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MYRMECOFAUNA (HYMENOPTERA: FORMICIDAE) AS A BIOINDICATOR OF THE QUALITY OF SOILS SUBMITTED TO THE APPLICATION OF PIG FARMING WASTEWATER

Myrmecofauna (Hymenoptera: Formicidae) como bioindicador da qualidade dos solos submetidos à aplicação da água residuária da suinocultura

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Abstract - The structure of ant communities is of particular interest as a bioindicator, given their importance in environmental impact studies, as they present abundance and species richness, specialized taxa, wide geographical distribution, and are easily sampled, in addition to being sensitive to environmental changes. Therefore, the objective of this study was to evaluate the effects of wastewater application (0, 100, 200, and 300 m^3 ha^{-1}) combined with nitrogen fertilization (0 and 100% of the recommended dose for the crop) on the myrmecofauna in plantations of minimilho in the municipality of Cascavel, PR. To evaluate the myrmecofauna, pitfall traps were installed and organisms were classified by gender. The Formicidae family exhibited increased density up to 200 m^3 ha^{-1} doses of pig farming wastewater, but no changes were observed in response to chemical fertilization. However, when sorted by gender at the taxonomic level, no significant effects were observed on the different groups, except for the Solenopsis genus following the use of 0 or 300 m^3 ha^{-1} pig farming wastewater.

Keywords - edaphic fauna, edaphic ants, water reuse in agriculture.

Resumo - A estrutura das comunidades de formigas é de particular interesse como bioindicadoras dada sua importância em estudos de impacto ambiental, uma vez que apresentam abundância e riqueza de espécies, táxons especializados, ampla distribuição geográfica, facilmente amostrada, além de serem sensíveis às mudanças ambientais. Considerando o exposto O objetivo do trabalho foi avaliar os efeitos da aplicação de água residuária da suinocultura (0, 100, 200 e 330 m^3 ha^{-1}) combinada com adubação nitrogenada (0 e 100% da dose recomendada para a cultura) sobre a mirmecofauna em plantações de minimilho no município de Cascavel – PR.”. Para a avaliação da mirmecofauna, foram instaladas armadilhas de queda sendo os organismos classificados ao nível de gênero. A família Formicidae teve densidade aumentada até a dose 200 m^3 ha^{-1} de água residuária da suinocultura, contudo sem mostrar alterações decorrentes da adubação química. No entanto, a classificação ao nível taxonômico de gênero demonstrou não existir efeitos significativos sobre os diferentes grupos, exceto para o gênero Solenopsis, quando utilizadas as doses de 0 e 300 m^3 ha^{-1} de água residuária da suinocultura.

Palavras-chave - fauna edáfica, formigas edáficas, reuso de água na agricultura.

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INTRODUCTION

Brazil displays indicators in pig farming of high productivity in advanced technology, and is positioned among the top countries for increasing pig production. This is because Brazil possesses state-of-the-art technology in all areas of pig production: genetics, nutrition, sanitation, management, facilities, and equipment. (ABCS, 2011; 2016). However, high production per unit area leads to the accumulation of effluents in the properties, which in most cases, exceed the agricultural area required to absorb the production waste (SEGANFREDO, SOARES and KLEIN, 2003). Under this scenario, environmental agencies have shown great concern, since when the soil bearing capacity is exhausted, this waste can cause a large amount of environmental damage (SEIDEL et al., 2010). In this regard, studies investigating water reuse in the environment have gained importance, and are usually related to physical-chemical changes in the soil (CAMPOS et al., 2012; LUCAS et al., 2013; MENEGHETTI et al., 2013; KESSLER et al., 2013; KESSLER et al., 2014; MAFRA et al., 2014), contamination of surface and groundwater (MAGGI et al,. 2011; BOLZANI, OLIVEIRA and LAUTENSCHLAGER 2012; MAGGI et al., 2013; CAPOANE et al., 2015), and the contribution to crop productivity (MENEGHETTI et al., 2012; CAMPOS et al., 2013). Only recently have efforts been increased in studies on soil biology, especially those focused on meso and macrofauna (ALVES et al., 2008; TESSARO et al., 2011; TESSARO et al, 2013; CASTALDELLI et al., 2015: SILVA et al., 2016).

The addition of organic residues can influence soil biota, since they act as a food source and modify soil temperature and coverage In addition, they contain toxic substances and harmful heavy metals, which adversely affect the fauna (BARETTA et al., 2003; MELO 2006). In this regard, the need to identify and quantify the disturbances caused by human activities in diverse environments has attracted the attention of researchers searching for organisms that can monitor the degree of ecosystem integrity. Therefore, several studies have shown that ants have potential for use as bioindicators of environmental quality, in natural or altered areas (RIBAS et al., 2012a). Ants have been studied in various types of environments and situations, such as areas subjected to burning (BOSCARDIN et al., 2014); contaminated areas (RIBAS et al., 2012c); agroforestry systems and agro-ecosystems (GONZÁLEZ-VALDIVIA et al., 2013; RAMÍREZ et al., 2012); crop-livestock systems (CREPALDI et al., 2014); agricultural crops (COUTO et al,. 2010); in the rehabilitation of mined areas and degraded areas (ROSADO et al., 2014, RIBAS et al., 2012b, ROCHA et al., 2015); in revegetation of riparian areas (GOLLAN et al., 2011); and in forest disturbances (LEAL et al,. 2012; MIRANDA et al., 2013). Such potential is due to the high abundance and species richness of these specialized groups, their wide geographical distribution, sampling facilities, and their sensitivity to changes in environmental conditions (HOFFMANN and ANDERSEN, 2003). Ants are distributed in 327 genera and 16 subfamilies, and 13,188 species exist (BOLTON, 2016). Of these, 119 genera are found in the Neotropical region, belonging to eight subfamilies, with about 3,100 described species (FERNÁNDEZ and OSPINA, 2003).

Based on the above, coupled with the lack of information on ants in relation to organic fertilization, this study aimed to evaluate the effect of pig farming wastewater (PFW) application combined with chemical fertilization on the density and diversity of myrmecofauna in typic dystroferric Red Latosol cultivated with baby corn in a subtropical region.

MATERIAL AND METHODS

This study was conducted in Cascavel, PR, Brazil (24° 48 'S and 53 26' W), at an altitude of 760 m. The weather is humid subtropical (Cfa), with an average annual rainfall of 1,800 mm, hot summers, infrequent frosts, and a tendency for rainfall to be concentrated in the summer months; however, there is no definite dry season. The average temperature is 20°C and average relative humidity is 75%. The soil of the area studied is a typic dystroferric Red Latosol with clayey texture (EMBRAPA, 2006), which, since 2006, has received nutrients from the application of PFW and nitrogen fertilization (NFR). Notably, the treatments used in this study have been consistent since 2006, ensuring a track record of 3 years of PFW application combined with NFR for each treatment.

At the beginning of the current study, the soil was chemically characterized before treatments were applied; the results are shown in Table 1.

The PFW was collected in an integrated bio system composed of a bio digester followed by a sedimentation tank and stabilization pond., Chemical characterization was performed according to the methodology of Apha et al. (1998) (Table 2).

Table 1. Chemical characterization of experimental parcels before application of wastewater and nitrogen fertilization

Attribute	Treatment					
	NFR		PFW			
	0	100	0	100	200	300
Sodium (mg dm^{-3})	2.91	2.50	2.66	2.50	3.00	2.66
Calcium (cmol$_c$ dm^{-3})	5.85	5.81	5.86	6.24	5.36	5.87
Magnesium (cmol$_c$ dm^{-3})	3.71	3.45	3.71	3.69	3.30	3.63
Potassium (cmol$_c$ dm^{-3})	0.35	0.45	0.22	0.30	0.49	0.59
H+Al (cmol$_c$ dm^{-3})	2.72	2.66	2.72	2.42	3.02	2.58
Sum of bases (cmol$_c$ dm^{-3})	9.93	9.72	9.82	10.24	9.16	10.10
CTC pH 7,0 (cmol$_c$ dm^{-3})	12.66	12.39	12.55	12.66	12.22	12.68
Organic Carbon (g dm^{-3})	12.67	11.50	11.80	12.04	12.11	12.39
Organic matter (g dm^{-3})	19.78	21.78	20.31	20.72	20.83	21.31
Sat. Bases (%)	72.06	77.88	77.32	80.64	74.36	67.56
Phosphorus (mg dm^{-3})	8.68	13.77	8.87	11.63	14.21	8.87
Iron (mg dm^{-3})	96.69	99.35	105.21	96.74	83.38	106.75
Manganese (mg dm^{-3})	62.16	62.52	60.47	63.91	61.07	63.91
Copper (mg dm^{-3})	10.72	10.49	10.39	10.31	10.80	10.93
Zinc (mg dm^{-3})	2.21	2.96	2.02	2.87	3.60	3.85
pH	6.48	6.55	6.55	6.61	6.36	6.55
Dry mass (kg h^{-1})	57.00	62.31	44.81	61.32	62.56	69.87

*PFW: pig farming wastewater (0, 100, 200, and 300 m^3 in the baby corn crop cycle); NFR: nitrogen fertilization (0 - without addition of NFR; 100 - NFR dose recommended for the crop - 80 kg ha^{-1})

Table 2. Chemical characterization of pig farming wastewater.

Attribute	Result
pH ($CaCl_2$)	7.9
Electrical conductivity (dS m^{-1})	2.1
Turbidity (NTU)	278
DBO (mg L^{-1})	550
DQO (mg L^{-1})	1450
Total Nitrogen (mg L^{-1})	338.8
N-Nitrate (mg L^{-1})	0.40
N-Nitrite (mg L^{-1})	8.00
Total Phosphorus (mg L^{-1})	211.9
Potassium (mg L^{-1})	440.0
Sodium (mg L^{-1})	17.0
Calcium (mg L^{-1})	2.25
Iron (mg L^{-1})	75.0
Magnesium (mg L^{-1})	0.95
Manganese (mg L^{-1})	16.5
Copper (mg L^{-1})	12.5
Zinc (mg L^{-1})	76.5
Totals (mg L^{-1})	1481
Stationary Totals (mg L^{-1})	729.0
Volatile Totals (mg L^{-1})	671.0

PFW was applied in a single step, 7 days before the sowing of baby corn, was sown on the remains of oat culture. The variety BR 106, which has an approximate cycle of 80 days, was sowed manually by direct seeding, providing a stand of 180,000 plants ha^{-1}. Given the needs of baby corn crop, which are based on those of corn, NFR was applied at a dose of 80 kg ha^{-1} nitrogen in the form of urea. Fertilization

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was performed in two stages, by applying 30% of the recommended dose at sowing, and the remaining during the stage of development characterized by three to four developed leaves.

The edaphic myrmecofauna was sampled using pitfall traps installed in each experimental parcel; traps comprised flasks with a 6-cm diameter, buried in the ground, with the hollow end level with the soil surface Preservative solution (200 mL) of 4% formaldehyde was placed in the traps. Samples were collected at three different times: 7 days after sowing (DAS), at the 15th leaf stage (41 DAS), and after the development of spikelets (72 DAS). In each collection, the traps remained in the field for 7 days and their contents were identified in the laboratory to the taxonomic level of genus, using a binocular magnifying glass and dichotomous keys for classification as detailed by Baccaro (2006) and Bolton (1994). Ant density, expressed as the population size, was estimated by converting the number of individuals per trap/day.

For each treatment, data were submitted to analysis of variance using the randomized blocks experimental design, in a 2 × 4 factorial design (two levels of fertilization, 0 and 80 kg/ha of N-urea, and four doses of PFW, 0, 100, 200, and 300 m^3 ha^{-1}) for a total of eight treatments performed in triplicate.

When necessary, the mathematical model was transformed (y = x0.5 + 0.5) to normalize the data, using the Open Source Software SISVAR, version 4.2 (Ferreira 2003), adopting the F test at $p < 0.05$, followed by the Scott-Knott test at 5%.

RESULTS AND DISCUSSION

Table 3 shows the results of the test comparing the mean ant density in the three study periods.

Table 3. Average ant density of the Formicidae family (bodies/trap/day), collected on the, by treatment applied and timepoint.

Treatment					
NFR (%)		PFW (m^3 ha^{-1})			
0	100	0	100	200	300
First collection – 7 DAS					
3,54 A	4,13 A	4,16 A	3,21 A	5,26 A	2,97 A
Second collection – 41 DAS					
3,86 A	3,19 A	2,54 A	2,80 A	6,14 B	2,61 A
Third collection – 72 DAS					
3,22 A	2,26 A	1,69 A	2,57 A	4,35 B	2,35 A

*PFW: pig farming wastewater; NFR: nitrogen fertilization; DAS: days after sowing. Capital letters in the same row do not differ by the Scott-Knott test at 5% probability.

The density of organisms belonging to the Formicidae family was influenced by the use of wastewater, and was highest with the 200 m^3 ha^{-1} dose at 41 and 72 DAS compared with the other treatments.

Ants are the dominant taxonomic group in most ecosystems, and are present in various habitats. According to Marinho et al. (2002) and Andersen et al. (2002), ants are regarded as a suitable bioindicator in areas that have been subjected to human actions, such as soil management, industrial pollution, and the successful rehabilitation of degraded areas, because of the strong association between the state of vegetation, soil, and decomposition. Some group characteristics guarantee them, generally, this status, such as their high abundance, species richness, ease of sampling, separation into morpho-species, and the existence of specialized taxa that can perceive environmental changes (SILVA and BRANDÃO 1999). The results (Table 3) show that initially (at 7 DAS), there were no differences between the doses of PFW, probably because of the high mobility group and the similar quality of food between areas analyzed without developed vegetation. According to Schmidt, Ribas, Schoereder (2013), reduced vegetation cover can distinctly affect different myrmecofauna groups, with negative effects on specialist species in closed and cooler areas, and positive effects on specialized species in more open and warmer areas. Oliveira et al. (2011), also described the important role of vegetation on these organisms, noting that increased complexity of the vegetation contributes to greater diversity and group density.

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However, from the second collection, the predilection of the group treated with 200 m^3 ha^{-1} was visible, with a gradual increase in density observed as the PFW dose increased up to 200 m^3 ha^{-1}. However, a decrease in the density of the group was observed with 300 m^3 ha^{-1}, with levels very close to those reported with 0 m^3 $ha^{-1.}$

The results also showed that over time (41 DAS), there was a decrease in the density of these organisms. This suggests that the systematic use of PFW under the evaluated conditions can lead to reduced populations of local myrmecofauna. This result is consistent with the findings of Alves et al. (2008), whom, when using pig slurry stored in dunghill for stabilization, observed that the myrmecofauna behaved in the same way at similar doses. Another factor that may have contributed to this reduction in the present study was the long dry season (30 days), which coincided with the evaluation period up to 72 DAS.

Taken together, these results suggest that, within certain limits (up to 200 m^3 ha^{-1}), the use of effluents with the studied characteristics enhance soil conditions for myrmecofauna; however, it becomes a limiting factor at higher doses.

The response observed here is important, because the structure of ant communities is critical in studies investigating environmental impacts, since they maintain and restore soil quality, and act to redistribute particles, nutrients, and organic matter, thus improving water infiltration into the soil, due to its increased porosity and aeration (LOBRY DE BRUYN, 1999).

There were no significant differences in NFR between the periods analyzed, suggesting that the use of nitrogen fertilizers in the doses applied here does not alter the population density of these organisms.

Table 4 compares the mean ant density for each subfamily and genus identified.

In the three samples (Table 4), ants were captured that belonged to five of the 14 subfamilies found in Brazil (Ponerinae, Formicinae, Dolichoderinae, Ecitoninae, and Myrmicinae) (Bolton 2003), and to 16 distinct genera, with the highest number of collected genera from the subfamily Myrmicinae. The predominance of this subfamily could be explained by their high natural abundance and for being a group of ants their remarkable adaptability to many different ecological niches in the Neotropics (FOWLER et al., 1991). The dominance of this subfamily has also been reported in studies conducted in other types of crops, such as those by Couto et al., (2010) in growing soybeans, Santos, Carrano-Moreira and Torres (2012) in sugarcane, and Costa, Campos and Margarido (2014) in the cultivation and management of green manure.

It was also noted that in the three periods evaluated, the Dolichoderinae subfamily, *Dorymyrmex* genus, were present at the highest density compared with the other subfamilies, although this tendency was not statistically significant. According to Macedo (2004), this genus may occur in high abundance because these ants reduce the number of native ants close to their nests; they are very aggressive and can monopolize food sources, because of the strength of the recruited workers. This aggressive behavior may result in the emergence of other, mainly phytophagous insects, over the long term, since belonging to this genus can means the removal of predatory species from the environment.

Among the species of ants found of the Myrmicinae, the presence of the Acromyrmex genus in the first sampling period was notable. This group is characterized by species of leaf-cutting ants (Lacau et al., 2008), which are considered pests in agriculture, as they use fresh leaves, shoots, and flowers as substrates for fungal cultivation (HÖLLDOBLER and WILSON 1990). Considering its negative potential relative to plant growth, the occurrence of this group is undesirable in agricultural systems. Because of its occurrence during the first sampling period, it is possible that this group was inhibited by the application of nitrogen and PFW, making this a viable practice. However, further studies evaluating this genus in response to these parameters are needed.

The results of the first sampling did not reveal any differences in the density of ants between genera in any of the factors assessed. According to Wink et al. (2005), this reflects the low quality of food in the soil and organic matter, because under this initial condition, no differences in vegetation cover were observed. However, small variations were observed regarding the number of genera found under the different treatments. Of the 14 genera found at 7 DAS with the 0 NFR treatment, 12 were reported with the 100% NFR dose (80 kg ha^{-1} of N-urea) and with doses of 0 and 200 m^3 ha^{-1}, while 11 genera were found with the 100 and 300 m^3 ha^{-1} doses. However, these results do not necessarily indicate a preference of the groups under different treatments, and may be related to the high mobility of the groups moving from one area to another (CORDEIRO et al., 2004).

Table 4. Average density of edaphic ants in all genera (genus/trap/day) collected in pitfall traps following treatment with different doses of PFW and NFR in the three samples.

		Treatment					
		AND		PFW			
Subfamily	Genus	0	100	0	100	200	300
First Collection – 7 DAS							
Ponerinae	*Hypoponera*	0.32 A	0.28 A	0.28 A	0.28 A	0.33 A	0.30 A
	Pachycondyla	0.11 A	0.09 A	0.16 A	0.14 A	0.04 A	0.07 A
Formicinae	*Camponotus*	0.13 A	0.09 A	0.21 A	0.02 A	0.16 A	0.04 A
Dolichoderinae	*Dorymyrmex*	0.73 A	0.88 A	0.73 A	0.95 A	0.76 A	0.78 A
	Tapinoma	0.11 A	0.14 A	0.00 A	0.02 A	0.42 A	0.07 A
	Dolichoderus	0.21 A	0.36 A	0.33 A	0.02 A	0.57 A	0.23 A
Ecitoninae	*Nomamyrmex*	0.20 A	0.67 A	0.38 A	0.09 A	1.14 A	0.14 A
	Neivamyrmex	0.36 A	0.39 A	0.40 A	0.38 A	0.52 A	0.21 A
Myrmicinae	*Solenopsis*	0.61 A	0.58 A	0.33 A	0.71 A	0.76 A	0.59 A
	Pheidole	0.03 A	0.00 A	0.00 A	0.00 A	0.00 A	0.07 A
	Atta	0.05 A	0.00 A	0.11 A	0.00 A	0.00 A	0.00 A
	Olygomyermex	0.22 A	0.34 A	0.38 A	0,14 A	0.40 A	0.21 A
	Acromyrmex	0.09 A	0.02 A	0.11 A	0.00 A	0.11 A	0.00 A
	Cephalotes	0.03 A	0.08 A	0.07 A	0.09 A	0.07 A	0,00 A
Second Collection – 41 DAS							
Ponerinae	*Hypoponera*	0.29 A	0.35 A	0.54 A	0.35 A	0.21 A	0.19 A
	Pachycondyla	0.10 A	0.15 A	0.14 A	0.14 A	0.07 A	0.16 A
Formicinae	*Camponotus*	0.03 A	0.00 A	0.07 A	0.00 A	0.00 A	0.00 A
	Brachymyrmex	0.01 A	0.01 A	0.00 A	0.00 A	0.00 A	0.04 A
Dolichoderinae	*Dorymyrmex*	0.96 A	0.71 A	0.69 A	1.09 A	0.69 A	0.88 A
	Tapinoma	0.16 A	0.08 A	0.07 A	0.26 A	0.09 A	0.07 A
	Dolichoderus	0.05 A	0.05 A	0.07 A	0.14 A	0.00 A	0.02 A
Ecitoninae	*Nomamyrmex*	0.13 A	0.03 A	0.02 A	0.04 A	0.26 A	0.00 A
	Neivamyrmex	0.40 A	0.19 A	0.19 A	0.14 A	0.69 A	0.16 A
	Eciton	0.02 A	0.05 A	0.02 A	0.00 A	0.11 A	0.02 A
Myrmicinae	*Solenopsis*	0.63 A	0.70 A	0.49 B	0.28 A	0.54 A	1.33 B
	Atta	0.19 A	0.14 A	0.04 A	0.16 A	0.21 A	0.23 A
	Olygomyermex	0.72 A	0.71 A	0.09 A	0.11 A	2.40 A	0.26 A
	Cephalotes	0.11 A	0.03 A	0.07 A	0.11 A	0.09 A	0.02 A
Third Collection – 72 DAS							
Ponerinae	*Hypoponera*	0.32 A	0.33 A	0.23 A	0.35 A	0.23 A	0.47 A
	Pachycondyla	0.08 A	0.05 A	0.07 A	0.04 A	0.09 A	0.07 A
Formicinae	*Camponotus*	0.00 A	0.03 A	0.00 A	0.07 A	0.00 A	0.00 A
	Brachymyrmex	0.00 A	0.01 A	0.00 A	0.01 A	0.00 A	0.00 A
Dolichoderinae	*Dorymyrmex*	0.74 A	0.78 A	0.64 A	1.40 A	0.33 A	0.69 A
	Tapinoma	0.23 A	0.21 A	0.19 A	0.11 A	0.33 A	0.26 A
	Dolichoderus	0.02 A	0.05 A	0.09 A	0.02 A	0.02 A	0.02 A
Ecitoninae	*Nomamyrmex*	0.05 A	0.03 A	0.02 A	0.02 A	0.09 A	0.04 A
	Neivamyrmex	0.19 A	0.19 A	0.19 A	0.07 A	0.30 A	0.19 A
	Eciton	0.01 A	0.02 A	0.02 A	0.02 A	0.00 A	0.02 A
Myrmicinae	*Solenopsis*	0.36 A	0.49 A	0.28 A	0.26 A	0.52 A	0.66 A
	Pheidole	0.00 A	0.02 A	0.00 A	0.00 A	0.04 A	0.00 A
	Atta	0.03 A	0.08 A	0.11 A	0.04 A	0.02 A	0.04 A
	Olygomyermex	0.23 A	0.49 A	0.21 A	0.07 A	0.83 A	0.35 A

*PFW: pig farming wastewater; NFR: nitrogen fertilization; DAS; days after sowing. Capital letters in the same line do not differ by the Scott-Knott test at 5% probability.

The results presented in Table 4 indicate there was no significant difference among ant genera in response to NFR in all sampling periods, showing that the distribution of the groups was independent of this factor.

Conversely, after 41 DAS, differences in the PFW factor were observed between doses of 0 and 300 m³ ha⁻¹ in the Myrmicinae subfamily, Solenopsis genus. The behavior of this genus differs in response to environmental quality. According to Fernandes (2003) and Nascimento, Morini, and Brandão (2001), this genus is common in disturbed areas, and adapts well to disturbed sites, justifying the increase in response to PFW at 300 m³ ha⁻¹ compared with the other doses. However, in a study of the myrmecofauna in a *Pinus elliottii* plantation, Matos et al. (1994) noted that high proportions of this group of ants occur in soils with low vegetation cover, consistent with the result of the present study at 0 m³ ha⁻¹, with reduced vegetation cover. This is reinforced by the findings of Marinho et al. (2002), who reported that this species was among the most aggressive in the use of resources, justifying their success under these conditions. This group is also more resistant to food shortages and competes with other species of ants or other groups of animals by having an efficient mass recruitment strategy (Fowler et al. 1991).

The analysis performed at 72 DAS showed that the ant densities of the collected genera did not vary in response to the different treatments, however, a non-significant decrease in the density of the Solenopsis genus was observed in relation to the second sample. Despite this reduction, the pattern of density distribution between the different treatments remained consistent with that observed after 41 DAS; the largest average was recorded for the 300 m³ ha⁻¹ dose Comparing the results obtained for the group at 41 and 72 DAS with the chemical parameters of the experimental parcels (Table 1), one can suggest that the Solenopsis genus is more tolerant to the presence of heavy metals, such as copper and zinc, compared with the other groups representative of the myrmecofauna. However, the population decline observed in all groups at 72 DAS, seems to be associated with the long period of drought and consequent reduction in food availability rather than the cumulative effects of PFW on the groups.

Although the results of this study suggest that the use of PFW can induce changes in the edaphic ant community, more longer-term studies, and the use of other cultures are needed to better understand the interaction of these factors with the studied group. In this case the importance of ants as bioindicators is evident.

CONCLUSIONS

The application of PFW induced significant positive effects on the Formicidae family up to a dose of 200 m³ ha⁻¹; however, no effect was found on the density of organisms between the different genera.

NFR did not affect the density of the Formicidae family, or the studied genera.

These results suggest that PFW can promote changes in the edaphic myrmecofauna; however, further studies of longer duration and with other cultures should be performed to better understand the interaction of these factors with this group of organisms.

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