CAPÍTULO 06
WILD FAUNA BIODIVERSITY EVOLUTION IN SUGARCANE PLANTATIONS UNDER ORGANIC FARMING AND ECOLOGICAL MANAGEMENT

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RESUMO: Pesquisas e estudos direcionados para avaliar o papel desempenhado pelos territórios do agro na conservação da fauna silvestre ainda são escassos. As diferentes tecnologias utilizadas nos sistemas de produção agrícola promovem efeitos diferenciados sobre a composição dos povoamentos da fauna silvestre. Hoje com as novas técnicas agrícolas como o plantio direto, agricultura orgânica e controle biológico de pragas estão ampliando a oferta de recursos naturais e de nichos ecológicos dentro das áreas produtivas, e possibilitando o ganho de espécies da fauna silvestre, com o aumento da biodiversidade. Esse projeto de pesquisa foi desenvolvido pela equipe da EMBRAPA Territorial vem conduzindo estudos para detectar e caracterizar a biodiversidade de vertebrados em territórios de fazendas produtoras de cana-de-açúcar. A área de estudo compreende um conjunto de fazendas com 7.868 hectares sob cultivo orgânico e manejo ecológico, localizadas na região de Sertãozinho, SP. A Usina São Francisco iniciou há quase quatro décadas processos de restauração ecológica dos ambientes circunvizinhos as áreas de plantio de cana-de-açúcar em produção orgânica, além de manter a preservação dos remanescentes florestais. O aumento significativo da biodiversidade faunística ao longo dos anos foi promovido pela emergência espacial e aumento da complexidade ocorrida na vegetação restaurada nas Áreas de Proteção Permanente. Foram realizadas campanhas de levantamentos de dados e monitoramento da fauna durante todo o ano e ao longo dos anos, os resultados confirmaram a eficácia dos métodos empregados. Foram registradas e identificadas 341 espécies de vertebrados silvestres no conjunto dos dez ambientes amostrados (27 anfíbios, 25 répteis, 246 aves e 43 mamíferos), das quais 49 das espécies estão sob algum risco ou ameaça de extinção no estado de São Paulo. O itinerário metodológico adotado para avaliar a biodiversidade faunística permitiu atingir os objetivos da pesquisa e revelou-se plenamente adequado. Os resultados obtidos até o momento indicam que o cultivo em

sistemas orgânicos, associado ao manejo ecológico tem ampliado a biodiversidade faunística.

PALAVRAS-CHAVE: agricultura orgânica, fauna silvestre, espécies ameaçadas, biodiversidade.

ABSTRACT: Studies on the agricultural areas role in wildlife conservation are still quite incipient. The kind of management employed in these systems can promote a differentiated discrimination on the composition of faunal settlement. This project was developed by EMBRAPA Territorial team and collaborating researchers, specialized in wildlife. It aims to detect and to characterize the vertebrates' biodiversity in a defined territory. The study area includes a 7,868 acres group of farms under organic cultivation and ecological management, situated in Sertãozinho, Southestern Brazil. More than three decades ago, the Usina São Francisco staff began the restoration processes of the natural environment around the organic sugar cane planted areas and also preserved the native remnants. The significant increase of biodiversity along the years was a result of the spatial flora emergence and the restored vegetation complexity in the so-called Permanent Protection Areas. The present results were obtained through regular maintenance and sampling efforts. Data collection and wildlife monitoring campaigns were held over the years and in the course of each year. And the results confirmed that the employed methods were effective. A total of 341 wild vertebrates species were registered and identified in the ten sites studied altogether (27 amphibians, 25 reptiles, 246 birds and 43 mammals). Among those, 49 species are considered under extinction risk or threat, in São Paulo State's Red List. The methodological itinerary adopted to assess the faunal biodiversity allowed to achieve the research objectives; proved itself fully adequate and confirmed its effectiveness. The results obtained so far indicate that organic farming systems associated with the suitable ecological management favors the increase of faunal biodiversity.

KEYWORDS: organic agriculture, wildlife, endangered species, biodiversity.

1. INTRODUCTION

The conservation of faunal biodiversity contributes to the maintenance of vegetation, since the fundamental role that vertebrates play in seed dispersion and even in the pollination of plant species present in forest stands is already known (Brasil, 1967; SMA-SP, 2010 a). Primates, bats, cottages, hummingbirds, are some of these vectors and can be considered forest planters. The occurrence of wild vertebrate species in agricultural areas has been studied in a still very incipient way. Little attention has been paid to the effective role of agroecosystems in the conservation of faunal biodiversity (Beca *et al*., 2017). The type of management and technification employed in these productive systems may be more or less selective about the composition and structure of the faunal settlements. EMBRAPA Territorial researchers, collaborators and wildlife experts have been developing research aimed at understanding these ecosystem services and the degree of sustainability generated by different production systems in relation to the maintenance and preservation of wild vertebrate populations and settlements. A study has been monitoring for almost two decades to qualify and quantify the evolution of wildlife biodiversity in organic production systems with sugarcane crops in the region of Sertãozinho, SP. The study area covers a set of 7 farms adding up an area of 7,868 hectares with organic cultivation and ecological management of the preserved environments and adjacent to the cultivated areas, and about 80% of this territory are represented by the sugarcane fields (Miranda; Miranda, 2004; Miranda, 2010; Miranda *et al*., 2011 (a, b); Miranda *et al*., 2012 (a, b, c); Miranda; Ariedi Jr., 2013 (a, b)).

2. OBJECTIVE

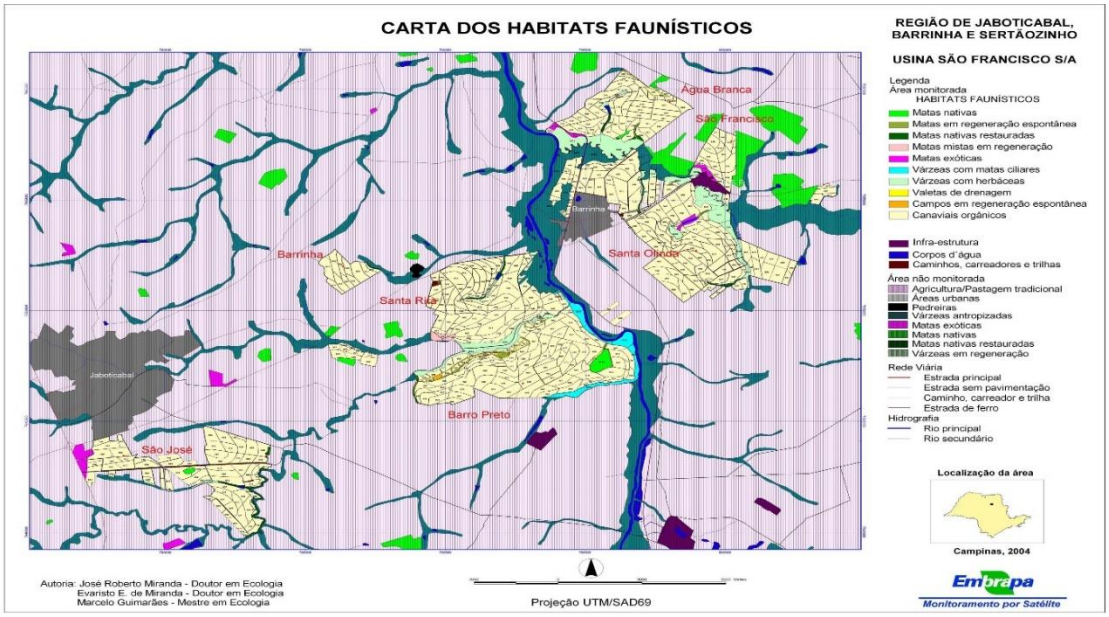
The objectives of this study were multiple, they aimed to develop, test, adapt and confirm the effectiveness of a methodological itinerary to characterize the composition and structure of terrestrial vertebrate populations, through indicators of wealth and diversity within the pilot territories. However, the mosaic of habitats offered in the perimeters delimited by all the power plant's farms could not be neglected. As well as, in an objective manner, to qualify and quantify the

riches of the wild fauna existing in these properties of organic sugarcane, taking into consideration the various environments adjacent to the crops, since the resources offered in this complex landscape satisfy the various dimensions necessary for the maintenance of these populations of fauna. Also, special attention was paid to the occurrence of species of wild vertebrates considered to be at risk or threatened with extinction in the state of São Paulo and that can be considered as biological indicators.

3. MATERIAL AND METHODS

The study area comprises the agricultural areas 100% certified for organic production, natural environments preserved and restored associated belonging to the São Francisco Plant. The set of farms is located in the watersheds of the Pardo and Mogi-Guaçú Rivers, tributaries of the Paraná River (Miranda; Miranda, 2004). The analog interpretation of images from the QuickBird satellite showed, in the territory of the seven farms studied, about ten faunal macro-habitats. The level of spatial perception defined for the cartographic expression of these macro-habitats was on the scale of 1:20,000. The land use and occupation categories served as the basis for the qualification of these ten types of environments, which make up a life support mosaic for terrestrial vertebrates, are presented below: 1. Organic sugarcane plantations; 2. Exotic forests; 3. meadows with herbs; 4. Ciliary floodplains; 5. Restored native forests; 6. Mixed forests in regeneration; 7. Native forests; 8. Drain drains; 9. Spontaneously regenerating forests; 10. Field in spontaneous regeneration. Each macro-habitat has distinct ecological conditions, providing differentiated resources for the fauna, and therefore plays a very discriminatory role in the spatial distribution of species, populations, and interfere in the composition and structure of faunal settlements (Figure 1).

Figure 1 – Letter of the 10 faunal macro-habitats present in the farms of the São Francisco Power Plant in Sertãozinho-SP.



Source: The authors.

The random stratified sampling strategy was adopted, because it considers the intrinsic spatial heterogeneity of the farms (macro-habitats) and ensured a judicious qualitative comparison between the faunal settlements of the different macro-habitats. It is balanced by a number of relatively equivalent surveys in the various macro-ecological situations, regardless of the size of its surface area or dimension, ensuring an equitable sampling effort (Frontier, 1983). The fact that the surveys were distributed in a random manner within each stratum offered the same probability of occurrence for all species and allowed the elaboration of relative frequency profiles of presence for each one of them. This evidenced the composition and structure of the different animal settlements and made it possible to characterize the specific riches for each faunal macro-habitat and the territory formed by the set of the seven farms (Daget; Godron, 1982).

Due to the variability of the dynamic ecological conditions of the media, during the different seasons of the year, surveys of terrestrial vertebrate fauna were carried out over the years. The cycle of seasonal variations, mainly of humidity and temperature, was contemplated in a concomitant manner with the possible fluctuations in the composition of the stands, in terms of biological activity and migratory behavior of certain species (Billaud, 2002) in all the sampled strata. All surveys for the inventory of the species in the field were carried out following defined criteria and methodological itineraries and using the

previously prepared form, in regular campaigns between the years 2002 to 2012, in the 10 environments (macro-habitats) mapped and available for wild fauna in the agricultural areas of the São Francisco Plant.

In the zoo-ecological surveys carried out in the field, a pre-coded form was used to collect various information referring to the prospection point, describing the existing environmental conditions. This data shee*t al*lowed to collect homogeneous and objective data about the location, the physical environment, the structure of the dominant vegetation and plant species, the degree of anthropization and finally, the vertebrate species detected.

This information was further processed, especially for the characterization of the biological riches of the faunal settlements in each macro-habitat. Among the list of parameters relating to the composition of a faunal settlement, the specific richness is that which provides a first dimension of the size or quantity of species detailed to a given type of environment. It can be broken down into four major types: total wealth, average wealth, accumulated wealth and exclusive wealth, each presenting its own characteristics and bringing information about its composition (Blondel, 1979).

The faunal groups were sampled through combinations of techniques that did not present any harm to the animals, without capture or collection of individuals, used in wildlife ecology studies. The techniques used in the study were limited to visual and auditory search, search for vestiges such as burrows, nests, feces, footprints, displacements with vehicles for occasional encounters, and the use of trail cameras. Due to the daily activity behavior of the species, surveys and observations were carried out at different times, in the morning, twilight and night periods. Seasonal climatic variations promote fluctuations in the composition of the stands, some species can decrease or increase their biological activities as a function of temperature, humidity, food availability, etc. In the same way other animals, such as for example migratory birds are observed only during their periods of movement, seeking places for feeding, resting, and even for breeding. Through this peculiarity, surveys were carried out over the different seasons of the years to detect as much of the forest species as possible (Miranda; Miranda, 2004; Miranda; Ariedi Jr., 2013 b).

This universe of environments allowed us to inventory the total biodiversity and in each of these macro-habitats. The objectives of this work were multiple,

they aimed to test, adapt and develop a methodological itinerary for assessing the biodiversity of wild vertebrates in the delimited territory. As well as this, to analyze the quality of the faunal wealth of wild vertebrates existing in a property cultivated with organic sugarcane and in the various environments adjacent to and associated with ecological management. Special attention was paid to the occurrence of species of wild vertebrates considered to be at risk or threatened with extinction in the state of São Paulo.

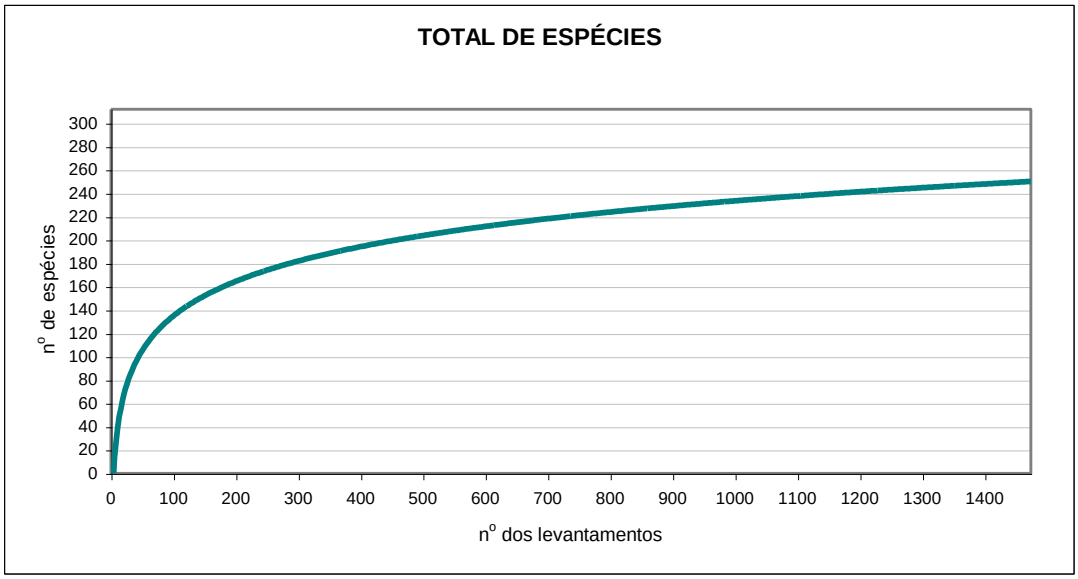
4. RESULTS AND DISCUSSION

As a result of the maintenance in regularity of the sampling effort, between the years 2002 to 2016, 341 species of wild vertebrates were registered and identified in the set of the ten environments sampled in the seven farms (27 amphibians, 25 reptiles, 246 birds and 43 mammals), of which 49 were in a situation of ecological fragility, and were under some risk or threat of extinction in the state of São Paulo, according to State Decree No. 56,031 (SMA-SP, 201 0(b). Examples of these endangered species are the anhuma (*Anhima cornuta*), the hawk-bellied (*Busarellus nigricollis*), the maguari (*Ciconia maguari*) and the gray suiriri (*Suiriri suiriri*); the cauré (*Falco rufigularis*), the long-billed chorus (Herpsilochmus longirostris), the tuiuiú (*Jabiru mycteria*), the maned sandwich (*Schabiru istoclamys melanopis*), the cricket john (*Synallaxis hypospode*) and the little black star (*Synallaxis scutata*); the maned wolf (*Chrysocyon brachyurus*), the ocelot (*Leopardus pardalis*), the red brocket (*Mazama americana*), the giant anteater (*Myrmecophaga tridactyla*) and the cougar (*Puma concolor*), among several other species. For example, the number of birds registered in the study area represents almost 30% of the bird species listed in all the biomes of the state of São Paulo and about 14% of all species of Brazilian avifauna.

The accumulated wealth curve illustrates a strong deceleration in the gain of new species from 1400 surveys and indicates that almost all species were detected (Figure 2). In the organic sugarcane plantations alone, approximately one hundred species of wild vertebrates have been recorded. This fact is due to the fact that they are harvested without burning, with raw sugarcane, without the use of agrochemicals, among other factors related to organic cultivation and ecological management. In addition, after harvesting, a plant biomass of

approximately 20 tons of dry matter per hectare/year is left on the soil and will be broken down by soil biota. These decomposers form the basis of a food pyramid or web and greatly expand the supply of prey from the ecological food niche to various vertebrates.

Figure 2 – Accumulated richness curve expressing the number of species detected in the total surveys carried out in all faunal macro-habitats.



Source: The authors.

The value of total wealth can be considered expressive. Approximately one hundred species of wild vertebrates have been recorded in the interior of the organic sugarcane plantations. This fact is due in good measure to the use of harvesters for almost four decades, without burning, the raw sugarcane cultivated without any use of agrochemicals, as well as other factors arising from organic cultivation and ecological management of the other environments present in the landscapes of the mill's farms. After harvesting, a plant biomass of approximately 20 tons per hectare/year is left on the soil, which will be broken down by the soil biota, avoiding the incidence of solar radiation, as well as facilitating infiltration, moisture retention and erosion caused by rainfall in bare soils. These decomposers, especially the same fauna, are responsible for the formation of the base of a food pyramid, which contributes substantially to meeting the needs of the food dimension of the ecological niche of several vertebrates.

Other macro-habitats also provide ecological conditions and resources necessary for breeding and shelter for wild animals and fulfill the needs of terrestrial vertebrates.

Table 1 – Values of total, average and exclusive riches in the ten faunal habitats of the São Francisco Power Plant, SP.

	HABITATS											
RIQUEZAS	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**TOTAIS**	**%**
Riqueza Total	121	93	171	138	161	92	143	134	100	92	**341**	100
Riqueza Média	0,364	0,338	0,538	0,527	0,441	0,368	0,444	0,438	0,4	0,367	-	-
Riqueza Exclusiva	12	3	26	11	16	4	15	8	5	2	102	37

Legend:

Habitat 1 - Organic Sugarcane;
Habitat 2 - Exotic Forests;
Habitat 3 - meadows with herbaceous trees;
Habitat 4 - Floodlands with Riparian Forest;
Habitat 5 - Restored Native Forests;
Habitat 6 - Mixed Forest in Regeneration;
Habitat 7 Native Forests;
Habitat 8 - Drainage Valles;
Habitat 9 - Spontaneously Regenerating Forests;
Habitat 10 – Field in Spontaneous Regeneration.

Source: The authors.

All biological wealth indices (total, average and exclusive) showed great variability in the habitats (Table 1). The total wealth was highest in the Várzeas with Herbaceous, with 171 species. In descending order were: the Restored Native Forests, 161 species; the Native Forests, 143 species; the Várzeas with Riparian Forests, 138 species; the Drainage Vallettes, 134 species; the Forests in Spontaneous Regeneration and the Exotic Forests were the inhabitants with the smallest specific richness with 92 species each, a number lower than the 121 found in the areas occupied by the Organic Canavials.

The macro-habitat No. 3, Várzeas com Herbáceas, congregates a series of natural microenvironments associated mainly with the stream of Onça, a tributary of the river Mogi-Guaçú, which runs in an extensive plain. Besides the main channel of the stream, there are marginal lagoons formed by ancient meanders abandoned, where over thousands of years, due to the deposition of sediments carried by the waters. These floodplains are complex environments formed by abandoned meanders, bogs, baths, ponds, dikes, in short a range of similar environments covered naturally by various grasses such as *Hyparrhenia rufa*, the razor grass (*Echinochloa polystachya*), among others, *a brachiaria* (*Brachiaria decumbens*), among others, all of herbaceous size (less than 0.50 meters), with some shrubs and scattered trees. Some permanently flooded

places the vegetation cover shows predominance of taboas (*Typha domingensis*). However, the main similarity between the various micro-environments of the floodplains is characterized mainly by the predominance of the vertical structure of the vegetation cover, which is low and by the large production of vegetal biomass generated by the grasses. This biomass plays a fundamental role in the trophic chains, in the wildlife of herbivores, besides serving as a shelter and place of reproduction for countless species of vertebrates. Several species of paluicultural and liminal birds, whether resident or migratory, build their nests in aquatic *vegetation, such as the jaçanã (Jacana jacana*), the water chicken (*Gallinula chloropus*), the garibaldi (*Chrysomus ruficapillus*), the small suiriri (*Satrapa icterophrys*), the marsh treasury (*Gubernetes yfase*), the naughty (*Arundinicola leucocephala*), the three-poted *saracura Aramides cajanea*), the harvester (the *Platalea ajaja*), etc. Likewise, is the most favorable environment for shelter, foraging of most amphibian species, more than 90% of the detected species have been found in this macro-habitat, including because these wetlands are fundamental to the reproductive cycle of these vertebrates, whose evolution has not redeemed them from an ambiguous life between water and land.

Although these environments have a relatively small surface area on the farms of the São Francisco Mill, they house close to 48% of all the biodiversity of vertebrates detected in the set of 10 fauna habitats. This is not only the habitat with the greatest specific richness, but it was also where the greatest value of exclusive wealth occurred, that is to say, 26 species of vertebrates with the financing of the ecological conditions offered on the floodplains of the rivers and streams. The largest area of meadows with herbaceous vegetation is found in the stream of Onça. From its headwaters in the region of Luis Antonio, almost 70 kilometers in a straight line from its mouth on the Mogi Guaçu river, it travels more than double this distance due to its great sinuosity, shaped by the plain where it rests its bed. In the region of Ribeirão Preto, excluding the Mogi Guaçu river, the streams of the Onça are the largest river of floodplains with herbaceous vegetation and represent a source of propagating species of vertebrates, for the repopulation of other environments of the regional context and works as a great corridor for the wild fauna.

5. CONCLUSIONS

The processes initiated more than two decades ago by the São Francisco ecological restoration plant, the Permanent Protection Areas and other environments surrounding the sugarcane plantation areas were fundamental for the expansion of the specific wealth. The significant increase in the specific wealth of vertebrates over the years of this research, is due to several factors that made possible the colonization and implantation of new species, in the light of the supply of food resources, shelters, reproductive conditions and of the available ecological niches. The complexity resulting from the spatial and phenological emergence of the restored vegetation in the Permanent Protection Areas also contributed to this expansion of faunal biodiversity, including being enriched with seeds of new plant essences disseminated by countless animals and consecrated ecological interactions between the fauna and the floristic composition of these environments. Forest cover along waterways facilitated connectivity with native forest stands and other types of natural environments that make up the landscapes of these agroecosystems.

The methodological route adopted to assess the fauna biodiversity allowed the objectives of the research to be achieved and proved to be fully suitable for studies in the defined territory. The results obtained through the maintenance in regularity of the sampling effort, in which campaigns of data surveys and monitoring of the fauna were carried out throughout the year and over the years, confirm the effectiveness of the methods employed and the extremely high specific richness, 341 species of wild vertebrates, in the type of system for producing sugarcane studied. Of these, 49 are at some risk or are threatened with extinction in the state of São Paulo and are ecological indicators of the quality of the natural resources offered by this standard of agricultural system. It is safe to say that the expansion of wildlife biodiversity occurs through the spatial and temporal stability of the environments, as well as the increasing predictability of the supply of available natural resources. Today, it can be said that the wild fauna is totally integrated into the productive process, with symbiotic interactions with the mosaic of environments present in the properties.

The results indicate increasingly harmonious and conciliatory relationships between wildlife conservation and organic production systems committed to

contributing to "Conservationist Public Policies." The diachronic approach of this research, over almost two decades, has been consolidating the understanding of the evolution of faunal biodiversity in agro-ecosystems, without prejudice to the production and productivity of crops. Each year, new species are added by natural processes to the faunal settlement, and many of them will find possibilities of permanent implantation, constituting populations through reproductive processes and occupying dimensions of available ecological niches.

The adoption of an ecological management of the landscapes, organic practices and the harvesting of raw sugarcane for about 40 years, the mill itself have also been fundamental for the quality of the soils and for the increase of the biodiversity of terrestrial vertebrates. Currently, about 20% of the sugarcane plantations are annually in formation (sugarcane plant) and are not harvested; they fulfill an important role of refuge for the fauna during the harvesting period, which extends roughly between April and November. It can be said that the areas of crops are perceived by the fauna as if they were an extension of their territories for feeding, reproduction and refuge, besides being used as corridors for their movements in this kaleidoscope of uses and occupation of these territories. Grasses were planted in the carriers and represent more than 700 hectares of pasture for herbivorous animals. The results show in detail the importance of spatial and temporal stability in land use, the food predictability represented by the decomposers of post-harvest biomass for the maintenance of wild vertebrate populations. The results effectively illustrate the evolution of specific wealth and biodiversity over time, which has been occurring in sugarcane plantations under organic cultivation and ecological management of the landscapes creating "Noah's Islands" for the fauna in agricultural areas.

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