Brazilian Journal of Biology
ISSN 1519-6984 (Print)
ISSN 1678-4375 (Online)

https://doi.org/10.1590/1519-6984.228799
Original Article

Characterization of edaphic fauna in different monocultures in Savanna of Piauí

L.A.P. L. Nunes[a]*, *M. M. C. Pessoa*[a], *A. S. F. Araujo*[a], *R. S. Sousa*[a], *J. D. C. Silva*[b], *L. F. C. Leite*[c] and *L. R. Barbosa*[d]

[a]Universidade Federal do Piauí – UFPI, Centro de Ciências Agrarias, Departamento de Engenharia Agrícola e Solos, Soil Quality Lab., Teresina, PI, Brasil

[b]Instituto Federal do Piauí – IFPI, Oeirás, PI, Brasil

[c]EMBRAPA Meio Norte, Teresina, PI, Brasil

[d]Universidade Federal da Paraíba – UFPB, Departamento de Solos e Engenharia Rural, Programa de Pós-graduação em Ciência do Solo, Areia, PB, Brasil

*e-mail: luisalfredo@ufpi.edu.br

Received: September 16 2019 – Accepted: February 14, 2020 – Distributed: August 31, 2021
(With 2 figures)

Abstract

Vegetation cover may show diversity and composition patterns of the soil invertebrate community, as a function of litter quantity and quality in a specific habitat. The objective of this work was to characterize the distribution of edaphic fauna in different monocultures. The study was carried out at Chapada Grande farm in Regeneração, PI. Four monoculture areas were chosen: no-tillage soybean, eucalyptus, pasture, and a preserved native cerrado forest. Soil fauna was collected in a dry and wet period by pitfall traps containing 4% formaldehyde. The edaphic fauna was evaluated by the number of individuals per trap per day, average richness and richness, Shannon diversity index and Pielou uniformity index. Data were submitted to analysis of variance and multivariate Principal Component Analysis (PCA). The highest number of individuals per day trap and of average richness were registered in the pasture, eucalyptus and forest areas in both periods, while soybean showed lower values with predominance of Coleoptera and Formicidae groups. The pasture and forest areas showed of higher Shannon index values in the two evaluated seasons, probably due to higher contributions organic residues in the soil that favors the shelter, feeding and reproduction conditions. Regarding the Pielou index, the soybean system showed higher values in this variable. The Aranae, Coleoptera, Formicidae and Diptera groups predominated in the humid period, while Coleoptera and Formicidae predominated in the dry period. Systems that generate greater accumulation of residues harbor a greater diversity of invertebrates of the edaphic fauna. Seasonality had an effect on all variables analyzed and the wet period showed more expressive values.

Keywords: pitfall traps, soil invertebrates, no tillage, seasonality.

Caracterização da fauna edáfica em diferentes monoculturas no Cerrado piauiense

Resumo

A cobertura vegetal pode mostrar padrões de diversidade e composição da comunidade de invertebrados do solo, em função da quantidade e qualidade da serapilheira em determinado habitat específico. O objetivo deste trabalho foi caracterizar a distribuição da fauna edáfica em diferentes monocultivos. O estudo foi realizado na fazenda Chapada Grande no município de Regeneração, PI. Foram escolhidas quatro áreas de monocultivos: soja em sistema de plantio direto, eucalipto, pastagem, além de uma mata nativa de cerrado preservada. Foram realizadas coletas da fauna do solo, em período seco e úmido, por meio de armadilhas do tipo pitfall contendo 4% de formol. A fauna edáfica foi avaliada pelo número de indivíduos por armadilha por dia, riqueza e riqueza média, índice de diversidade de Shannon e índice de uniformidade de Pielou. Os dados foram submetidos à análise de variância e à análise multivariada de Componentes Principais (ACP). O maior número de indivíduos por armadilha dia e de riqueza média foram registrados nas áreas pastagem, eucalipto e mata nos dois períodos, enquanto que a soja mostrou valores inferiores com predomínio dos grupos Coleoptera e Formicidae. As áreas de pastagem e mata mostraram maiores valores de índice de Shannon nas duas épocas avaliadas provavelmente em função de maiores aportes de resíduos orgânicos no solo que favorece as condições de abrigo, alimentação e reprodução. Em relação ao índice de Pielou o sistema com soja mostrou maiores valores nessa variável. Os grupos Araneae, Coleoptera, Formicidae e Diptera predominaram no período úmido, enquanto Coleoptera e Formicidae se destacaram no período seco. Sistemas que geram maior acúmulo de resíduos abrigam uma maior diversidade de invertebrados da fauna edáfica. A sazonalidade apresentou efeito sobre todas as variáveis analisadas sendo que o período úmido mostrou valores mais expressivos.

Palavras-chave: armadilhas pitfall, invertebrados do solo, plantio direto, sazonalidade.

1. Introduction

Savanna soils in the state of Piauí have been gradually explored with annual crops, pastures, and, more recently, reforestation (Aguiar and Monteiro, 2005). It is known that the Cerrado is a tropical savanna of low vegetation, formed mainly by grasses that coexist with shrubs and sparse trees contributing a great amount and variety of residues in the soil (Hoffmann and Jackson, 2000) that favor the reproduction of the invertebrates, with availability of food and shelter (Silva et al., 2006).

However, with changes in the composition of tree species, through cultivation of a single species, the number of ecological niches decreases, favoring intra and interspecific competition (Cole et al., 2006), as well as changes in abiotic factors such as temperature, moisture, light intensity and soil physical and chemical conditions (Riutta et al., 2012, Ashford et al., 2013). Andersen (1999) considers that monocultures tend to favor certain faunal groups by supplying a single food substrate, which may lead to the emergence of pest insects.

The implementation of crops made through the no-tillage system as in the case of soybean, has as main characteristic the minimum preparation of the soil, with maintenance of a constant covering of straw on the surface in milder climates, despite the low C / N ratio of the crop. This creates conditions favorable to the survival of soil organisms gradually as the benefits in terms of improvement of the soil environment by the presence of straw are becoming present (Bartz et al., 2013; Kladivko, 2001). On the other hand, the use of grass *Brachiaria brizantha* (Hochest.) Stapf. cv. Marandu has been efficient in the accumulation of organic residues in the soil, due to its abundant root system that presents continuous renewal and high rhizospheric effect, which, maintained at the surface favors the biota activity of the soil, by supplying edible organisms (Rossi et al., 2013).

In its turn, the Eucalyptus grandis Hill (ex Maiden), in which soil preparation in the region is limited to plowing and harvesting at the time of planting, provides a large amount of litter with low nutritional quality and high C / N ratio, which contributes to slow decomposition of the organic matter (Pulrolnik et al., 2009). For Cortes et al. (2015) the large amount of litter generated by eucalyptus, provides certain environmental conditions favorable to the action of macro and microorganisms allowing rapid mineralization and maintaining soil nutrient availability.

The effects on the diversity of soil fauna have been the main focus of scientific investigations regarding the substitution of forest by monoculture systems, mainly regarding loss of habitat quality and its ecological and evolutionary consequences. Some studies have already shown the differences in the diversity, composition of fauna species in different ecosystems resulting from the process of fragmentation of forests in equilibrium, such as the Caatinga (Araújo et el., 2010), Mata de Cocais (Nunes et al., 2012), Mata Atlântica (Pereira et al., 2013), Cerrado (Araújo et al., 2017) and areas with distinct floristic domains (Nunes et al., 2019).

The objective of this work was to characterize the distribution of the edaphic fauna in two seasons of the year and in four different monocultures in the Savanna of Piauí.

2. Material and Methods

The study was carried out at the Chapada Grande Farm, located in the municipality of Regeneração / PI, with an altitude of 400 m, geographic coordinates (06 ° 14 '16 "South latitude and 42 ° 41' 18" West longitude). The climate, according Alvares et al. (2013), is type Aw (tropical rainy). The region presents an average annual temperature of 26.4 ° C and precipitation with rainfall distributed from October to May with an average of 1,238 mm.

The soil of the study areas was classified as a yellow distrotic oxisol (Jacomine, 1986) with a clayey texture (Table 1). The particle size analyzes were performed at the Soil Laboratory of the Federal University of Piauí.

Four adjacent areas cultivated with eucalyptus, soybean, pasture and, as a reference, a Savanna forest was used (Figure 1). The areas were chosen using as criteria the proximity of the desired crops and for presenting the same soil class. In each area, 100 m^2 georeferenced plots were demarcated where the soil was collected. The cultivated areas were all established in 2008 as follows: (1) Area of thirty hectares cultivated with rice in the first year and soybean in subsequent years. The initial soil preparation consisted of plowing, furrowing, root harvesting and incorporation of 4 t ha^{-1} of limestone and fertilization of 250 kg ha^{-1} of NPK. The conventional management was carried out with the use of plow and grate until the year 2013. In 2014, began to be used in a system of no-tillage. Annually the application of the agricultural defense contact and ingestion systemic insecticide with active ingredients Acetamipride + Bifentrinals for the control of white fly. (2) Area under eucalyptus (clone Ma - 2000) planted after deforestation of Savanna forest with the use of bushes and burning of branches and leaves covers thirty hectares. The initial soil preparation consisted of plowing, sorting and subsoiling for planting and incorporation of 4 t ha^{-1} of limestone and 400 kg ha^{-1} of triple superphosphate.

Table 1. Soil size composition of soils under different vegetal cover at Chapada Grande Farm - PI.

Vegetal cover	Sand	Silt	Clay	Texture
Soybean	367	192	441	Clayey
Eucalyptus	224	373	403	Clayey
Pasture	273	219	508	Clayey
Native Forest	288	280	432	Clayey

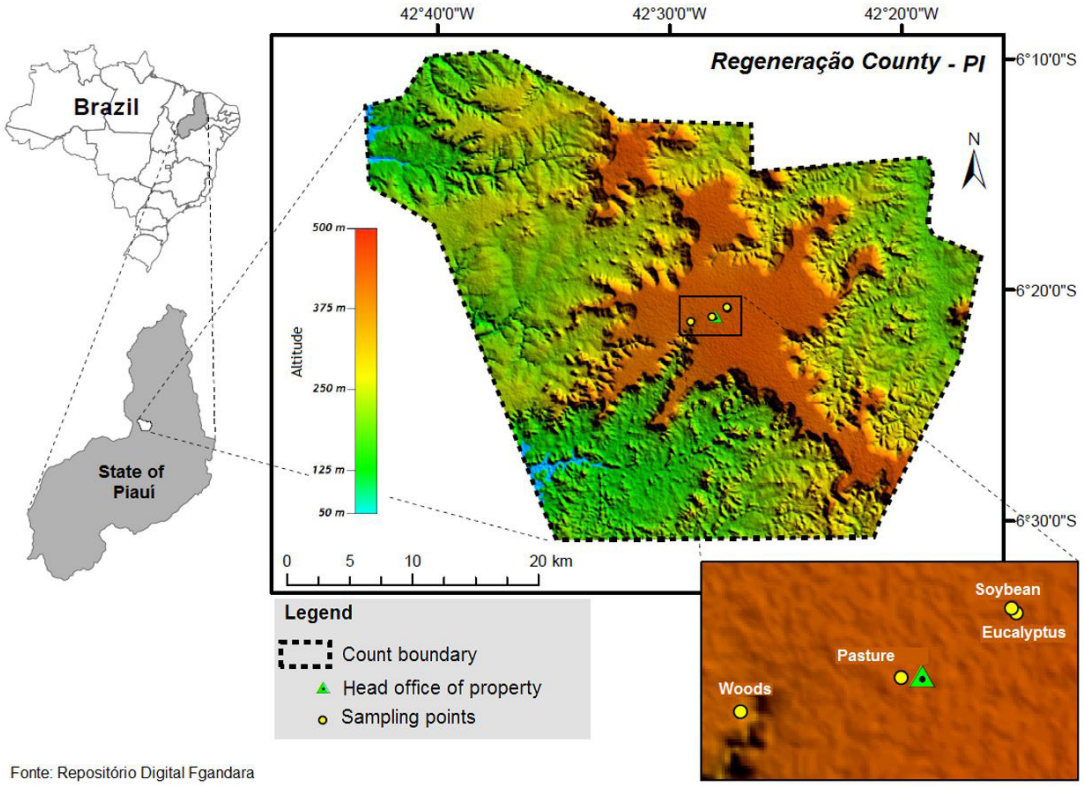

Figure 1. Location of the soil sample collection points at Chapada Grande Farm, Regeneração / PI.

Eucalyptus was planted at a spacing of 3.5 × 2.5 m. Cover fertilization was performed with NPK (20-00-20) using 150 kg / plant. Manual weeding was also carried out in the area two months after planting and harrowing between rows three months after planting. (3) Twenty five hectare pasture area with prevalence of grass *Brachiaria brizantha* managed under intensive grazing with three animal units (AU) per hectare for eight months. Before grazing, this area was cultivated with soybean until 2011 in a conventional system. (4) The Cerrado native forest area consists of natural vegetation and did not have anthropic interference for reference use about forty hectares.

Fauna collections were carried out in the months of March (wet period) and September (dry period) in 2018. Pit-fall traps consisting of plastic containers 10 cm high and 10 cm in diameter (containing formaldehyde to 4% to about 1/3 of its volume) buried in the soil until its opening was exactly at the surface level. A total of eight traps were placed with an average distance of 10 meters between each one, meters in the form of a transect in the central part of each system, where they remained for seven days. The contents of each vial from the traps were analyzed individually with the use of Petri dish and tweezers under binocular magnifying glass, and the amount of each species present in each sample per collection area was recorded for the level of large taxonomic groups.

The edaphic fauna was evaluated by the number of individuals per trap per day, fauna richness, which corresponds to the number of groups identified, and average richness that represents the average number of individuals per trap. The total number of taxonomic groups present was evaluated by the Shannon diversity index which was calculated by means of the following formula: $H = -\Sigma\ pi \times \log 2\ pi$, where pi is the proportion of individuals belonging to the each family.

For the analysis of uniformity, that is, relative abundance, the Pielou Uniformity Index was used, using the following expression: $U = H / \log nS$, where H corresponds to the Shannon index, n is the total number of individuals in the community and S is the total number of species found in each management system.

Six litter samples were collected near the trap sites using a wooden template measuring 0.5 x 0.5 m, out of a total of eight, which was randomly released and the surpluses of leaves, branches and fruits were cut with a knife within the limits of the same until the contact with the soil. The storage was done in paper bags following the methodology described by Scoriza et al. (2012).

Soil temperature was measured at 0 C with the aid of an appropriate soil thermometer. To determine the soil moisture were collected near the traps, at a depth of 0.0-0.10 m. For moisture assessment the samples were submitted to the thermogravimetric method, which consists of weighing the moist soil mass (MU) and then drying it in an oven at 105-110ºC for 24 hours and, after this period, determining its dry mass (DM). Humidity was calculated by the Equation 1:

$$U = \frac{Msm - Dsm}{Msm} \times 100 \quad (1)$$

Where: U = soil moisture (kg kg^{-1}); Mu = most soil mass (g); Ms = dry soil mass (g)

The number of individuals per trap per day, mean soil fauna richness and Shannon diversity indexes and Pielou uniformity were calculated using the software Dives 3.0 (Rodrigues, 2015). These indices were submitted to analysis of variance (ANOVA) and when significant submitted to the statistical test of LSD at 5% of significance. Parameters analyzed as orders were submitted to multivariate analysis of Principal Components (PCA). Biplots of the ACP were plotted separately for the rainy and dry period of the year to show the relationships between the systems of land use. All analyzes were performed using the program R v.3.6.0 (R Core Team, 2019).

3. Results and Discussion

The highest number of individuals per day trap and average richness were recorded in areas with pasture, eucalyptus and native forest in both periods, while the soybean system showed lower values with predominance of the Coleoptera and Formicidae groups and other less common ones (Table 2). These results can indicate that the intensity and degree of interference of the management practices that each culture influences the presence and activity of the fauna of the soil, due to resource restrictions for these organisms (Santos et al., 2016; Baretta et al., 2014).

The use of the no-tillage system in soybean, which involves the maintenance of straw in the soil, has been practiced in an attempt to increase the organic matter content and to improve soil quality after harvesting the annual crop (Aita and Giacomini, 2003; Torres et al., 2015), which supposedly favored the presence of individuals of the edaphic fauna. However, in the soil conditions of the Cerrado, where a prolonged drought accompanied by high temperature for a good part of the year favors a more rapid decomposition of the vegetal residues by the microorganisms, reducing their persistence on the soil (Pacheco et al., 2008, Kliemann et al., 2006). Moreover, only soybean is not able to maintain a good amount of residues on the soil surface, since it is degraded faster, the ideal was to rotate with other crops, such as brachiaria or sorghum, with different C / N ratios (Rossi et al., 2013).

This can be verified by the total litter values in the soil use systems studied in Table 3. The litter production in the study areas was seasonal, with the highest production occurring during the dry season. The highest production occurred in eucalyptus and forest systems followed by pasture and soybean.

In addition, the application of agricultural pesticides in the rainy season to contain the pest attack in the soybean crop may have contributed to the decrease of these variables

Table 2. Number of individuals with respective standard errors, total richness and average soil fauna richness under diferente vegetal cover at Chapada Grande Farm - PI.

Vegetal Cover	Ind. trap^{-1} day^{-1} ± Default error	Richness	Average reichness	Index Shannon	Index Pielou
Rainy season					
Soybean	6.73 c ± 2,15	14	6.85 b	2.12 b	0.81 a
Pasture	22.04 b ± 0.40	15	9.57 a	2.07 b	0.64 c
Eucalyptus	23.02 b ± 0.80	17	11.75 a	2.55 a	0.75 b
Forest	28.96 a ± 3.84	20	10.80 a	2.38 a	0.71 b
Dry season					
Soybean	8.96 b ± 7.81	10	4.80 b	1.54 c	0.77 a
Pasture	20.67 a ± 6.38	14	8.60 a	1.99 b	0.69 b
Eucalyptus	20.04 a ± 4.05	18	9.75 a	2.23 a	0.70 b
Forest	20.34 a ± 1.29	18	10.85 a	2.16 a	0.66 b

Table 3. Litter accumulation, temperature and soil moisture under different vegetal cover at Chapada Grande Farm - PI.

Vegetal cover	Litter T ha^{-1}	Temperature ˚C	Moisture Kg kg^{-1}
Rainy season			
Soybean	0.92 c	28.1	14.5 b
Pasture	1.40 bc	27.7	16.5 ab
Eucalyptus	2.76 a	26.6	18.1 a
Native Forest	1.75 b	26.5	17.7 ab
Dry Season			
Soybean	1.44 b	35.4	2.09 b
Pasture	1.94 b	33.2	2.40 ab
Eucalyptus	3.40 a	31.9	3.86 a
Native Forest	3.60 a	31.6	3.56 ab

of the edaphic fauna in this management system. Silva et al. (2012) concluded that the use of the herbicide applied in pre-emergence in the sugarcane crop contributed to the decrease of Collembolas population when compared to fallow and manual weeding up to 80 days after application.

In relation to the diversity index of Shannon, eucalyptus and forest showed higher values in the two seasons probably due to the greater contributions of organic residues in the soil that favors the conditions of shelter, feeding and reproduction and creates larger ecological niches, as also verified by Cortes et al. (2015). On the other hand, the soybean management system showed higher values of the Pielou index, which represents the uniformity of the distribution of the number of individuals in the different groups in each area. This happens normally when the system has very few groups with very low density. In this case, since the density values are not very divergent between the groups, the "equitability" component of the diversity index becomes very high, as also observed by Nunes et al. (2012).

The results of this research showed that the vegetation cover of the studied areas resulted in an environmental variation of the climatic factors temperature and humidity. A higher temperature was observed at 2 to 4 ^{0}C in soybean and pasture, respectively, in relation to the other areas studied. Moisture in spite of being lower in soybean and pasture did not reach close to zero due to the clayey texture of the studied areas that retains the water more strongly. (Table 3).

Thus, the lower values observed in the studied soil fauna variables in no-tillage soybean cultivation may be related to the high temperatures observed in this Cerrado region, both in the accelerated degradation of organic soil residues, which due to the absence of crop rotation also presents low C / N ratio, as in the low water available for the metabolism of edaphic individuals. These climatic factors are commonly identified as determinants of the population dynamics of the edaphic fauna (Santos et al., 2016; Manhães et al., 2013).

Although diversity has been lower in no-tillage (Table 2), some research has found that maintenance of crop residues on the soil surface and lack of soil tillage in soil conservation management systems may benefit certain groups of soil macrofauna in regions of mild temperatures (Baretta et al., 2014),

Table 4 shows the relative composition of the edaphic fauna community in the different management systems studied for the two periods. We include in the table the term others which corresponds to the groups that occurred in small proportions. The influence of seasonality on

Table 4. Relative distribution (%) of the taxonomic groups of the edaphic fauna under different vegetal cover at Chapada Grande Farm - PI.

Grups	Soybean	Pasture	Eucalyptus	Native Forest	Total (%)
Rainy season					
Acari	-	-	1.71	1.40	0.78
Araneae	6.10	3.06	16.91	5.71	7.95
Blattodea	-	-	1.78	2.37	1.04
Collembola	-	22.03	10.16	12.03	11.05
Coleoptera	38.19	3.62	14.20	22.30	19.58
Dermaptera	3.71	1.30	1.01	-	1.51
Diptera	10.34	2.16	4.42	3.86	5.20
Formicidae	23.07	51.13	37.47	44.51	39.05
Homoptera	-	0.96	-	-	0.24
Hymenoptera	11.14	6.51	8.92	1.84	7.10
Ortoptera	-	6.12	-	3.25	2.34
Outros	7.45	3.11	3.42	2.73	4.10
Dry season					
Acari	-	35.96	1.69	10.30	11.99
Araneae	-	4.31	10.96	7.46	5.68
Blattodea	-	-	1.52	2.10	0.91
Collembola	-	-	11.05	15.17	6.56
Coleoptera	32.47	28.16	45.90	6.10	28.16
Diplópoda	-	-	4.37	0.68	1.26
Diptera	-	0.76	1.25	2.34	1.09
Formicidae	43.63	24.00	19.52	52.28	34.86
Hymenoptera	-	1.44	-	-	0.36
Ortoptera	20.72	3.86	1.43	0.99	6.75
Pseudoscorpionidae	-	-	-	1.05	0.26
Outros	3.18	1.51	2.31	1.53	2.12

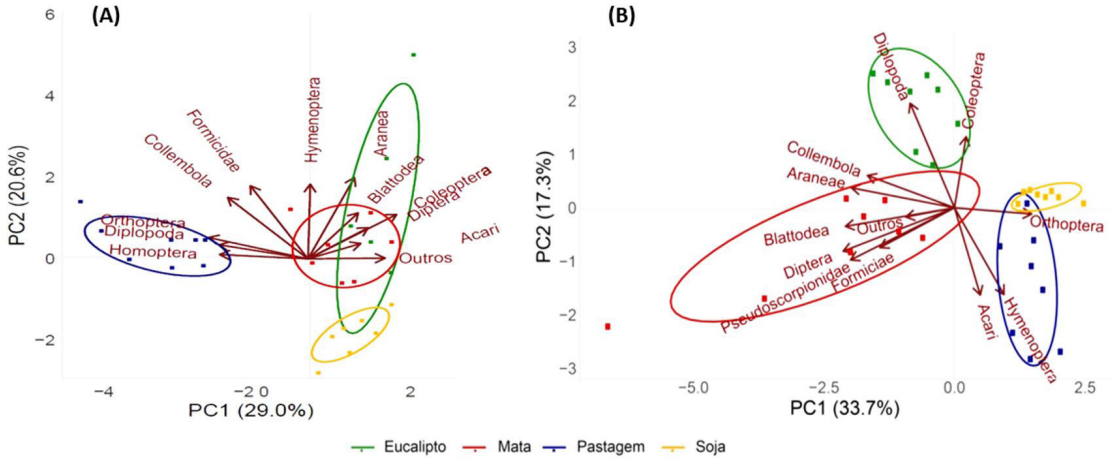

Figure 2. Relationship between main component 1 (PC 1) and main component 2 (PC 2), considering the soil use systems and soil fauna groups in the rainy (A) and dry (B) periods of the year. In the PCA chart, the values in the x and y axes represent the percent change explained by axis 1 and axis 2, respectively.

fauna can occur in the life cycles of organisms - latency of events such as mating, reproduction, egg laying and dispersion of young people - and in the supply of resources, which will temporarily modify the community structure (Manhães et al., 2013).

In the wet period the groups Aranae, Coleoptera, Diptera, Formicidae and Hymenoptera were present in all areas during the period of good humidity. On the other hand, the groups Formicidae and Coleoptera, which present saprophagous and predatory organisms and which simultaneously exercise these two functions, predominated in the dry period. A study carried out by Nunes et al. (2019), showed that these organisms represented about 60% of the total of individuals in cerrado soils, favored by dense litter.

The Blattodea group occurred only in eucalyptus and native forest in both periods, similar results to those found by Pompeo et al. (2016) in which they evidenced the presence of this group only in native forest and Pinnus reforestation. For Triplehorn and Johnson (2005) this group are recognized as generalists in their eating habits and usually occur in forest habitat, due to the various substrates, niches and resources that this environment offers, as they are saprophagous individuals, and use organic matter as a food source.

The presence of the Formicidae group under diverse conditions, such as dry or humid, occurs because they comprise one-third of the total biomass of insects of the ecosystems, since it occupies diverse niches in the ecosystem, and they colonize the areas when these do not present adequate conditions of survival to other groups of soil fauna (Leal, 2004). In addition, the Formicidae group is responsible for several ecological functions, acting as seed dispersers, in soil physical and chemical structuring, predation, nutrient cycling, among others (Bolico et al., 2012).

The study of the relationship between the distribution of individuals from each taxonomic group and the soil management systems was performed through an ordering generated by the main components (Figure 2). The variables were distributed in two main components that explained 49.6 (29.0% for the first and 20.6% for the second component) in the wet period, and 51% of the total variability among the management systems (33. 7% for the first and 17.3% for the second component), in the dry period. With the principal component analysis (PCA) for both periods, it is possible to separate the studied units by their differences in the composition of the edaphic macrofauna community.

The interpretation of this diagram shows that in the humid period the forest and the eucalyptus system were associated with several taxonomic groups in the humid period, mainly Aranae, Blattodea, Coleoptera, Diptera and others, which are some groups that occurred in a smaller proportion. The pasture showed higher affinity with the Diplopoda, Homoptera and Ortopthera groups, while the soybean system was not associated with any group. It is noteworthy that in the wet period the soybean system received insecticide application.

In the dry season, the eucalyptus system showed a correlation with a larger number of groups, among them Blattodea, Diptera, Formicidae and others, in relation to the other areas. Certainly, the large amount of litter generated by eucalyptus, despite the low nutritional quality and high C / N ratio (Pulrolnik et al., 2009), provides certain environmental conditions that favored reproduction, feeding and shelter soil invertebrates. For Moço et al. (2005), management systems that include the maintenance of plant residues on the soil surface provide a more favorable environment for the colonization of the environment by most groups of soil fauna.

4. Conclusion

Systems generate higher wast accumulation provide better conditions for increase the abundance, richness and diversity of soil invertebrates

The groups Aranae, Coleoptera, Formicidae and Diptera predominated in the humid period, while Coleoptera and Formicidae stood out in the dry period.

Seasonality had an effect on all analyzed variables, with the wet period showing more expressive values

Acknowledgements

The authors would like to thank Fazenda Chapada Grande for allowing this study to be developed and the Coordenação de Aperfeiçoamento de Pessoal de Nivel Superior" (CAPES) for granting a Masters scholarship to Maristela Moura Calaço Pessoa.

References

AGUIAR, T.J.A. and MONTEIRO, M.S.L., 2005. Modelo agrícola e desenvolvimento sustentável: a ocupação do cerrado piauiense. *Ambiente & Sociedade*, vol. 8, no. 2, pp. 161-178. http://dx.doi.org/10.1590/S1414-753X2005000200009.

AITA, C. and GIACOMINI, S.J., 2003. Decomposição e liberação de nitrogênio de resíduos culturais de plantas de cobertura de solo solteiras e consorciadas. *Revista Brasileira de Ciência do Solo*, vol. 27, no. 4, pp. 601-612. http://dx.doi.org/10.1590/S0100-06832003000400004.

ALVARES, C.A., STAPE, J.L., SENTELHAS, P.C., DE MORAES GONCALVES, J.L. and SPAROVEK, G., 2013. Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift (Berlin)*, vol. 22, no. 6, pp. 711-728. http://dx.doi.org/10.1127/0941-2948/2013/0507.

ANDERSEN, A., 1999. Plant protection in spring cereal production with reduced tillage. II Pests and beneficial insects. *Crop Protection (Guildford, Surrey)*, vol. 18, no. 8, pp. 651-657. http://dx.doi.org/10.1016/S0261-2194(99)00071-X.

ARAÚJO, A.S.F., MAGALHÃES, L.B., SANTOS, V.M., NUNES, L.A.P.L. and DIAS, C.T.S., 2017. Biological properties of disturbed and undisturbed Cerrado sensu stricto from Northeast Brazil. *Brazilian journal of biology = Revista brasleira de biologia*, vol. 77, no. 1, pp. 16-21. http://dx.doi.org/10.1590/1519-6984.06715. PMid:27382993.

ARAÚJO, V.F.P., BANDEIRA, A.G. and VASCONCELLOS, A., 2010. Abundance and stratification of soil macroarthropods in a Caatinga Forest in Northeast Brazil. *Brazilian journal of biology = Revista brasleira de biologia*, vol. 70, no. 3, suppl., pp. 737-746.

ASHFORD, O.S., FOSTER, W.A., TURNER, B.L., SAYER, E.J., SUTCLIFFE, L. and TANNER, E.V.J., 2013. Litter manipulation and the soil arthropod community in a lowland tropical rainforest. *Soil Biology and Biochemistry*, vol. 62, no. 1, pp. 5-12.

BARETTA, D., BARTZ, M.L.C., FACHINI, I., ANSELMI, R., ZORTÉA, T. and BARETTA, C.R.D.M., 2014. Soil fauna and its relation with environmental variables in soil management systems. *Ciência Agronômica*, vol. 45, no. 5, pp. 871-879. http://dx.doi.org/10.1590/S1806-66902014000500002.

BARTZ, M.L.C., PASINI, A. and BROWN, G.G., 2013. Earthworms as soil quality indicators in Brazilian no-tillage systems. *Applied Soil Ecology*, vol. 69, no. 1, pp. 3-48. http://dx.doi.org/10.1016/j.apsoil.2013.01.011.

BOLICO, C.F., OLIVEIRA, E.A., GANTES, M.C., DUMONT, L.F.C., CARRASCO, D.S. and D'INCÃO, F., 2012. Mirmecofauna (Hymenoptera, Formicidae) de duas marismas do Estuário da Lagoa dos Patos, RS: diversidade, flutuação de abundância e similaridade como indicadores de conservação. *EntomoBrasilis*, vol. 5, no. 1, pp. 11-20. http://dx.doi.org/10.12741/ebrasilis.v5i1.147.

COLE, L., BRADFORD, M.A., SHAW, P.J. A. and BARDGETT, R.D., 2006. The abundance, richness and functional role of soil meso and macrofauna in temperate grassland - A case study. *Applied Soil Ecology*, vol. 33, no. 2, pp. 186-198.

CORTES, C.T., BARBOSA, L.R., MORAIS, G.P., NUNES, L.A.P.L., ARAÚJO, A.S.F. and CORREIA, M.E.F., 2015. Soil fauna under eucalypt stands of different ages in the Savanna of Piauí. *Científica (Jaboticabal)*, vol. 43, no. 1, pp. 280-286. http://dx.doi.org/10.15361/1984-5529.2015v43n3p280-286.

HOFFMANN, W. and JACKSON, R., 2000. Vegetation climate feedbacks in the conversion of tropical savanna to grassland. *Journal of Climate*, vol. 3, no. 10, pp. 1593-1602. http://dx.doi.org/10.1175/1520-0442(2000)013<1593:VCFITC>2.0.CO;2.

JACOMINE, P.K.T. 1986. *Levantamento exploratorio - reconhecimento de solos do estado do Piaui.* Rio de Janeiro: EMBRAPA-SNLCS/ SUDENE-DRN, 782p.

KLADIVKO, E.J., 2001. Tillage systems and soil ecology. *Soil and Tillage Research*, vol. 61, no. 1-2, pp. 61-76. http://dx.doi.org/10.1016/S0167-1987(01)00179-9.

KLIEMANN, H.J., BRAZ, A.J.P.B. and SILVEIRA, P.M., 2006. Taxas de decomposição de resíduos de espécies de cobertura em Latossolo Vermelho distroférrico. *Pesquisa Agropecuária Tropical*, vol. 36, no. 1, pp. 21-28.

LEAL, I.R., 2004. Dispersão de sementes por formigas na caatinga. In I.R. LEAL, M. TABARELLI and J.M.C. SILVA, eds. *Ecologia e conservação da Caatinga: uma introdução ao desafio*. Recife: EDUFPE, pp. 593-624.

MANHÃES, C.M.C., GAMA-RODRIGUES, E.F., SILVA MOÇO, M.K. and GAMA-RODRIGUES, A.C., 2013. Meso- and macrofauna in the soil and litter of leguminous trees in a degraded pasture in Brazil. *Agroforestry Systems*, vol. 7, no. 5, pp. 993-1004. http://dx.doi.org/10.1007/s10457-013-9614-0.

MOÇO, M.K., GAMA-RODRIGUES, E.F., GAMA-RODRIGUES, A.C. and CORREIA, M. E. F., 2005. Caracterização da fauna edáfica em diferentes coberturas vegetais na região norte fluminense. *Revista Brasileira de Ciência do Solo*, v. 29, no. 4, pp. 555-564.

NUNES, L.A.P.L., ARAÚJO, A.S.F., PESSOA, M.M.C., SOUSA, R.S., SILVA, J.D.C. and MATOS-FILHO, C.H.A., 2019. Edaphic fauna in a vegetation gradient in the Sete Cidades National Park. *Brazilian journal of biology = Revista brasleira de biologia*, vol. 79, no. 1, pp. 45-51. http://dx.doi.org/10.1590/1519-6984.174135. PMid:29641637.

NUNES, L.A.P.L., SILVA, D.I.B., ARAÚJO, A.S.F., LEITE, L.F.C. and CORREIA, M.E.F., 2012. Caracterização da fauna edáfica em sistemas de manejo para produção de forragens no Estado do Piauí. *Ciência Agronômica*, vol. 43, no. 1, pp. 30-37.

PACHECO, L.P., PIRES, F.R., MONTEIRO, F.P., PROCÓPIO, S.O., ASSIS, R.L., CARMO, M.L. and PETTER, F.A., 2008. Desempenho de plantas de cobertura em sobressemeadura na cultura da soja. *Pesquisa Agropecuária Brasileira*, vol. 43, no. 7, pp. 815-823.

PEREIRA, G.H.A., PEREIRA, M.G., ANJOS, L.H.C., AMORIM, T.A. and MENEZES, C.E.G., 2013. Decomposição da serrapilheira,

diversidade e funcionalidade de invertebrados do solo em um fragmento de Floresta Atlântica. *Bioscience Journal*, vol. 29, no. 5, pp. 1317-1327.

POMPEO, P.N., SANTOS, M.A.B., BIASI, J.P., SIQUEIRA, S.F., ROSA, M.G., BARETTA, C.R.D.M. and BARETTA, D., 2016. Fauna e sua relação com atributos edáficos em Lages, Santa Catarina – Brasil. *Revista Scientia Agraria*, vol. 17, pp. 42-51.

PULROLNIK, K., BARROS, N.F., SILVA, I.R., NOVAIS, R.F. and BRANDANI, C.B., 2009. Estoques de carbono e nitrogênio em frações lábeis e estáveis da matéria orgânica de solos sob eucalipto, pastagem e cerrado no Vale do Jequitinhonha – MG. *Revista Brasileira de Ciência do Solo*, vol. 33, no. 5, pp. 1125-1136. http://dx.doi.org/10.1590/S0100-06832009000500006.

R CORE TEAM, 2019. *R: a language and environment for statistical computing*. Vienna: R Foundation for Statistical Computing.

RIUTTA, T., SLADE, E.M., BEBBER, D.P., TAYLOR, M.E., MALHI, Y., RIORDAN, P., MACDONALD, D.W. and MORECROFT, M.D., 2012. Experimental evidence for the interaction effects of forest edge, moisture and soil macrofauna on leaf litter decomposition. *Soil Biology and Biochemistry*, vol. 49, no. 1, pp. 124-131.

RODRIGUES, W.C., 2015. *DivEs - Diversidade de Espécies v3.0. Guia do Usuário. Entomologistas do Brasil*. Vassouras: AntSoft, 33 p.

ROSSI, C.Q., PEREIRA, M.G., GIÁCOMO, S.G., BETTA, M. and POLIDORO, J.C., 2013. Decomposição e liberação de nutrientes da palhada de braquiária, sorgo e soja em áreas de plantio direto no Cerrado goiano. *Semina: Ciências Agrárias*, vol. 34, no. 4, pp. 1523-1534. http://dx.doi.org/10.5433/1679-0359.2013v34n4p1523.

SANTOS, D.P., SANTOS, G.G., SANTOS, I.L., SCHOSSLER, T.R., NIVA, C.C. and MARCHÃO, R.L., 2016. Caracterização da macrofauna edáfica em sistemas de produção de grãos no Sudoeste do Piauí. *Pesquisa Agropecuária Brasileira*, vol. 51, no. 9, pp. 1466-1475. http://dx.doi.org/10.1590/s0100-204x2016000900045.

SCORIZA, R. N., PEREIRA, M. G., PEREIRA, G. H. A., MACHADO, D. L. and SILVA, E. M. R., 2012. Métodos para coleta e análise de serrapilheira aplicados à ciclagem de nutrientes. *Floresta e Ambiente*, vol. 2, no. 2, p. 1-18.

SILVA, R.F., AQUINO, A.M., MERCANTE, F.M. and GUIMARÃES, M.F., 2006. Macrofauna invertebrada do solo sob diferentes sistemas de produção em Latossolo da Região do Cerrado. *Pesquisa Agropecuária Brasileira*, vol. 41, no. 4, pp. 697-704. http://dx.doi.org/10.1590/S0100-204X2006000400022.

SILVA, R.F., SCHEID, D.L., CORASSA, G.M., BERTOLLO, G.M., KUSS, C.C. and LAMEGO, F.P., 2012. Influência da aplicação de herbicidas pré-emergentes na fauna do solo em sistema convencional de plantio de cana-de-açúcar. *Biotemas*, vol. 25, no. 3, pp. 227-238. http://dx.doi.org/10.5007/2175-7925.2012v25n3p227.

TORRES, J.L.R., PEREIRA, M.G., RODRIGUES JUNIOR, D.J. and LOSS, A., 2015. Production, decomposition of residues and yield of maize and soybeans grown on cover crops. *Ciência Agronômica*, vol. 46, no. 3, pp. 451-459.

TRIPLEHORN, C.A. and JOHNSON, N.F., 2005. *Borror and DeLong's introduction to the study of insects*. 7th ed. Belmont: Thomson Brooks/Cole, 864 p.