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Abundance and diversity of beetles (Insecta: Coleoptera) in land use and management systems

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ABSTRACT: Soil beetles' communities are responsible for many ecosystem services, and are very sensitive to environmental changes. Thus, this study aimed to evaluate the abundance and diversity of the soil coleoptera fauna under uses and management and also to identify relationships of the beetle community with soil's physical and chemical properties. The experiment had six experimental plots set up an Oxisol (*Latossolo*): corn (CO), soybean (SO), 7-year-old eucalyptus (EI), 4-year-old eucalyptus (EII), preserved Cerrado (PC), and disturbed Cerrado (DC). Soil beetles were sampled at 128 points for each experimental plot, where the soil physical and chemical properties were analyzed. The Coleoptera fauna organisms were identified at the family, subfamily, and gender level, and then, the number of individuals per day, richness, Shannon diversity indexes, and Pielou evenness were determined. The data were analyzed using multivariate techniques (hierarchical grouping and factor analysis). On total, 750 specimens of beetles were collected, distributed into 9 families, 14 subfamilies, and 27 genera. The most abundant family was Scarabaeidae (11 genera) with the highest occurrence in the PC (143 specimens) and DC (81 specimens). Cultivation with SO presented the greatest number of trap day individuals (ind trap^{-1} day^{-1} = 0.548); however, the highest diversity was found in the PC. (20 taxonomic groups) and CO (16 taxonomic groups). Shannon diversity was higher for the CO (H' = 3.107), followed by the PC (H' = 2.699), and the lowest value was found for the SO (H' = 1.530). The similarity dendrogram grouped the plots into two extracts, demonstrating how the intensity of land use influences the abundance and diversity of beetle fauna. The factor analysis grouped the Coleoptera and the physical and chemical soil properties in two factors: elements related to the state of aggregation and porous system's elements. The Coleoptera community was influenced by the intensity of land use and the portion with anthropized natural vegetation showed the highest richness, demonstrating that the Coleoptera fauna responds to environmental changes. Edaphic beetles in the different use and management systems were primarily related to soil physical properties, which explain the state of aggregation (pH, altitude, Ca^{2+}, BD, clay, macroporosity, silt, K^+, and microporosity) and the porous soil system (sand and total porosity).

Keywords: soil biodiversity, soil properties, soil quality, ecosystem disturbances.

INTRODUCTION

The Coleoptera fauna of the soil has high abundance and diversity, being represented by organisms that respond quickly to environmental changes (Silva et al., 2011; Bogoni and Hernández, 2014; Barretto et al., 2019) and can thus be used as an indicator of soil environmental quality. The order Coleoptera represents the most diverse group of the Insect Class, with about 400,000 described species in the world, distributed in 170 families (Segura, 2012). For Brazil, Monné and Costa (2019) shown that only 32,000 species, belonging to 114 families, are described, and few studies have been devoted to the analysis of Coleoptera fauna in land use and management systems.

The diversity of the Coleoptera fauna organisms in the natural systems is in dynamic equilibrium (Aquino, 2001,2005), while in agricultural production systems, we have a diversity associated with land use, influenced by management, involving colonizing organisms. Depending on the degree of the environmental disturbance, they can become pest insects (Garlet et al., 2015), resulting in increased use of pesticides.

Soil beetles play an important role in nutrient cycling (Hanski and Cambefort, 1991; Nichols et al., 2008; Slade et al., 2011; Portilho et al., 2012), in the physical quality of the soil, with the increase of total soil porosity (Bogoni and Hernández, 2014; Pompeo et al., 2016; Tissiani et al., 2017; Barretto et al., 2019). The abundance of beetles is affected by land use and management (Hanski and Cambefort, 1991; Milhomem et al., 2003), and their occurrence is associated with the amount and quality of plant residues in agricultural production systems, including forest production (Araújo et al., 2004; Price and Young, 2006; Bartelt, 2010; Hernández-Torres, 2018).

Soil beetles also have diverse habits (Brown and Keith, 1991; Ewing and Cline, 2005; Moraes and Köhler, 2011; Santos et al., 2014), with phytophagous species (Louzada, 2008; Korasaki et al., 2013), detritivores (Araújo et al., 2004), predators (Cividanes and Cividanes, 2008; Cividanes et al., 2009; Triplehorn and Johnson, 2011; Korasaki et al., 2013), fungivores (Louzada, 2008; Korasaki et al., 2013), being their ecological function regulated and/or determined according to the degree of disturbance of the environment, and of environmental characteristics, influencing the diversity and abundance of soil Coleoptera fauna (Gonçalves, 2017).

Therefore, it is necessary to understand how the soil Coleoptera fauna occurs in natural systems and how agricultural and forest production systems influence it. However, it must be considered that the diversity of the Coleoptera fauna is dynamic, and that production systems with lower environmental impact reflect more homogeneous diversity components. Furthermore, the magnitude of the biological differences in different land use and management systems reflects a complex and dynamic set of interactions in the soil-plant-atmosphere system that make up the natural and agricultural production systems.

Thus, the main hypothesis of this study is that soil use and management influence the coleopteran community; and that the lower the degree of environmental disturbance the greater the abundance and diversity of soil beetles. Our objectives were: a) to evaluate the abundance of the beetle community in land use and management systems; b) to quantify how land use and management influence the diversity of the Coleoptera fauna; c) to relate Coleoptera fauna organisms with physical and chemical properties of the soil.

MATERIALS AND METHODS

The experiment was conducted at Fazenda Unha de Gato, municipality of Mata Roma (Maranhão State, Brazil) whose geographical coordinates are: 3° 43’ 36.44” S and 43° 11’ 10.30” O. The climate of the region is hot tropical and humid with rains during summer and autumn and dry winter (Aw), with an average annual temperature of 28.5 °C and an average annual rainfall of 1,500 mm. The soil of the experimental area is an Oxisol (Soil Survey Staff, 2014), which corresponds to a *Latossolo Vermelho Amarelo Distrófico típico* according to the Brazilian Soil Classification System (Santos et al., 2018), whose main physical and chemical properties are presented in table 1.

Six experimental plots were considered: corn (CO - 103 ha); soybean (SO-113 ha), eucalyptus stage I (E1 - 5.71 ha), eucalyptus stage II (E2 - 5.71 ha), preserved Cerrado (PC - 33.08 ha), and disturbed Cerrado (DC – 20.44 ha). The cultivation of corn (CO - *Zea mays* L.) and soybean (SO - *Glycine max* L.) started in 2007, with the natural vegetation being removed. Since then, the area has been managed under no-tillage system with soybean and corn cultivation in rotation. Eucalyptus plots (EI and EII - *Eucalyptus* ssp.) were planted in 2009 and 2012, respectively; the EI plot has trees of cut age (7 years) and an approximate height of 12 m, with soil cover around 90 % and few weeds; in EII, the trees are approximately 5 m (4 years old), with ground cover of about 70 %, and a high number of weeds and patches of uncovered soil. The natural vegetation in the study area is composed of savannah formations of Brazilian Cerrado Biome, with an upper tree extract composed of different density and height gradients, herbaceous extract and subarbustive, with different floristic composition. The plots with natural vegetation were characterized according to their purpose: PC is maintained as a permanent preservation area without any management; and DC is a natural area being used for cattle grazing in drought years.

Samples were taken on May 1, 2016 in 387 m transepts, containing 130 points and 3 m spacing between points, and the georeferenced sample points using GPS with postprocessed differential correction (DGPS). Deformed and undeformed soil samples were collected at the sampling points to determine the following properties: texture (clay, silt, and sand), bulk density, total porosity (PT), macroporosity (Macro), microporosity (Micro), pH($CaCl_2$), phosphorus (P), calcium (Ca), Mg (magnesium), potassium (K), cation exchange capacity (CEC), and organic carbon (OC), following the methodology proposed by Camargo et al. (2009) and van Raij et al. (2001) - table 1.

Soil Coleoptera sampling was performed using pitfall traps with no attractant and 4 % formaldehyde solution (Aquino et al., 2001). The pitfall traps remained in the field for seven days and then taken to the laboratory, where the traps were sorted by separating the material from the Coleoptera fauna. After mounting, the specimens were identified to family and subfamily levels using an identification key (Quintero, 2012; Rafael et al., 2012; Cajaíba and Silva, 2015; Lima, 2015) and by comparison with the material previously identified in the Entomological Collection of the Paraense Museum - Emílio Goeldi (MPEG)

Table 1. Average values of soil physical and chemical properties sampled in experimental plots cultivated with soybean (SO), corn (CO), eucalyptus (EI and EII), preserved Cerrado (PC) and disturbed Cerrado (DC)

Area	Clay	Silt	Sand	BD	PT	Micro	Macro	OC	P	pH($CaCl_2$)	K^+	Ca^{2+}	Mg^{2+}	CEC
	g kg^{-1}			Mg m^{-3}	m^3 m^{-3}			g dm^{-3}			mmol$_c$ dm^{-3}			
SO	147.0	107.0	747.0	1.47	27.0	14.20	20.7	19.0	14.0	5.00	2.40	26.0	5.0	56.40
CO	80.0	70.0	590.0	1.72	38.6	13.20	22.7	22.0	49.0	5.00	0.70	18.0	3.0	46.70
EI	257.0	56.0	657.0	1.32	30.0	15.90	20.9	27.0	10.0	4.70	0.30	14.0	5.0	54.30
EII	202.0	81.0	702.0	0.55	28.5	15.05	20.8	23.0	12.0	4.85	1.35	20.0	5.0	55.35
PC	261.0	58.9	681.0	0.97	33.6	15.50	17.8	15.0	7.0	4.10	0.20	2.0	1.0	35.20
DC	256.0	57.0	667.0	1.22	34.4	15.40	18.7	21.0	8.0	4.20	0.50	3.0	3.0	42.50

BD: bulk density; PT: total pososity; Micro: microporosity; Macro: macroporosity; OC: organic carbon; P: phosphorus; K: potassium; Ca: calcium; Mg: magnesium; CEC (cation exchange capacity). The properties were determined according to the methodology described by Camargo et al. (2009) and van Raij et al. (2001).

and the collection of the LABSOLOS - UFMA Soil and Environment Laboratory – Federal University of Maranhão.

From the Coleoptera fauna data of the experimental plots, the number of individuals per day trap (ind $trap^{-1}$ day^{-1}) and the total richness were determined, and the following indexes were calculated: Shannon diversity (H') and equitability Pielou (J'). The number of individuals per day trap (ind $trap^{-1}$ day^{-1}) represents the total Coleoptera fauna organisms collected over the seven days of sampling, and the richness was determined by the total number of taxonomic groups identified in each of the experimental plots. Shannon (H') and Pielou (J') indexes were determined as described by Magurran (1988).

Multivariate data analysis was performed considering the hierarchical clustering technique and factor analysis using the Statistica 7.0 software. The clustering technique was used to group the Coleoptera data in the experimental plots by joining (tree clustering), from the Euclidean distance, allowing to determine if the subgroups formed had internal similarity or external dissimilarity. Data on Coleoptera fauna and soil physical and chemical properties were analyzed using the factor analysis technique, using the latent dimensions (shared variance) to observe the set of relationships between the properties. For factor analysis, the data were selected considering only the properties without collinearity, followed by standardization (null mean and unit variance), and the extracted factors considering the principal component analysis determined from the correlation matrix between the variables, and properties with factor loadings >0.7 in absolute value are selected (Jeffers, 1978).

RESULTS

The Coleoptera community of the study area was represented by 9 families, 14 subfamilies, and 27 genera (Table 2). The family with the highest group diversity was Scarabeidae (11 genera), followed by the family Carabidae, which showed great variability, being represented by four subfamilies and eight genera. The other families contributed with a smaller number of taxa (Table 2).

In total, 750 specimens of beetles were collected, with a predominance of the Scarabaeidae family that contributed 47.2 % of the total sample (Figure 1). Following the most abundant families were Nitidulidae (29.86 %), Carabidae (14.53 %), and Tenebrionidae (5.06 %). The remaining families together represented only 3.3 % of the total sample. The most abundant genus was *Stelidota* (29.9 %), followed by *Deltochilum* (19.3 %), *Canthon* (8.5 %), *Calosoma* (7.7 %), *Dichotomius* (7.1 %), and *Canthidium* (6.3 %).

The higher richness of Coleoptera taxa was observed in the PC (20 taxa), followed by CO (16), DC (14), EI (12), and SO and EII, with nine taxa each. The abundance was higher in the SO (24.5 %), followed by PC (24.4 %), CO (20.4 %), DC (13.2 %), EI (9.2 %), and EII (8.2 %) (Table 2; Figure 1). Regarding the positivity rate of the traps, it was found that it was higher in the CO plot (45.4 % of the coleopteran positive traps), followed by PC (40 %), SO (36.9 %), EI and DC (23.1 %), and EII (16.9 %) (Table 3). The highest value for Shannon diversity was found for CO (3.107), followed by PC (2.883), DC (2.699), EI (2.587), EII (2.099), and SO (1.530). The greater data uniformity, assessed using the Pielou index, was reported for DC (0.780), followed by CO (0.777), EI (0.722), PC (0.667), EII (0.662), and SO (0.460), the least uniform.

The dendrogram of similarity presented two extracts: the first extract represents 19 % of the Euclidean distance, grouping CO, SO, and EII, where CO and SO have greater similarity of the order of 15 %; the second extract represents 26 % of the Euclidean distance and grouped EI, PC, and DC, where EI and PC present similarity up to 13 % (Figure 2).

The multivariate factor analysis allowed to group two components that explain 72.15 % of the variability of data (Table 4). Factor 1 explained 49.60 % of data variability involving

Table 2. Identified Coleoptera families and number of individuals sampled in corn (CO), soybean (SO), eucalyptus (EI and EII), preserved Cerrado (PC), and disturbed Cerrado (DC)

Taxonomic Group	CO	SO	EI	EII	PC	DC
Carabidae Family						
Carabinae Subfamily						
Calosoma spp.	7	51	-	-	-	-
Cicindelinae Subfamily						
Megacephala sp.	3	-	-	-	-	-
Pentacomia sp.	-	-	-	-	1	-
Harpalinae Subfamily						
Poecilus sp.	-	-	-	-	3	-
Selenophorus sp.	6	2	-	1	-	-
Tetragonoderus sp.	9	4	-	-	-	-
Scaritinae Subfamily						
Oxydrepanus sp.	-	-	1	-	-	-
Scarites sp.	2		2	3	10	4
Chrysomelidae Family						
Eumolpinae Subfamily						
Eumolpinae sp.	-	-	1	-	-	-
Allocolaspis sp.	-	-	-	-	-	1
Costalimaita sp.	1	-	-	-	-	-
Galerucinae Subfamily						
Galerucinae sp.	-	-	-	-	1	-
Monomacra sp.	-	-	-	-	1	-
Styrepitrix sp.	-	1	-	-	-	2
Curculionidae Family						
Baridinae Subfamily						
Conoderini sp.	-	-	-	-	1	-
Histeridae Family						
Histerinae Subfamily						
Omalodes sp.	-	-	-	1	-	-
Nitidulidae Family						
Nitidulinae Subfamily						
Stelidota spp.	52	115	8	30	10	9
Ptilidae Family						
Ptilidae sp.	-	-	2	-	-	-
Scarabaeidae Family						
Scarabaeinae Subfamily						
Anomiopus sp.	-	-	-	-	-	1
Atheucus spp.	-	-	-	-	4	-
Canthidium spp.	6	-	3	1	33	4
Canthon spp.	3	1	1	4	20	35
Coprophanaeus sp.	4	1	1	2	4	16
Deltochilum spp.	3	1	28	18	77	18
Dichotomius sp.	27	-	16	-	2	8
Ontherus spp.	1	-	1	-	1	-
Onthophagus sp.	1	-	-	-	-	-
Pseudocanthon sp.	-	-	-	-	1	-
Uroxys spp.	-	-	-	2	5	-

Continue

Continuation

Staphylinidae Family						
Aleocarinae Subfamily						
Aleocarinae sp.	-	-	-	-	3	1
Staphylininae Subfamily						
Philonthina sp.	-	-	-	-	1	-
Xanthopigina sp.	-	-	-	-	3	-
Scydmaeninae Subfamily						
Euconnus sp.	-	-	5	-	-	-
Tenebrionidae Family						
Tenebrioninae Subfamily						
Tenebrionini sp.	15	3	-	-	2	-
Blapstinus sp.	13	5	-	-	-	-
Total of individuals	**153**	**184**	**69**	**62**	**183**	**99**
Total of taxon's	**16**	**9**	**12**	**9**	**20**	**14**

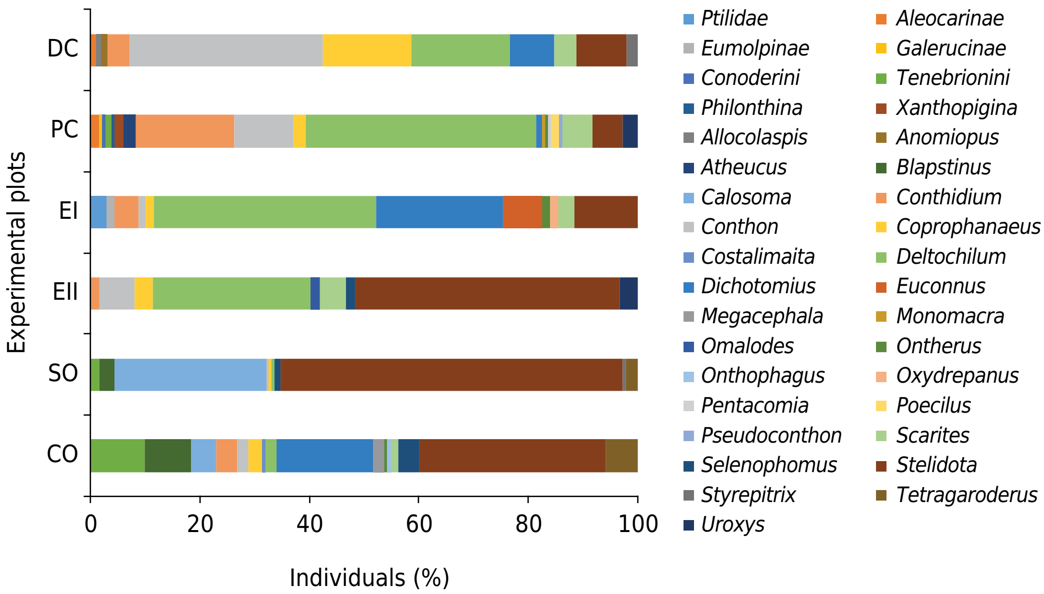

Figure 1. Coleoptera taxa and number of individuals sampled in the treatments: soybean (SO), corn (CO), eucalyptus (EI and EII), preserved Cerrado (PC), and disturbed Cerrado (DC).

Table 3. Biological diversity indexes for beetles in the different experimental plots: soybean (SO), corn (CO), eucalyptus (EI and EII), preserved Cerrado (PC), and disturbed Cerrado (DC)

Area	N	Total	ind trap^{-1} day^{-1} (± SD)	CV	Richness	Shannon (H')	Pielou (J')
				%			
CO	59 (45.4 %)	153	0.370±1.857	501.307	16	3.107	0.777
SO	48 (36.9 %)	184	0.548±0.714	130.435	10	1.530	0.460
EI	30 (23.1 %)	69	0.448±0.143	31.884	9	2.587	0.722
EII	22 (16.9 %)	62	0.295±0.571	193.548	12	2.099	0.662
PC	53 (40.8 %)	183	0.493±0.143	28.962	11	2.883	0.667
DC	30 (23.1 %)	99	0.471±0.143	30.303	20	2.699	0.780

N: number of points with occurrence of coleoptera and positivity rate of the traps; Total: total of organisms collected; ind trap^{-1} day^{-1}: individuals trap^{-1} day^{-1}; SD: standard deviation; CV: coefficient of variation.

15 properties with factor loadings greater than 0.7: *Blapstinus sp*. (-0.828), *Deltochilum spp*. (0.831), *Scarites* sp. (0.821), *Selenophorus sp.* (-0.822), *Stelidota spp.* (-0.760), *Tetragonoderus sp*. (-0.847), altitude (-0.950), clay (0.842), silt (-0.754), BD (-0.905), microporosity (0.744), macroporosity (-0.843), pH (-0.953), K^+ (-0.745), and Ca^{2+} (-0.949). Factor 2 explained 22.54 % of the variability and grouped three properties: *Dichotomius sp*. (0.737), sand (0.996), and total porosity (-0.777).

The cultivation of SO presented the largest number of ind $trap^{-1}$ day^{-1} (0.548 ± 0.714), followed by PC (0.493 ± 0.143), DC (0.471 ± 0.143), EI (0.448 ± 0.143), CO (0.370 ± 1.857), and EII (0.295 ± 0.571), as shown in table 3. The CV values (%) for the number of beetles on traps with individuals was between 28.962 % for PC and 501.307 % for MI.

DISCUSSION

The beetle fauna was considered rich, with a wide variety of genera belonging to different families. The predominance of Scarabaeidae confirms the association of this family with forest systems (Nichols et al., 2008; Slade et al., 2011; Portilho et al., 2012; Costa et al., 2014; Pompeo, 2016), where there is continuous input of litter, with diverse composition and quality, resulting in high nutrient cycling rates (Nichols et al., 2008). The higher occurrence of this family is in the PC and DC plots. Scarabids are known to be important in the process of nutrient removal and reintroduction in the soil (Hanski and Cambefort, 1991; Nichols et al., 2008; Slade et al., 2011), as they respond rapidly to environmental changes, making them important indicators for monitoring ecosystems (Silva et al., 2011).

Deltochilum and *Canthon* (Scarabaeidae) genera were more abundant in native vegetation (PC and DC) and eucalyptus plots (EI and EII), showing that use and management systems, with continuous input of organic material, favored the occurrence of these organisms (Pompeo et al., 2016). These genera are sensitive to anthropogenic action under the environment (Halffter and Favila, 1993; Barretto et al., 2019), and their occurrence is related to less disturbed environments (Hanski and Cambefort, 1991; Milhomem et al., 2003; Bogoni and Hernández, 2014), justifying its occurrence in areas with native vegetation

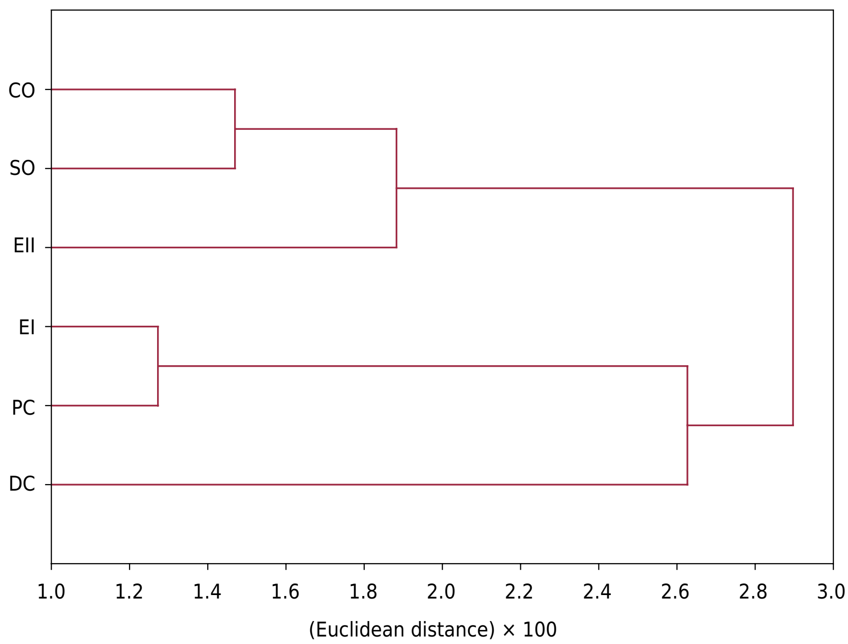

Figure 2. Dendrogram of similarity for beetles in experimental plots [soybean (SO), corn (CO), eucalyptus (EI and EII), preserved Cerrado (PC), and disturbed Cerrado (DC)].

Table 4. Analysis of factors (processes) and factor loadings that represent the correlation coefficients between soil properties and each factor

	Fator 1	Fator 2
% of variance	49.60 %	22.54 %
Cumulative %	49.60 %	72.14 %
Eigenvalue	13.88	6.31
pH	-0.953*	-0.125
Altitude	-0.950*	0.162
Ca^{2+}	-0.949*	0.164
BD	-0.905*	-0.413
Tetragonoderus sp.	-0.847*	0.434
Clay	0.842*	0.245
Deltochilum spp.	0.831*	0.186
Blapstinus sp.	-0.828*	0.484
Macro	-0.823*	-0.496
Selenophorus sp.	-0.822*	0.517
Scarites sp.	0.821*	0.359
Stelidota spp.	-0.760*	-0.466
Silt	-0.754*	0.597
K^+	-0.745*	0.630
Micro	0.744*	0.222
Sand	-0.039	0.996*
TP	0.150	-0.777*
Dichotomius sp.	-0.457	0.737*
Interpretation	Elements related to the state of aggregation	Porous system elements

* Properties with factor loading significative [>0.7 (Jeffers, 1978)]; Ca^{2+}: exchangeable calcium; BD: bulk density; Macro: macroporosity; K^+: exchangeable potassium; Micro: microporosity; TP: total porosity.

(PC and DC). The genera *Canthidium* spp., *Coprophanaeus* sp., *Dichotomius* spp., and *Ontherus* sp. in the experimental plots with PC and DC, presented varied abundance, and according to Lima et al. (2015), these groups are dependent on the availability of environmental resources.

The family Nitidulidae represented by the genus *Stelidota* presented greater abundance for the systems with SO and CO, which is justified by the fact that it is associated with cultivation systems with high input of organic material (Price and Young, 2006; Bartelt, 2010; Hernández-Torres, 2018). This family is composed of detritivorous organisms, and for this reason, they are associated with management systems with a rapid increment of plant residues on the soil surface (Araújo et al., 2004). On the other hand, the genus *Stelidota* has generalist characteristics (Ewing and Cline, 2005; Moraes and Köhler, 2011; Santos et al., 2014), which, in part, justifies its occurrence in the other portions of this study.

The Carabidae family presented greater abundance in the SO, CO, and PC plots, and for the CO plot, the highest genera richness was described. This family is described as an environmental regulator (Cividanes and Cividanes, 2008; Cividanes et al., 2009; Triplehorn and Johnson, 2011; Korasaki et al., 2013), encompassing predatory species that are often used for biological control of agricultural pests. It is also indicated as a bioindicator of environmental quality due to its ecological fidelity (Brown and Keith, 1991; Quinteiro, 2012), when compared to other families of coleopterans, that are more generalist in relation to the environment.

The Tenebrionidae family occurred in CO and SO systems, distributed in two taxa: *Tenebrionini* sp. and *Blapstinus* sp., being in agreement with the ecological characteristics of the group that has been negatively associated with climate elements such as relative air humidity, and positively with insolation, which in turn results in higher average temperature values (Gonçalves, 2017). Thus, the management systems with higher vegetation cover (EI, EII, PC, and DC) involve systems with shrub and tree extract, having less insolation and higher relative humidity, when compared to the cultivation systems (CO and SO).

The largest abundance of beetles in the experimental plot with SO was due to the genus *Stelidota* that occurred with high frequency. However, Pompeo et al. (2016) studying the diversity of beetles in different land use systems [natural vegetation (Atlantic Forest), eucalyptus reforestation, pasture, crop-livestock integration, and direct tillage with soybean and corn] in southern Brazil, reported greater abundance in areas with native forest related to the family Staphylinidae. Portilho et al. (2012) studying edaphic fauna in different land use systems in central-western Brazil, found the highest abundance for a no-tillage plot, followed by natural vegetation plots [Semideciduous and Cerrado (Brazilian savanna)]. Gonçalves (2017) studying the relationship between soil beetles and climate parameters throughout the year in northeastern Brazil under natural vegetation (Mata dos Cocais), found the highest abundance for the Scarabaeidae family.

The higher richness of organisms in DC and CO plots is related to food selectivity since in DC, it is used for grazing animals in drought years, making the food availability in this area different. Portilho et al. (2012) describe that Coleoptera fauna benefits from animal excrement in pasture areas, altering the diversity and abundance of coleopteran soil fauna. Price and Young (2006) described that in corn cultivation, Coleoptera benefits from the availability of decaying plant material, favoring mainly organisms with detritivorous habits. Thus, the occurrence of adapted taxa and selective habits related to the quantity and quality of the straw in CO, made this treatment present the highest Shannon diversity value (H’ = 3.107). We highlight that the Shannon diversity index (H’) quantifies the diversity of an area by the number of species and their relative abundance (Magurran, 1988), demonstrating that in CO, many groups of soil Coleoptera fauna occur and this occurrence is related to the food selectivity of these organisms, resulting in lower Pielou equitability (J’ = 0.777). Silva et al. (2018) studying the diversity of soil fauna on different land uses and management also found higher Shannon values related to SO and CO crops. Cajaíba and Silva (2015) studying Coleoptera fauna in an area of the Amazon Rainforest found Shannon values ranging between 2.09 and 2.51 at the edge and inside the forest plot. Lima et al. (2015) studying the Coleoptera fauna under natural vegetation and cultivated field, found Shannon values of 2.54 and 1.62, respectively, demonstrating the decrease in Coleoptera diversity associated with land use and management. Pompeo et al. (2016) described Shannon values of 1.77 for the no-tillage system and 1.28 for natural vegetation for the beetle fauna sampled in southern Brazil.

Soil use and management influenced the abundance and diversity of soil beetles for the present study, grouping the plots with CO, SO, and EII, according to the similarity dendrogram. Silva et al. (2018) studying the soil fauna in different systems of use and management, found similar results, emphasizing that in addition to the intensity of use, it should be considered the vegetation cover of the plots under study. In this sense, we can explain the grouping between CO and SO considering the temperature and soil moisture in these areas, as reported by Garlet et al. (2015) and Gonçalves (2017). The grouping of EII in the same extract as CO and SO can also be explained by the amount of insolation this plot received, since EII is composed of young eucalyptus plants with 70 % vegetation cover.

The similarity dendrogram grouped in a second extract EI, PC, and DC, involving vegetative compositions of natural forests (PC and DC) and eucalyptus forests (EI), with EI comprising a plot of trees larger than 12 m and aged 12 years. The differentiation of DC in this extract is due to the fact that this plot is used as a natural pasture for cattle in drought years. Portilho et al. (2012) report that, in pasture areas, Coleoptera fauna may benefit from animal excrement, resulting in a greater or lesser abundance of organisms. The use of the plot with DC as natural pasture in specific years also favors the development of specific creeping plants, since cattle are selective in their feed, which results in a different creeping plant community, as described by Silva et al. (2018). The greater similarity between EI and PC may be related to the percentage of vegetation cover in these plots (100 %). The structure that the forests composes produces a climate of its own, such as the incidence of shade, decreased sun rays due to canopy, vegetation cover and varied organic matter availability, which are fundamental for the stability of beetle communities (Halffter and Favila, 1993; Lima et al., 2015; Barretto et al., 2019).

Factor analysis summarized the various variables into a smaller set of dimensions with minimal information loss, as follows: Factor 1 = elements related to the state of aggregation; and Factor 2 = porous system elements.

In Factor 1, the taxa *Tetragonoderus* sp., *Blapstinus* sp., *Selenophorus* sp., *Scarites* sp., and *Stelidota* spp. are the ones that most contributed to explain the set of relations of the Coleoptera fauna with the physical and chemical properties (pH, altitude, Ca^{2+}, BD, clay, macroporosity, Silt, K^+, and microporosity). The pH was the property that most explained the presence of soil coleopteran taxa, demonstrating that along the landscape, changes in pH values result in a different coleopteran community, reflecting the occurrence of less abundant groups (*Tetragonoderus* sp., *Deltochilum* spp., *Blapstinus* sp., and *Scarites* sp.) or greater abundance (*Stelidota* spp.). Importantly, factor analysis does not take into account land use and should therefore only be used to identify complex interrelationships between variables. Silva et al. (2018) studying soil edaphic fauna in different soil uses and managements, described that the occurrence of invertebrate soil fauna was mainly explained by the soil Ca^{2+} content, and that the Coleoptera fauna taxa was the variable that more explained in terms of total variation for the variables under study.

The variables that relate to the soil porous system (Factor 2 - sand, total porosity, and *Dichotomius* sp.) have a clear and expected relationship, since the taxon *Dichotomius* sp. is associated with the disintegration of fecal masses, which are shaped into spheres and transported over the ground and in ground-excavated galleries (Pompeo et al., 2016; Tissiani et al., 2017), thus contributing to the maintenance of the soil total porosity. Lavelle et al. (2006) and Schiavon et al. (2014) describe the importance of soil invertebrate fauna as ecosystem engineers, and responsible for modifying the environment, influencing soil dynamics and the ecosystem. Bogoni and Hernández (2014) and Barretto et al. (2019) also highlight that this taxon is sensitive to changes in the environment and can thus be used as quality indicators, since its populations may indicate the degree of imbalance in agricultural ecosystems.

CONCLUSIONS

The Coleoptera community was influenced by soil use and management, and benefited from systems with lower environmental impact. Forest systems presented higher specimen abundance when compared to soybean and corn agricultural production systems. The soybean plot presented the highest diversity of taxa, followed by management systems with less soil mobilization (natural and forest systems). However, the highest Shannon diversity (*H’*) and Pielou equitability (*J’*) are described for systems with natural vegetation and eucalyptus, demonstrating how soil use and management interfere with soil Coleoptera fauna. Soil beetles in the different use and management systems were primarily related to soil physical properties, corresponding to the state of aggregation (pH, altitude, Ca^{2+}, BD, clay, macroporosity, silt, K^{+}, and microporosity) and the porous system (sand and total porosity).

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