EDAPHIC MESOFAUNA IN FLOODPLAIN AND HIGHLAND NONFLOODED FORESTS IN THE AMAPA, BRAZILIAN AMAZON

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RESUMO

O solo é um dos recursos importantes para conservar e manter as florestas. Parte dessa importância se deve aos organismos edáficos, que são classificados em: macro, meso e microrganismos. Os mesorganismos (ácaros, colêmbolos, dipluros, proturos e pequenos insetos) têm tamanho entre 100 µc a 2 mm. O objetivo deste estudo foi verificar se a abundância e diversidade da mesofauna edáfica são maiores em floresta de terra firme quando comparada à de várzea. O estudo foi realizado em 4 áreas de florestas nativas no Amapá. Para homogeinizar o efeito da vegetação, as amostras de terra foram coletadas sob 22 andirobeiras em cada tipo florestal. Foi utilizado cilindro de 98 cm^3 para a coleta de 8 amostras de terra por andirobeira para avaliação da mesofauna, utilizando o extrator de Berlese-Tullgreen modificado. Foram calculadas: diversidade, riqueza, abundância e frequência. Foi realizado o teste Qui-Quadrado para comparar a proporção relativa dos grupos e o teste “t” para comparar as diferenças entre as médias em cada tipo florestal. Foram encontrados 1.858 organismos distribuídos em 9 grupos, na floresta de terra firme e 1.755, em 10 grupos, em floresta de várzea. Não foi possível observar diferença estatística na abundância total dos mesorganismos entre as florestas estudadas. Os ácaros foram os organismos que apresentaram maior abundância relativa em ambos os ambientes. No entanto, houve diferença significativa para a densidade dos grupos específicos hymenoptera, isoptera, diplura e pseudoescorpiã, os quais tiveram uma maior densidade em floresta de terra firme. A partição da abundância total entre os grupos também foi diferenciada em função do tipo florestal. Não foi encontrado nenhum indivíduo do grupo Thysanoptera na terra firme. A diversidade da mesofauna edáfica foi significativamente maior na terra firme do que na várzea, devido a maior equitabilidade. A abundância e riqueza de grupos de organismos que compõem a mesofauna edáfica de floresta de terra firme é semelhante àquela encontrada em floresta de várzea, no entanto há maior diversidade e equitabilidade entre os grupos na floresta de terra firme.

ABSTRACT

Soil is an important resource to conserving and maintaining forests. Part of this importance is due to edaphic organisms that are classified into: macro, meso and microrganisms. The mesorganisms (mites, springtails, Diplura, Protura and small insects) have size between 2 mm to 100 µc. This study aimed at evaluating whether the abundance and diversity of edaphic mesofauna in nonflooded highland forest (*hereafter terra firme forest*) is greater than floodplain forest *(várzea)*. The study was conducted in four areas of Amazon forest in the State of Amapa. In order to homogenize the vegetation effect, soil samples were collected at 22 crabwoods trees (*Carapa guianensis* Aubl.*)* in each forest type. We used cylinders of 98 cm^3 to collect 8 soil samples in each *C. guianensis.* The organisms were extracted using a modified Berlese-Tullgreen extractor. The diversity, richness, abundance and species frequency were calculated. We performed a chi-square test to compare the relative proportion of groups and a t-test to compare differences between means for each forest type. We found 1,858 organisms in 9 groups in terra firme forest and 1,755 in 10 groups in floodplain forest. Non statistical differences were found in total abundance of mesorganismos between forests types. The mites were the organisms with highest relative abundance in both environments. However, there were significant differences for the density of Hymenoptera, Isoptera, Diplura and Pseudoescorpiã groups, which had a higher density in terra firme forest. The partition of total abundance between the groups was different depending on the forest type. None specimen of the group Thysanoptera was found in terra firme. The diversity of edaphic mesofauna was significantly higher on terra firme forest than in floodplain forest, because there was a greater ***evenness***. Our findings also showed that abundance and richness of the organisms groups of the edaphic mesofauna in terra firme forest is similar to that found in floodplain forest, however, greater diversity and ***evenness*** between the groups in terra firme forest was found.

INTRODUCTION / OBJECTIVES

Forest ecosystems are important in maintaining biodiversity, ensuring the survival and perpetuation of the species (WINK et al., 2005). Much of the forest has suffered predatory exploitation caused by anthropic activities that convert and fragment large areas into small patches of natural forests. This exploitation along with the lack of information on the ecological behavior of plant and animal species has threatened many species by extinction around the world, including the Amazon forest.

The Amazon forest holds different natural ecosystems, among these are the terra firme and floodplain ecosystems. Despite numerous studies on the

Amazon region, only few have been carried out aiming to understand the Amazon ecosystem functioning.

Soil is an important resource for the maintenance of forests, especially in the case to Amazon. Therefore, it is necessary to create knowledge about this resource that, among other functions, provides water and nutrients needed to keep plant and animal species that depend on forest.

Soil is composed of mineral matter, water containing solutes, gases, organic matter and living organisms. Each of these components occupies a fraction of volume soil that vary greatly with the soil type in particular and the prevailing forest conditions (EPSTEIN & BLOOM, 2006). According to Primavesi (1990), these five components are strongly integrated in such a way that soil becomes a "living and dynamic system" with its own metabolism in which the organisms are part, influencing and changing each other.

The living part of soil (i.e. soil organisms) has a "key function" in maintaining the ecosystem; it carries organic materials over the soil profile, decomposes and releases organic elements in the form of minerals which will be absorbed by the roots. Thus, soil organisms become responsible for nutrient cycling and energy transfer to the soil-plant-atmosphere, being the support and productivity base of terrestrial ecosystems in equilibrium (MOREIRA & SIQUEIRA, 2002).

Soil organisms are classified according to their sizes, in: macro, meso and micro-organisms (CORREIA & OLIVEIRA, 2000). According to Correia (2002), mesorganisms are in between of 100 µc and 2 mm, representatives of this group are: mites, springtails, diplura, protura and some small insects. They are important in nutrient cycling, fragmenting vegetal material and acting as regulators of population and microbial activity.

Accordingly, with this study we evaluated that the abundance and diversity of edaphic mesofauna in terra firme forest is higher than in floodplain forest.

MATERIAL AND METHODS

The study was conducted in four areas of Amazon forests in the State of Amapa; two of them were located in terra firme forest at the “Resex Rio Cajari” ($0^{o}15'S$, $52^{o}25'W$ and $1^{o}5'S$; $51^{o}31'W$) and the other two in the floodplain forests. These latter, one are located in the “Fazendinha” ($0^{o}03'04,24"S$ and $51^{o}0,7'42,72"$ W) an Environmental Protection Area (EPA), and the second in the “Escola Família Agroextrativista (EFA) do Carvão” ($0^{o}35'06,8"S$ and $52^{o}14'11,2"W$).

The climate of the area Rio Resex Cajari corresponds to tropical savanna and tropical monsoon, with an annual average rainfall between 2300 mm and 2400 mm (PELL et al., 2007). The rainy season occurs most frequently between February and June. The dry season occurs from September to November. The annual average temperature is 26°C (INMET, 2011). The predominant soils are “Latossolo-Amarelo and Vermelho-Amarelo (RABELO, 1999).

The climate of the floodplain forests areas corresponds to hot and wet equatorial, with maximum temperatures of 38ºC and minimums rarely below 18ºC. The annual rainfall ranges around 2500 mm, mainly between the months

January to July (INMET, 2011). The soil type is “Hidromórfico Gleysado” (VIEIRA, 2000).
Due to the crabwood tree (*Carapa guianensis* Aubl.) is a species easily observed in the two forest types of the study area, soil samples were collected at the base of 22 andirobeiras in each forest types.
As to the mesofauna analysis, eight samples were collected with metal rings (5 cm x 5 cm) attached to an soil auger. In the laboratory, each sample set (metal ring + soil) was placed in the modified Berlese-Tullgreen extractor (NEVES et al., 2008). Further, a screening and identification of these organisms was carried out at the group level using specialized taxonomic keys.
We calculated the Shannon diversity index using software Dives, and abundance, frequency and richness of groups. With the chi-square-test we compared the relative proportion of groups in the total density, while with t-test we compared means of the variables for each forest type.

RESULTS / DISCUSSION
We found 1858 soil organisms in terra firme forest distributed in 9 groups, and 1755 soil organism in floodplain forest divided into 10 groups (Table 1).

Table 1 - Abundance, diversity of groups and relative frequency (%) of the representative bodies of edaphic mesofauna collected in floodplain and highland nonflooded forests in Amapa, brazilian amazon.

	Abundance		Relative Frequency (%)	
Groups	Highland	Floodplain	Highland	Floodplain
Acarina	483	1087	26.00	61.94
Araneae	22	9	1.18	0.51
Collembola	187	335	10.06	19.09
Diplura	262	33	14.10	1.88
Hymenoptera	331	49	17.81	2.79
Isoptera	137	27	7.37	1.54
Immature	365	181	19.64	10.31
Protura	44	26	2.37	1.48
Pseudoescorpiones	27	4	1.45	0.23
Thysanoptera	-	4	0.00	0.23
Total	1,858	1,755	100	100
Shannon Index (H')	0.81	0.52	-	-
Richness	9	10	-	-

Neves et al. (2008) in their study of edaphic mesofauna carried out in September 2007 in Fazendinha EPA, found 3972 mesorganisms. This large number of organisms compared with our findings may have been due to their sampling effort, since the authors worked on three transects (630 m, 910 m and 500 m) collecting samples every 10m.
No statistically significant differences were found in the total abundance of mesorganisms between the two forests types ($t = 0.562$, $DF = 42$, $p = 0.577$). However, the partition of the total abundance between the groups varied depending on forest type as confirmed by the chi-square-test ($x^2 = 46.096$, $DF = 9$, $p < 0.001$). A possible answer to the similarity of the abundance in the two forest types, is that soil mesorganisms, although typically of terrestrial habits,

they are well adapted to forest with high humidity (CORREIA, 2000, FRANKLIN et al., 2001).

A fact that calls attention is that none individual was not found in the Thysanoptera group on terra firme forest (Table 1). Considering the number of samples collected (186) this was not expected, since this group is typical of terrestrial organisms and generally they are present in terra firme forests, according to Uhkig (2005).

The diversity of edaphic mesofauna was significantly higher in terra firme forest than in the floodplain forest ($t = 7.1797$, $DF = 42$, $p < 0.001$). Moço et al. (2005) emphasize that diversity of groups is associated with the relationship between the number of groups (richness) and the distribution of the number of individuals between groups (evenness). Though we found in terra firme forest an mesorganisms group less than in floodplain forest, there was a greater evenness resulting in a greater diversity.

Mites were the soil organisms that showed highest relative abundance in both forest types. However, terra firme forest accounted for 26% of the organisms and floodplain forest for 62%, indicating a lower evenness in the floodplain forest. It is known that the Acarina and Collembola groups are dominant in most forests type (CORREIA & OLIVEIRA, 2000; UHLIG, 2005). During data collection period (i.e. September), although Amazon summer was the season at that time, floodplain forest soils showed high humidity (mean = 41%), nearly twice terra firme forest soils (mean = 21%), which may have favored greater abundance of mites and springtails in the floodplain forest. Ducatti (2002) found a greater number of mites in the samples collected during warm and humid periods and highlights that those are adequate conditions for the presence of mites.

According to Vargas et al. (1997), mite population can be influenced by many factors due they are present in a wide variety of forest types. Moreover Castilho (2008) emphasizes that mites have a high survivability in any forest type, because they practically only depend on organic matter to live. Franklin et al. (2001) affirm that many species of mites that live in forests with flooding regimes have a structure like "plastron", allowing tracheal breathing. Neves et al. (2008) evaluated edaphic mesofauna in one of two areas of floodplain studied in this work, they found prevalence of mites (2794) and springtails (754).

Morais et al. (2010) studied the density and richness of soil mesofauna in different systems of land use in riverine communities in the Western Amazon; they found hymenoptera, mites and springtails as the dominant groups in environments of primary forest, secondary forest and plantation. Macambira & Oliveira (2002) studied edaphic mesofauna in reforested areas of terra firme forest in Pará and reported that the representative groups are almost always, mites and springtails.

Trueba et al. (1999) reported that the population of springtails is influenced by a shortage of available soil water. Assad (1997) affirms that springtails are organisms highly dependent on soil moisture, and that they are found in humid forests or in aquatic environments, rarely found in dry forests.

Our results also showed a significant difference between forest types (Table 1) for the groups Hymenoptera ($T = 5.9107$, $df = 42$, $p < 0.001$), Isoptera ($T = 3.0697$, $df = 42$, $p = 0.004$), Diplura ($T = 7.7785$, $df = 42$, $p < 0.001$) and Pseudoscorpion ($T = 4.8878$, $df = 42$, $p < 0.001$), and which had a higher density

on terra firme forest. The lower abundance of these groups in the floodplain forest may be due to periodic flooding. Although Toledo (2003) affirms that social insects (some Hymenoptera and Isoptera) have high resistance to climatic variations, extremes conditions of flooding and water saturation in the soil can hinder the reproduction of these organisms which would require niches with better drainage and shorter periods of flooding to reproduce. In floodplain estuarine forest the area with proper drainage is small, usually restricted to the borders of rivers and streams. Rodrigues et al. (2010) studied the association of the attributes of fertility, particle size and soil biology with seed production and river distance in floodplain forest; they observed that distance was negatively correlated with the levels of silt and sand and with the immature organisms. It is common to observe in the floodplain forest areas the migration of scorpions to higher positions on the ground (i.e. leaves and litter at the base of trees). Probably the pseudoscorpions behave the same way, that is to say, migrate from the ground to protect themselves in higher locations, where low tide does not reach. In addition to the difficulties that immature soil organisms have to face for their reproduction during their life cycle on the ground, those who have not adapted yet to flooding need to use energy to escape from daily floods in the floodplain estuarine forest, thus decreasing the likelihood of growth population. Campos et al. (2008) also found a lower abundance of Isoptera, Hymenoptera and pseudoscorpion in their work carried out in floodplain forest.

CONCLUSIONS

The abundance and richness of organisms groups of the edaphic mesofauna of terra firme forest is similar to that found in floodplain forests of the Amazon estuary in the State of Amapá, nonetheless, there is greater diversity and evenness between the groups on terra firme forest.

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