks

Litter production, measured weekly over 24 weeks with 20 litter samplers of 0.25 m^2 in each site, was higher in the primary forest than in the secondary forest and the plantation (Fig. 3). In contrast, litter stocks from monthly collections over 5 months using 20 samples (large soil-cores of 21 cm diameter) in each site were lowest in the primary forest and highest in the secondary forest (Fig. 4). An additional method (litter from a 4m^2 area, monthly collected) showed the same tendency (Fig. 5). According to these preliminary data, the high litter production in the primary forest corresponds to the lowest litter stocks on the ground of all sites, which means that decomposition rates must be highest in the primary forest.

Microbial biomass and respiration

The preliminary data for soil respiration presented refer only to the litter layer and still need to be confirmed. Soil microbial respiration (basic respiration) was on average lowest in the samples from primary forest in July and September. The highest values were measured from plantation samples in July and secondary forest samples in September (Figure 6, 7). However, the differences between the months and the sites are low and probably not significant.

Fauna

Soil fauna consists of "mesofauna", here defined as all animals collected with the 6.4-cm-diameter soil core and extracted in the Kempson apparatus; and "macrofauna", defined as the soil animals except typical mesofauna groups (mites and springtails) collected with 21-cm-diameter soil cores and extracted with the Berlese. Soil fauna densities were highest in the primary forest site at the first two sampling dates (July: Fig. 8, 9; September: Fig. 10, 11), and lowest in the secondary forest. In all sites a higher percentage of meso- and macrofauna was extracted from the soil subsample, e.g. below the superficial 5 cm including the litter.

Feeding activity and decomposition rates

A preliminary test of litter bag mesh sizes in 1996 has shown that a mesh size of 250 µm is best used to discriminate between macro- and mesofauna effects on decomposition rates (Höfer et al. submitted).

Data on weight loss during the first three retrieval dates of litter bags are not yet available, but weight loss during the three retrieval dates of mini containers was always highest in the primary forest, followed by the plantation sites and was lowest in the secondary forest (Table 1-3). As can be expected, weight loss was lower in containers with mesh size of 20µm, when compared with the containers with mesh size of 250 µm.

These data coincide well with the observation of higher mesofauna densities in the primary forest and the plantations.

On the other hand, feeding activity, measured by bait lamina exposition, was higher in the plantation sites than in primary and secondary forest sites, both during the preliminary test in July and the regular exposition in December. This result probably reflects the problems encountered with the use of such unspecified "activity" measures. Considerable calibration with standard faunal assessments is needed before bait lamina experiments will yield reliable data.

The results presented here point to a considerable importance of the soil fauna in enhancing the litter decomposition in primary forests. However, these conclusions will have to be confirmed by our future collections (data from 1998 and 1999).

Acknowledgements

We wish to acknowledge the assistance and cooperation of several persons and institutions: The BMBF is thanked for financing this project. The CNPq provided funds for visiting scientists and accepted our proposals to fund brazilian technicians. The director of the EMBRAPA, Dr. E.A.V. Morales, and the EMBRAPA administration were always accessible for our needs and proposals and enabled and partly financed reconstructions necessary for a successful operation of the project.

The INPA encouraged and supported the cooperation between the Brazilian institutions. We thank Prof. Dr. R. Lieberei, Institute for Applied Botany, University of Hamburg, for encouragement and helpful comments during the initial phase of the project and Dr. Stüttgen and Dr. Gubelt of Kernforschungszentrum Jülich for their patience and help with administrative problems.

TABLE 1: Cl TABLE 1: Checklist for Data Return in SHIFT ENV 52 "Soil fauna & litter decomposition" 1997 — **Data: 29.04.98** — Shiorg.wb3 - page DataCheck

grey areas: no data e grey areas: no data expected; white areas: data expected; green areas: data ok

Sample Type		Sample Type		Litter Production Leaves, Wood etc.				Litter Stocks Leaves, Wood etc. monthly				
Fraction		Fraction		Dry Weight of 5 litter fractions	grind gemahlen	C/N analysiert	Ash-Cont. verascht	Dry Wt.	grind	C/N	Ash-Cont.	
n		n		60								
Responsilevel		Responsilevel		G-F-V		Martina	Martina	Marcos	Martina	Martina	Martina	
YEAR	DAY	YEAR	DAY									DAY
1997	21-Jul	1997	21-Jul					from SONDA				23-24
	28-Jul		28-Jul									
	04-Aug		04-Aug									
	11-Aug		11-Aug									
	18-Aug		18-Aug									
	25-Aug		25-Aug									
	01-Sep		01-Sep									
	08-Sep		08-Sep					from SONDA				9-10
	15-Sep		15-Sep									
	22-Sep		22-Sep									
	29-Sep		29-Sep									
	06-Oct		06-Oct									
	13-Oct		13-Oct									
	20-Oct		20-Oct									
	27-Oct		27-Oct									
	03-Nov		03-Nov									
	10-Nov		10-Nov									
	17-Nov		17-Nov									
	24-Nov		24-Nov									
	01-Dec		01-Dec					from SONDA				2-3
	09-Dec		09-Dec									
	15-Dec		15-Dec									
	22-Dec		22-Dec									
	29-Dec		29-Dec									
1998	05-Jan	1998	05-Jan					7.1				
	12-Jan		12-Jan									
	19-Jan		19-Jan									
	26-Jan		26-Jan									
	02-Feb		02-Feb									

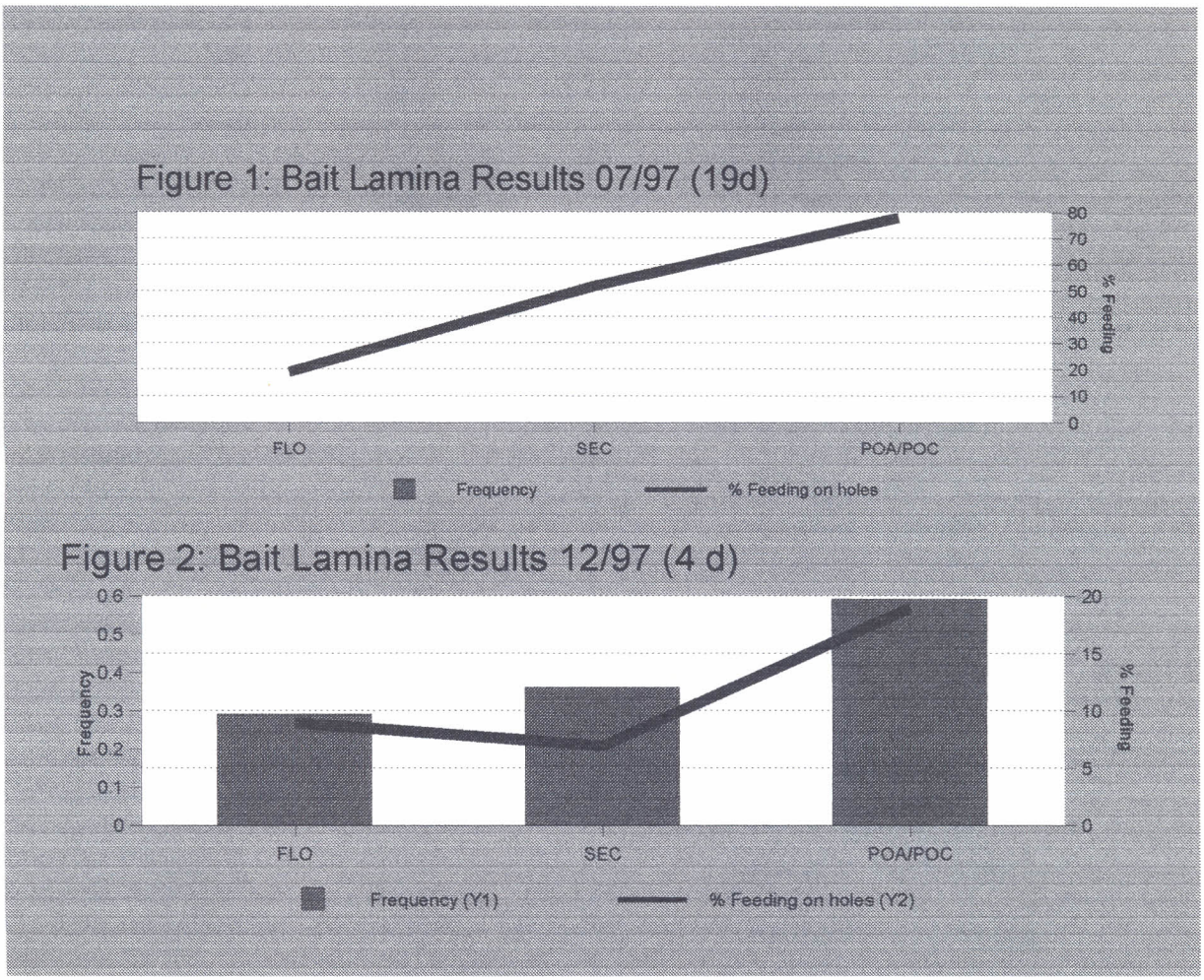
DAY	Basic Program MESO			ENCHY		EW minhocas		MICRO			MICRO soil			RESP.R.
	Fauna sampling	Soil Hum.	Fauna sorting	sampling	extraction identification	sampling	preservation	Respir.	pH	Soil Hum.	grind	C/N	ash content	
n	120			120		6		120	120	120	120			
Responsilevel	Beth/Elis	G-F-V	V-G	JR	JR	Ric.Hi		Maristela	Maristela	Maristela	Martina			Regina
21-Jul														
28-Jul														
04-Aug														
11-Aug														
18-Aug														
25-Aug														
01-Sep														
08-Sep														
15-Sep														
22-Sep														
29-Sep														
06-Oct														
13-Oct														
20-Oct														
27-Oct														
03-Nov														
10-Nov														
17-Nov														
24-Nov														
01-Dec														
09-Dec														
15-Dec														
22-Dec														
29-Dec														
05-Jan														
12-Jan														
19-Jan														
26-Jan														
02-Feb														

DAY	Litter Bags etc. I: series I (rainy seas.) II: series II (dry season)	LITBAG					MINI-CONTAINER				BAIT-L.
		Taxa Dec.	Respir.	grind	C/N	Ash free	weight loss	grind	C/N	Ash free	
Responsilevel		Flavio	Maristela	Martina	Martina	Martina	Hubert				
	DAY										
21-Jul											
28-Jul											
04-Aug											
11-Aug											
18-Aug											25.7.-13.8
25-Aug											
01-Sep											
08-Sep											
15-Sep											
22-Sep											
29-Sep											
06-Oct											
13-Oct											
20-Oct											
27-Oct	I:START:27.10.						I:START:27.10.				
03-Nov											
10-Nov											
17-Nov											
24-Nov	I: 25d:21.11.						I: 25d:21.11.				
01-Dec											
09-Dec											
15-Dec											11.-15.12.
22-Dec	I: 57d:23.12.						I: 57d:23.12.				
29-Dec											
05-Jan											
12-Jan											
19-Jan	I: 84d:19.1.						I: 84d:19.1.				
26-Jan											
02-Feb											

FIGURES

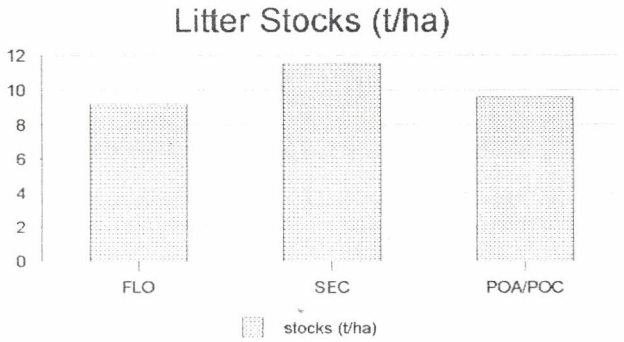
In all figures, FLO represents the primary forest, SEC the secondary forest, and POA/POC the polyculture plantation sites

Figures 1 and 2:



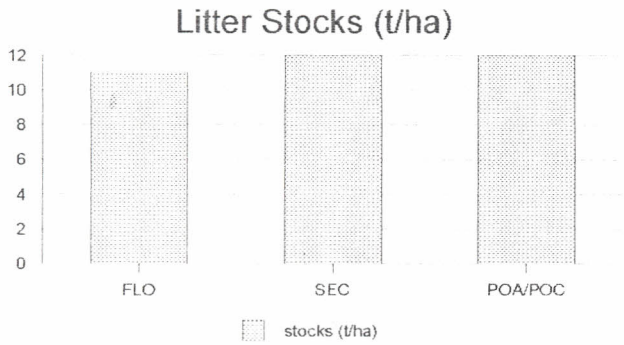
Figures 3 to 5:

ENV 52: Litter Data 1997



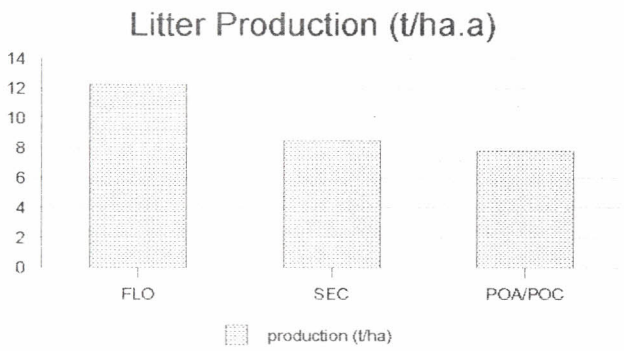
Data from monthly collections (20 samples of 21 cm in each site)

07-12/97 = 5 months average



Data from 3-monthly collections (2 samples of 4m^2 in each site)

07, 09, 12/97 = 3 months average



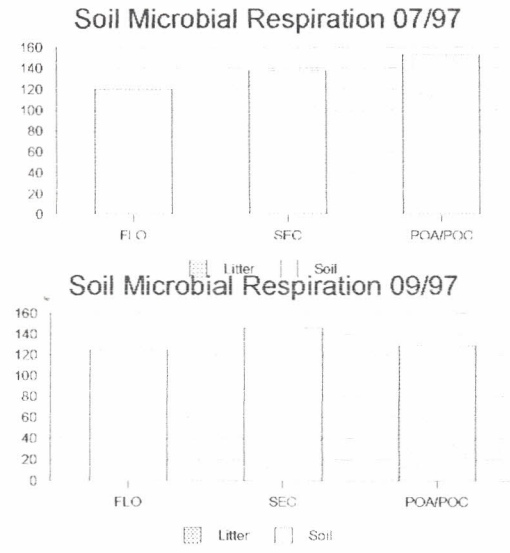
Data from weekly collections (20 collectors of 0.5m^2 in each site)

07-12/97 = 24 weeks

Figures 6 and 7:

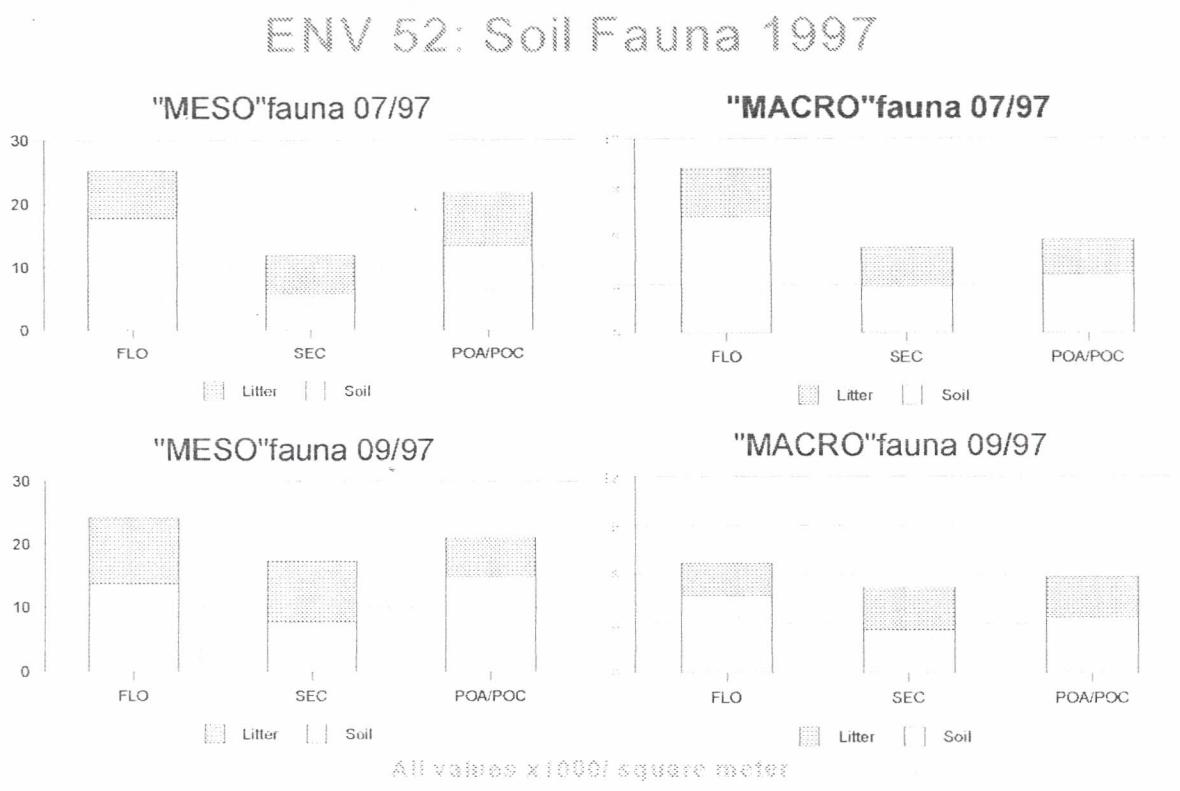
ANUREP97 Fig 6 and 7.wpd

ENV 52: Soil Microflora 1997



Microbial respiration: Basal Respiration (nl CO_2/min.g soil)

Figures 8 to 11:

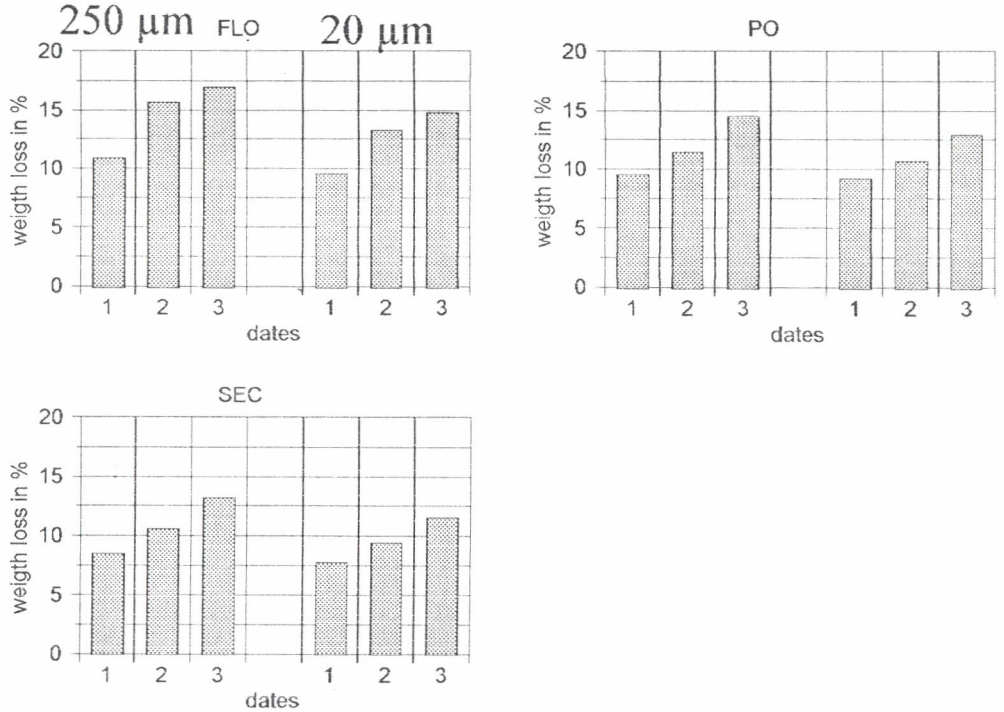


ANUREP97 Fig 8 to 11.wpd

Figure 8	Figure 9
Figure 10	Figure 11

weight loss in minicontainers

1. series



ANUREP97 Fig 12.wpd

Annexed Materials

1. Manuscript submitted to the journal Pedobiologia in February 1998:

Hubert Höfer, Jörg Römbke, Marcos Garcia, Elizabeth Franklin, Christopher Martius, Bernhard Förster, Ludwig Beck: **A proposal for the standardization of the mesh size of litter bags to be used in soil biological studies in tropical rainforests**

2. Abstract of poster presented at the 11. Jahrestagung der Deutschen Gesellschaft für Tropenökologie (gtö 98), 20.-22.2.1998, Bielefeld:

Höfer, H., Martius, C., Römbke, J., Garcia, M.B., Beck, L.: **Shift project ENV 52: Soil fauna and litter decomposition - the use of adapted soil biological methods in Amazonian rain forests**

3. Abstracts of posters and speech to be presented at the III SHIFT Workshop, 15.-20.3.1998, Manaus/Brazil:

Speech:

C. Martius, E. Franklin, M. Garcia, A. Harada, H. Höfer, F. Luizão, R. Luizão, J.W. de Morais, E. Oliveira: **Soil fauna and litter decomposition in primary and secondary forests and in a polyculture forestry plantation in Amazonia - Objectives, methods and first experiences.**

Posters:

L. Beck, L. Gasparotto, B. Förster, E. Franklin, M. Garcia, A. Harada, H. Höfer, F. Luizão, R. Luizão, C. Martius, J. W. de Morais, E. Oliveira, J. Römbke: **The role of the soil fauna in the litter decomposition process in primary forests, secondary forests and a polyculture plantation in Amazonia (SHIFT project ENV 52)**

M. Garcia, H. Höfer, C. Martius, J. Römbke & L. Beck: SHIFT project ENV 52: **Soil fauna and litter decomposition. The use of adapted soil biological methods to study macrofauna in Amazonian rain forests**

E. Franklin, M. Garcia, F. Luizão, R. Luizão, J.W. de Morais, E. Oliveira: **SHIFT project ENV 52: Soil fauna and litter decomposition. The use of adapted soil biological methods in Amazonian rain forests: Mesofauna**

C. Hanne & C. Martius, B. Förster & M. Garcia: **Impact of Amazonian termite populations on the carbon-cycle of differently used forest systems: Respiration rates of different termite food-guilds**

M. Farias, B. Förster, R. Luizão: **Microbial respiration and biomass in tropical forest soil and litter**

J. Römbke, M. Meller & M. Garcia: **Earthworm densities in central Amazonian primary and secondary**

W. Amelung, C. Martius, M. Garcia, R. Kueper, D. Ullbrich, W. Zech: **Organic matter in termite mounds of an Amazonian rain forest**

F. Luizão, E. Franklin, E.P. Oliveira, M. Garcia, H. Höfer, C. Martius: **Litter-bag experiments on decomposition and mesofauna colonization of leaves in primary and secondary forests on degraded croplands in central Amazonia**

4. Two abstracts of posters to be presented at the VII International Congress of Ecology INTECOL 1998, Florence, Italy 19-25 July, 1998:

Martius, C., Höfer, H., Römbke, J., Garcia, M.B., Beck, L.: **Shift project ENV 52: Soil fauna and litter decomposition - the use of adapted soil biological methods in Amazonian rain forests**

C. Hanne, & C. Martius: **Impact of Amazonian termite populations on the carbon cycle of natural and managed forest systems: respiration rates in different termite food guilds**

5. Two abstracts of posters to be presented at the Annual Reunion of Ecology Society in Germany, September 1998:

Martius, H. Höfer, E. Franklin, M. Garcia, F. Luizão, L. Beck: **Studies of litter decomposition in three tropical forest sites in Amazonia using litter bags and mini-containers**

W. Amelung, C. Martius, A.G. Bandeira, M. Garcia, T. Gonter & W. Zech: **Lignin and other organic substances in termite mounds of moist and dry ecosystems in Brazil**

A proposal for the standardization of the mesh size of litter bags to be used in soil biological studies in tropical rainforests

Hubert Höfer [1], Jörg Römbke [2], Marcos Garcia [3], Elizabeth Franklin [4], Christopher Martius [5], Bernhard Förster [2] and Ludwig Beck [5]

[1] Abteilung Ökologie, II. Zoologisches Institut der Universität Göttingen, Berliner Str. 28, D-37073 Göttingen, Germany
[2] ECT Oekotoxikologie GmbH, Böttgerstr. 2-14, D-65439 Flörsheim, Germany
[3] Empresa Brasileira de Pesquisa Agropecuária - Centro de Pesquisa Agroflorestal da Amazônia Ocidental (Embrapa-CPAA), Caixa Postal 319, 69.011-970 Manaus/AM, Brazil
[4] Instituto Nacional de Pesquisas da Amazônia (INPA), Caixa Postal 478, 69.011-970 Manaus/AM, Brazil
[5] Staatliches Museum für Naturkunde, Postfach 6209, D-76042 Karlsruhe, Germany

Key words: Tropical Rain Forest, Soil Biology, Litter Bags, Mesofauna

Up to now, no standard set of methods for soil biological investigations in tropical rain forests exists. The only text coming next to such a standard is the well-known "Handbook of Methods of Tropical Soil Biology and Fertility" first published by Anderson & Ingram in 1989, and later revised (Anderson & Alexander 1993). This book focuses mainly on soil fertility and gives very detailed descriptions of soil chemical and physical methods. Unfortunately, the handbook is far less complete in the field of soil biology. Many methodological suggestions for the investigation of various animal groups as well as for the adaptation of functional measurements like organic matter decomposition are scattered in the literature, however, no recommendations are given for the use of litter bag experiments. Litter bags were used in studies of temperate forests for more than 40 years (Bocock & Gilbert 1957), but we know of no methodological recommendation for tropical forests. This method, usually performed to measure the decomposition rate of confined litter, can also be used to estimate the contribution of microbes and soil animals of different size and/or functional groups to the decomposition of organic matter (Swift et al. 1979). Litter samples are enclosed in bags of different mesh sizes which give access to those groups which pass the mesh and selection of mesh size depends on the range of the body size of the target fauna.

According to Swift et al. (1979) and several other authors the following mesh sizes of litter bags have been used to discriminate between various size groups of soil organisms, usually microorganisms, meso- and macrofauna (Table 1).

As can be seen from the data in Table1, there is a general understanding that meso- and macrofauna animals can be excluded completely when a mesh size of 0.02 up to 0.05 mm is used. On the other hand, it is clear that all animals can enter a litter bag with a mesh size of more than 7 mm (most often used: 10 mm). No consensus exists on the mesh size which excludes the macrofauna (usually defined as having a body diameter of 2 - 16 mm and/or a body-length of > 10 mm; Swift et al. 1979), but admits colonization by the mesofauna. Mesh sizes ranging from 0.2 to 2 mm were used to date (Table 1).

In order to determine which mesh size is best suited for the purpose to discriminate between macro- and mesofauna in neotropical areas, we performed a litter bag study with the following mesh sizes: 0.02, 0.25, 0.5 and 10 mm. The study was carried out in the context of a larger

investigation on the role of the soil fauna and microflora in litter decomposition in rain forests and former degraded areas under regeneration of the vegetation cover in central Amazonia[1].

Ten litter bags of each mesh size were exposed in the field. They were made out of polyester gauze, had a size of 25 X 30 cm and were each filled with 10 g of air-dried leaves of *Vismia* cf. *guianensis* (Guttiferae), a common tree of primary and secondary rain forests in central Amazonia. They were randomly distributed on the soil surface in an undisturbed "terra firme" forest (EMBRAPA-CPAA Station, 24 km North of Manaus) for 31 days (April 15 - May 16, 1996). The soil is a typical clayey ferralsol with a pH of 4 - 5 and an organic content of 2.4 - 5.3 %. During the period of exposure the average temperature was 24.9°C (Max. 26.3°C, Min. 23.2°C) and the total precipitation was 195.6 mm (data from an automatic field station). The remaining litter was transported to the laboratory where the fauna was extracted using a modified Kempson apparatus (Adis 1987).

Large numbers of mesofauna animals were found in the bags of the three larger mesh sizes, whereas almost none appeared, as expected, in the 0.02 mm bags. Exceptions (Table 2) can be explained assuming that eggs of Acari and Collembola were laid through the meshes of some bags. In individual cases, bags seem to have been damaged by roots or animal attack; thus allowing larger animals to penetrate than mesh size would do. However, differences between the smallest and the other mesh sizes are highly significant for Acari, Collembola and the whole mesofauna (Mann Whitney U test: $p>0.000$), showing that access of even very small animals is effectively hindered.

Animals of the macrofauna groups were found only in small numbers in the 0.25 mm bags, but appeared much more abundant in the 0.5 mm bags (Table 2, differences are significant at the 0.1 % level for isopods, pseudoscorpions and spiders and the sum of all macrofauna groups, significant at 1% level for diplopods). Both Acari and Collembola were found in higher numbers in the bags with 0.25 mm mesh than in the 0.5 mm bags (significant at 5 % level). This might be due to a protection effect of the 0.25 mm bags, which apparently did not allow access of the predator groups Araneae and Pseudoscorpiones. The 0.5 mm bags showed no significant differences in colonization by meso- or macrofauna when compared to the 1 cm bags ($p=0.571$ and $p=0.880$).

The results of our preliminary study clearly lead to the choice of the following mesh sizes to be used: 0.2, 0.25 and 10 mm. These sizes appeared to be the most suitable to distinguish between the contributions of the three size classes of the soil fauna. In fact, they are the same as those proposed during a meeting of the German Working Group on Mesofauna (ATHIENS et al. 1989), based on the experiences of seven working groups, covering mainly forest and agricultural sites.

The experiment also allows to determine the sample numbers necessary to evaluate decomposition effects by differentiation of the access of the target animals. The standard error values (in % of the mean) of the faunal abundances in ten bags of each mesh size were calculated as follows: 11.6 % for mesofauna in the 0.25 mm bags; 27 % for macro-, 10.5 % for mesofauna and 11.2 % for all animals in the 1 cm bags. Single macrofauna groups showed values of 19.6 % (Diplopoda), 21 % (Isopoda), 51 % (adult Coleoptera), 56 % (Araneae) and 90 % (Formicidae) in the large bags.

Ten bags of the intermediate mesh size, collected and evaluated at every retrieval date along the

---

[1]This is publication 1 of the project ENV 52 "Soil fauna and litter decomposition" in the SHIFT Programme (Studies on Human Impact on Forests and Floodplains in the tropics) under the auspices of the German / Brazilian Governmental Agreement on the Cooperation in Research and Technology.

decomposition period under study (mostly along one year) seem to give reasonably accurate measures of colonization by mesofauna. However, the standard errors for macrofauna in ten bags of the large mesh size are still high and we recommend to use more than 10 bags of each mesh size and retrieval date, when macrofauna effects are to be differentiated.
Mean weight loss in the bags after 1 months of exposure was 2.5 g in 0.02 mm bags, 2.7 g in 0.25 mm bags, 2.58 in 0.5 mm bags and 2.71 g in 1 cm bags. Due to the very short exposure time the differences between the different mesh sizes are very low and no correlation of faunal colonization and decomposition can be made.

Adis, J. (1987) Extraction of arthropods from Neotropical soils with a modified Kempson apparatus. J. Trop. Ecol. **3**, 131-138.
Ahrens, B., Hoffmann, K-H., Zilligen-Geilen, C. (1989) Protokoll zum 5. Plenum Bodenmesofauna - Methoden zum Streuabbau - am 6. und 7. Oktober 1988 in Bonn (unpublished)
Anderson, J.M., Proctor, J., Vallack, H. (1983) Ecological studies in four contrasting lowland rain forests in Gunung Mulu National Park, Sarawak. III. Decomposition processes and nutrient losses from leaf litter. J. Ecol. **71**, 503-527.
Anderson, J.M. & Ingram, J.S.I. (1989) Tropical Soil Biology and Fertility: A Handbook of Methods. C.A.B. International, Wallingford, UK.
Anderson, J.M. & Alexander, J.I. (1993) Tropical Soil Biology and Fertility: A handbook of Methods. 2nd ed., C.A.B. International, Wallingford, UK.
Bocock, K.L., Gilbert, O.J. (1957) The disappearance of leaf litter under different woodland conditions. Plant and Soil **9**, 179-185.
Dunger, W.,& Fiedler, H.J. (1989) Methoden der Bodenbiologie. G. Fischer Verlag, Jena.
Irmler, U., Furch, K. (1980) Weight, energy, and nutrient changes during the decomposition of leaves in the emersion phase of Central-Amazonian inundation forests. Pedobiologia **20**, 118-130.
Madge, D.S. (1965) Leaf fall and disappearance in a tropical forest. Pedobiologia **5**, 273-288.
Postle, A.C., Majer, A.D., Bell, T.D. (1986) Soil and litter invertebrates and litter decomposition in Jarrah (*Eucalyptus marginata*) forest affected by Jarrah dieback fungus (*Phytophthora cinnamomi*). Pedobiologia **29**, 47-69.
Swift, M.J., Heal, O.W., Anderson, J.M. (1979) Decomposition in Terrestrial Ecosystems. Studies in Ecology Vol. 5.Blackwell Scientific Publication, Oxford, London.

Table 1. Mesh sizes used in litter bag studies in which the role of different soil fauna groups has been investigated

mesh size [mm]			study site	reference
small	medium	large		
0.002	1.25	10	Ibadan, Nigeria	Madge 1965
0.05	1-2	5-10	in general	Swift et al. 1979
	0.5	15	Manaus, Brazil	Irmler & Furch 1980
0.04		7-10	Sarawak, Malaysia	Anderson et al. 1983
0.04	1.5	7	Australia	Postle et al. 1986
0.02-0.05	0.2-0.5	> 10	in general	Dunger & Fiedler 1996

Table 2. Number of animals per litter bag with different mesh sizes (only groups with more than 10 individuals summed over all bags are listed) extracted by a Kempson apparatus; n = 10; all numbers are rounded next to 1 individual specimen.

mesh size [mm]	0.02	0.25	0.5	10	all bags
animal group	mean number of individuals per bag ± standard deviation				total number
Araneae	0 ± 0	0 ± 0	3 ± 3	4 ± 6	67
Pseudoscorpiones	0 ± 0	1 ± 1	5 ± 2	8 ± 10	140
Isopoda	0 ± 1	0 ± 0	6 ± 5	7 ± 5	136
Diplopoda	0 ± 0	1 ± 2	4 ± 4	4 ± 2	81
Coleoptera adult	0 ± 0	1 ± 2	1 ± 1	0 ± 0	21
Macrofauna	0.7 ± 0.8	3.1 ± 3.5	18.1 ± 8.5	22.5 ± 19.3	445
Coleoptera immature	0 ± 0	1 ± 1	1 ± 1	1 ± 1	23
Acari	16 ± 10	160 ± 56	105 ± 42	181 ± 70	4617
Collembola	14 ± 14	139 ± 80	102 ± 62	69 ± 30	3233
Copepoda	0 ± 0	3 ± 3	4 ± 4	1 ± 2	85
Mesofauna	30.3 ± 17.3	302.1 ± 111.1	211.8 ± 89.3	252.8 ± 83.9	8346
Diptera immature	1 ± 1	1 ± 1	1 ± 1	2 ± 2	44
Diptera ad.	1 ± 1	1 ± 1	0 ± 1	0 ± 0	31
Homoptera	0 ± 0	0 ± 0	1 ± 1	1 ± 1	24
Formicidae	4 ± 10	6 ± 14	9 ± 19	7 ± 18	256
Protura	0 ± 0	1 ± 2	1 ± 2	1 ± 2	35
Total	36.6 ± 17.3	314.3 ± 115.9	242.6 ± 95.8	285.7 ± 100.9	8791

Presentation: Oral - Presentation no°: no number - Project: SHIFT ENV 52

Soil fauna and litter decomposition in primary and secondary forests and in a polyculture forestry plantation in Amazonia - Objectives, methods and first experiences

C. Martius[1], E. Franklin[2], M. Garcia[3], A. Harada[4], H. Höfer[1], F. Luizão[2], R. Luizão[2], J.W. de Morais[2], E. Oliveira[2]

[1] Staatliches Museum für Naturkunde Karlsruhe, Germany
[2] INPA, Manaus/AM, Brazil
[3] Embrapa-CPAA, Manaus/AM, Brazil
[4] Museu Paraense Emílio Goeldi, Belém/PA, Brazil

An overview over the activities in the first year of the project will be given and first result will be presented on litter quantity, soil fauna and microflora activity and decomposition rates in the three studies sites (primary forest, 13-year old secondary forest, and the polyculutre plantation system consisting of 4 commercially used tree species planted in rows between adventitious vegetation consisting mainly of *Vismia* trees).

Presentation: Poster - Presentation no°: 94 - Project: SHIFT ENV 52

The role of the soil fauna in the litter decomposition process in primary forests, secondary forests and a polyculture plantation in Amazonia (SHIFT Project ENV 52)

L. Beck[1], L. Gasparotto[2], B. Förster[3], E. Franklin[4], M. Garcia[2], A. Harada[5] H. Höfer[7], F. Luizão[4], R. Luizão[4], C. Martius[1], J. W. de Morais[4], E. Oliveira[4], J. Römbke[3]

[1] Staatliches Museum für Naturkunde Karlsruhe, Germany
[2] Embrapa-CPAA, Manaus/AM, Brazil
[3] ECT Oekotoxikologie GmbH, Flörsheim, Germany
[4] INPA,Manaus/AM, Brazil
[5] Museu Paraense Emílio Goeldi, Belém/PA, Brazil

A general description of the project is given on this poster. The project is closely related to existing projects of the SHIFT programme in Manaus, which aim to develop methods for sustainable land use in Amazonian rain forests, using an experiment on recultivation of a fallow rubber plantation with mixed plantations of annual and perennial plants (polyculture systems) (projects ENV 23, 42, 45). In the present project, litter quantity and quality, decomposition rates, and the abundance, biomass, and respiration of soil-inhabiting microbes, arthropods and earthworms will be studied comparatively in one of the polyculture systems (a forestry plantation consisting of 4 tree species) and in plots of nearby secondary and primary forest. The aim of this study is to evaluate the specific contribution of the soil microflora and of the different functional soil fauna groups to the decomposition of organic matter and the resulting nutrient supply to the plants. Our basic hypothesis is that a functional soil fauna is of extreme importance for the maintenance of "healthy" nutrient cycles in the systems, and that biotic and abiotic factors of the sites can be managed in order to optimize the cycling of nutrients. In view of the high variability in the distribution of the fauna in tropical soils, only an exhaustive and very time-consuming sampling scheme will allow to address these questions and to provide a model of the underlying processes which will be applicable in similar situations. One aim, however, is to approach the establishment of short-term methods of bioindication of the "operative health" of the decay processes which allow less labour-intensive though significative sampling in future studies.

Presentation: Poster - Presentation no°: 95 - Project: SHIFT ENV 52

SHIFT project ENV 52: Soil fauna and litter decomposition. The use of adapted soil biological methods to study macrofauna in Amazonian rain forests

Marcos Garcia[1], Hubert Höfer[2], Christopher Martius[2], Jörg Römbke[3], Ricardo Ott[4] and Ludwig Beck[2]

[1] Embrapa-CPAA, Manaus/AM, Brazil
[2] Staatliches Museum für Naturkunde Karlsruhe, Germany
[3] ECT Oekotoxikologie GmbH, Flörsheim, Germany
[4] INPA, Pós-Graduação, Manaus/AM, Brazil

A comparative study of litter quantity and quality, decomposition rates, and the abundance, biomass, and respiration of soil-inhabiting microbes, arthropods and oligochaetes has been started in a polyculture forestry plantation and in plots of nearby secondary and primary forest in 1997. The aim is to evaluate the specific contribution of the soil microflora and of the different functional soil fauna groups to the decomposition of organic matter and the resulting nutrient supply to the plants.
The following methods for the study of the macrofauna (all soil fauna of >2mm body diameter or >10mm body length and of either saprophagous or predatory habits) have been adapted to neotropical conditions on the base of preliminary tests.

- Extraction of the soil fauna from large soil-cores is used to determine macrofauna species composition, abundance and biomass.
- Manual sampling for macrofauna from the litter layer in areas of 4 m^2 yields additional information for very large fauna.
- Formol-extraction of earthworms in areas of 4 m^2 has been proved to be superior to hand-sorting for the assessment of large earthworms. Additionally, wet-sieving is an efficient method for the extraction of enchytraeids.
- Additional stratified and bait sampling is necessary for termites and ants because social insects are not adequately sampled with the classical soil core extraction.
- Experiment on enhancement and exclusion of predators are used to determine the impact of predators on saprophagous soil fauna (macro- and mesofauna).
- Measurements of the respiration rates of selected soil animals (using an Infrared-Gas-Absorption-Spectrometer - IRGA) together with population estimates will allow to assess turnover rates of the different soil fauna groups
- Chemical analises (C/N-ratio, macro- and micronutrients, exchangeable cations, humic substances) of soil, plant residues and soil animal products will allow to estimate the contribution of each faunal group to the turnover of selected elements.

Presentation: Poster - Presentation no°: 96 - Project: SHIFT ENV 52

Soil fauna and litter decomposition. The use of adapted soil biological methods in Amazonian rain forests: Mesofauna

E. Franklin[1]; E.P. Oliveira[1], J.W. Morais[1], L. Beck[2]

[1] INPA,Manaus, Brazil; [2] Staatliches Museum für Naturkunde Karlsruhe, Germany

The soil mesofauna is being studied in the three systems described in the poster on Litterbags In each system, 40 x 40 m plots were marked with grid lines 1-m apart where the soil samples are taken at random with asteel cylinder (diameter 6,4 cm) driven into the soil by a mallet. Each sample is divided in sub-samples (litter layer and mineral soil 0-5 cm). Each sub-sample is inverted and placed in the sample container made of plastic (diameter 7,5 cm) whose bottom consists of a plastic grid (mesh size of 1 mm). Each sample container is placed in a plastic box (diameter 9 cm) and sealed with a plastic lid. The material is placed in an insulated box to prevent drying during transportation.

In the laboratory, each sample container is covered by a white cotton screen, tightly secured by a plastic snap-ring, and placed in the top of a recipient (diameter 8 cm) containing a the killing-preserving agent (1 part of saturated picric-acid solution to 3 parts of water). The Kempson extraction apparatus (capacity 72 sample units) consists of rectangular cabinets (155 cm x 92 cm) made of aluminum. Eighth infrared lamps (150 W; 230 V) mounted in the top of the cabinets, positioned 10 cm above the samples, are used as a heat source. The temperature is controlled by a thermostat. The removable tray for the sample containers separates the extraction chambers in two compartments: the lower compartment, containing a water bath, is temperature-controlled by a copper coil which is connected to a refrigerator (type C40, Haake GmbH, Karlsruhe, FRG). Extraction takes 14-15 days. Initial temperature (=top of the sample) is 22 C, and is raised daily by 4 C and maintained at 59 C from the 9th day onward. Cooling temperature of the water bath (initial 21°.C) is lowered daily by 4 C for four days, maintained at 6 C from the 5th-9th day and raised to 21 C from the 10th-14th day. To allow the gradual escape of moist air, the top of the upper compartment is opened after 9 days of extraction. Room temperature should not exceed 32°C. The aim of this extraction procedure is to maintain a high humidity level in the cabinet and a gentle temperature gradient between in the sample container during the first days.

Soil/litter mesofauna is fixed in 70% alcohol, identified and counted for reporting densities and biomass in the ecosystems. For understanding the influence of soil mesofauna on ecosystems process our study will depend upon a functional rather than a taxonomic classification. The taxon will be organized into functional units: size classes/biomass, trophic levels (predator, fungivore, herbivore or detritivore), feeding biology, etc.

Gut contents of some animals collected in the field will be also analyzed. Representative species will be selected for laboratory studies of consumption, respiration, faeces production and contribution to substrate-quality changes (C/N ratios) estimated by measures for some individuals (IRGA, C/N Analyzer).

Presentation: Poster - Presentation no°: 97 - Project: SHIFT ENV 52

Impact of Amazonian termite populations on the carbon cycle of natural and managed forest systems: respiration rates in different termite food guilds

C. Hanne [1], C. Martius [2], B. Förster[3], M. Garcia[4]

[1]II. Zoologisches Institut, Universität Göttingen,Göttingen, Germany
[2] Staatliches Museum für Naturkunde, Karlsruhe, Germany
[3] ECT Oekotoxikologie GmbH, Flörsheim, Germany
[4] Embrapa-CPAA, Manaus/AM, Brazil

Termites of tropical forests are a dominant group amongst primary destruents. Divided into mainly four food guilds, e.g. wood-feeders, humus-feeders, leaf-harvesters and generalists, termites are believed to have an high impact on nutrition-cycles of tropical forests. Eight representative species in Central Amazonia representing the different food guilds were studied in order to determine their respiration-quotients as an important feature of their metabolic potential. For a period of ten months we took monthly samples in three different forest-systems: a wood plantation, a secondary forest and a primary forest. Following species have been investigated: *Anoplotermes banksii, Constrictotermes sp., Heterotermes sp., Labiotermes labralis, Nasutitermes sp., Neocapritermes sp., Syntermes molestus* and *Termes fatalis*. The mound-building termites were captured by taking direct samples from mounds. The subterranean species were investigated with monitoring stations which contained different baits. With an Infra-Red-Gas-Absorption-Spectrograph the respiration-quotient (l CO_2/ min/ g biomass) for each species was determined, with the termites separated by castes. We could prove a strong dependence of respiration-quotient on food guild membership for the investigated species. Preliminary data indicate that representatives of all food guilds were encountered on the primary forest plots, but not in the secondary forest and in the plantation plots. The total absence of some food guilds on the polyculture-study sites may indicate that important carbon sources will not be adequately decomposed in these plots.

Presentation: Poster - Presentation no°: 98 - Project: SHIFT ENV 52

Microbial Respiration and Biomass in Tropical Soil and Litter

Maristela Farias[1], B. Förster[2], & R. Luizão[3]

[1] EMBRAPA-CPAA, Manaus/AM, Brazil
[2] ECT Oekotoxikologie GmbH, Flörsheim, Germany
[3] INPA, Manaus/AM, Brazil

Microorganisms are the most abundant organisms in soil and litter layers. In the northern hemisphere more than 80 % of the non-plant biomass of soil is provided by microorganisms. They are thus an important structural element of the soil compartment. Moreover they play a major role in the decomposition of organic matter and in the cycling of nutrients, thus fulfilling essential ecosystem functions. It follows that microbial biomass and metabolic activity are ecologically relevant end-points and appropriate parameters for the description of the structure and function of ecosystems.

We measured the microbial substrate-induced respiration (SIR) and the basal respiration (BR) of the top soil and of the litter layer of a primary forest, a secondary forest and of a plantation. Measurements were made in a continuos flow-through system connected with an Infra-red gas analyzer (IRGA). Microbial biomass was calculated on the basis of the SIR values.

First results indicate that the SIR-method is appropriate to measure microbial respiration of tropical soils and litter. From the data of the first three sampling dates it seems that microbial biomass of the three field sites does not differ significantly. There is a high natural spatial variability within each field site.

Presentation: Poster - Presentation no°: 99 - Project: SHIFT ENV 52

Earthworm densities in central Amazonian primary and secondary forests and a polyculture forestry plantation

Jörg Römbke[3], Michael Meller[2] and Marcos Garcia[1]

[1] Embrapa-CPAA, Manaus/AM, Brazil
[2] Staatliches Museum für Naturkunde Karlsruhe, Germany
[3] ECT Oekotoxikologie GmbH, Flörsheim, Germany

Earthworms are known to be the most important group of soil animals in temperate regions of the world but their contribution to ecosystematic soil functions, especially litter decomposition, in the humid tropics remains largely unexplored. Therefore, the species composition, abundance and biomass of these organisms have been determined in a polyculture forestry plantation and in plots of nearby secondary and primary forest since 1997.

Contrary to recommendations from the literature, hand-sorting was not successful to collect the earthworms due to two reasons:
1. The individual size of the various species differs greatly (approx. 2 cm to 80 cm in length)
2. They are very inhomogenously distributed.
However, in a pre-study it could be confirmed that Formol-extraction in areas of 4 m^2 is an easy and quick method to sample earthworms qualitatively and quantitatively. Unfortunately, the use of mustard as a more natural and less toxic alternative to Formol as successful used in Europe was not efficient.

After three sampling dates in the period from July to December 1997 the following preliminary results can be presented:
The number of species is relatively low (approx. 5 - 10). Most if not all of them belong to the mainly neotropical family Glossoscolecidae. Up to now, none of these is described. No peregrine species (i.e. worms found circumtropical) were found, which is strange since especially *Pontoscolex corethrurus* is widely distributed in the area of Manaus.
Again, as far as can be assessed today, the abundance of earthworms in the three plots is low in comparison to other tropical humid rain forest sites (< 10 ind/m^2 compared to approx 50 ind/m^2 (based on just four studies!)). On the other hand, since most of the species living on the three investigation plots are very large, the amount of biomass is among the highest numbers ever found in rain forests (up to 20 g fresh weight per square meter).
Due to the limited amount of data gained so far, potential differences between the three plots and, in general, the role of these animals (e.g. the association of the individual species with one of the three main ecological groups of earthworms) in the study area is not clear yet. However, the enormous biomass of earthworms in all three plots indicates that they have a key function for processes like organic matter decomposition.

Presentation: Poster - Presentation no°: 100 - Project: SHIFT ENV 52

Organic matter in termite mounds of an Amazonian rain forest

W. Amelung[1], C. Martius[2], M. Garcia[3], U. Kueper[1], D. Ullbrich[1], and W. Zech[1]

[1] Institute of Soil Science and Soil Geography, University of Bayreuth, Germany
[2] Staatliches Museum für Naturkunde, Germany
[3] Embrapa-CPAA, Manaus/AM, Brazil

Termites play an important role in organic matter and nutrient cycles of tropical ecosystems, but since it is thought that termites are unable to decompose lignin in a significant scale, lignin should accumulate in their mounds. This study was designed to investigate how termites alter the organic matter in the rain forest around Manaus, Brazil. Samples were collected from the outer and inner parts of typical termite nests of *Nasutitermes, Termes, Embiratermes, Cornitermes, Anoplotermes,* and *Constrictotermes* genera, as well as from the surrounding topsoil (0-10 cm) and potential wooden food. Chemical analysis is still in progress but includes the determination of organic C, N, lignin-derived phenols, and carbohydrates. The termite nests were significant sinks for organic matter and its associated nutrients. The organic C contents ranged between 100 and 500 g kg^{-1} in the nests, compared to 17 to 42 g kg^{-1} in the surrounding topsoils. Lignin contents of the mounds were even higher than in wood, thus giving support to the assumption that lignin is accumulated in preference to other organic compounds. Except for *Nasutitermes ssp.*, there was no significant difference in organic C between the samples from exterior and interior of the nests. In the mounds of the xylophageous *Nasutitermes ssp.*, however, the nest interior had significantly lower C contents and C/N ratios that the exterior. This seems to be accompanied by lower lignin contents and higher degree of lignin side-chain oxidation. We suggest that the interior part of the nests comprised regions of higher organic matter turnover including degradation of lignin. As lignin oxidation might not have happened in the gut of the termite itself, more research is required to clarify the role of symbiotic microorganisms to the biochemical transformations of organic matter. This might be achieved by future analyses of different microbial biomarkers, such as amino sugars.

Presentation: Poster - Presentation no°: no number - Project: SHIFT ENV 52

Litter-bag experiments on decomposition and mesofauna colonization of leaves in primary and secondary forests on degraded croplands in central Amazonia

F.J. Luizão[1], E. Franklin[1], E.P. Oliveira[1], J.W. de Morais[1], H. Höfer[2], C. Martius[2], L. Beck[2]

[1] INPA,Manaus/AM, Brazil
[2] Staatliches Museum für Naturkunde Karlsruhe, Germany

Two litter-bags experiments were designed to study the rates of decomposition, nutrient release and its relationships with soil and litter mesofauna which colonize decomposing material. Three ed to exclude selected groups of animals from the nylon bags: 20 μm, 250 μm, and 1 cm. The first experiment was started on October 27th, 1997, late dry season, and the second is pl[illegible] (one of each mesh size) was placed on the litter layer at random, following a 1-m apart grid of lines marked in 40 x 40 m plots of a primary forest, a 10-years old secondary forest growing after removal and abandonment of old *Hevea* (rubber tree) fields, and a 10-years old second growth enriched four years ago with fruit and timber species planted in narrow rows. All three systems are located on similar yellow clay latosols (Oxisols), near one to another and on the same large plateau, at the EMBRAPA-CPAA (Brazilian Agro-husbandry Research Agency - Center for Agroforestry Research in Western Amazonia), 30 km northeast of Manaus, AM. Litter bags were filled with approximately 7.5 g of air-dried leaves of *Vismia* spp., collected from the second growth floor and previously air-dried and stored in laboratory. A sub-set of eighteen samples were kept to be oven-dried at 65-70 °C up to constant weight, in order to calculate a correction factor for the initial dry weight of the leaves in litter bags. For each mesh size, 336 litter bags were used: 112 for each forest type. Seven retrievals are planned: after 30, 60, 90, 120, 180, 270, and 360 days after installation of the experiment in the field. At each retrieval time, 16 sets of litter bags (one mesh size in each set) are collected at random, and immediately proccessed in laboratory at EMBRAPA. Ten litter bags are opened and the leaves are visually inspected for the main physical and biological actions occurring on the material (breakdown, action of termites, hyphae and mycelia formation, root penetration, action of termites, soil or other residues accumulation, and presence of soil/litter fauna). After the inspection, the leaves are placed in a Berlese funnel for mesofauna extraction (with picric acid as conservation liquid) for 5-8 days, up to completely drying the decomposing leaves. Then, the leaves are retrieved from the funnels, brushed gently for removing any residues, oven-dried at 65 °C up to constant weight, ground-milled, and stored for chemical analyses (C, N, P, K, Ca, and Mg). First results will be presented.

VII International Congress of Ecology INTECOL 1998, Florence, Italy 19-25 July, 1998:

Abstract:

C. Hanne (1) & C. Martius (2)

(1) II. Zoologisches Institut, Universität Göttingen, Berliner Str. 28, 37073 Göttingen, Germany
(2) Staatliches Museum für Naturkunde, Erbprinzenstr.13, 76133 Karlsruhe, Germany

IMPACT OF AMAZONIAN TERMITE POPULATIONS ON THE CARBON CYCLE OF NATURAL AND MANAGED FOREST SYSTEMS: RESPIRATION RATES IN DIFFERENT TERMITE FOOD GUILDS

Termites of tropical forests are a dominant group amongst primary destruents. Divided into mainly four food guilds, e.g. wood-feeders, humus-feeders, leaf-harvesters and generalists, termites are believed to have an high impact on nutrition-cycles of tropical forests. Eight representative species in Central Amazonia representing the different food guilds were studied in order to determine their respiration quotients as an important feature of their metabolic potential. For a period of ten months we took monthly samples in three different forest systems: a wood plantation, a secondary forest and a primary forest. Following species have been investigated: Anoplotermes banksii, Constrictotermes sp., Heterotermes sp., Labiotermes labralis, Nasutitermes sp., Neocapritermes sp., Syntermes molestus and Termes fatalis. The mound-building termites were captured by taking direct samples from mounds. The subterranean species were investigated with monitoring stations which contained different baits. With an Infra-Red-Gas-Absorption-Spectrograph the respiration quotient (l CO2/ min/ g biomass) for each species was determined, with the termites separated by castes. We could prove a strong dependence of respiration rate on food guild membership for the investigated species. Preliminary data indicate that representatives of all food guilds were encountered on the primary forest plots, but not in the secondary forest and in the plantation plots. The total absence of some food guilds on the polyculture study sites may indicate that important carbon sources will not be adequately decomposed in these plots.

VII International Congress of Ecology INTECOL 1998, Florence, Italy 19-25 July, 1998:

Abstract:

Martius, C. (1), Höfer, H. (2), Römbke, J. (3), Garcia, M.B. (4) & Beck, L. (1)

(1) Staatliches Museum für Naturkunde Karlsruhe, Germany
(2) Zoology II, University of Göttingen, Germany
(3) ECT GmbH, Flörsheim, Germany
(4) EMBRAPA-CPAA, Manaus, Brazil

SHIFT PROJECT ENV 52: SOIL FAUNA AND LITTER DECOMPOSITION - THE USE OF ADAPTED SOIL BIOLOGICAL METHODS IN AMAZONIAN RAIN FORESTS

A comparative study of litter quantity and quality, decomposition rates, and the abundance, biomass, and respiration of soil-inhabiting microbes, arthropods and earthworms has been started in a polyculture forestry plantation and in plots of nearby secondary and primary forest in 1997. The aim is to evaluate the specific contribution of the soil microflora and of the different functional soil fauna groups to the decomposition of organic matter and the resulting nutrient supply to the plants. The effect of the secondary vegetation and its residues on polyculture plantations is of special interest.
The following methods have been adapted to neotropical conditions on the base of preliminary tests:
- litterbags with mesh sizes of 20 µm, 250 µm, 1 cm; and mini-container bars with mesh sizes of 20 µm and 250 µm - to measure decomposition rates;
- bait lamina to measure mesofauna feeding rates;
- Kempson - extraction of small soil-cores - for mesofauna abundance and biomass
- wet-funnel extraction of small soil-cores - for enchytraeid abundance and biomass
- Berlese - extraction of large soil-cores - for macrofauna abundance and biomass
- IRGA respiration measures of soil and litter - to determine soil microbial biomass
- fumigation-extraction of soil-cores - to determine microbial carbon content
- stratified and bait sampling of termites and ants
- manual sampling for macrofauna and formol-extraction of earthworms in 4 m^2 - areas - -
litter quantity manipulation
experiments to study effects on soil fauna and microflora
- respiration measures with selected soil animals (IRGA)
- chemical analises (C/N-ratio, exchangeable cations, humus) of soil, plant residues and soil animal products

Poster Abstract
GfÖ-Tagung Ulm, Germany, September 1998

Lignin and other organic substances in termite mounds of moist and dry ecosystems in Brazil

W. Amelung[1], C. Martius[2], A.G. Bandeira[3], M. Garcia[4], T. Gonter[1] and W. Zech[1]

[1] Institute of Soil Science and Soil Geography, University of Bayreuth, Germany
[2] Staatliches Museum für Naturkunde Karlsruhe, Germany
[3] Universidade Federal da Paraíba, João Pessoa/PB, Brazil
[4] Embrapa-CPAA, Manaus/AM, Brazil

Termites play an important role in organic matter and nutrient cycles of tropical ecosystems, but since it is thought that termites are unable to decompose lignin in a significant scale, lignin should accumulate in their mounds. This study was designed to investigate how termites alter the organic matter in a rain forest near Manaus, Amazonia, Brazil (Embrapa-CPAA, Manaus/AM), and in a semi-arid savanna (sertão) about 300 km W of Natal, NE Brazil (Estação Ecológica do Seridó, IBAMA, Serra Negra do Norte, Brazil). Samples were collected from the outer and inner parts of typical termite nests of *Nasutitermes, Termes, Embiratermes, Cornitermes, Anoplotermes,* and *Constrictotermes* genera, as well as from the surrounding topsoil (0-10 cm) and potential wooden food. Chemical analysis, which is still in progress, includes the determination of organic C, N, lignin-derived phenols, and carbohydrates. Nests from the dry area are still being analyzed, but the termite nests in Amazonia were significant sinks for organic matter and its associated nutrients. The organic C contents ranged between 100 and 500 g kg^{-1} in the nests, compared to 17 to 42 g kg^{-1} in the surrounding topsoils. Lignin contents of the mounds were even higher than in wood, thus giving support to the assumption that lignin is accumulated in preference to other organic compounds. Except for *Nasutitermes ssp.*, there was no significant difference in organic C between the samples from exterior and interior of the nests. In the mounds of the wood-feeding *Nasutitermes ssp.*, however, the nest interior had significantly lower C contents and C/N ratios that the exterior. This seems to be accompanied by lower lignin contents and higher degree of lignin side-chain oxidation. We suggest that the interior part of the nests comprise regions of higher organic matter turnover including degradation of lignin. As lignin oxidation might not have happened in the gut of the termite itself, more research is required to clarify the role of symbiotic microorganisms to the biochemical transformations of organic matter. Therefore, we are also carrying out analyses of different microbial biomarkers, such as amino sugars.

Poster Abstract
GfÖ-Tagung Ulm, Germany, September 1998

Studies of litter decomposition in three tropical forest sites in Amazonia using litter bags and mini-containers

gfö-u981.wpd

C. Martius, H. Höfer, E. Franklin, M. Garcia, F. Luizão, L. Beck
SMNK, Karlsruhe; INPA, Manaus/Brasil; Embrapa-CPAA, Manaus/Brasil

Studies of litter decay which help to understand nutrient cycling in tropical forests are one contribution to the management and preservation of these heavily threatened ecosystems. In the context of studies on the regeneration of degraded former rain forest sites with polyculture systems, extensive investigations on the role of soil organisms in nutrient cycling are carried out within a recent research project (SHIFT ENV 52: Soil Fauna & Litter Decomposition). The use of litter bags is a standard procedure in studies of litter decomposition. A variation of this method are the mini-containers devised by EISENBEIS (1990); they permit easier manipulation and allow improved statistical analysis of the data. To date, mini-containers have never been tested in the tropics. We devised a parallel study of litter-bags and mini-containers started in the late dry season of 1997. Study sites are one primary forest, a 10 year old secondary forest growing after removal and abandonment of old rubber trees (*Hevea*) plantations, and a 7 year old plantation (polyculture system) of four different tree species planted in rows, with secondary vegetation (dominated by *Vismia* cf. *guinanensis*) tolerated between, all three systems being located on yellow clay oxisols at the Embrapa-CPAA (Brazilian Agency for Agro-Husbandry Research - Center for Agroforestry Research in Western Amazonia) near Manaus, Amazonia, Brazil. Litter bags were exposed at randomized points within the three sites in groups (sets) of three bags; each of a different mesh size (20 µm, 250 µm, and 1 cm) to exclude selected groups of animals. For each mesh size, 336 litter bags were used (112 in each forest type). Seven retrievals are planned, at 30, 60, 90, 120, 180, 270, and 360 days after installation of the experiment in the field. Parallel to the litter bags, mini-container bars were exposed in the field, each containing 6 polyethylene-containers equipped with gauze of a mesh-size of 20 µm (to exclude all fauna and admit only microflora), and 6 containers with 250 µm (to exclude macrofauna but admit mesofauna). The containers were filled with weighed pieces (100 mg) punched out of air-dried *Vismia* leaves. A total of 10 bars per site was used, bars being exposed in the same sampling quadrats as the litter bags, next to them. Bars were retrieved at 3 dates (30, 60, 90 days after exposure). We will present results and methodological considerations.