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Edaphic mite communities in different land uses

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ABSTRACT: Soil mites play an essential role in the fragmentation of organic material, which facilitates the decomposition process by microorganisms and subsequent promotion of soil fertility, play an indispensable role in the trophic chain, and can be influenced by different soil uses. More structured and stable systems tend to have more extraordinary richness and abundance of edaphic mites. In this study, the influence of three agroecosystems types with differences in land use (agroforestry system, native vegetation, pasture) were compared concerning their edaphic mite communities. A nonparametric test was later performed to analyze the difference in the abundance and richness of agroecosystems. Thirty-one morphospecies of mites and 117 individuals were found. The highest abundance of edaphic mites was observed in agroforestry systems, and the more incredible richness of edaphic mites was observed in native vegetation. Thus, we conclude that the mite community presents itself as a soil indicator, reflecting both soil parameters and changes in use and management.
Keywords: agroecosystem; agroforestry systems; Cerrado; species richness; organic matter.

Comunidade de ácaros edáficos em diferentes usos do solo

RESUMO: Os ácaros do solo desempenham um papel importante na fragmentação do material orgânico, o que facilita o processo de decomposição por microrganismos e a subsequente promoção da fertilidade do solo, desempenhando um papel importante na cadeia trófica e podendo ser influenciados por diferentes usos da terra. Sistemas mais estruturados e estáveis tendem a apresentar maior riqueza e abundância de ácaros edáficos. Neste estudo, a influência de três tipos de agroecossistemas com diferenças no uso da terra (sistema agroflorestal, vegetação nativa, pastagem) foi comparada em relação às suas comunidades de ácaros edáficos. Posteriormente, foi realizado um teste não paramétrico para analisar a diferença na abundância e riqueza dos agroecossistemas. Foram encontradas 31 morfoespécies de ácaros e 117 indivíduos. A maior abundância de ácaros edáficos foi observada nos sistemas agroflorestais, e a maior riqueza de ácaros edáficos foi observada na vegetação nativa. Assim, concluímos que a comunidade de ácaro se apresenta como indicadores de solo, refletindo tanto os parâmetros do solo quanto as alterações de uso e manejo.
Palavras-chave: agroecossistema; sistemas agroflorestais; Cerrado; riqueza de espécies; matéria orgânica.

1. INTRODUCTION

Integrating trees, crops, and animals in an agroforestry system can improve soil fertility due to the deposition of soil organic matter (DOLLINGER et al., 2018). Tree species sequester and incorporate organic matter into the soil, which benefits the recycling of nutrients in deeper layers (STÖCKER et al., 2020). The roots of the deeper trees also absorb more nutrients from the subsoil compared to crops with shallower root systems (conventional, pasture), which implies a type of safety net effect by providing soil erosion and additionally improving capacity for infiltration of soil water (NAIR et al., 2009).

Agroforestry systems have a greater diversity of habitats, allowing more richness and abundance of living organisms in the soil (ALTIERI, 2012). Soil fauna can be an example of the balance and functioning of agroecosystems and soil factors, reflecting decomposition and mineralization processes. An important representative of soil fauna are soil mites (Arachnida, Acari), classified as mesofauna due to their body size (0.1-0.2 and 1.5-2 mm) in length, and they are among the most abundant and widespread soil arthropods in most soils (LAVELLE et al., 2001).

Soil mites play an essential role in the fragmentation of organic material, which optimizes the decomposition process by microorganisms and the subsequent promotion of soil fertility (DHOORIA, 2016). Specifically, they are predominant in the soil's structural organization, forming and destroying aggregates and altering their mounting on the profile (BROWN et al., 2015). Studies on the importance of mites, especially soil mites, are developing in Brazil as they play a significant role in the food chain.

Soil mites can comprise up to four trophic levels: lichen feeders, primary and secondary detritivores, and predators (SHARMA et al., 2017). They can be classified according to their functional role in the soil, such as shredders of organic matter and ecosystem engineers that influence soil porosity, and detritivorous mites feed on dead matter (plant and animal), resulting in the fragmentation of this material and optimize decomposition of organic matter. Therefore, detritivore mites facilitate and accelerate the decomposition carried out by bacteria and fungi. Many soil mites feed on algae, fungi, and decomposing organic matter (BARETTA, 2011; BROWN et al., 2015).

The soil-dweller organisms are sensitive to physical, chemical, and biological changes. These organisms respond differently to the management used in the soil. They are often used for studies that involve some environmental disturbance, such as bioindicators of soil quality responding to changes in their habitat, such as changes in their abundance, richness, or morphology (BARETTA et al., 2011).

Among the changes in the soil, compaction can directly affect individuals inhabiting the soil pores, as in mites. These mites move around in galleries and pores, which can be reduced by compacting the soil, reducing their dispersion and locomotion. Another impact on soil is the overturning of the topsoil, which directly interferes with the distribution of organic matter. This process leaves the soil more exposed and causes changes in soil temperature and humidity, affecting conditions for organisms (MOÇO et al., 2010).

Given the importance of soil mites in the trophic network of terrestrial ecosystems and their interaction with the land use type, this work aimed to analyze how agroecosystems' soil and forest structure influence the soil mite community. The richness and abundance of the edaphic mite community were also characterized and quantified in each type of land use (agroforestry systems, native forest, and pasture) to compare with the environmental soil variables in the Cerrado biome.

Thus, considering the life history of these organisms, we hypothesize that the abundance and richness of edaphic mites are greater in environments with more incredible environmental structures, recognizing that these environments offer greater availability of food resources, niches, and more favorable environmental conditions.

2. MATERIAL AND METHODS

2.1. Study area

Data was collected in 12 locations (Table 1) of varying ages and dimensions, located in 10 municipalities in Goiás. The collections were carried out in the rainy season, following a paired design, collecting samples from agroforestry systems (AFS) (the practice of growing trees and crops in interacting combinations), pasture areas (Pasture) (*Urochloa* spp. in all areas), and areas of forest vegetation (Cerrado Forest) within a radius of up to 5 km, minimizing local sampling effects. The soil and climate are characterized in the table below. Further details of the area are in the table in the appendix.

Tabela 1. Localização, área total em m² dos sistemas agroflorestais multiestratificados estudados.
Table 1. Location, total area in m² of the studied multi-stratified agroforestry systems.

Agroforestry system	City	Area (m²)	Age (years)	Soil
1	Aragoiânia	18000	3	Cambisol
2	Ceres	12000	13	Oxisols
3	Ceres	80000	4	Oxisols
4	Cristianópolis	80000	9	Oxisols
5	Cristianópolis	25000	2	Oxisols
6	Rio Verde	180000	1	Oxisols
7	Jataí	80000	10	Oxisols
8	Hidrolândia	400	3	Oxisols
9	Sto Antônio de Goiás	900	2	Oxisols
10	Aragoiânia	1350	1	Cambisol
11	Goianira	12000	2	Cambisol
12	Niquelândia	20000	3	Cambisol

2.2. Data collection

Four points were selected for each agroecosystem for each land use type (agroforestry systems, pasture, native forest), totaling 12 points per sampling unit. For the variance of each point, the mites of each separate point were counted. The facts were collected randomly by walking through each environment (Filgueiras et al., 1994) and avoiding the edges of each system. The four samples within each treatment were chosen to verify the variance within each treatment. The collection procedure consisted of removing the litter from the surface and opening trenches of approximately 20 cm x 25 cm x 25 cm (SANTOS et al., 2008).

2.3. Mite Sampling and Identification

To estimate the components of the edaphic mesofauna, 300 g of soil was collected, and the samples were packed in plastic bags and conditioned in a cool place without sunlight until they were taken to the Berlese-Tullgren funnel (KARYANTO et al., 2008). Then, the invertebrates were extracted after 15 days in pots containing 70% alcohol. The extraction method consisted of descending mesofauna migration due to sunlight and incandescent lamps (60w). The individuals were collected in containers containing 70% alcohol solution, and the mites were sorted in magnifying glasses at 40 X magnification. Subsequently, they were mounted on slides using Hoyer's medium (MORAES; FLECHTMANN, 2008) and identified up to the order level/ morphospecies under a light microscope with phase.

2.4. Physical-Chemical Parameters

In the laboratory, the samples were air-dried, ground, and passed through a 2 mm mesh sieve for soil particle size composition, and part of the soil samples were used in the grain size analysis. Chemical and physical soil analyses (organic matter, pH; P, Al; H+Al; Ca; Mg; K; Cation exchange capacity; Base Saturation, sand, lime, and clay) were carried out following the methods described by Embrapa (2011).

2.5. Statistical analyses

Species richness was measured as the number of morphospecies observed for each sampling point. Due to the difficulty in collecting the appropriate number of species for studies on soil mites, it was decided to use the morpho-species level in some cases. A rarefaction curve of species was used to test sample sufficiency, showing stabilization of the curve.

A Kruskal-Wallis test compared the average richness and abundance for different agroecosystems. The averages for soil fertility elements were also analyzed using the Kruskal-Wallis method to verify the difference between these elements for the other soil uses.

3. RESULTS

A total of 30 mite morphospecies were identified. This included a total abundance of 117 individuals found in the different agroecosystems (Table 2). The full richness of mite species for agroforestry systems and pastures was 18 species for each. For native vegetation, there was a total of 14 species. The highest total abundance was found in agroforestry systems, with 60 individuals sampled (Table 3).

Tabela 2. Riqueza, abundância, riqueza total e abundância da ordem de ácaros edáficos encontrados em cada agroecossistema estudado.
Table 2. Richness, abundance and total richness and abundance of edaphic mite order found in each studied agroecosystem.

Orders	Richness	Abundance
Mesostigmata	8	53
Astigmata	9	28
Oribatida	7	20
Prostigmata	6	16
Total	30	117

Tabela 3. Riqueza de espécies da comunidade de ácaros e abundância total da comunidade de ácaros para cada agroecossistema estudado (ASF = sistema agroflorestal, NAT = vegetação nativa, PAST = pastagem).
Table 3. Species richness of the mite community and abundance total of the mite community for each studied agroecosystem (ASF = agroforestry system, NAT = native vegetation, PAST = pasture).

Agroecosystem	Richness	Abundance
ASF	18	60
NAT	14	21
PAST	18	37

For the mite richness, there was no difference between the agroecosystems (p> 0.05) (Figure 1a). However, we observed a significant relationship between the abundance of mites and the different uses of the soil (asf – 60, nat – 21, and past 3; p <0.05) (Figure 1b). The agroecosystem with the most incredible mite abundance was the agroforestry system, followed by pasture and native vegetation, with an equal abundance of mites (Figure 1b).

Some soil parameters showed differences between different soil management (forest, pasture, and AFS) (p<0.05). Aluminum (Figure 2A) was higher in soil samples from forest formation, and potential acidity (Figure 2B) was higher in forest soil. Phosphorus (Figure 2C) presented a higher level in the pasture soil. Base saturation (Figure 2D) and aluminum and potential acidity indices were higher in forest soils. pH (Figure 2E) presented the highest values for forest soil and ASF and the lowest in pasture soils.

4. DISCUSSION

The present results show that the abundance of edaphic mites responds to different land uses. Greater abundance was found for agroforestry systems; the other uses of the soil affected the abundance of soil mites. For richness, similar results between natural and modified environments were observed. Minor et al. (2007) studied different land uses (corn fields and short-term intensive forest plantations), and they reported a significant factor of the type of soil use on the diversity of mites both on a small and local scale with more diversity in agroforestry systems compared to corn.

In a Costa Rica study, Balogh et al. (2008) examined three vegetation types: a plain with tropical forest, a forest of moss, and a mountain range (rock vegetation). The authors observed that the mite community was determined mainly by the vegetation type related to the habitat's ecological effects, such as type of vegetation.

Uhlig (2005) and Baretta et al. (2011) also observed a high abundance of soil mites in agroforestry systems. According to the authors, these peaks may be related to the greater availability of food that remains in the soil after a harvest or pruning of the system, as these organisms are essential in the fragmentation of organic matter, which optimizes nutrient cycling. The practices used in agroforestry systems bring the productive environment closer to the natural environment. Important environmental structures, such as the diversity of trees and the deposition of organic matter in the soil, were also determining factors in the presence of the mite community. These mechanisms probably increase the number of niches to be explored, creating microhabitats, thus increasing food resources and species diversity. John et al. (2006) suggested that the soil mite community was also related to plant diversity characteristics and soil conditions.

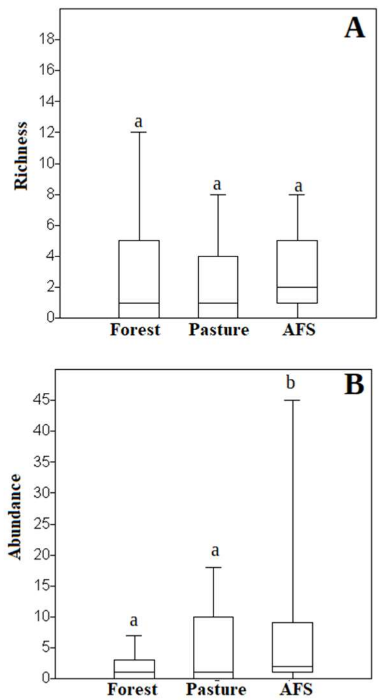

Figura 1. A) Box plot da riqueza (S) e B) abundância (quantidade de indivíduos de cada espécie = ind/S) da comunidade de ácaros para os diferentes agroecossistemas (SAF = sistema agroflorestal, Floresta = floresta nativa e Pastagem). O desvio de erro (variância dos dados) é representado pela barra externa com letras, a segunda barra é o primeiro quartil e a segunda barra é a média de cada tratamento, respectivamente, de cima para baixo. Letras diferentes na barra significam diferença estatística entre os tratamentos.
Figure 1. A) Box plot of richness (S) and B) Abundance (quantity of individual of each species = ind/S) of the mite community for the different agroecosystems (AFS = agroforestry system, Forest = native forest, and Pasture). The error deviation (data variance) is represented by the external bar with letters; the second is the first quartile, and the second is the average for each treatment, respectively, from top to bottom. Different letters on the bar mean statistical differences between treatments.

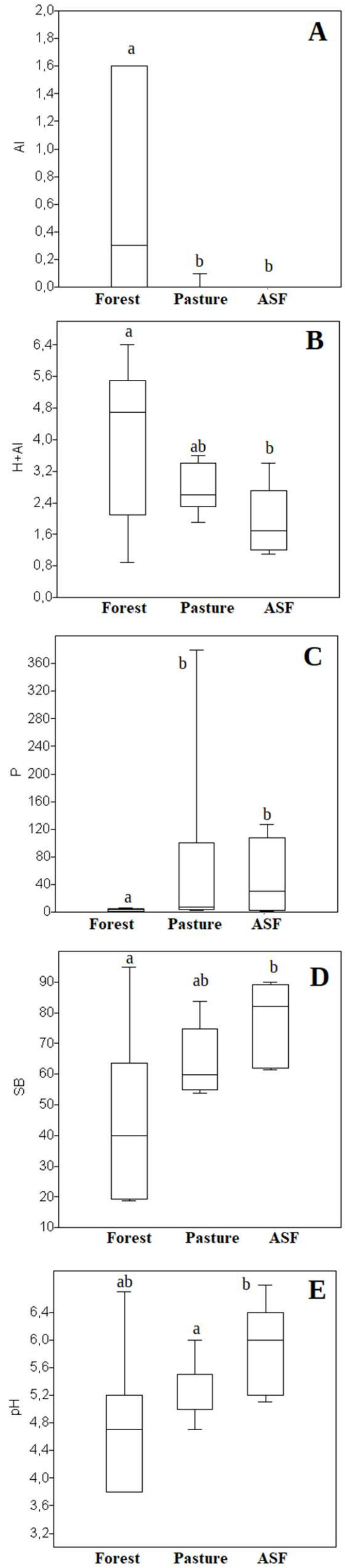

Figura 2. Média dos elementos do solo que apresentaram diferença entre os agroecossistemas. Letras diferentes (a, b e ab) indicam significância estatística superior a 95% de significância. A) Alumínio (Al), B) Acidez Potencial (H+ Al), C) Fósforo (P), D) Saturação de base (SB), E) pH.
Figure 2. Average of soil elements that showed a difference between each agroecosystem. Different letters (a, b, and ab) indicate statistical significance at greater than 95% significance. A) Aluminium (Al), B) Potential Acidity (H+ Al), C) Phosphorus (P), D) Base Saturation (SB), E) pH.

According to the intermediate disturbance hypothesis (Connell, 1978), pastures can be seen as a system of moderate stress, in which the high density is maintained by regular disturbances that can decrease the probability of competitive exclusion. The density can be higher than in natural environments where competitive exclusion can facilitate the dominance of particularly competitive species. These pasture characteristics can also explain the results of the mite community found in the Cerrado pastures, explaining the greater abundance of mites in pastures (ARROYO; ITURRONDOBEITIA, 2006).

In contrast, Bedano et al. (2006) reported that compacted pasture areas affect the presence of mites, and the availability of organic matter influenced the densities of mites, mainly in agricultural areas. According to Osler et al. (2005), this can be explained by the benefits of plowing the soil structure to incorporate the crop residues, increasing the soil microbial activity by serving as food for the mites. The presence of mites in the pasture may be related to the food type since some mites feed exclusively on pasture nematodes (Hansen, 2000), which was observed in some pastures with appropriate soil management. Clapperton et al. (2002) found a greater abundance of mites related to pastures due to the amount of food resources for microorganisms. The higher organic matter contents and moderate soil temperatures in grazing treatments with low disturbance would increase the activity and the abundance of microorganisms, subsequently increasing the abundance of mites.

Continuous grazing systems favor soil compaction and decrease the quality of pastures and soil, as well as the richness and abundance of mites (CECCONI et al., 2008). Native vegetation and agroforestry systems showed a greater abundance of species than pastures, possibly due to the amount of organic matter these systems have. The same was found by Rodrigues et al. (2007) when analyzing spiders and other soil arthropods in the cultivation of corn and native vegetation, reporting greater diversity in habitat with more significant deposition of organic matter in the soil.

The present results showed the relationship between soil mites and environments with a high amount of organic matter. The environmental variables of the soil, such as pH, clay, and magnesium, were the main determinants of the richness and abundance of the mite community. The presence of magnesium in the Cerrado soils determines the growth of plants. In other words, the diversity of plants is related to the magnesium content, and this element influenced the mites due to the relationship of the mite community with the presence of vegetation.

The Cerrado soil typically has an acidic pH and pH, and the presence of aluminum affects the presence of edaphic mites (BEDANO et al., 2006). This fact was confirmed by Behan-Pelletier (1999), who developed a bioindication system for soil acidity based on the analysis of the Oribatida numbers according to soil pH value. Rapid population declines were observed when pH was changed. A positive relationship between the abundance of mites and high-pH soils was found by Maribie et al. (2011). On the other hand, Fagan et al. (2006) and Liiri et al. (2002) found less richness and abundance of mites in more acidic soil. These last authors also observed a positive relationship in the richness and abundance of organic matter in the soil and with more diversified habitats (i.e., a greater variety of vegetation) than those with just a tree species (in the case of these studies, monoculture of conifers).

Litter decomposition is critical in the terrestrial ecosystem and the carbon cycle. It is estimated that it contributes up to 70% to the existence of some soil species. Simpson et al. (2012) observed that OM decomposition activity was higher in the middle of the forest and lower at the edge. The higher organic matter content observed in the native forest is attributed to the more excellent carbon supply in these areas due to the decomposition of litter, thus increasing the soil organic carbon content and acting as an essential source of negative soil charge. Salton et al. (2008) observed that this negative effect on the soil can increase aluminum hydroxide and, consequently, the soil pH and cation exchange capacity. Bartz et al. (2014) observed that the phosphorus content was higher in pasture environments due to organic fertilization provided by cattle urine and feces. The results indicate that the soil environmental variables are good predictors for the distribution of the soil mite community, as these are sensitive to soil changes (LUIZÃO et al., 2004).

Due to the high sensitivity of soil fauna to changes in the system management, this can be used as an indicator to measure the impact of management practices on the soil and also as a bioindicator of soil quality due to its expected effects regarding ecological factors (ROVEDDER et al., 2004). The soil fauna also has a high diversity and rapid reproduction capacity, serving as excellent bioindicators, and their properties or functions indicate and determine the quality or level of soil degradation.

The present work is the first study of soil mites in agroforestry systems in the Cerrado. Therefore, further studies on how different land uses affect this community become essential to determine the relationship between these organisms and the soil trophic chain. It is well known that modification of the natural landscape affects the edaphic mite community (BEDANO et al., 2006; OSLER; MURPHY, 2005), and previous studies have demonstrated such interference in pasture management with native forests of the Cerrado. However, none compared them directly to determine that agroforestry systems (syntropic, agroforestry, silvopastoral, etc.) have more significant effects on the edaphic mite community when compared to other types of soil use. It will be essential to improve ecological studies to investigate how the factors influence the mite fauna at the deepest hierarchical level, considering the life history of each group.

5. CONCLUSIONS

The agroforestry system was a favorable environment for the edaphic mite community, presenting more abundance of organisms than native vegetation. The most incredible abundance was observed in the agroforestry systems; however, the mite richness was similar between the SAFs, pastures, and native vegetation.

Most soil mites were related to aspects of soil fertility, such as high pH, CEC, Ca, P, Mg, and V. This study confirms that land use characteristics have substantial effects on the abundance of the edaphic mite community but not the richness. Thus, we reinforce the need for studies investigating this group's different land uses and ecological interactions with agroforestry systems in the Cerrado Biome.

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