ISSN 1807-1929
Revista Brasileira de Engenharia Agrícola e Ambiental
Brazilian Journal of Agricultural and Environmental Engineering
v.26, n.2, p.103-110, 2022
agriambi
Campina Grande, PB – http://www.agriambi.com.br – http://www.scielo.br/rbeaa

DOI: http://dx.doi.org/10.1590/1807-1929/agriambi.v26n2p103-110

Edaphic fauna and physico-chemical attributes of soil in different phytophysionomies of Cerrado[1]

Fauna edáfica e atributos físicos e químicos do solo em diferentes fitofisionomias de Cerrado

Raimunda A. Silva[2*] & Glécio M. Siqueira[2]

[1] Research developed at Parque Estadual do Mirador, Mirador, MA, Brazil
[2] Universidade Federal do Maranhão/Departamento de Geociências, São Luís, MA, Brazil

HIGHLIGHTS:
Soil fauna is strongly influenced by plant composition.
High levels of organic material favor the presence of edaphic fauna.
Cerrado physiognomies presented different abundances and richness of soil organisms.

ABSTRACT: The edaphic community comprises several organisms that perform ecological functions in the environment, such as litter fragmentation, nutrient cycling, and modifications of soil structure, in addition to acting as food chain regulators. Thus, the objective of this study was to evaluate the composition of the edaphic fauna and the physical and chemical attributes of soil in different physiognomies of Cerrado in the Parque Estadual do Mirador (PEM). The study was carried out in two Cerrado formations (Sparse Cerrado and Typical Cerrado) in PEM, where 100 pitfall traps were installed. The edaphic organisms were screened and identified in terms of orders, suborders, subfamilies, families, abundance, richness, Shannon diversity, and Pielou's equitability. A total of 4,149 individuals were collected from two experimental plots. The plot in the Typical Cerrado showed greater taxonomic richness (25 groups) and greater Shannon diversity (H' = 1.65), while the plot in Sparse Cerrado presented 19 edaphic groups and Shannon diversity equal to H' = 1.51. The factorial exploration explained 84.43% of the original data from the Sparse Cerrado and 90.84% from the Typical Cerrado. It is concluded that the plot in the Typical Cerrado showed greater differences in terms of richness and abundance due to the more favorable conditions for soil fauna, such as a high content of organic material and greater vegetation cover.

Key words: edaphic organisms, nutrient cycling, chain regulators

RESUMO: A comunidade edáfica é composta por diversos organismos que mantêm interações ecológicas nos ambientes, como fragmentação de serapilheira, ciclagem de nutrientes, modificações na estrutura do solo, além de reguladores de cadeia trófica. Assim, o objetivo deste estudo foi avaliar a composição da fauna edáfica, os atributos físicos e químicos do solo em diferentes fisionomias de cerrado no Parque Estadual do Mirador (PEM). O estudo foi desenvolvido em duas formações de Cerrado (Cerrado Ralo e Cerrado Típico) no Parque Estadual do Mirador, onde foram instaladas 100 armadilhas pitfall. Os organismos edáficos foram triados, identificados em termos de ordens, subordens, subfamílias e família; a partir disso foram estimados os parâmetros abundância, riqueza, diversidade de Shannon e equitabilidade de Pielou. Um total de 4.149 indivíduos foram coletados nas duas parcelas experimentais. A parcela em Cerrado Típico apresentou maior riqueza taxonômica (25 grupos); e maior diversidade de Shannon (H' = 1,65), enquanto a parcela em Cerrado Ralo apresentou 19 grupos edáficos e diversidade de Shannon igual a H' = 1,51. A exploração fatorial explicou 84,43% dos dados originais do Cerrado Ralo e 90,84% dos dados do Cerrado Típico. Conclui-se, que a parcela em Cerrado Típico demonstrou maior diferença em termos de riqueza e abundância, decorrente das condições favoráveis à fauna edáfica como alto teor de matéria orgânica e maior cobertura vegetal.

Palavras-chave: organismos edáficos, fragmentação de serapilheira, cadeia trófica

• Ref. 251285 – Received 19 Apr, 2021
* Corresponding author - E-mail: ray-234@hotmail.com
• Accepted 06 Aug, 2021 • Published 01 Sept, 2021
Edited by: Hans Raj Gheyi

Introduction

The Cerrado, with high biodiversity and a high degree of endemism, is the second-largest biome in Brazil, covering approximately 22% of the Brazilian territory (Oliveira & Marquis, 2002); however, only 2% of this biome is protected through parks and reserves. In this context, in the State of Maranhão, the Parque Estadual do Mirador (PEM) comprises a Conservation Unit created in 1980 in the Cerrado domain. It contains forest vegetation (Cerradão and Riparian Forest) and savanna (Dense Cerrado, Typical Cerrado, and Sparse Cerrado (Ribeiro & Walter, 2008).

Edaphic organisms are important components of ecosystems, particularly with respect to the modification of the physical and chemical attributes of soil (Martins et al., 2018; Silva et al., 2018). They perform several services in the environment, including the processing of organic matter (Bedano et al., 2016; Franco et al., 2016), nutrient cycling (Wagg et al., 2014), changes in physical structures, in addition to acting in the food chain regulation (Siqueira et al., 2016; Roy et al., 2018).

Thus, physical, chemical, and biological attributes are important for elucidating soil modifications, as the quality of these attributes directly influences the growth and development of vegetation (Franco et al., 2016). Some studies have sought to elucidate the relationship between soil attributes and edaphic fauna. According to Moço et al. (2010), the quality and quantity of organic matter in soil is a key factor in edaphic fauna distribution.

In this sense, the hypothesis for the present study was that the abundance, diversity, and richness of soil fauna in the PEM are conditioned by changes in vegetation. Therefore, this study aimed to evaluate the relationship between soil fauna organisms and soil physicochemical attributes in different physiognomies of Cerrado in the PEM, Maranhão state, Brazil.

Material and Methods

The experimental plots were arranged in the Parque Estadual do Mirador (PEM, State of Maranhão, Brazil), which has 766,781 ha and is located under the geographical coordinates: 6° 42' 9.803" S and 44° 42' 54.936" W, and altitude of 432 m (Figure 1A). According to Köppen, the climate of the region is classified as Aw (humid tropical), with annual mean precipitation of 1.183 mm and mean monthly temperature varying between 24 and 32 °C. The natural vegetation of PEM is classified as Cerrado (Ribeiro & Walter, 2008), presenting forest formations (Riparian Forest) and savanna formations (Cerradão, Dense Cerrado, Typical Cerrado, and Sparse Cerrado (Figure 1A). The soil in the PEM is classified as an Oxisol, according to Soil Survey Staff (2014), and is formed from geological formations known as Corda and Sambaíba (Bandeira, 2013).

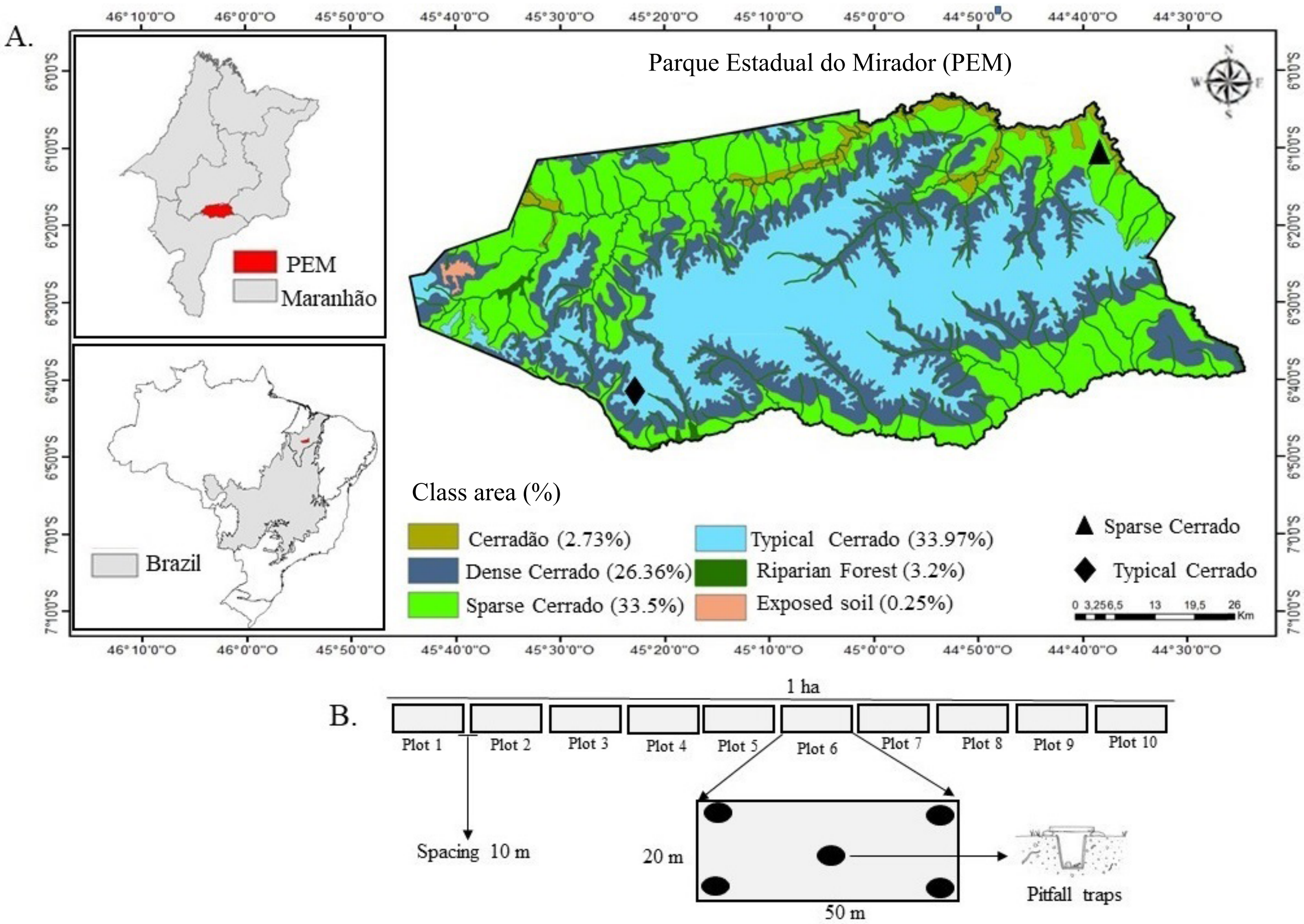

Figure 1. Location of the experimental plots in the Parque Estadual do Mirador, Maranhão state, Brazil (A) and experimental plots (B)

On August 21, 2017, sampling was carried out in the two main physiognomies of the Cerrado in the PEM: Sparse Cerrado and Typical Cerrado (Figure 1A), during the dry season, characterized by the absence of precipitation and with a mean temperature of 36 °C. The physiognomy with Sparse Cerrado comprises vegetation with shrub-trees, with a mean height of trees between 2 and 3 m (Ribeiro & Walter, 2008), and the physiognomy of the Typical Cerrado comprises vegetation composed of trees with a mean height of about 3 to 6 m (Ribeiro & Walter, 2008). In each of the vegetation physiognomies, 10 subplots of 20 × 50 m (1000 m^2) were installed 10 m apart (Figure 1B), from which the following characteristics were determined: soil fauna organisms (abundance, richness, Shannon's diversity, and equitability of Pielou), according to the methodologies of Aquino (2001), physical attributes of soil (texture [sand, silt, and clay], bulk density [BD], total porosity [TP]) according to Camargo et al. (2009); chemical attributes of soil (organic carbon [OC], pH, phosphorus [P], potassium [K], calcium [Ca], magnesium [Mg], the sum of bases [SB], and cation exchange capacity [CEC]), according to van Raij et al. (2001). For vegetation assessment, the number of tree specimens present in each subplot was counted, and the diameter at breast height (DBH) was measured for the shrub-tree layer with a diameter ≥ 0.1.

The soil fauna organisms were sampled using pitfall traps. Five traps were installed in each subplot, totaling 50 traps per Cerrado physiognomy (Figure 1B). The traps remained in the field for seven days, containing a 4% formaldehyde solution to preserve the organisms (Aquino, 2001). Subsequently, the organisms were screened and identified at the level of class, order, suborder, family, and subfamily.

In the present study, the Formicidae family was counted after its separation from the order Hymenoptera, considering evidence that Formicidae organisms participate in multiple environmental interactions and explore several ecological niches (Prado et al., 2019).

After the identification of soil fauna organisms, the following ecological indices were determined: abundance (total number of individuals collected in seven days of sampling), total richness (number of groups present in each plot), and values of Shannon's diversity index and equitability of Pielou, for the two plots under study. Shannon's diversity index was used to quantify the diversity of edaphic fauna in the two physiognomies of Cerrado, considering the number of individuals present in each sample and the relative abundance of groups (Eq. 1).

$$H' = \sum_{i=1}^{N} pi \log_2 p_i \qquad (1)$$

where:

H' - represents Shannon's diversity;

N - corresponds to the number of individuals belonging to the i species in the sample,

p_i - corresponds to the relative abundance; and,

$\log_2$ - corresponds to the logarithm at base 2.

The Pielou equitability index considers Shannon's diversity and richness present in each sample, enabling the characterization of the uniformity of the sampled area (Eq. 2).

$$U = \frac{H'}{\log_2 S} \qquad (2)$$

where:

U - corresponds to Pielou's equitability;

H' - corresponds to Shannon's diversity; and,

$\log_2 S$ - corresponds to the logarithm in base 2 of richness.

The ecological indexes of edaphic fauna (abundance, richness, Shannon diversity, and Pielou equitability), soil physical and chemical attributes, and DBH (m) were subjected to statistical summarization [mean (X), standard deviation (SD), coefficient of variation (CV%), asymmetry, and kurtosis; the normality of the data was verified by the Kolmogorov-Smirnov test (D-KS, $p < 0.01$)]. The comparison of means was made by t-test, and the intensity of Pearson's linear correlations was classified according to Santos (2007), which were classified as low ($r = \leq 0.5$) and high ($r = \geq 0.5$). Subsequently, the data were subjected to multivariate analysis to obtain the factors that explained the original data and the presentation of factors with factor loadings greater than 0.7 (Jeffers, 1978).

Results and Discussion

A total of 2,258 individuals were identified in the Sparse Cerrado and 1,891 individuals in the Typical Cerrado (Table 1). The highest taxonomic richness was recorded for the Typical Cerrado (25 groups), followed by the Sparse Cerrado with 19 taxonomic groups. The greater diversity of the Typical Cerrado is related to a greater density of trees (Gholami et al., 2017; Sauvadet et al., 2017) and the quantity of food resources (Moço et al., 2010) available in this system, compared to the Sparse Cerrado.

The Shannon diversity index (Table 1) was higher for the Typical Cerrado (H' = 1.65) than for the Sparse Cerrado (H' = 1.51). The Typical Cerrado had the lowest abundance (Table 1); however, the greatest abundance does not mean greater diversity, since this parameter reflects the environment, corroborating the environmental characteristics of the Typical Cerrado, such as microclimate (Kamau et al., 2017), dense arboreal layer, and lower frequency of the herbaceous layer (Ribeiro & Walter, 2008), and the amount of litter (Bedano et al., 2016). Even with environmental differences between the two vegetation physiognomies, the Pielou equitability values were close (U = 0.38 - Typical Cerrado and U = 0.35 - Sparse Cerrado), indicating low variability in the uniformity of groups.

The most abundant groups were Formicidae (1,530 and 1,146 individuals in Sparse Cerrado and Typical Cerrado, respectively); Acari (252 individuals, Sparse Cerrado and 116 individuals, Typical Cerrado); Collembola (35 individuals, Sparse Cerrado and 235 individuals, Typical Cerrado), and Coleoptera (96 individuals, Sparse Cerrado and 99 individuals, Typical Cerrado). The predominance of Formicidae, Acari, Collembola, and Coleoptera in the Cerrado areas was highlighted by Moço et al. (2010), Prado et al. (2019), and Silva et al. (2018). While ants are described as being responsible for the fragmentation and incorporation of litter into the soil (Silva et al., 2017), mites and springtails are associated with the

Table 1. Taxonomic groups and soil fauna diversity indexes in two physiognomies within the Parque Estadual do Mirador, Maranhão state, Brazil

Taxonomic grups	Sparse Cerrado		Typical Cerrado	
	Abundance	Numbers individuals/traps (%)	Abundance	Numbers individuals/traps (%)
TAXA CHELICERATA				
Subclass Acari	252	17(34)	116	29(58)
Order Araneae	106	5(10)	51	26(52)
Order Pseudoescorpionida	2	1(2)		
Order Solifugae	23	2(4)	21	11(22)
Family Scorpionidae	2	2(4)	5	5(10)
TAXA MYRIAPODA				
Class Symphyla	6	1(2)	3	2(4)
Class Diplopoda	2	1(2)	42	7(14)
TAXA HEXAPODA				
Order Protura	4	4(8)	4	4(8)
Order Collembola	35	9(18)	235	33(66)
Order Poduromorpha	10	4(8)	21	9(18)
Order Diplura			59	10(20)
Order Zygentoma	4	4(8)	2	2(4)
Order Orthroptera	3	1(2)	3	3(6)
Order Zoraptera			2	2(4)
Suborder Blattaria	132	11(22)	28	14(28)
Suborder Isoptera	10	2(4)	2	2(4)
Order Hemiptera	19	2(4)	5	2(4)
Suborder Sternorrhyncha			2	2(4)
Order Psocoptera			2	1(2)
Order Coleoptera	96	21(42)	99	37(74)
Order Hymenoptera	17	5(10)	23	10(20)
Family Formicidae	1,530	39(78)	1,146	50(100)
Order Lepidoptera	5	1(2)	6	4(8)
Order Strepsiptera			1	1(2)
Order Diptera			13	9(18)
Abundance	2,258		1,891	
Richness	19		25	
Shannon	1.51		1.65	
Pielou	0.35		0.38	

amount and quality of organic material in the soil (Sauvadet et al., 2017). The Coleoptera, on the other hand, are organisms associated with soil structure and fertility of the soil (Bernardes et al., 2020).

The statistical summary is presented in Table 2. There were statistical differences in the values of abundance of soil fauna (56.450 for Sparse Cerrado and 37.820 for Typical Cerrado) and average richness (5.640 for the Typical Cerrado and 4.050 for the Sparse Cerrado) according to the t-test (Table 2). Several organisms interact in the soil environment and support functions, such as litter fragmentation, nutrient cycling, and modification of soil structure, while also acting as food chain regulators. Thus, as shown previously, the diversity and abundance of soil fauna organisms reflect the vegetation composition in Cerrado environments, indicating that fragmentation can lead to loss of diversity and, consequently, to loss of ecosystem services.

The average value of OC was higher for the Typical Cerrado (OC = 11.005 g dm^{-3}) than for Sparse Cerrado (OC = 4.423 g dm^{-3}). The incorporation of OC is influenced by the composition of the vegetation present in the environment and the action of litter fragmenting organisms (Formicidae, Isoptera, and Coleoptera), which provide organic material to the soil (Bedano et al., 2016; Maggiotto et al., 2019). In this sense, the soil fauna is a key element in the dynamics of edaphic properties because it promotes physical and chemical modifications of soil (Ayuke et al., 2009).

The DBH values showed statistical differentiation, describing the high variability of environments present in the Cerrado biome, as described by Ribeiro & Walter (2008). The statistical differentiation of the Cerrado environments demonstrated the importance of environmental conservation and sustainable land use.

Silt (g kg^{-1}) was the only physical attribute under examination that showed statistical differentiation in the experimental plots installed in the Oxisol of PEM. Regarding chemical attributes, there were statistical differences for pH, P, Ca, SB, and CEC, indicating that the soil in the plot of Typical Cerrado had lower values for these attributes. According to Bandeira (2013), the PEM soils, formed from Corda Formation sediments, have greater variability than the soils formed from the Sambaíba Formation, thus justifying the differences in the mean values of physical and chemical attributes, as well as of CV values (%).

The correlations between the soil fauna organisms and the physical and chemical attributes of soil, as well as the DBH (m), are shown in Figures 2 and 3, where the correlation values were classified according to the classification of Santos (2007).

In the Sparse Cerrado plot (Figure 2), high correlations were found between Solifugae and Hymenoptera (r = 0.53), Collembola versus Araneae (r = 0.56), and Hymenoptera versus Coleoptera (r = 0.57), indicating that two communities of organisms stood out: predators (Solifugae, Hymenoptera, and Araneae), and organic matter shredders (Collembola and

Table 2. Summary statistics for the biological, physical, and chemical attributes of soil in the Parque Estadual do Mirador, Maranhão state, Brazil

	Mean ($\bar{X}$)	Variance	SD	CV (%)	Skew	Kurtosis	D*
			Sparse Cerrado				
Abundance	56.450 A	1585.587	39.819	70.539	1.763	3.678	0.138n
Richness	4.050 B	4.869	2.207	54.485	0.582	0.338	0.134n
Shannon	0.038 A	0.000	0.018	48.690	1.031	1.273	0.109n
Pielou	0.016 A	0.000	0.012	70.111	0.507	0.573	0.098n
Sand (g kg^{-1})	791.788 A	26103.870	161.567	20.405	-1.106	-0.358	0.269Ln
Silt (g kg^{-1})	65.713 B	3468.806	58.897	89.628	0.773	-0.682	0.191n
Clay (g kg^{-1})	142.500 A	12444.872	111.557	78.285	1.174	-0.122	0.281Ln
BD (kg dm^{-3})	1.393 A	0.008	0.089	6.417	-1.166	0.176	0.217n
TP (m^3 m^{-3})	0.421 A	0.002	0.040	9.399	-1.134	-0.267	0.278Ln
OC (g dm^{-3})	4.423 B	9.079	3.013	68.132	1.749	2.532	0.228n
pH ($CaCl_2$)	4.161 A	0.124	0.352	8.472	0.452	0.280	0.134n
P (g dm^{-3})	4.023 A	17.653	4.202	104.451	4.890	27.162	0.317Ln
K ($mmol_c$ dm^{-3})	0.993 A	0.078	0.279	28.062	3.010	13.138	0.204n
Ca ($mmol_c$ dm^{-3})	10.825 A	76.558	8.750	80.829	1.639	2.367	0.282Ln
Mg ($mmol_c$ dm^{-3})	10.417 A	31.013	5.569	53.459	0.487	-0.231	0.125n
SB ($mmol_c$ dm^{-3})	25.349 A	161.066	12.691	50.066	1.011	0.830	0.159n
CEC ($mmol_c$ dm^{-3})	68.458 A	1186.027	34.439	50.307	1.041	0.203	0.171n
DHB (m)	0.577 B	0.157	0.396	68.653	0.803	0.266	0.107n
			Typical Cerrado				
Abundance	37.820 B	327.008	18.083	47.814	1.204	1.751	0.134n
Richness	5.640 A	4.766	2.183	38.707	0.25	0.153	0.155n
Shannon	0.033 A	0.000	0.011	34.706	0.765	0.515	0.102n
Pielou	0.014 A	0.000	0.005	37.698	0.32	0.596	0.112n
Sand (g kg^{-1})	817.100 A	16242.653	127.447	15.597	-1.314	0.974	0.167n
Silt (g kg^{-1})	125.700 A	6458.622	80.366	63.934	0.967	0.091	0.197n
Clay (g kg^{-1})	57.200 B	4231.786	65.052	113.728	1.607	1.568	0.248Ln
BD (kg dm^{-3})	1.356 A	0.006	0.077	5.706	-0.045	-1.387	0.138n
TP (m^3 m^{-3})	0.412 A	0.002	0.044	10.765	-0.942	-0.389	0.201n
OC (g dm^{-3})	11.005 A	68.541	8.279	75.227	1.273	2.702	0.125n
pH ($CaCl_2$)	3.962 B	0.057	0.239	6.026	-0.656	-0.058	0.159n
P (g dm^{-3})	2.832 B	5.759	2.400	84.741	1.497	0.93	0.236Ln
K ($mmol_c$ dm^{-3})	0.966 A	0.282	0.531	55.006	1.674	2.034	0.295Ln
Ca ($mmol_c$ dm^{-3})	5.700 B	26.418	5.140	90.173	0.363	-1.329	0.186n
Mg ($mmol_c$ dm^{-3})	10.160 A	27.484	5.243	51.6	0.685	-0.725	0.207n
SB ($mmol_c$ dm^{-3})	19.189 B	112.708	10.616	55.325	0.902	-0.538	0.242Ln
CEC ($mmol_c$ dm^{-3})	58.231 B	587.837	24.245	41.637	1.164	1.61	0.149n
DBH (m)	0.611 A	0.051	0.225	54.706	1.405	2.476	0.187n

SD - Standard deviation; CV - Coefficient of variation (%); D* - Kolmogorov Smirnov normality test at 0.01; BD - bulk density; TP - total porosity; OC - organic carbonic; P - phosphorus; K - potassium; Ca - calcium; Mg - magnesium; SB - sum of bases; CEC - cation exchange capacity; DBH (m) - diameter at breast height. Means followed by the same letters in the column do not differ by t-test

Coleoptera). Correlations involving predatory organisms reveal the characteristics that enable them to explore and adapt to the environment.

It is pertinent to highlight that the Solifugae group also showed negative correlations with the soil physical attributes in the Sparse Cerrado: Solifugae versus Sand (r = -0.21), Solifugae versus BD (r = -0.21), and Solifugae versus TP (r = -0.21) demonstrating that this group thrives in environmental situations with high clay content. According to Valdivia et al. (2011), members of the Solifugae have a close relationship with the pedological characteristics of the environment. These characteristics can determine the abundance and distribution of the group because they affect oviposition, soil excavation, and the available food resources.

Figure 3 shows the correlations between the soil fauna and the physical and chemical soil properties in the Typical Cerrado. The correlations between the edaphic fauna, the physical and chemical attributes of the soil, and DBH (m) were considered low according to the classification of Santos (2007), except for those between Solifugae and Hymenoptera (r = 0.51), Diptera versus Araneae (r = 0.53), and Myriapoda versus Diplopoda (r = 0.67), which were significant (r ≥ 0.5) and positive, indicating the growth of food-chain regulatory groups (Solifugae, Araneae, and Diptera) that depend on the abundance of prey organisms (Valdivia et al., 2011).

Multivariate analysis, through the factorial approach, in the plot of Sparse Cerrado (Table 3), explained 84.43% of the relationships between the variables. Factor 1 explained 66.32%, Factor 2 explained 12.11%, and Factor 3 explained 6.00%. Specifically, Factor 1 grouped variables that indicated the physical, chemical, and biological qualities of soil (pH [0.982], BD [0.982], TP [0.982], K [0.981], Collembola [0.976], OC [0.945], P [0.982], Coleoptera [0.926], sand [0.905], clay [-0.904], Mg [0.827], silt [-0.820], Blattaria [0.75132], and Araneae [0.748)]). Soil fertility indicators constituted Factor 2, as follows: SB (0.874) and CEC (0.799), while Factor 3 included organisms that explored multiple ecological niches (Formicidae [-0.969]).

The associations of the edaphic groups in Factor 1 are related to a series of interactions between the edaphic fauna and the physical and chemical attributes of soil, establishing a relationship between the organisms responsible for the

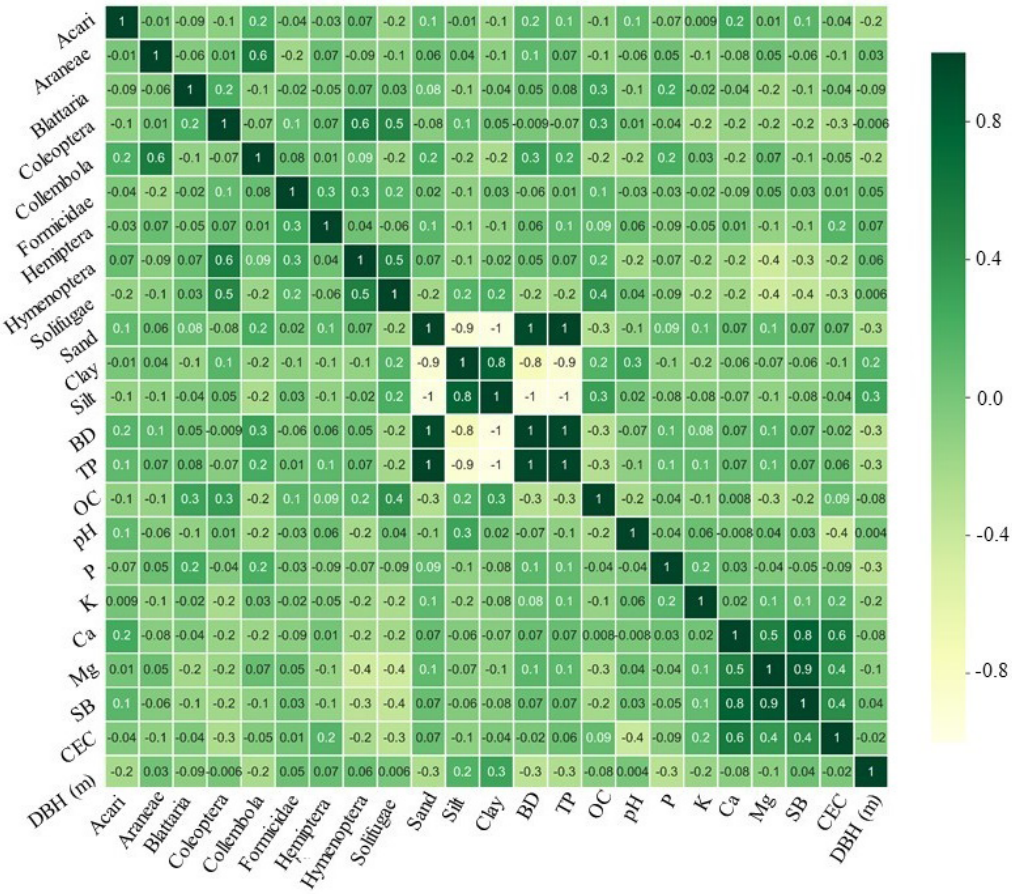

Figure 2. Correlation matrix for physical, chemical, and biological attributes in Sparse Cerrado in the Parque Estadual do Mirador, Maranhão state, Brazil

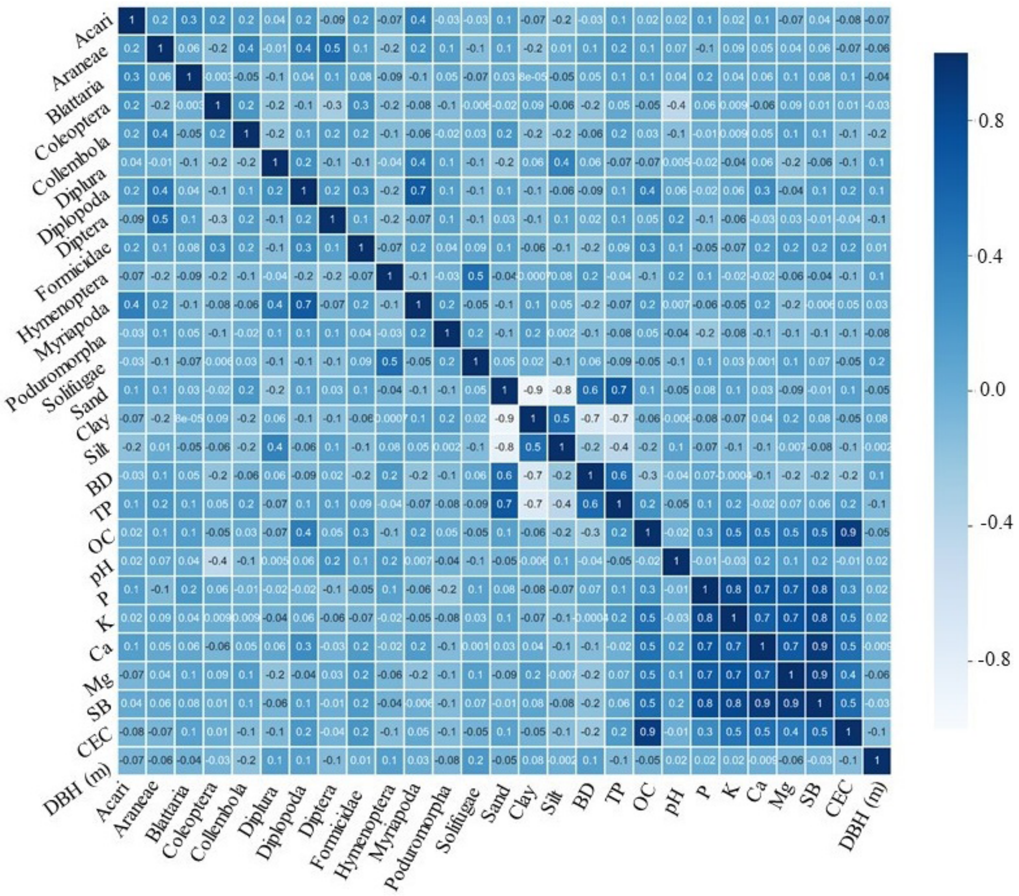

Figure 3. Correlation matrix for physical, chemical, and biological attributes in Typical Cerrado in the Parque Estadual do Mirador, Maranhão state, Brazil

fragmentation and decomposition processes (Coleoptera, Acari, and Collembola) and trophic relationships (Araneae), corroborating the findings of Bedano et al. (2016) and Roy et al. (2018). On the other hand, the presence of a single group (Formicidae) in Factor 3 was due to the variety of trophic guilds explored by this group (Aquino, 2001), in addition to the intrinsic social behavior of these organisms (Prado et al., 2019).

The factor analysis for the plot of the Typical Cerrado explained 90.84% of the original data (Table 3), distributed in three factors: Factor 1 (65.51%), Factor 2 (18.44%), and Factor 3 (6.89%). Factor 1 was grouped as follows: pH (0.970), BD (0.970), TP (0.969), Araneae (0.966), K (0.964), Blattaria (0.958), Coleoptera (0.943), P (0.929), Acari (0.938), Collembola (0.880), sand (0.854), clay (-0,817), Ca (0.749), and Mg (0.709). Factor 2, mainly comprising SB and CEC, was associated with soil fertility. The Formicidae family was the only factor associated with Factor 3, indicating the complexity of interactions for this group (Prado et al., 2019).

Table 3. Factor analysis containing the first three factors with factor loadings of representative correlation coefficients for soil fauna and physical and chemical attributes of soil in the physiognomy of Sparse Cerrado and Typical Cerrado in the Parque Estadual do Mirador, Maranhão state, Brazil

Properties	Sparse Cerrado		
	Factor 1 66.32%	Factor 2 12.11%	Factor 3 6.00%
pH ($CaCl_2$)	0.982	0.102	0.038
BD (kg dm^{-3})	0.982	0.122	0.0236
TP (m^3 m^{-3})	0.982	0.125	0.0209
K (mmol$_c$ dm^{-3})	0.981	0.127	0.023
Collembola	0.976	0.107	0.019
OC (g dm^{-3})	0.945	0.061	-0.066
P (g dm^{-3})	0.942	0.094	0.030
Coleoptera	0.926	-0.017	-0.031
Sand (g kg^{-1})	0.905	0.307	-0.043
Clay (g kg^{-1})	-0.904	-0.343	0.074
Mg (mmol$_c$ dm^{-3})	0.827	0.433	0.027
Silt (g kg^{-1})	-0.820	-0.386	0.270
Blattaria	0.751	-0.010	-0.015
Araneae	0.748	-0.024	0.186
SB (mmol$_c$ dm^{-3})	0.351	0.786	0.092
CEC (mmol$_c$ dm^{-3})	-0.280	0.760	-0.058
Formicidae	0.007	-0.040	-0.969
Interpretation	Elements of physical, chemical, and biological quality of soil	Indicators of soil fertility	Organisms with multiple ecological niches
Properties	Typical Cerrado		
	Factor 1 65.51	Factor 2 18.44	Factor 3 6.89
pH ($CaCl_2$)	0.970	0.158	0.130
BD (kg dm^{-3})	0.970	0.162	0.135
TP (m^3 m^{-3})	0.969	0.167	0.138
Araneae	0.966	0.151	0.143
K (mmol$_c$ dm^{-3})	0.964	0.210	0.118
Blattaria	0.958	0.172	0.147
Coleoptera	0.943	0.130	0.192
P (g dm^{-3})	0.929	0.332	0.023
Acari	0.938	0.153	0.156
Collembola	0.880	0.125	0.137
Sand (g kg^{-1})	0.854	0.414	0.236
Clay (g kg^{-1})	-0.817	-0.331	-0.229
Ca (mmol$_c$ dm^{-3})	0.749	0.588	-0.002
Mg (mmol$_c$ dm^{-3})	0.709	0.608	0.001
SB (mmol$_c$ dm^{-3})	0.280	0.874	-0.160
CEC (mmol$_c$ dm^{-3})	-0.216	0.799	0.361
Formicidae	0.298	0.124	0.815
Interpretation	Elements of physical, chemical, and biological quality of soil	Indicators of soil fertility	Organisms with multiple ecological niches

Using multivariate statistics, the biological, physical, and chemical attributes of the soil in both experimental plots were grouped into three coincident factors, which explain the existing processes between the variables in the plots.

Notably, regardless of the differences between vegetation types (Sparse Cerrado and Typical Cerrado), because there is no disturbance, the patterns of occurrence of factors and variables remain as subsidiaries in the management process, favoring the development of integrated indicators of quality. Among the soil fauna, ants have a particularly high potential as indicators of environmental quality because they have high diversity and the capacity to explore the environment (Silva et al., 2017; Prado et al., 2019).

In the Typical Cerrado, the taxonomic groups are more uniformly distributed compared to the Sparse Cerrado. Our results demonstrated that the invertebrate fauna in the two physiognomies differed with respect to the values of abundance and richness but with small differences in the magnitude of diversity indices (Shannon and Pielou). This demonstrates how vegetation composition influences the ecology of different taxonomic groups (Gholami et al., 2017; Roy et al., 2018; Silva et al., 2019).

Conclusions

1. The invertebrate fauna of soil in the Parque Estadual do Mirador (PEM) are associated with soil structure (physical attributes) and with indicators of the chemical quality of soil (chemical attributes).

2. The groups Formicidae, Coleoptera, and Collembola are organisms associated with the chemical quality of the soil in the two physiognomies of Cerrado in PEM.

3. In the PEM physiognomies, the diversity and richness of taxonomic groups are influenced by the plant cover present in the sample area.

Acknowledgements

The authors would like to thank the Fundação de Amparo à Pesquisa e ao Desenvolvimento Científico e Tecnológico do Maranhão (FAPEMA - Process UNIVERSAL - 00976/19, COOPI - 04938/18, BD-02105/17, BEST-EXT-00361/19, and BINST-00362/19). We also thank the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq - Process 429354/2016-9 and 103961/2018-6). In addition, we thank the Secretaria de Estado do Meio Ambiente e Recursos Naturais (SEMA) for supporting collections at Parque Estadual do Mirador, Maranhão, Brazil.

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