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DIVISÃO 2 - PROCESSOS E PROPRIEDADES DO SOLO

Comissão 2.1 - Biologia do solo

EFFECT OF BRUSHWOOD TRANSPOSITION ON THE LEAF LITTER ARTHROPOD FAUNA IN A CERRADO AREA[1]

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SUMMARY

The results of ecological restoration techniques can be monitored through biological indicators of soil quality such as the leaf litter arthropod fauna. This study aimed to determine the immediate effect of brushwood transposition transferred from an area of native vegetation to a disturbed area, on the leaf litter arthropod fauna in a degraded cerrado area. The arthropod fauna of four areas was compared: a degraded area with signal grass, two experimental brushwood transposition areas, with and without castor oil plants, and an area of native cerrado. In total, 7,660 individuals belonging to 23 taxa were sampled. Acari and Collembola were the most abundant taxa in all studied areas, followed by Coleoptera, Diptera, Hemiptera, Hymenoptera, and Symphyla. The brushwood transposition area without castor oil plants had the lowest abundance and dominance and the highest diversity of all areas, providing evidence of changes in the soil community. Conversely, the results showed that the presence of castor oil plants hampered early succession, negatively affecting ecological restoration in this area.

Index terms: ecological restoration, signal grass, mesofauna, Acari, Collembola.

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RESUMO: *EFEITO DA TRANSPOSIÇÃO DE GALHARIA SOBRE A FAUNA DE ARTRÓPODES DA SERAPILHEIRA, EM UMA ÁREA DE CERRADO*

Os resultados das técnicas de restauração ecológica podem ser monitorados pelos indicadores biológicos de qualidade de solo, como a fauna de artrópodes associada à serapilheira. Este estudo teve o objetivo de verificar o efeito imediato da aplicação da técnica de transposição de galharia, em uma área degradada de cerrado. Os dados são referentes à fauna de artrópodes associada à serapilheira de quatro áreas: uma degradada com braquiária; duas experimentais de transposição de galharia, com e sem a presença de mamona; e uma de cerrado nativo. Foram encontrados 7.660 indivíduos, pertencentes a 23 táxons. Acari e Collembola foram os táxons mais abundantes em todas as áreas estudadas, seguidos por Coleoptera, Diptera, Hemiptera, Hymenoptera e Symphyla. A área de transposição de galharia sem mamona destacou-se das demais por diferenças nas abundâncias dos táxons, por um índice de diversidade mais alto e pela baixa dominância, constituindo indícios de alteração na comunidade do solo. As evidências demonstram que a presença da mamona prejudica a sucessão inicial, influindo negativamente na restauração ecológica.

Termos de indexação: restauração ecológica, braquiária, mesofauna, Acari, Collembola.

INTRODUCTION

The leaf litter arthropod fauna affects soil processes through excavation, intake, and transport of organic and mineral material (Lima et al., 2007), participating in organic matter decomposition and nutrient cycling (Seastedt, 1984; Oliveira & Souto, 2011). Due to these characteristics of the invertebrate soil community, and for varying in species richness and individual abundance depending on the conservation status of the area, it has been widely used as biological indicator of soil quality (Rovedder et al., 2004; Oliveira & Souto, 2011). Thus, the study of the arthropod fauna provides important information on the soil community, acting as a tool to evaluate the recovery process in areas of ecological restoration (Ruf et al., 2003; Hodkinson & Jackson, 2005; Yi et al., 2006; Hoffmann et al., 2009).

Ecological restoration is an intentional activity that initiates or facilitates the recovery of degraded, disturbed, transformed, or entirely destroyed ecosystems (SER, 2004). “Nucleation” is an ecological restoration technique that consists of the creation of small heterogeneous nuclei of organic matter in a degraded area, which attract species of the surrounding environments, facilitating the restoration of this area. An example of a nucleation technique is “brushwood transposition”, by which brushwood (stems, leaves, branches, and roots of native species) is transferred from an area of native vegetation to a degraded area and arranged in heterogeneous nuclei in the disturbed area. The technique is suitable for areas affected by a major soil withdrawal, totally bare of soil nutrients. This leads to the incorporation of organic matter into the soil by brushwood faggots and provides suitable shelter and microclimate for various animals as well as appropriate microhabitats for the development of wood-boring beetles, termites, and other arthropods (Reis et al., 2003; SMA, 2011).

Most studies evaluate only the recovery and development of vegetation when examining ecological restoration procedures (Pais & Varanda, 2010). However, the characteristics of vegetation do not always differ between disturbed and recently restored areas, whereas their arthropod communities do differ (Longcore, 2003), due to the sensitivity of these organisms to environmental changes (Rovedder et al., 2004; Pais & Varanda, 2010; Oliveira & Souto, 2011). Despite the growing recognition of the appropriateness of using the soil community in the evaluation of ecological restoration procedures (Yi et al., 2006; Pais & Varanda, 2010), studies with this focus are still rarely undertaken in Brazil.

Considering that arthropods play an essential role in various ecosystem functions and respond directly to habitat manipulation (Maleque et al., 2006), this study aimed to determine the immediate effect of brushwood transposition on the arthropod community associated with leaf litter (mesofauna) in a degraded cerrado area. The cerrado was chosen for this study because it is one of the most biodiverse ecosystems on the planet, but becoming increasingly degraded and fragmented (Oliveira & Marquis, 2002; Rocha et al., 2011). Additionally, vegetation loss has occurred at an alarming rate. Originally, the cerrado covered a quarter of the Brazilian territory but has lost half of its area within only 50 years (Ganem, 2010). Furthermore, little is known about ecological restoration procedures in the cerrado (Cavassan, 2012), and the procedure described in this study has been applied in ombrophilous mixed and ombrophilous dense forests only (Reis et al., 2003).

MATERIAL AND METHODS

The study was conducted in an ecological conservation area of the Universidade Estadual

Paulista-UNESP, campus Bauru, São Paulo, Brazil. The area (between 22º 21' S, 49º 01' W and 22º 20' S, 49º 00' W) is composed of native cerrado vegetation, and the predominant vegetation type is cerradão (woodland savanna) (Cavassan et al., 2006). The climate is Cwa, according to Köppen's classification.

Two meters of soil were removed from the cerradão area in 1998. A second disturbance occurred in 2004 by the installation of a golf course, followed by invasion of signal grass (*Brachiaria decumbens* Stapf), which remained unchanged until October 2010, when the brushwood transposition procedure started. Two experimental areas of 810 m^2 were outlined for brushwood transposition: one on from which all young castor oil plants (*Ricinus communis* L.) had been removed, and another on which the naturally occurring invasion by castor oil plants was not controlled. An area of the same size of signal grass field was maintained untouched as control area, representing the initial restoration state. An adjacent area of native cerrado vegetation, representing the final restoration state, was used as a second control.

Soil was sampled from March to November 2011, totaling 26 leaf litter samples: six per area of signal grass, brushwood transposition without castor oil plants (BT without castor oil plants), and brushwood transposition with castor oil plants (BT with castor oil plants), and eight samples in the cerrado area. Sampling occurred simultaneously, except for two additional samples in the cerrado area.

The sampling procedure was standardized to collect a 1 L volume of litter due to the low litter deposition in the signal grass area and the irregular terrain in the brushwood transposition areas. The samples were transferred to Berlese funnels, which were placed under a 25 W lamp, above a vial containing 70 % alcohol with one drop of dishwashing detergent to break the surface tension, preventing floating of the collected specimens. Because arthropods try to escape from the heat of the lamp, they descend through the funnel and fall into the vial where they end up dying. The Berlese funnel is one of the most effective methods for extracting arthropods from leaf litter (Triplehorn & Jonnson, 2011). The samples were maintained in Berlese funnels for 14 days to ensure maximum arthropod extraction. The captured arthropods were stored in preservative solution (70 % alcohol) for later identification. Next, all individuals were sorted and identified using Zeiss stereomicroscopes according to the identification key and taxonomic nomenclature of Triplehorn & Jonnson (2011), at the order or class levels, which represent the ecological complexity of soil communities in a simple manner (Stork & Eggleton, 1992).

The mean values for each taxon were calculated for each area. We also calculated the Shannon diversity index, Simpson dominance index, and Spearman correlation coefficients (r_s) for each area, and a similarity dendrogram of the four areas (calculated using the pair group method, Bray-Cutis index, and 2,000 bootstrap replications) using PAST software version 2.15 (Hammer et al., 2001). The data were compared by the chi-square test (χ^2) using Microsoft Office Excel 2007 software, to determine whether the differences between the areas were significant at the 5 % level.

RESULTS AND DISCUSSION

In total, 7,660 individuals belonging to 23 taxa were sampled, of which 98.7 % were identified at the order or class level. There were significant differences in abundance among the areas for the total number of individuals ($\chi^2 = 4.0x10^{-26}$) and for Acari ($\chi^2 = 3.3x10^{-5}$), Blattodea ($\chi^2 = 0.02188$), Coleoptera ($\chi^2 = 1.0x10^{-7}$), Collembola ($\chi^2 = 1.3x10^{-9}$), and Symphyla ($\chi^2 = 0.00557$). Conversely, there was no difference in species richness among the areas ($\chi^2 = 0.96269$), which is in accordance with other studies that reported between 15 and 21 soil macrofauna taxa belonging to different orders and families in cerrado habitats (Silva et al., 2006; Aquino et al., 2008) (Table 1).

The area of BT with castor oil plants had a high dominance index, as well as the two control areas, mainly due to the predominance of Acari orders, resulting in lower diversity indices ($r_s = -1.0$; $p = 0.01$). This taxon is highly sensitive to soil alteration, and its abundance correlates negatively with the soil management in the area (Bedano et al., 2006) suggesting that the area of BT without castor oil plants is most affected by changes in soil quality. These data support the bioindicator potential of the Acari order (Koehler, 1999; Behan-Pelletier, 1999; Bedano et al., 2006), which had the highest abundance in the cerrado area. The second most abundant order was Collembola, which is a group of great importance for soil processes (Stork & Eggleton, 1992). However, the abundance of Collembola individuals was smaller in the cerrado area (Table 1).

The orders Acari and Collembola are the major constituents of soil mesofauna (Seastedt, 1984; Franklin et al., 2005; Yi et al., 2006; Barros et al., 2010), likely due to their high adaptive capacity (Yi et al., 2006), which is reflected in their feeding habits. According to Seastedt (1984), most Acari and Collembola species have mouthparts that can break down organic matter while they feed on the microflora (especially fungi) attached to it. Moreover, according to Seastedt (1984), Koehler (1999), and Bedano et al. (2006), some Acari species are predators of Collembola and other invertebrates, regulating their density. Thus, there is an intimate relationship between these two taxa and the leaf litter associated with them, which explains their high numbers in soil mesofauna and the values observed in our study. However, there was a negative correlation ($r_s = -1.0$; $p = 0.01$) between

Table 1. Mean number of individuals per taxon and Shannon diversity and Simpson dominance indices in each study area

Taxon	Signal grass	Brushwood transposition: Without castor oil plant	Brushwood transposition: With castor oil plant	Cerrado	χ^2
Acari	202.8	58.8	263.5	317.8	$3.3x10^{-5}$ *
Araneae	1.7	0.5	0.7	2.1	0.85459
Blattodea	1.2	2.2	0.0	0.1	0.02188 *
Chilopoda (class)	0.2	0.2	0.3	0.1	0.98256
Coleoptera	5.5	12.5	5.8	1.9	$1.0x10^{-7}$ *
Collembola	34.0	34.3	28.2	18.1	$1.3x10^{-9}$ *
Dermaptera	0.0	0.0	0.2	0.0	0.94394
Diplopoda (class)	0.0	0.3	0.2	0.0	0.66660
Diplura	1.3	0.0	2.0	0.6	0.69168
Diptera	5.8	6.0	5.8	4.4	0.12705
Embiidina	0.0	0.0	0.0	0.1	0.96794
Embioptera	0.0	0.2	0.0	0.0	0.74166
Hemiptera	5.8	6.0	9.7	5.9	0.28116
Hymenoptera	11.3	9.8	9.3	14.6	0.15571
Isopoda	0.3	0.0	0.3	0.1	0.96191
Isoptera	0.0	0.0	0.0	0.5	0.79470
Lepidoptera	0.8	0.5	0.5	1.5	0.93150
Opiliones	0.0	0.0	0.2	0.3	0.96720
Orthoptera	0.7	0.8	0.0	0.0	0.30693
Protura	2.7	0.0	0.0	0.4	0.09302
Psocoptera	0.3	0.0	3.3	1.4	0.32781
Symphyla (class)	11.0	1.0	10.3	1.1	0.00557 *
Thysanoptera	1.0	0.8	2.7	1.5	0.87487
Unidentified	2.3	1.7	6.7	4.4	0.66380
Mean (total of individuals)	288.7	135.6	349.7	376.9	$4.0x10^{-26}$ *
Number of taxa	17	15	17	19	0.96269
Shannon diversity	1.18	1.64	1.01	0.71	0.94037
Simpson dominance	0.52	0.28	0.60	0.73	0.97729

*Statistically significant at 5 %.

Acari abundance and diversity in all areas. Conversely, there was a positive correlation ($r_s = +1.0$; $p = 0.01$) between Collembola abundance and diversity in all areas.

In addition to Acari and Collembola, the most frequent orders were Coleoptera, Diptera, Hemiptera, Hymenoptera, and the class Symphyla, but abundance varied between areas and these differences were not always statistically significant. The abundance of individuals in the orders Blattodea and Coleoptera was significantly different between the areas ($\chi^2 = 0.02188$ and $\chi^2 = 1.0x10^{-7}$, respectively), with a higher abundance in the area of BT with castor oil plants, suggesting that the presence of castor oil plants in the area did not favor the development of these taxa. Moreover, wood-boring beetle larvae benefit from the presence of brushwood faggots (Reis et al., 2003) by participating in the decomposition process, which ultimately fertilizes the degraded soil. Thus, the lower abundance of beetle larvae in the area of BT with castor oil plants suggests that soil restoration may be impaired in that area. The abundance of individuals in the class Symphyla also differed significantly between the areas ($\chi^2 = 0.00557$), with a similar number of individuals in the areas of signal grass and of BT with castor oil plants (higher abundance) and cerrado and BT without castor oil plants (lower abundance), suggesting this taxon as a potential bioindicator (Table 1).

The area of BT without castor oil plants had the highest diversity, although the species richness and abundance were lowest of all areas (Table 1). The dendrogram shows the dissimilarity of this to the other areas studied (Figure 1). According to Southwood et al. (1979), insect diversity increases with the successional habitat age and decreases slightly at

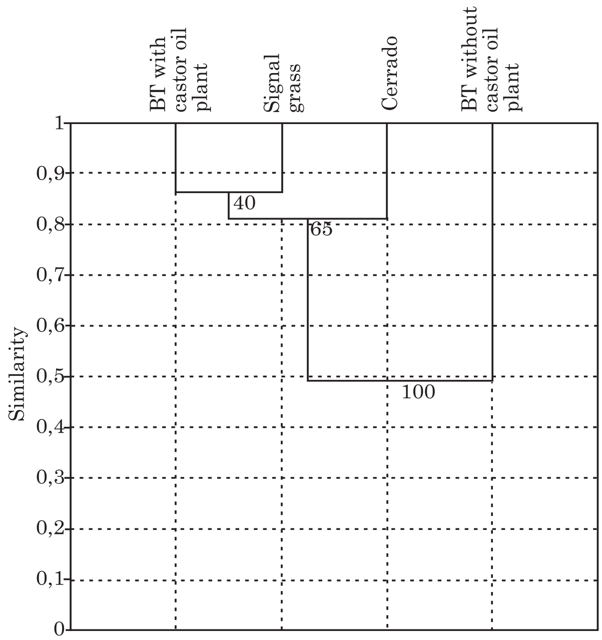

Figure 1. Similarity dendrogram of the four study areas (BT: brushwood transposition).

climax. Thus, our results suggest that the area of BT without castor oil plants is in succession.

The same analysis (arthropods, diversity, and dendrogram) indicated that the successional process is impaired in the area of BT with castor oil plants. Moreover, the higher similarity (0.86) between signal grass and area of BT with castor oil plants (Figure 1), which may be related to the fact that both are invasive alien plants (Leão et al., 2011), also indicates that the presence of castor oil plants in this BT area is not improving soil restoration. Nevertheless, the entire successional process in brushwood transposition areas should be further investigated and monitored over years.

Our results show the immediate effect of brushwood transposition on soil arthropod communities. This information can be useful for management purposes in areas where native vegetation, from which brushwood is extracted, has been removed. The restoration required after deforestation can be achieved using this simple and low-cost procedure, which helps restore the ecological conditions of degraded ecosystems.

CONCLUSIONS

1. There were changes in the abundance structure of the arthropod fauna in the leaf litter after brushwood transposition.

2. The higher abundance of Coleoptera in the area of brushwood transposition without castor oil plants indicates that the procedure is appropriate to accelerate wood decomposition with subsequent improvement in soil quality.

3. The presence of castor oil plants in the brushwood transposition area hampered the succession of arthropod fauna, negatively affecting soil restoration in the area.

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