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What is the influence of agroecological and conventional crops under ant assemblages?

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Abstract: The objective of the study was to compare the richness and diversity of ant assemblages in an agroecological system under peach orchard, conventional system under peach orchard cultivation and native vegetation in rural properties located in a Pampa Biome. The study was conducted in four samplings in 2017: 1st and 09th March (summer); 24th and 31st July (winter); and four samplings in 2018: 23rd and 30th January (summer); 31st July and 07th August (winter). Pitfall traps were used. The assemblages were characterized and compared using richness, number of occurrences of ants, Shannon diversity (H'), equitability, rarefaction analysis and Chao 1. The association of the species with the samples was evaluated by a Principal Component Analysis (PCA). The agroecological system had the highest number of occurrences, while the conventional orchard the lowest number. Richness and abundance were greatest during the summer. The conventional peach orchard obtained the lowest H' for both seasons when compared to the agroecological orchard and native vegetation. The PCA explained 77.40% of the occurrence of ants in the environments and in the seasons. The results found demonstrated that conservationist systems tend to harbor greater wealth and diversity of ant assemblages, as well as occurring in native áreas.

Key words: myrmecofauna, agroecology, pitfall traps, biodiversity, peach orchard.

INTRODUCTION

The management of ecologically based systems considering environmental preservation emerged in the beginning of the 21st century as the emergence of a paradigm shift process, in order to prevent the degradation of natural resources (Silva et al. 2015). Such systems understand the soil holistically, that is, they see that the physical, chemical and biological properties interact with each other and depend on each other (Borsato 2015).

Of particular concern has been the degradation that conventional management has been causing in the soil. This is the basic ecological component of the functioning of ecological processes in ecosystems and sustainable agricultural yield (Gliessman 2009). Common practices of this type of management, such as plowing, harrowing and the use of pesticides, can degrade the soil, reducing its quality and causing erosion, superficial crusting and reduction of soil organic matter (Bartz et al. 2013). These changes result in the variation of temperature, humidity and aeration of the soil, determining factors for the establishment and development of the organisms that inhabit the soil (Baretta et al. 2011). The soil, in addition to being a substrate for plant growth and food production, should also be considered a living "being", as it contains thousands of animals and microorganisms (Brown et al. 2015), being a habitat for edaphic macrofauna. It encompasses organisms with a body diameter greater than 2 mm and covers more than 20 taxonomic groups (Swift et al. 1979). The potential of the ants to be used in the evaluation of soil quality, since its groups are sensitive to environmental changes and to soil preparation and management, therefore, it can assist in monitoring soil biodiversity (Baretta et al. 2014).

Ants, in particular, are considered of fundamental importance for maintaining soil quality, being useful as bioindicators (Lutinski & Garcia 2005, Crepaldi et al. 2014). The richness and diversity of these organisms tends to increase according to the complexity of the environments, due to the greater availability of niches (Holdefer et al. 2017).

The type of soil and vegetation are the main determining factors for the composition of ant assemblages, thus, species identification are important indicators for environmental monitoring (Schmidt et al. 2013). Ant biodiversity has been studied in order to understand the disturbances caused by the constant simplification of natural ecosystems.

Therefore, this work aimed to characterize and compare the richness and diversity of the ant assemblages in agroecological peach orchards, conventional peach orchards and native vegetation in the Pampa Biome.

MATERIALS AND METHODS

Study location

The study was carried out in two familiar agricultural agroecosystems and a native vegetation area located in the Pampa Biome. The Pampa Biome is located in the southern half of Rio Grande do Sul, it is the smallest Brazilian biome in extension (176,496 km²), corresponding to approximately 2.07% of the national territory. The natural landscapes of the Pampa are characterized by the dominance of countryside vegetation in flat relief, wavy to strongly wavy (Boldrini 2020). The familiar agricultural agroecosystems, as well as the native vegetation, are located in the region of Colônia São Manoel (31 ° 26 ‘S and 52 ° 33’ W), 8th district of Pelotas, RS, Brazil, in the physiographic region called Serra do Sudeste. The soil of agroecosystems was classified as Neossolo Litólico Eutrófico (Santos et al. 2017). The region has a natural vegetation cover classified as small-scale fields and forests, close to the savanna (Porto 2002). According to the Köppen classification, type Cfa (C: warm temperate climate, with average temperature of the coldest month between 3 and 18 ° C; f: in no month is precipitation below 60 mm; a: temperature of the warmest month is higher than 22 ° C).

The temperature and precipitation graphs are shown in figure 1.

Study areas

a) Agroecological peach orchard:

It is located at geographic coordinates 31°25’55”S and 52°33’24”W. This agroecosystem was originally made up of native vegetation, later used for pasture. In 2002, 195 plants of the cultivar Granada were implanted. The spacing between plants has a distance of 2m and between lines of 4m, in an area of approximately 0.22 hectares (ha). This area is surrounded by native vegetation. In the summer period spontaneous vegetation appears. A mechanical mowing is carried out in March. In winter, *Vicia sativa* L. (vetch), *Avena sativa* L. (oats) and *Lolium multiflorum* L. (Italian ryegrass) are sown. The soil correction consists of applying lime (around half a kilogram per plant when the farmer deems it necessary). For monitoring fruit flies, McPhail traps were used as described in Garcia & Lara (2006). These were installed 10m apart at a height of approximately 1.5m inside

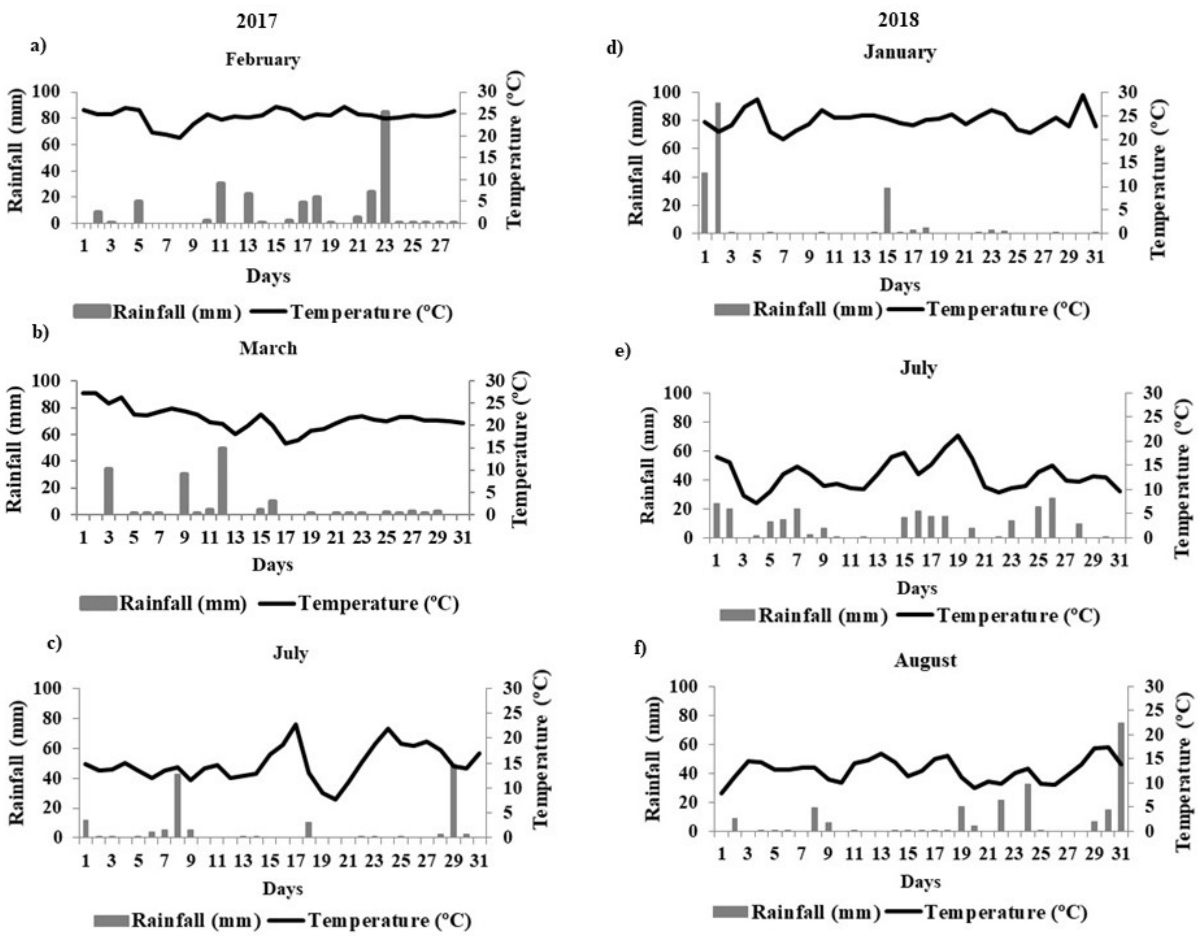

Figure 1. **Precipitation, and temperature in Pelotas, RS, Brazil.a) February 2017; b) March 2017; c) July 2017; d) January 2018; e) July 2018 and f) August 2018.**

the treetops. The interior of each trap contained an attractive aqueous solution.

b) The area of native vegetation is located on the agroecological farmer's property and is 40 years old on average. It is located at geographic coordinates 31° 25'45"S and 52°33'25"W with an area of approximately 1ha. It contains species such as: *Rapanea ferruginea* Ruiz & Pav. (capororoca), *Luehea divaricata* Mart & Zucc. (açoita-cavalo), *Matayba elaeagnoides* Radlk. (camboatá), *Ficus carica* L. (fig), *Allophylus edulis* St. Hil. (vacum), *Eugenia myrcianthes* Nied (pessegueiro-do-mato), *Cedrela fissilis* Vell. (cedar) among other species (Gomes et al. 2019). Surrounding this vegetation, there is the area of agroecological orchard. Due to the preservation and representativeness of the local biodiversity, this area was used as a reference in comparison to the others.

c) Conventional peach orchard:

It is located at geographic coordinates 31°25'33"S and 52°33'30"W. This agroecosystem was originally made up of native vegetation. In 1996, 200 plants of the Esmeralda cultivar were implanted. The spacing between plants has a distance of 2m and between lines of 4m, in an area of approximately 0.22 hectares (ha). The surrounding area has native vegetation and other crops such as a vegetable garden.

The orchard is managed with herbicides, fertilization with highly soluble fertilizers and the soil is without vegetation cover between the peach cultivation lines. In this agroecosystem a systemic herbicide (N-(fosfonometil) glicina) of broad spectrum and desiccant of spontaneous plants is applied, in addition to the use of Bordeaux mixture in early spring (late September). As a phytosanitary treatment, a contact and ingestion organophosphate insecticide (fruit filling stage), systemic action organophosphate insecticide and acaricide (control of the fruit fly) and systemic fungicide from the triazole and sulfur group are used.

According to the farmers' report, the areas produce quality fruits that are marketed locally.

Ant collection

Four samplings were undertaken in 2017: 1st and 09th March (summer); 24th and 31st July (winter); and four samplings were undertaken in 2018: 23rd and 30th January (summer); 31st July and 07th August (winter).

Were used pitfalls as per adapted method in all samplings (Lutinski et al. 2013). The pitfall traps were composed of a plastic pot with a capacity of 1L, inserted in the soil until the height of its opening, being protected by a clay tile. In each trap, we added 200 mL solution composed of 5% bihydrated glycerin, 22% distilled water and 73% 96º Gl alcohol. In each environment we installed 9 pitfalls along a linear transect perpendicular to the edge, observing the distance of 10 meters between consecutive traps (Lutinski et al. 2013). On average, as traps they remained in the field for 7 days. After that period they were removed and replaced.

Specimens were stored in bottles containing 70% ethanol and transported to the Soil Biology Laboratory at the Universidade Federal de Pelotas (Pelotas) for sorting and identification using the taxonomic keys proposed by Baccaro et al. (2015) and the classification was based on Bolton (2019).

Statistical analysis

The richness was defined as the number of species that occurred in each area. The relative frequency based on the occurrence of each species in each sampled environment and the abundance based on the relative frequency (Lutinski et al. 2017a). The richness of the areas was also compared using a non-parametric estimator (Chao 1) in EstimatesS 8.0 (Colwell 2006, Chao 1987) and compared by rarefaction analysis based on species occurrences using the EcoSim 7 software (Gotelli & Entsminger 2001).

In order to test the possible associations between ant species, environment (local) and season (summer and winter) was used the Principal Component Analysis (PCA) using the Past statistical program (Hammer et al. 2001).

RESULTS

The species *Nylanderia fulva* (Mayr, 1862) presented the highest frequency in the agroecological (24.2%) and conventional (31.9%) orchards (Table I).

Of the thirty species sampled, eight occurred in the three environments: *Gnamptogenys striatula* Mayr, 1884, *Gnamptogenys* sp.1, *Camponotus* sp.1, *Camponotus* sp.2, *Nylanderia fulva*, *Pheidole* sp.1, *Pogonomyrmex naegelli* Emery, 1878 and *Pachycondyla striata* (Smith, 1858) (Table I).

The most frequent genera in the samples were *Nylanderia*, *Pheidole*, *Pachycondyla*, *Gnampnotgenys* and *Cyphormymex*, respectively. The genus *Solenopsis* was not collected in native vegetation, however, in the conventional orchard it represented 18.6% of the total records for the agroecosystem, where as in the agroecological orchard the genus represented 1.2% of the records.

Table I. Species, occurrences and relative frequency (%) in agroecological peach orchard, conventional peach orchard and native vegetation in Colônia São Manoel, Pelotas, RS, Brazil, 2017 and 2018.

Taxon	AP	NV	CP
Subfamily Ectatomminae			
Gnamptogenys striatula Mayr, 1884	5 (1,9)	24 (16,0)	1 (0,9)
Gnamptogenys sp. 1	2 (0,8)	14 (9,3)	1 (0,9)
Gnamptogenys sp. 2	1 (0,4)	5 (3,3)	
Subfamily Formicinae			
Camponotus alboannulatus Mayr, 1887	5 (1,9)		
Camponotus cingulatus Mayr, 1862	5 (1,9)		1 (0,9)
Camponotus crassus Mayr, 1862	3 (1,2)		
Camponotus lespesii Forel, 1886	7 (2,7)	4 (2,7)	
Camponotus rufipes (Fabricius, 1775)	18 (6,9)		
Camponotus sp. 1	14 (5,4)	2 (1,3)	4 (3,5)
Camponotus sp. 2	3 (1,2)	1 (0,7)	1 (0,9)
Camponotus sp. 3	4 (1,5)		1 (0,9)
Nylanderia fulva (Mayr, 1862)	63 (24,2)	22 (14,7)	36 (31,9)
Subfamily Myrmicinae			
Acanthognathus teledectus Brown & Kempf, 1969			1 (0,9)
Acromyrmex ambiguus (Emery, 1888)	14 (5,4)	4 (2,7)	
Cyphomyrmex rimosus (Spinola, 1851)	23 (8,8)	1 (0,7)	
Cyphomyrmex strigatus Mayr, 1887	7 (2,7)	1 (0,7)	
Mycocepurus goeldii (Forel, 1893)	1 (0,4		
Mycocepurus sp.	1 (0,4)		
Pheidole sp. 1	50 (19,2)	33 (22,0)	34 (30,1)
Pheidole sp. 2		1 (0,7)	
Pheidole sp. 3	2 (0,8)		
Pogonomyrmex naegelii Emery, 1878	1 (0,4)	3 (2,0)	8 (7,1)
Solenopsis saevissima (Smith, 1855)	3 (1,2)		16 14,2)
Solenopsis sp. 1			5 (4,4)
Subfamily Ponerinae			
Anochetus neglectus Emery, 1894	1 (0,4)		
Hypoponera sp. 1	3 (1,2)	3 (2,0)	
Hypoponera sp. 2	5 (1,9)		3 (2,7)
Hypoponera sp. 3	3 (1,2)	2 (1,3)	
Pachycondyla harpax (Fabricius, 1804)	2 (0,8)	8 (1,3)	
Pachycondyla striata Smith, 1858	14 (5,4)	22 (14,7)	1 (0,9)
Richness (S)	27	17	14
Abundance (occurrences)	260	150	113

***AP: agroecological peach orchard; CP: conventional peach orchard; NV: native vegetation.**

The species *Acanthognathus teledectus* Brown & Kempf, 1969 collected in the conventional orchard is the first record for the state of Rio Grande do Sul. The species *Pachycondyla harpax* (Fabricius, 1804) was found in the agroecological peach orchard and in the native vegetation, not being in the conventional peach orchard.

A total of 5,323 ant specimens of thirty species were collected, in four subfamilies and 13 genera, corresponding to 523 occurrences, with the greatest richness found in the agroecological orchard (S = 27), followed by native vegetation (S = 17) and conventional orchard (S = 14), as well as abundance (occurrences) n = 260, n = 150 and n = 113, respectively. The agroecological peach orchard and native vegetation showed the highest richness while in the conventional peach orchard there was the lowest richness (Figure 2). In all evaluated agroecosystems, richness and abundance were higher during the summer (Table II).

The conventional peach orchard obtained the lowest Shannon diversity index (H') for both seasons when compared to the agroecological orchard and native vegetation. This index was higher in the summer for the agroecological orchard, while in the winter the native vegetation obtained the highest value.

Equitability (J') followed the same trend as Shannon's diversity, with the agroecological orchard and native vegetation having the highest values for summer and winter, native vegetation having the highest value. During the study period, the highest values of Chao1 were found in the summer for the agroecological and conventional orchards, since in these areas rare species occurred (Table II). Principal component analysis (PCA) explained 77.40%

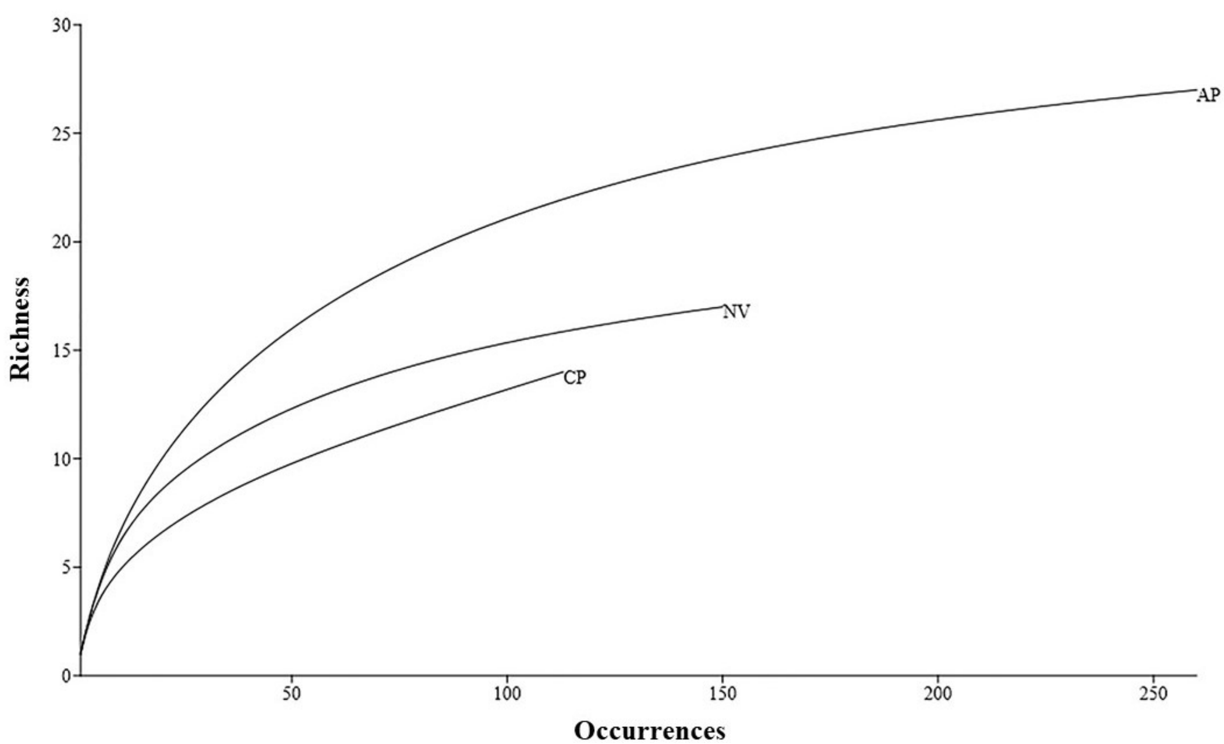

Figure 2. Comparison by the rarefaction method, based on the number of occurrences and of the accumulated richness of ant assemblages from three environments in Colônia São Manoel, Pelotas, RS, Brasil (2017-2018).

of ants occurrence in the summer and winter environments and seasons (Figure 3).

Five species showed a positive association with the samplings carried out in the conventional peach orchard and in the agroecological peach orchard in winter: *Camponotus* sp.1, *P. naegelli*, *N. fulva*, *Pheidole* sp.1 and *Solenopsis saevissima* (Smith, 1855). The native vegetation, regardless of the season and the agricultural orchard in summer, showed a positive association with five species: *Acromyrmex ambiguus* (Emery, 1888), *P. striatra, G. striatula, Gnamptogenys* sp.1 and *Cyphomyrmex rimosus* (Spinola, 1851). All other species occurred regardless of the type of environment.

DISCUSSION

The higher frequency of *N. fulva* found in orchards can be explained by the fact that the species is considered generalist and native to southern Brazil and northern Argentina (Wang et al. 2016). According to the authors, this species is important in biological conservation control, as it predates larvae of Coleoptera and Lepidoptera pest species. However, it also has the tendency to form symbiotic relationships with Hemiptera that feed on plants and may intensify the problems arising from pests. *N. fulva* workers tend various honeydew producing hemipterans in Florida landscapes and natural areas (Sharma et al. 2013) especially in the warmer months.

The eight species that occurred in the three environments are mainly predators and collectors of *honeydew* and seeds. In citrus orchards there are approximately 123 species of ants that can collect *honeydew* (Samways et al. 1982). *Camponotus* sp., *C. crassus, C. rufipes* and *Pheidole* sp. were observed collecting aleirodid *honeydew* in organic mandarin (*Citrus reticulata* Blanco) orchards (Rodrigues & Cassino 2011).

Ants of the genus *Gnamptogenys* are usually generalist predators, with some species considered specialists in certain prey (myriapods and beetles), thus acting in the control of these organisms in the environment (Baccaro et al. 2015). According to the same authors, they also collect *honeydew* from hemiptera and extrafloral nectar from plants. The species *G. striatula* has a preference for structurally more complex environments, as its diet is specialized, requiring greater food availability (Andersen 2000). The highest incidence of this species was found in the area of native vegetation, as it has greater species diversity, offering the complexity that the species needs.

C. crassus and *C. rufipes* most often climb plants approximately 1m to collect extrafloral nectar and/or honeydew from aphids and scale insects (Lange et al. 2019). *C. lespesii* is very

Table II. Richness, abundance, Shannon diversity index, equitability and Chao 1, from three environments in Colônia São Manoel, Pelotas, RS, Brazil (2017 – 2018).

Indicators	APs	APw	NVs	NVw	CPs	CPw
Richness (Sobs)	27	10	16	8	12	5
Abundance	197	63	120	30	91	22
Shannon diversity (H’)	2.76	1.56	2.29	1.83	1.86	1.25
Equitability (J’)	0.84	0.68	0.83	0.88	0.75	0.78
Chao1	29.5	12	19	8.5	22	6

***APs: agroecological peach orchard (summer); APw: agroecological peach orchard (winter); NVs: native vegetation (summer); NVw: native vegetation (winter); CPs: conventional peach orchard (summer); CPw: conventional peach orchard (winter).**

common in the Neotropical region (Rosumek 2017) and also visits extrafloral nectaries (Byk & Del-Claro 2010). The *Camponotus* genus occurred mainly in the agroecological peach orchard, as this species can feed on extraforal nectar and *honeydew*. *Camponotus sp*. was associated with *Aetalion reticulatum* (L.) (Hemiptera: Aethalionidae) in *açaizeiro-de-touceira*, *Euterpe oleracea* Martius (Arecaceae) (Santos & Silva 2021).

The species *P. striata* is considered a predator and gatherer of fruits and seeds. The transport of this material to the nests and the processing of these foods can influence the chemical and physical characteristics of the soils around the nests, as the transport of fruits and seeds can facilitate germination and increase the recruitment of seedlings on the nests or in the surroundings (Passos & Oliveira 2004), thus helping to disperse seeds in ecosystems.

The species of the genus *Pogonomyrmex* are collectors and predators, however, they are mostly collectors (Hölldobler & Wilson 1990). Ants of the *P. naegelli* species that inhabit the Brazilian Cerrado, have a predominantly granivorous diet during the dry/cold season, and in the wet/warm season, they consume both seeds and arthropods (mainly termites and other ants) (Belchior et al. 2012).

Among the five most frequent genders in this study, Abeijon et al. (2019) registered the presence of two of them, *Pachycondyla* and *Pheidole*, in peach orchard agroecosystems in the same physiographic region of the present study. Still, Rosado et al. (2012) collected 24 genera of ants in areas of fields and vineyards in Rio Grande do Sul, eleven of them were also verified in this study. According to Antweb (2020), in Brazil there are 115 genera of ants and 1515 species already described.

Ants of the genus *Solenopsis* are associated with anthropization (Lutinski et al. 2014, 2017b), loss and fragmentation of tropical forests, reducing the richness of other ant species by competitiveness (Dejean et al. 2015). This is the case of *Solenopsis saevissima*, a species that is often found in environments modified by man. The results obtained by Dejean et al. (2015) corroborate those of this study. The authors found that the decrease in species richness as the level of anthropization intensified, so that the abundance of *S. saevissima* was greater in anthropized environments, as well as in the conventional orchard.

In this work, the species *A. teledectus* was sampled in the conventional orchard. However, there are reports that it has also been found in an agroecological coffee area without shading and in a forest fragment located in Mexico (Urrutia-Escobar & Armbrecht, 2013). The authors associated the species with the degree of conservation of the environments, since it is considered demanding in the search for its habitat.

Pachycondyla harpax it is an important species as a bioindicator of conserved environments and of low human impact (Tibecherani et al. 2018). Corroborating with the results found in this study, in which no specimen was found in the conventional orchard. According to the literature, this species is a potential predator of small invertebrates such as termites, myriapods and soft-bodied insects, which are probably absent in the conventional peach agro-ecosystem, (Garcia-Pérez et al. 1997, Braga et al. 2010, Oliveira et al. 2015). Predatory insects, such as ants of the species *P. harpax*, compose one of the most important groups of natural enemies, playing a fundamental role in the regulation of arthropod pest populations in several crops (González et al. 2014).

The genera *Solenopsis* and *Pheidole* have wide adaptation, which can be found from natural environments to the most disturbed

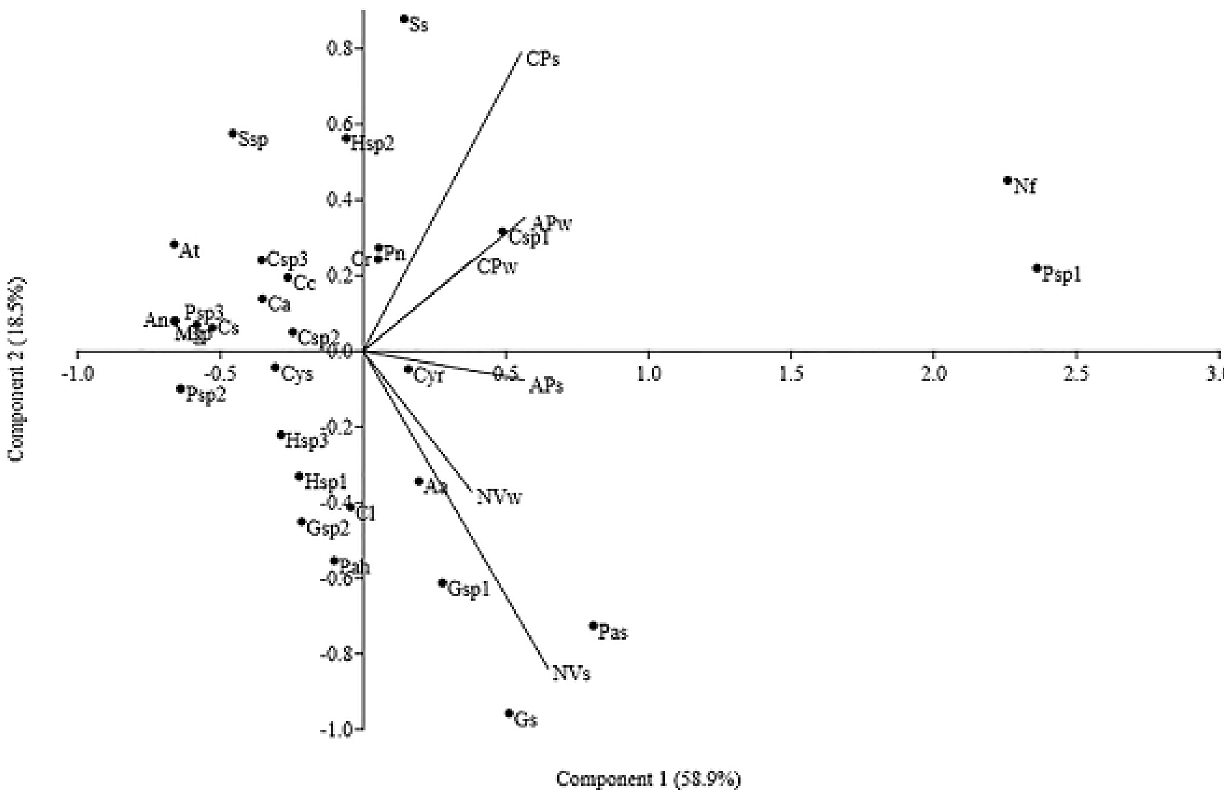

Figure 3. Association (principal component analysis) of ant species with three environments from rural properties located in Colônia São Manoel, Pelotas, RS, Brasil, (2017 – 2018). *APs: agroecological peach orchard (summer); APw: agroecological peach orchard (winter); CPs: conventional peach orchard (summer); CPw; conventional peach orchard (winter); NVs: native vegetation (summer); NVw: native vegetation (winter) **Gs: Gnamptogenys striatula; Gsp1: Gnamptogenys sp. 1; Gsp2: Gnamptogenys sp. 2; Ca: Camponotus alboannulatus; Cc: Camponotus cingulatus; Cs: Camponotus crassus Cl: Camponotus lespesii; Cr: Camponotus rufipes; Csp1: Camponotus sp. 1; Csp2: Camponotus sp. 2; Csp3: Camponotus sp. 3; Nf: Nylanderia fulva; At: Acanthognathus teledectus; Aa: Acromyrmex ambiguus; Cyr: Cyphomyrmex rimosus; Cys: Cyphomyrmex strigatus; Mg: Mycocepurus goeldii; Msp: Mycocepurus sp.; Psp1: Pheidole sp. 1; Psp2: Pheidole sp. 2; Psp3: Pheidole sp. 3; Pn: Pogonomyrmex naegelii; Ss: Solenopsis saevissima; Ssp: Solenopsis sp. 1; An: Anochetus neglectus; Hsp1: Hypoponera sp. 1; Hsp2: Hypoponera sp. 2; Hsp3: Hypoponera sp. 3; Pah: Pachycondyla harpax; Pas: Pachycondyla striata.

ones (Hölldobler & Wilson 1990, Freire et al. 2012), confirm the results found, since these genera were collected in agroecological and orchards conventional. Similarly, Estrada et al. (2019) found such genera in several areas of orchard and vegetable garden under organic and conventional cultivation. *Pheidole* sp. and *Solenopsis* sp. are important pest regulators in orchards, acting in the biological control of *Anastrepha fraterculus* (Wiedemann, 1830) (Diptera, Tephritidae) (Galli & Rampazzo 1996, Fernandes et al. 2012).

The richness of ants found in the agroecological peach orchard reflects the preservation of the agroecosystem. The importance of the structural complexity of the environments due to the time of implantation of the organic system is reflected in the diversity of ants (Urrutia-Escobar & Armbrecht 2013, Holdefer et al. 2017). The agroecosystem of the agro-ecological orchard, 15 years old at the time of the research, seems to corroborate the hypothesis, linked to the permanent vegetal coverage of the soil, as well as the absence of the application of pesticides, which provides different niches for the shelter and food of these organisms. The data of richness and number of occurrences verified in the native vegetation, are similar to the conventional orchard, even though they are superior. Although the area is close to the agroecological orchard.

A similar result was found by Silva et al. (2012), when evaluating the edaphic fauna in the same rural property, found similar values of wealth between forest and a conventional system, differing from the agroecological area.

These data corroborate those obtained by Santos et al. (2017) who collected twice as many ants in organic sugarcane plantations compared to conventional sugarcane plantations. Estrada et al. (2019) in a study of mirmecofauna in several areas of perennial plants under organic and conventional cultivation, they also observed that areas under organic cultivation were richer and more abundant compared to conventional areas.

Regarding the rarefaction curves, they did not reach asymptote, indicating that the sampling effort did not fully analyze the ant assemblies, being possible to register additional species in all environments. However, the lack of stabilization in the sampling curves is commonly observed in ant communities, a pattern that may be related to the aggregate distribution or rarity of some species (Lutinski et al. 2017b, 2018).

The higher Shannon (H') index found in the agroecological orchard and native vegetation corroborates those found in the literature. Golias et al. (2018) found higher H' values for an Atlantic Forest fragment compared to a lemon and orange grove, however they were maintained under conventional management. Estrada et al. (2019) found greater diversity for organic crops when compared to conventional crops.

Thus, in summer the equitability (J') and diversity of H' were similar between the agroecological orchard and native vegetation, while in winter it was superior for native vegetation. These results reflect the diversity and complexity of the orchard maintained under agroecological management, as well as the native vegetation, since in these environments the soil cover is maintained for the preservation and maintenance of organic matter, providing different niches for the shelter of edaphic fauna.

Silva et al. (2012) found greater diversity in the forest area in the rainy season in relation to agroecological and conventional areas. According to the authors, forests, in general, provide diversified conditions for the existence of greater biodiversity due to its more complex structures: large number of plant species and interconnected crowns forming a continuous canopy.

Temperature and rainfall have a direct influence on the activity of edaphic organisms, influencing, for example, foraging. The fluctuation of the activity of the ant assemblages in the face of temperature variations can influence the behavior of these organisms, suggesting that there are species tolerant and intolerant to heat. As the Calazans et al. (2020) study suggests, ant community can exhibit an thermal optimum of 22.4°C. Species such as *Cyphormymex minutus* and *Wasmannia lutzi* are more active at lower temperatures, while species such as *Pheidole* sp., *Pogonomyrmex naegelli* and *Solenopsis* sp. are more active at higher temperatures. Figure 1 show the climatic conditions during the collections of the present research. Higher temperature averages in the summer may have influenced the activity of the mirmecofauna.

The type of soil and vegetation are the main determining factors for the composition of ant assemblages, thus, species identification is an important indicator for environmental monitoring (Schimidt et al. 2013). Intensive agricultural practices cause losses in edaphic biodiversity and can affect ecosystem services.

Soil management systems that promote sustainability, that is, less intensive, unused or with less agrochemicals, more crop species, whether in rotation or consortium, are more favorable and with a greater capacity to provide refuge for biodiversity, which can improve ecosystem functions.

According to Magurran (2011) Chao1 consists of an estimator of the absolute number of species in an assembly and is based on the number of rare species. This explains the higher values for this index in orchards in the summer, since each of them presents a unique species. *Anochetus neglectus* was collected only in the agroecological orchard and *A. teledectus* only in the conventional orchard.

Therefore, the species *P. striata* and *G. striatula*, which were associated with native vegetation and the agroecological orchard in the summer, were also found by Lutinski et al. (2018) in a forest fragment and a permanent preservation area, indicating that these species can be bioindicators of environmental quality. The genus *Pachycondyla* is predominantly predator and has an important role in the population control of other organisms, being associated with areas of vegetation in an advanced stage of succession (Oliveira et al. 2015).

Prestes et al. (2006), found an increase in the population of this genus in banana cultivation, associated with an increase in the population of *Cosmopolites sordidus* (Coleoptera: Curculionidae), a species that can cause damage to the banana culture, which ended up culminating in the reduction of *C. sordidus*, and subsequently, reduction of the genus *Pachycondyla* as well. Conservation practices, such as the use of green manures, direct planting and the absence or decrease in the use of insecticides can positively affect epigeic populations (populations that live in litter) (Brown et al. 2015).

The richness of the agroecological orchard in winter was similar to that found for native vegetation (Table II), however the PCA (Figure 3) demonstrates the similarity of the conventional and agroecological orchard areas in that season. This result can be explained due to the relative frequency of *Camponotus* sp.1 and *N. fulva* in these areas, since the values are close (Table I).

In the conventional orchard area, the least variation of the H' index occurred during the seasons (Table II), this may explain the proximity of the values for such area in the summer and winter in the PCA analysis (Figure 3). Whereas, the area of agroecological orchard in the summer approached the native vegetation in the summer and winter (Figure 3), and may have been influenced by the presence of the species *C. rimosus*, which occurred in these two areas not being found in the conventional orchard (Table I).

The results found demonstrated that conservationist systems tend to harbor greater wealth and diversity of ant assemblages, as well as occurring in native areas. Agroecological systems can be a viable alternative to conventional systems in the preservation of ecosystems to maintain edaphic biodiversity, through the absence of the use of pesticides and the maintenance of vegetation cover. It tends to increase and preserve the diversity and richness of the ant assembly, favoring predatory species, thus contributing to the ecological management of pests.

The species *Acanthognathus teledectus* Brown & Kempf, 1969 collected in the conventional orchard is the first record for the state of Rio Grande do Sul. The agroecological system favored ant assemblages providing greater richness and diversity of species.

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REFERENCES

ABEIJON LM, KRUGER AP, LUTINSKI JA & GARCIA FRM. 2019. Can ants contribute to the conservative biological control of the south American fruit fly? Biosci J 35: 941-948.

ANDERSEN AN. 2000. Global ecology of rainforest ants: functional groups in relation to environmental stress and disturbance. In: AGOSTI D, MAJER JD, ALONSO LE & SCHULTZ T (Eds). Ants: standard methods for measuring and monitoring biodiversity. Washington: Smithsonian Institutional, p. 25-34.

ANTWEB. 2020. https://www.antweb.org/country.do?name=Brazil acess 06/02/2020.

BACCARO FB, FEITOSA RM, FERNANDEZ F, FERNANDES IO, IZZO TJ, SOUZA JLP & SOLAR R. 2015. Guia para os gêneros de formigas do Brasil - Manaus: Editora INPA, 388 p.

BARETTA D, BARTZ MLC, FACHINI I, ANSELMI R, ZORTÉA T & BARETTA CRDM. 2014. Soil fauna and its relation with environmental variables in soil management systems. Cienc Agron 45: 871-879.

BARETTA D, SANTOS JCP, SEGAT JC, GEREMIA EV, OLIVEIRA FILHO LCI & ALVES MV. 2011. Fauna edáfica e qualidade do solo. In: KLAUBERG FILHO O, MAFRA AL & GATIBONI LC (Eds). Tópicos em ciência do solo. Viçosa, MG, Sociedade Brasileira de Ciência do Solo, p. 141-192.

BARTZ MLC, PASINI A & BROWN GG. 2013. Earthworms as soil quality indicators in Brazilian No-tillage systems. Appl Soil Ecol 7: 39-48.

BELCHIOR C, DEL-CLARO K & OLIVEIRA PS. 2012. Seasonal patterns in the foraging ecology of the harvester ant *Pogonomyrmex naegelii* (Formicidae, Myrmicinae) in a Neotropical savanna: daily rhythms, shifts in granivory and carnivory, and home range. Arthropod Plant Interact 6: 571-582.

BOLDRINI II. 2020. Por que e para que conservar o Pampa? P. 12-29. In: TEIXEIRA FILHO A & WINCLE LT (Eds). Anais do I Congresso sobre o Bioma Pampa: Reunindo Saberes, Editora UFPel, Pelotas, RS.

BOLTON B. 2019. Synopsis and classification of Formicidae. Gainesville: Am Entomol Inst, 370 p.

BORSATO AV. 2015. Sistema de produção agrícola de base ecológica. In: NUNES RR & REZENDE MOO (Orgs). Recurso Solo: Propriedades e Usos. São Carlos: Editora Cubo, p. 499-523.

BRAGA D, LOUZADA JNC, ZANETTI R & DELABI EJ. 2010. Avaliação Rápida da Diversidade de formigas em sistemas de uso do solo no Sul da Bahia. Neotrop Entomol 39: 464-469.

BROWN GG. 2015. Biodiversidade da fauna do solo e sua contribuição para os serviços ambientais, p. 122-154. In: PARRON LM, GARCIA JR, OLIVEIRA EB, BROWN GG & PRADO RB (Eds). Serviços ambientais em sistemas agrícolas e florestais do Bioma Mata Atlântica, Embrapa, Brasília, DF.

BYK J & DEL-CLARO K. 2010. Nectar- and pollen-gathering Cephalotes ants provide no protection against herbivory: a new manipulative experiment to test ant protective capabilities. Acta Ethol 13: 33-38.

CALAZANS EG, COSTA FV, CRISTIANO MP & CARDOSO DC. 2020. Daily Dynamics of an ant community in a mountaintop ecosystem. Environ Entomol 14: 383-390.

CHAO A. 1987. Estimating the population size for capture-recapture data with unequal catchability. Biometrics 43: 783-791.

CREPALDI RA, PORTILHO IIR, SILVESTRE R & MERCANTE FM. 2014. Formigas como bioindicadores da qualidade do solo em sistema integrado lavoura-pecuária. Cienc Rural 44: 781-787.

COLWELL RK. 2006. EstimateS: statistical estimation of species richness and share species from simples: version 8 [online]. Connecticut: Connecticut University Editora. Available from: http://viceroy.eeb.ucon.edu/estimates.

DEJEAN A, CÉRÉGHINO R, LEPONDE M, ROSSI V, ROUX O, COMPIN A, DELABIE JHC & CORBARA B. 2015. The fire ant *Solenopsis saevissima* and habitat disturbance alter ant Communities. Biol Cons 187: 145-153.

ESTRADA MA, ALMEIDA AA, VARGAS AB & ALMEIDA FS. 2019. Diversidade, riqueza e abundância da mirmecofauna em áreas sob cultivo orgânico e convencional. Acta Biol Cat 6: 87-103.

FERNANDES WD, SANT'ANA MV, RAIZER J & LANGE D. 2012. Predation of fruit fly larvae Anastrepha (Diptera: Tephritidae) by ants in grove. Psyche 1(1): 1-7.

FREIRE CB, OLIVEIRA GV, MARTINS FRS, SOUZA LEC, RAMOS-LACAU LS & CORREA MM. 2012. Riqueza de formigas em áreas preservadas e em regeneração de caatinga arbustiva no sudoeste da Bahia, Brasil. Rev Bras Bioc 10: 131-134.

GALLI JC & RAMPAZZO EFL. 1996. Enemigos naturales de Anasatrepha (Diptera, Tephritidae) capturados con trampas de suelo emhuertoss de Psidium guajava. Bol San Veg Plagas 22(2): 297-300.

GARCIA FRM & LARA DB. 2006. Análise faunística e flutuação populacional de moscas-das-frutas (Diptera, Tephritidae) em pomar cítrico no município de Dionísio Cerqueira, Santa Catarina. Biotemas 19(3): 65-70.

GARCIA-PÉREZ JÁ, BLANCO-PIÑON A, MERCADO-HERNÁNDEZ R & BADII M. 1997. El comportamiento depredador de *Pachycondyla* harpax Fabr. sobre *Gnathamitermes tubiformans* Buckley en condiciones de cautiverio. Southwest Entomol 3: 345-353.

GLIESSMAN SR. 2009. Agroecologia: processos ecológicos em agricultura sustentável. 4ª ed. - Porto Alegre : Editora da Universidade/UFRGS, 654 p.

GOLIAS HC, LOPES J, HUBERT J, DELABIE C & AZEVEDO F. 2018. Diversity of ants in citrus orchards and in a forest fragment in Southern Brazil. EntomoBrasilis 11: 01-08.

GOMES GC, GOMES JCC, BARBIERI RL, MIURA AK & SOUSA LP. 2019. Environmental and Ecosystem Services, Tree Diversity and Knowledge of Family Farmers. FLORAM 26(1): 1-12.

GONZÁLEZ FML, JAHNKE SM, MORAIS RM & SILVA GS. 2014. Diversidad de insectos depredadores en área orizícola orgánica y de conservación, em Viamão, RS, Brasil. Rev Colomb Entomol 1: 120-128.

GOTELLI NJ & ENTSMINGER GL. 2001. EcoSim: null models software for ecology. Version 7.0. Acquired Intelligence Inc. & Kesey-Bear, 2001. Available from: <http://homepages.together.net/~gentsmin/ecosim.htm>. Accessed on: 23 Mar. 2016.

HAMMER O, HARPER D & RIAN PD. 2001. Past: Palaeonthological statistics software package for education and data analysis. Version. 1.37. Electronic Database accessible at: http://palaeo-electronica.org/2001_1/past/issue1_01.htm.

HOLDEFER DR, LUTINSKI JA & GARCIA FRM. 2017. Does organic management of agroecosystems contribute to the maintenance of the richness of ants? Semina: Ciênc Agrár 38: 3455-3468.

HÖLLDOBLER RB & WILSON EO. 1990. The ants. Harvard University, Cambridge, 772 p.

LANGE D, CALIXTO ESC, ROSA BB, SALES TA & DEL-CLARO K. 2019. Natural history and ecology of foraging of the *Camponotus crassus* Mayr, 1862 (Hymenoptera: Formicidae). J Nat Hist 53: 1737-1749.

LUTINSKI JA, BAUCKE L, FILTRO M, BUSATO MA, KNAKIEWICZ AC & GARCIA FRM. 2017a. Ant assemblage (Hymenoptera: Formicidae) in three wind farms in the State of Paraná, Brazil. Braz J Biol 77: 176-184.

LUTINSKI JA & GARCIA FRM. 2005. Análise faunística de Formicidae (Hymenoptera: Apocrita) em ecossistema degradado no município de Chapecó, Santa Catarina. Biotemas 18: 73-86.

LUTINSKI JA, LUTINSKI CA, BELING JF, BUSATO MA & CORRALO V. 2018. Ant Assemblages (Hymenoptera: Formicidae) associated to environments of a rural property in the extreme western region of the state of Santa Catarina. RBCIAMB (47): 12-23.

LUTINSKI JA, LUTINSKI CJ, GUARDA C, BUSATO MA & GARCIA FRM. 2017b. Richness and structure of ant assemblies (Hymenoptera: Formicidae) in Atlantic forest in southern Brazil. An Acad Bras Cienc 89: 2719-2729.

LUTINSKI JA, LUTINSKI CJ, IOP S & GARCIA FRM. 2013. Evaluation of an ant sampling protocol (Hymenoptera: Formicidae) in three modified environments located inside an austral Atlantic Forest area of Brazil. Ecol 23: 37-43.

LUTINSKI JA, LUTINSKI CJ, LOPES BC & MORAIS ABB. 2014. Estrutura da comunidade de formigas (Hymenoptera: Formicidae) em quatro ambientes com diferentes níveis de perturbação antrópica. Ecol Austral 24: 229-237.

MAGURRAN AE. 2011. Medindo a diversidade biológica. Tradução: Viana D.M. Curitiba: Ed. da UFPR, 261 p.

OLIVEIRA DM, FRANCO FS, SCHLINDWEIN M, LEITE EC & BRANCO CS. 2015. Mirmecofauna em agroecossistemas e sua função na transição agroecológica. Rev Verde Agroecologia Desenvolv Sustent 10: 01-15.

PASSOS L & OLIVEIRA PS. 2004. Interaction between ants and fruits of *Guapira opposita* (Nyctaginaceae) in a Brazilian sandy plain rainforest: ant effects on seeds and seedlings. Oecologia 139: 376-382.

PORTO ML. 2002. Os campos sulinos, sustentabilidade e manejo. Ciência & Ambiente 24: 119-138.

PRESTES TMV, ZANINI A, ALVES LFA, BATISTA FILHO A & ROHDE C. 2006. Aspectos ecológicos da população de *Cosmopolites sordidus*, (Germar) (Coleoptera: Curculionidae) em São Miguel do Iguaçu, PR. Semin Cienc Agrar 3: 333-350.

RODRIGUES WC & CASSINO PCR. 2011. Interação entre Formigas e Aleirodídeos (Sternorrhyncha, Aleyrodidae) em Cultivo Orgânico de Tangerina cv. Poncã (*Citrus reticulata* Blanco). EntomoBrasilis 4(3): 119-124.

ROSADO JLO, GONÇALVES MG, DRÖSE W, SILVA EJE, KRÜGER RF, FEITOSA RM & LOECK AE. 2012. Epigeic ants (Hymenoptera: Formicidae) in vineyards and grassland areas in the

Campanha region, state of Rio Grande do Sul, Brazil. Check List 8: 1184-1189.

ROSUMEK FB. 2017. Natural History of Ants: What We (do not) Know about Trophic and Temporal Niches of Neotropical Species. Sociobiology 64(3): 244-255.

SAMWAYS MJ, NEL M & PRINS AJ. 1982. Ants (Hymenoptera; Formicidae) foraging in citrus trees and attending honeydew producing Homoptera. Phytophylactica 14: 155-157.

SANTOS LAO, NARANJO-GUEVARA N & FERNANDES OA. 2017. Diversity and abundance of edaphic arthropods associated with conventional and organic sugarcane crops in Brazil. Fla Entomol 100: 134-144.

SANTOS RS & SILVA EM. 2021. Associação de formigas e abelhas-sem-ferrão com *Aetalion reticulatum* (L.) (Hemiptera: Aethalionidae) em plantio de açaizeiro-de-touceira 1. Entomol Begin 2: 1-4.

SCHMIDT FA, RIBAS CR & SCHOEREDER JH. 2013. How predictable is the response of ant assemblages to natural forest recovery? Implications for their use as bioindicators. Ecol Indic 24: 158-166.

SHARMA S, OI DH & BUSS EA. 2013. Honeydew-producing hemipterans in Florida associated with *Nylanderia fulva* (Hymenoptera: Formicidae), an invasive crazy ant. Fla Entomol 96(2): 538-547.

SILVA J, JUCKSCH I & TAVARES RC. 2012. Invertebrados edáficos em diferentes sistemas de manejo com café na zona da mata de Minas Gerais. Rev Bras de Agroecologia 7(2): 112-125.

SILVA MLN, FREITAS DAF & CÂNDIDO BM. 2015. Curso da EMATER: manejo do solo em sistemas agroecológicos de produção – Lavras: UFLA, 54 p.

SWIFT MJ, HEAL OW & ANDERSON JM. 1979. Decomposition in terrestrial ecosystems. Univ of California Press, 372 p.

TIBECHERANI M, NACAGAVA VAF, ARANDA R & MELLO RL. 2018. Review of Ants (Hymenoptera: Formicidae) as bioindicators in the Brazilian Savanna. Sociobiology 2: 112-129.

URRUTIA-ESCOBAR MX & ARMBRECHT I. 2013. Effect of two agroecological management strategies on ant (Hymenoptera: Formicidae) diversity on coffee plantations in southwestern Colombia. Environ Entomol 42: 194-203.

WANG Z, MOSHMAN L, KRAUS EC, WILSON BE, ACHARYA N & DIAZ RD. 2016. A Review of the Tawny Crazy Ant, *Nylanderia fulva*, an Emeergent Ant Invader in the Southern United States: Is Biological Control a Feasible Management Option? Insects 7: 1-10.

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JSC, ACRL and FRMG conceived and planned the experiments. ACRL and FRMG managed the research. JSC, JMOH and BDP carried out the experiments. JSC and JAL identified the ants at the species level. All authors contributed to the interpretation of the results. All authors provided critical feedback and helped shape the research. JAL provided statistical analysis.