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Ant functional groups and their effects on other insects in organic and conventional cropping areas

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Abstract. The present research aimed to study the functional groups of ants in organic and conventional cropping areas and assess their influence on the abundance of other insects in agroecosystems. Sampling was carried out in eight rural properties with organic, and eight with conventional crops in Paraíba do Sul, state of Rio de Janeiro, Brazil. Fifteen pitfall soil traps were installed to collect ants in each property, in April and May 2016. The ants collected were dry-mounted and identified. The insect abundances of the orders Coleoptera, Hemiptera, and Orthoptera were also obtained. Ants were classified into seven functional groups. The functional group with the largest number of species was "omnivores that inhabit the soil and the leaf litter," followed by "omnivores that inhabit the soil, the leaf litter, and the plants." The group "omnivores that inhabit the soil and the leaf litter" showed the highest abundance of ants in both types of crops. The mean richness of functional groups was significantly higher in organic than in conventional crops. We only observed the effect of the abundance of ants of the group "omnivores that inhabit the soil, the leaf litter, and the plants" on the abundance of coleopterans in conventional crops. Hence, areas with organic crops are more favorable for maintaining an ant fauna with higher functional diversity than areas using the conventional cropping system.

Keywords: Abundance; Agroecosystems; Arthropods; Ecological functions; Formicidae.

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Several insect species can cause a significant decrease in agricultural productivity (Gallo *et al.* 2002; Martins *et al.* 2009). The use of pesticides has been the main strategy to fight agricultural pests in the conventional cropping system due to the generally rapid elimination of the organism causing the phytosanitary problem (Pinto-Zevallos & Zarbin 2013). However, the indiscriminate use of pesticides favors the emergence of pest insects resistant to the active principles of pesticides (Leite *et al.* 2006; Martins *et al.* 2009) and negatively affects organisms not harmful to crops and natural enemies of pest insects, besides causing environmental pollution (Petroski & Stanley 2009; Zarbin *et al.* 2009; Chandler *et al.* 2011; Lopes & Lopes 2011).

The insect orders Hemiptera, Lepidoptera, and Coleoptera stand out for having the largest number of agricultural pest species, and along with the orders Diptera and Orthoptera, among others, they damage plants by sucking sap or consuming their parts, besides being vectors of phytopathogenic microorganisms (Gallo *et al.* 2002; Mitchell 2004; Zarbin *et al.* 2009).

Integrated pest management emerged as an alternative to fighting pest insects, addressing economic, social, and environmental issues (Silva *et al.* 2009; Lima *et al.* 2012). For integrated pest management, collecting information on interactions between insect pests and their natural enemies is paramount (Fernandes *et al.* 2003; Carvalho & Barcellos 2012).

Among the most important natural enemies of insect pests of crops are their predators, including ant species (Cividanes *et al.* 2009; Torres *et al.* 2009; Branco *et al.* 2010). A wide range of insect-pest predators in crop areas may be related to high plant diversity in these areas (Souza *et al.* 2015). Thus, as organic crops are often polycultures (Estrada *et al.* 2019), they favor the occurrence of insect-pest predators (Fernandes 2013; Souza *et al.* 2015). Organic crops can also maintain greater taxonomic diversity of ants than conventional crops by restricting synthetic chemical insecticides. Besides, organic food producers often maintain the leaf litter on the soil surface of the cultivated area (Estrada *et al.* 2019), which can influence the functional diversity of the ant fauna (Barbieri 2009).

Ants stand out among insects in agroecosystems due to their high abundance and diversity of behaviors, playing different roles in crop areas (Queiroz *et al.* 2006). These insects occupy nearly every available niche, nesting in treetops, leaf litter, and the ground (Silvestre 2000; Gomes *et al.* 2013). Leaf-cutting ants (genera *Atta* and *Acromyrmex*) are pests of a wide range of crop plants (Lima & Racca Filho 1996), as they cut off their green leaves and branches (Nickele *et al.* 2013). Ant species also harm plants and feed on the sap (Jetter *et al.* 2002) or associate with hemipterans to feed on their sugary feces (Penteado *et al.* 2012). This association is usually harmful to crops, as ants improve the hygiene conditions of the hemipterans and protect them from natural enemies, which increases the abundance of hemipterans, such as mealybugs (Queiroz & Oliveira 2001; Marchiori 2020). On the other hand, several species contribute to the nutrient cycling in the soil and change its chemical and physical characteristics (Farji-Brener & Ghermandi 2000; Almeida *et al.* 2019), even favoring plant germination and growth (Almeida 2012). Many ant species are potential pollinators and voracious predators (Gallo *et al.* 2002; Rico-Gray & Oliveira 2007). Predatory ant species contribute to the decrease in pest insect abundance in agroecosystems (Fowler *et al.* 1991; Fernandes *et al.* 1994; Eubanks 2001; Van-Mele & Cuc 2001).

Using ant functional groups in ecological studies is recommended (Majer 1983; Alonso 2000; Oliveira *et al.* 2014), as the species of a functional group tend to show similar response patterns to the environmental conditions to which they are exposed. Characteristics such as habitat preference, food consumed, foraging strategies, level of tolerance to environmental disturbances, and behavioral interactions, among others, can be used to define functional groups (Andersen 1997; Silvestre *et al.* 2003).

Despite the diverse ecological functions of the ant fauna, few studies have assessed ant functional groups in crop areas. Ant functional groups are affected by habitat characteristics related to the availability of nesting sites and food resources, which influence ants' behavioral aspects and survival (Andersen 1997; Delabie *et al.* 2000; Silvestre *et al.* 2003; Macedo *et al.* 2011; Castilho 2013; Apolinario *et al.* 2019).

Furthermore, there is little information on the effects of ant fauna on other arthropods in crop areas, especially organic crops. Studies on the impact of ant fauna on insects that can damage crop plants are crucial for using ants as biological control agents in integrated pest management (Silva & Carvalho 2000; Garcia *et al.* 2004; Almeida *et al.* 2007; Gullan & Cranston 2012). Functional groups of predatory ants can help reduce dependence on external inputs for pest management, supporting the environmental and economic sustainability of agricultural production.

The present study aimed to investigate ant functional groups in organic and conventional cropping areas and their influence on the abundance of other insects in agroecosystems.

MATERIAL AND METHODS

Data collection was carried out in Paraíba do Sul, state of Rio de Janeiro, in the region known as "Vale do Café" (Coffee Valley) in the Atlantic Forest Biome (IBGE 2022). Paraíba do Sul has 23.01% of its area covered by forests (Lima *et al.* 2020). The climate is classified as subtropical humid to sub-humid, with rainfall ranging from 15.8 mm (July) to 239.4 mm (December) and 1264.7 mm per year, and the average monthly temperature ranges from 16.1 °C (July) to 22.9 °C (February), with an annual average of 19.6 °C (Mattos *et al.* 1995; Alvares *et al.* 2013).

The data were collected in eight small rural properties with organic food crops and the same number of properties practicing conventional cultivation, considering the definition of an organic production system present in Law 10,831 of December 2003 (Brasil 2003). Hence, synthetic chemical insecticides are not used in the properties practicing organic cultivation, but such insecticides are used in conventional cultivation practice. The properties with conventional crops had from one to six species of crop plants, *i.e.*, *Manihot esculenta* Crantz (cassava), *Pimpinella anisum* L. (fennel), *Solanum gilo* Raddi (scarlet eggplant), *Citrus sinensis* (L.) Osbeck (orange), *Carica papaya* L. (papaya), *Passiflora edulis* Sims (passion fruit), *Capsicum annuum* L. (bell pepper), *Abelmoschus esculentus* (L.) Moench (okra), *Brassica oleracea* var. capitata L. (cabbage), and *Solanum lycopersicum* L. (tomato) (see Estrada *et al.* 2019). In contrast, the properties with organic crops had from 4 to 42 species, including those mentioned above and others, such as *Persea americana* Mill. (avocado), *Cucurbita* sp. (pumpkin), *Malpighia glabra* L. (acerola cherry), *Rosmarinus officinalis* L. (rosemary), *Lactuca sativa* L. (lettuce), *Musa paradisiaca* L. (banana), *Ipomoea batatas* (L.) Lam. (sweet potato), *Beta vulgaris* L. (beetroot), *Plectranthus barbatus* Andr. (boldo), *Allium cepa* L. (onion), *Sechium edule* (Jacq.) Sw. (chayote), *Brassica oleracea* L. (kale), *Phaseolus vulgaris* L. (beans), *Annona muricata* L. (soursop), *Citrus limon* Osbeck (lime), *Zea mays* L. (corn), *Citrullus lanatus* (Thunb.) (watermelon), and *Citrus reticulata* Blanco (tangerine) (see Estrada *et al.* 2019).

Insect sampling was carried out between April and May 2016 by installing 15 pitfall soil traps in each property, placed 10 m apart. The traps consisted of a 300 mL polyethylene cup, bearing 10 cm in diameter and 15 cm in height, containing 100 mL of 70% alcohol, and buried in the ground up to the rim for 48 hours (Almeida *et al.* 2007). The material collected in the traps was poured into plastic pots, identified with labels, containing 70% alcohol. The material was sorted and identified in the laboratory, and the ants were dry-mounted. The identification of ant fauna to the genus level followed Baccaro *et al.* (2015). Next, ants were separated into morphospecies and identified to the species level whenever possible by comparison with previously identified individuals and based on ant species identification keys found in the literature, a process similar to that carried out by Gomes *et al.* (2013) and Apolinário *et al.* (2019). The insects of the orders Coleoptera, Hemiptera, and Orthoptera were collected, identified, and counted.

The following environmental attributes were obtained next to each trap: leaf litter depth, measured with a graduated ruler; and air temperature, measured with a thermometer. The latter was obtained at ground level between 7:30 am and 9:00 am.

The classification of ant species into functional groups was based on information available in the literature on their feeding, nesting, and foraging habits. We considered the proposals of functional groups of Delabie *et al.* (2000), Silvestre *et al.* (2003), Macedo *et al.* (2011), Groc *et al.* (2014), and Pereira *et al.* (2016). We decided to place the leaf-cutting ants in a functional group ("leafcutters") and the ant species that cultivate fungus but do not cut leaves or plant branches in another functional group ("fungus-growers").

The number of ant functional groups represented the richness of functional groups. The diversity of ant functional groups was calculated using the Shannon Index. The abundance of ants was obtained by counting the number of traps in which they were collected, and the abundance of insects of the orders Coleoptera, Hemiptera, and Orthoptera was obtained by counting the number of individuals collected.

We used the t-test to check whether ant richness and functional diversity varied between areas with organic and conventional crops. We studied the influence of ant abundance on the abundance of insects of the orders Coleoptera, Hemiptera, and Orthoptera using Path Analysis, similarly to that performed by Eubanks (2001). This analysis can be seen as a "standardized multiple linear regression" (Souza 2013), which allows quantifying the direct effect of the abundance of the ant fauna on the abundance of the orders Coleoptera, Hemiptera, and Orthoptera, excluding the indirect effect, as an independent variable can indirectly change a dependent variable as a result of its interaction with other independent variables (Eubanks 2001; Akintunde 2012).

Besides the abundance of ants in general and the abundance of ants in functional groups, the leaf litter depth and air temperature were used in this analysis as independent variables, as these environmental attributes can affect the abundance of ants and other insects.

RESULTS AND DISCUSSION

We classified the collected ants into seven functional groups (Table 1). The functional group with the largest number of species was "omnivores that inhabit the soil and the leaf litter," followed by the groups "omnivores that inhabit the soil, the leaf litter, and the plants" and "generalist predators that inhabit the soil and the leaf litter." In general, this result is explained by most ant species being omnivorous and nesting and foraging both in the soil and leaf litter (Hölldobler & Wilson 1990; Baccaro *et al.* 2015), as these places have a high abundance of sites for nesting and feeding (Silva & Silvestre 2004; Gomes *et al.* 2013). In a study carried out by Pereira *et al.* (2016), the functional groups "generalist predators that inhabit the soil and the leaf litter" and "omnivores that inhabit the soil and the leaf litter" showed the highest species richness. On the other hand, to avoid associating the pattern observed here with a sampling bias, it is worth mentioning that the trap chosen for the present study is among the most used and the results were already expected (Corrêa *et al.* 2006).

All ant functional groups occurred in both conventional and organic crops, and the group "omnivores that inhabit the soil and the leaf litter" showed the highest abundance of ants in both types of crops (Table 2), similarly to what was observed by Pereira *et al.* (2016). The species abundance in the functional group "omnivores that inhabit the soil and the leaf litter" was significantly higher than that of other functional groups.

It is worth emphasizing that the absolute abundance was higher in the functional groups in organic crops, which certainly resulted from the non-use of pesticides. Besides, organic crops are more heterogeneous due to the larger number of plant species, which consequently provides higher diversity of resources and a soil leaf litter of varied composition (Vargas *et al.* 2017; Amaral *et al.* 2021). For example, populations of natural enemies of agricultural pests are more abundant in heterogeneous systems (Souza *et al.* 2015), corroborating our result.

Absolute species richness was also higher for the functional group "omnivores that inhabit the soil and the leaf litter" in conventional and organic crops (Table 3). In a study by Pereira *et al.* (2016), this functional group showed the second-highest richness. Notably, the number of species in the functional group "generalist predators that inhabit the soil and the leaf litter" was significantly higher in organic than conventional crops. Thus, the possible biological control provided by these predatory ant species can be maximized in organic crops.

The diversity of functional groups did not differ significantly between conventional and organic crops (Table 4). However, the mean richness of functional groups was significantly higher in organic crops, which can be explained by their structural complexity that directly affects species richness (Lassau & Hochuli 2004; Martins *et al.* 2011). Organic crops employ sustainable practices that protect biodiversity, using no pesticides and implementing soil conservation methods, such as maintenance of leaf litter, reducing erosive processes, and often have a significant number of species being cultivated (Khatounian 2001).

The "omnivores that inhabit the soil and the leaf litter" nest, for example, in the soil, between leaves, inside branches and fruits lying on the ground, under stones and trunks, and forage in the leaf litter, on the ground and in trunks, or low vegetation (Delabie *et al.* 2000; Gomes *et al.* 2013; Baccaro *et al.* 2015). Besides being omnivorous, these ants can be generalists and opportunists, and some species can collect honeydew from sap-sucking insects (such as aphids) and feed on extrafloral nectaries (Delabie *et al.* 2000; Ré 2007; Baccaro *et al.* 2015). They can also feed on other insects, even in crop areas, and some species disperse seeds (Rossi & Fowler 2004; Almeida *et al.* 2013).

The "omnivores that inhabit the soil, the leaf litter, and the plants" are mostly ants with a predominantly arboreal habit, usually nesting in the soil, on the trunk and canopy of trees, twigs on the ground, and epiphytes (Fowler *et al.* 1991; Gomes *et al.* 2013; Baccaro *et al.* 2015). They are common in both tropical forests and crop areas and forage on the soil and vegetation. They are generalist and are often associated with honeydew-producing hemipterans, such as mealybugs and aphids (Fowler *et al.* 1991; Delabie *et al.* 2000; Bolton 2003;

Table 1. Ant functional groups and species richness in crop areas in Paraíba do Sul, Rio de Janeiro State, Brazil. Note: the ant species present in this table were also used in Estrada *et al.* (2019).

Functional groups	Ant species	Richness
Omnivores that inhabit the soil and the leaf litter	*Brachymyrmex* sp.1, *Dorymyrmex* sp.1, *Dorymyrmex* sp.2, *Linepithema* sp.1, *Pheidole radoszkowskii* Mayr, *Pheidole* sp.1, *Pheidole* sp.2, *Pheidole* sp.3, *Pheidole* sp.4, *Solenopsis invicta* Buren, *Solenopsis* sp.1, *Solenopsis* sp.2, *Solenopsis* sp.3, *Solenopsis* sp.4, *Pseudomyrmex termitarius* (Smith), *Monomorium floricola* (Jerdon), *Pogonomyrmex abdominalis* Santschi	17
Omnivores that inhabit the soil, the leaf litter, and the plants	*Dolichoderus* sp.1, *Camponotus crassus* Mayr, *Camponotus depressus* Mayr, *Camponotus maculatus* (Fabricius), *Camponotus melanoticus* Emery, *Camponotus rufipes* (Fabricius), *Camponotus* sp.1, *Camponotus* sp.2, *Camponotus* sp.3, *Camponotus* sp.4	10
Plant-inhabiting omnivores	*Cephalotes* sp.1, *Crematogaster* sp.1, *Crematogaster* sp.2, *Crematogaster* sp.3, *Pseudomyrmex* sp.1	5
Generalist predators that inhabit the soil and the leaf litter	*Ectatomma brunneum* Smith, *Ectatomma edentatum* Roger, *Gnamptogenys* sp.1, *Neoponera* sp.1, *Neoponera obscuricornis* (Emery), *Pachycondyla striata* Smith, *Odontomachus bauri* Emery	7
Fungus-growers	*Cyphomyrmex* sp.1, *Mycocepurus goeldii* (Forel)	2
Leafcutters	*Atta sexdens rubropilosa* (Linnaeus), *Acromyrmex* sp.1, *Acromyrmex* sp.2, *Acromyrmex* sp.3	4
Predatory nomads	*Labidus coecus* (Latreille), *Labidus praedator* (Smith), *Neivamyrmex* sp.1	3

Table 2. Ant absolute and relative abundance (%) in different functional groups in conventional and organic crops in Paraíba do Sul, Rio de Janeiro State, Brazil.

Functional groups	Abundance		Relative abundance (%)	
	Conventional	Organic	Conventional	Organic
Omnivores that inhabit the soil and the leaf litter	52	164	56.52	64.82
Omnivores that inhabit the soil, the leaf litter, and the plants	18	26	19.57	10.28
Plant-inhabiting omnivores	3	10	3.26	3.95
Generalist predators that inhabit the soil and the leaf litter	10	27	10.87	10.67
Fungus-growers	1	4	1.09	1.58
Leafcutters	7	19	7.61	7.51
Predatory nomads	1	3	1.09	1.19

Table 3. Ant absolute and relative richness (%) in different functional groups in conventional and organic crops in Paraíba do Sul, Rio de Janeiro State, Brazil.

Functional groups	Richness		Relative richness (%)	
	Conventional	Organic	Conventional	Organic
Omnivores that inhabit the soil and the leaf litter	15	14	51.72	36.84
Omnivores that inhabit the soil, the leaf litter, and the plants	6	7	20.69	18.42
Plant-inhabiting omnivores	3	3	10.34	7.89
Generalist predators that inhabit the soil and the leaf litter	1	7	3.45	18.42
Fungus-growers	1	2	3.45	5.26
Leafcutters	2	3	6.90	7.89
Predatory nomads	1	2	3.45	5.26

Table 4. Mean richness and diversity of ant functional groups in conventional and organic crops in Paraíba do Sul, Rio de Janeiro State, Brazil.

Variables	Conventional	Organic
Richness	3.13 ± 1.46 a	4.75 ± 0.71 b
Diversity	0.79 ± 0.36 a	1.01 ± 0.20 a

Note: means followed by different letters indicate a significant difference in the t-test, using a 5% probability to assess significance.

Baccaro *et al.* 2015; Marchiori 2020).

The group "plant-inhabiting omnivores" comprises arboreal ants, though nests may also be found at the soil-leaf litter interface (Delabie *et al.* 2000; Gomes *et al.* 2013; Baccaro *et al.* 2015). They forage in trees and shrub vegetation but can also include leaf litter. They are often omnivorous and generalists; they can be predators but also feed on extrafloral nectaries and sugary secretions excreted by hemipterans (Delabie *et al.* 2000; Baccaro *et al.* 2015; Marchiori 2020).

"Generalist predators that inhabit the soil and the leaf litter" nest in the ground, decaying wood, abandoned termite mounds and the leaf litter, including hollow branches (Delabie *et al.* 1990; Silva *et al.* 2004; Gomes *et al.* 2013; Baccaro *et al.* 2015; Pereira *et al.* 2016). They forage predominantly on the ground and leaf litter and prey on various animals, such as several arthropods, including other ants, beetles, millipedes, termites, wasps, and caterpillars. They may also exploit carcasses, sugary secretions excreted by hemipterans, extrafloral nectaries, fruits, and seeds (Hölldobler & Wilson 1990; Medeiros 1997; Peternelli *et al.* 2004; Baccaro *et al.* 2015; Almeida *et al.* 2019). Some species are important seed dispersers in the Atlantic Forest (Almeida *et al.* 2013).

"Fungus-growers" include the collected genera *Cyphomyrmex* and *Mycocepurus*. *Mycocepurus* species create nests in the soil, whereas *Cyphomyrmex* species nest in the soil, leaf litter components, and under stones, and they collect animal and plant material deposited on the soil to grow the fungi for their food (Hölldobler & Wilson 1990; Baccaro *et al.* 2015).

"Leafcutters" including the genera *Atta* and *Acromyrmex*, nest underground and are among the main pests found in crop areas in Brazil (Lima & Racca Filho 1996; Schultz & Mcglynn 2000). These ants feed on fungi that they grow with parts of leaves, fruits, seeds, twigs, and flowers cut from plants (Hölldobler & Wilson 1990; Lopes 2005; Nickele *et al.* 2013).

The group "predatory nomads" includes the collected genera *Labidus* and *Neivamyrmex*. They forage on surfaces where they prey on arthropods and collect different types of food (such as seeds and fruits). These ants are considered generalists and can considerably reduce invertebrate populations at the soil-leaf litter interface (Kaspari & O'Donnell 2003; O'Donnell *et al.* 2007; Kaspari *et al.* 2011; Baccaro *et al.* 2015).

Ecological interactions such as parasitoidism and predation are important in regulating insect population size (Aguiar-Menezes & Menezes 2005). Some ant species, which are voracious predators, may contribute to reducing the abundance of insect pests in agroecosystems (Eubanks 2001; Van-Mele & Cuc 2001). In the present study, in areas practicing conventional cultivation, we only observed a direct effect of the abundance of the ant group "omnivores that inhabit the soil, the litter, and the plants" on the abundance of coleopterans, at the limit of significance (Table 5). The increase in the abundance of these ants decreased the abundance of coleopterans.

In the analyses carried out with the data collected in organic crops, there was no significant relationship between the abundance of ants and that of coleopterans, hemipterans or orthopterans (Table 6). These results differ from those found by other authors, who observed that the abundance of potential prey was negatively related to the abundance of some ants (Delabie & Fowler 1995; Eubanks 2001).

The result obtained in conventional crops, in which the increase in the abundance of the group "omnivores that inhabit the soil, the litter, and the plants" was negatively related to the abundance of coleopterans, motivates further studies on ants as biological control agents of coleopterans harmful to agriculture, as some coleopteran species can cause considerable economic losses (Zanuncio *et al.* 1993; Santos *et al.* 1997; Pereira & Almeida 2001; Sari *et al.* 2005; Sousa *et al.* 2022). However, several Coleoptera species benefit agricultural production as they are predators and participate in nutrient cycling in the soil (Flechtmann & Rodrigues 1995; Endres *et al.* 2005; Garlet *et al.* 2015).

Although we found no significant relationships between ant abundance and individuals of the orders Hemiptera and Orthoptera, new studies can assess this interaction by focusing on populations of species of these orders that are agricultural pests. The Orthoptera Order is known for having

Table 5. Direct relationship between the abundance of ants (in general and in each functional group) and the abundance of coleopterans, hemipterans and orthopterans in conventional crops, in Paraíba do Sul, Rio de Janeiro State, Brazil.

Relationship	Coefficient of determination (R^2)	Angular coefficient	p
Ants			
Coleoptera	0.512	0.823	0.34
Hemiptera	0.130	-0.058	0.93
Orthoptera	0.717	0.376	0.58
Omnivores that inhabit the soil and the leaf litter			
Coleoptera	0.372	0.103	0.94
Hemiptera	0.165	0.562	0.71
Orthoptera	0.825	1.140	0.16
Omnivores that inhabit the soil, the leaf litter, and the plants			
Coleoptera	0.764	-0.672	0.06
Hemiptera	0.519	0.660	0.15
Orthoptera	0.707	-0.134	0.67
Generalist predators that inhabit the soil and the leaf litter			
Coleoptera	0.554	0.557	0.27
Hemiptera	0.134	-0.058	0.93
Orthoptera	0.771	0.367	0.30

Table 6. Direct relationship between the abundance of ants (in general and in each functional group) and the abundance of coleopterans, hemipterans and orthopterans in organic crops, in Paraíba do Sul, Rio de Janeiro State, Brazil.

Relationship	Coefficient of determination (R^2)	Angular coefficient	p
Ants			
Coleoptera	0.394	0.035	0.93
Hemiptera	0.428	-0.173	0.67
Orthoptera	0.561	0.486	0.22
Omnivores that inhabit the soil and the leaf litter			
Coleoptera	0.414	0.151	0.72
Hemiptera	0.474	-0.284	0.49
Orthoptera	0.428	0.326	0.45
Omnivores that inhabit the soil, the leaf litter, and the plants			
Coleoptera	0.403	-0.108	0.81
Hemiptera	0.528	0.387	0.36
Orthoptera	0.452	0.379	0.40
Generalist predators that inhabit the soil and the leaf litter			
Coleoptera	0.434	-0.208	0.62
Hemiptera	0.407	-0.091	0.83
Orthoptera	0.405	0.281	0.51

several species that cause considerable damage to pastures and crops, resulting in significant economic losses (Cigliano *et al.* 2000, 2002; Lange *et al.* 2005; Guerra *et al.* 2012; Mariottini *et al.* 2012), likewise the Hemiptera Order (Silva & Athayde Sobrinho 2017; Cruz 2018).

Thus, organic crops are more favorable for maintaining an ant fauna with higher functional diversity than areas practicing the conventional cropping system. This fact results from the non-use of synthetic insecticides in organic crops and other characteristics of this cropping system, such as the presence of a larger number of crop species and greater leaf litter depth (Estrada *et al.* 2019). In addition, the abundance of typically predatory ants is higher in organic than in conventional crops. Predatory ants are relevant for the biological control of insect pests, which shows the importance of not eliminating predatory insects with insecticides.

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