EntomoBrasilis
e-ISSN 1983-0572

Ecology

Ant diversity (Hymenoptera: Formicidae) in two districts in the municipality of Barreiras-BA

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EntomoBrasilis 15: e974 (2022)

Abstract. In recent years, attention has focused on studies about myrmecofauna in urban environments, due to its high possibility of causing damage to food storage and household structures. Thus, the objective of this study was to identify the genera of ants and analyze their frequency and diversity in two neighborhoods in the municipality of Barreiras-BA. The study was conducted in Riachinho neighborhood, located on the edge of the urban perimeter and in Renato Gonçalves neighborhood in the central area of the city. The ants were collected weekly, using trap baits, in 180 houses, from November 2016 to April 2017. The collected ants were transported to the Zoology and Entomology Laboratory (LaZooEn) in the Universidade do Estado da Bahia, Campus IX. For identification, stereomicroscope and dichotomous key were used. A group of 14,846 ants were collected, of which 9,686 were collected in Renato Gonçalves neighborhood, and 5,160 in Riachinho neighborhood. Three subfamilies were identified, which included ten genera, being *Paratrechina, Brachymyrmex and Tapinoma* were among the most frequent. *Paratrechina* was the most representative (85.32%) in Riachinho, and *Brachymyrmex,* the most frequent in Renato Gonçalves (54.40%). The accumulation curves obtained were satisfactory in both areas, higher than 80%. Regarding Shannon index, it was found that Riachinho presented a lower diversity (H'= 0.663) than in Renato Gonçalves neighborhood (H'= 0.875). Studies addressing the occurrence of myrmecofauna may be paramount to collaborate with conservation practices both in the case of threatened species and for pest control practices.

Keywords: Cerrado; Habitat; Hexapoda; Household; Urbanization.

Edited by:
William Costa Rodrigues

Article History:
Received: 18.x.2021
First Answer: 25.xi.2021
Accepted: 14.xii.2021
Published: 26.i.2022

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Funding agencies:
Without funding declared

EntomoBrasilis Update Check

doi: 10.12741/ebrasilis.v15.e974

Ants are classified as eusocial insects and are inserted in a single family (Formicidae). Currently, almost 15,800 valid species, 24 subfamilies and 505 genera are known. Brazil has the greatest ants diversity across the Americas and one of the largest in the world, with 1,541 valid ant species known, distributed in 13 subfamilies and 118 genera (AntWeb 2021). These insects are especially important organisms in the terrestrial ecosystems' performance, since they are present in almost all possible habitats (Gallego-Ropero *et al*. 2013). Furthermore, they can occupy both natural and also environments that have undergone anthropic activity (Bicho *et al*. 2007).

In urban spaces, more specifically inside housing, small openings such as tiles, window trim and doorframes shelter ant nests, while in green spaces, such as gardens, nesting is found under leaves and openings in tree trunks (Soares 2005; Solis *et al*. 2007). The relevant diversity and abundance of ants in virtually all terrestrial environments turn them into ideal organisms for rapid inventories and monitoring programs (Freitas *et al*. 2006).

In recent years, attention has been turned to myrmecofauna studies in urban environments (Prezoto *et al*. 2017), due to its high possibility of causing damage to food storage and affecting housing structures (Bueno & Campos 2017), as also in various household objects (Costa *et al*. 2010). Hence, it is necessary to analyze the occurrence of ants in different types of urban environments, besides understanding the risks that they can offer in housing. For instance, ants belonging to Camponotus genus are common inside houses, causing damage to residential structures and appliances (Bueno & Campos 2017). Thus, the aim of this study was to identify the ant genera and analyze their frequency and diversity in households in two neighborhoods in the city of Barreiras-BA.

MATERIAL AND METHODS

The present study took place in the city of Barreiras-BA (12°09'10"S / 44°59'24" W) located in the extreme west of Bahia. Intended for the development of the research, two urban neighborhoods were selected, one in the central area, called Renato Gonçalves (12°09'15" S / 44°59'38" W), and another one in the neighborhood named Riachinho (12°8'28' 'S / 44°54'33" O), which is located on the edge of the urban perimeter and is located at 11.8 km apart from the first neighborhood (Figure 1).

Renato Gonçalves neighborhood (Figure 2) was chosen since there is a larger paved area with high buildings, commercial areas and an afforestated structure, in addition to the presence of green areas around the residences. Riachinho neighborhood (Figure 3) is an area integrated into the urban perimeter, whereby there is still no asphalt pavement. Nevertheless, it has a larger vegetation area (trees, shrubs and pastoral activity), as there are

Figure 1. Distance between Renato Gonçalves and Riachinho neighborhoods, Barreiras-BA, 2016. Source: Google Earth.

Figure 2. Renato Gonçalves neighborhood located in the central area of Barreiras-BA municipality, 2016/2017. Photos: Santos, J. 2016/2017.

rural properties that surround it. The buildings are made of simple masonry (slabless houses; no ceramic floor; external bathroom; presence of wire and/or wood fence delimiting the residences) and there is a restricted commercial area.

In order to survey myrmecofauna, 18 collections were carried out in each of the neighborhoods from November 2016 to April 2017. As to capture the ants, applying the bait trap model used by Soares *et al* (2006), was necessary.

The collection was carried out three times a month in five houses chosen randomly in each neighborhood, comprising a total of 180 houses sampled. For making the traps, a 10 cm height glass container was used, which was covered by a plastic lid, which center was perforated within a 1.5 cm diameter. In the center of this plastic lid, a plastic tube was placed, about 6.5 cm of height, which could not reach the bottom of the container (Figure 4). The liquid bait, made using a sugary chamomile solution, was placed inside the container (Figure 4) and subsequently, each trap was placed in the residences, in the following rooms: kitchen, bathroom, living room and bedrooms. Those traps were kept in the

Figure 3. Riachinho neighborhood located in urban area of Barreiras-BA municipality, 2016/2017. Photos: Santos, J. 2016/2018.

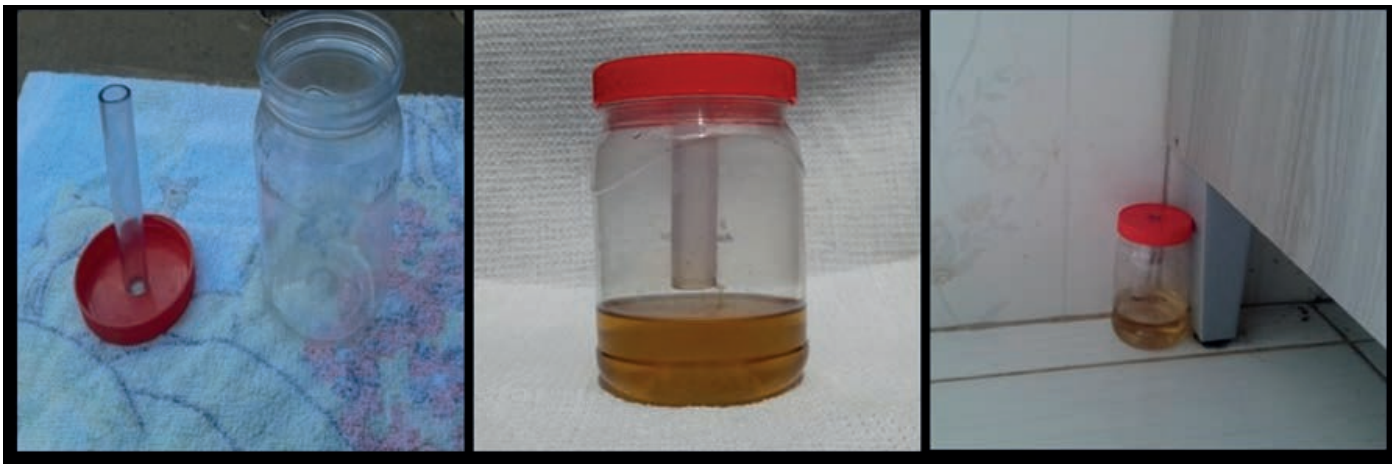

Figure 4. Trap used to collect ants in residences located in Renato Gonçalves and Riachinho neighborhoods, Barreiras-BA municipality, 2016/2017. Photos: Santos, J. 2016/2017

rooms for a period of 24 h (Figure 4).

The ants were collected and transported to the Zoology and Entomology Laboratory-LaZooEn, Universidade do Estado da Bahia-UNEB, Campus IX. For identification at the genus level, a stereomicroscope and the dichotomous key by Baccaro *et al.* (2015) were used, after that they were kept in the laboratory as voucher material.

Relative and absolute frequencies were utilized to show the genera occurrence and Shannon's index (H') was chosen in order to assess the diversity parameters between the neighborhoods. As for testing the results found in both areas, Mann-Whitney U Test was applied, since the data stated did not follow a normal distribution. Excel® software spreadsheets were used in the analysis of relative and absolute frequencies, Mann-Whitney and diversity index. The study collections sufficiency was verified by means of accumulation curves, applying EstimateS® software, version 9.1 (Colwell *et al*. 2012) and the used estimators were CHAO 1 and ACE.

RESULTS AND DISCUSSION

A total of 14,846 ants were collected, 5,160 in Riachinho area and 9,686 in Renato Gonçalves area, distributed into three subfamilies (Formicinae, Myrmicinae and Dolichoderinae) and 10 genera (Table 1).

The accumulation curves obtained had efficient collections in both neighborhoods, that is, the sampling effort was sufficient to sample the set of ant genera. CHAO 1 and ACE indexes for Riachinho showed 100% efficiency in both indexes (Figure 5), while the efficiency in Renato Gonçalves was 97.30% and 87.63%, respectively (Figure 6). When investigating the literature, it was not possible to find current studies that work at the genus level, what there has been about ant studies in urban areas are surveys at the species level, which also were efficient in their sampling. For instance, on an island in Florianópolis, an ant survey was carried out with 80 species, and the accumulation curve found was 95.93%, considered sufficient (Cereto *et al*. 2009). Another example is that in Miranda *et al*. (2006) who also found a satisfactory sampling effort using attractive baits (sardines and honey), in a myrmecofauna study (with 26 species), carried out in *Araguari* local park, located in an urban area. Iop *et al*. (2009) evaluated myrmecofauna present in residences and commercial areas (67 species) in Xanxerê municipality, Santa Catarina State and the estimated values of ant richness were satisfactory, since the accumulation curves (67 and 74.12 %) showed a stability approximation.

The most expressive subfamily in terms of number of individuals was Formicinae, followed by Dolichoderinae and Myrmicinae (Figure 7). Formicinae with its 13,945 individuals is distributed in the following genera: *Camponotus*, *Nylanderia*, *Brachymyrmex* and *Paratrechina* in both neighborhoods. Among them, *Paratrechina* stood out with the largest number of individuals in Riachinho.

Myrmicinae showed the greatest diversity of genera (Table 1), with *Pheidole* and *Ochetomyrmex* being found only in Renato Gonçalves, while *Tetramorium* only occurred in Riachinho. The genera *Wasmannia* and *Monomorium*, in turn, were found in both studied neighborhoods. The subfamily Dolichoderinae was represented only by the genus *Tapinoma*, which had the highest absolute frequency in Riachinho.

Using a collection technique (Pitfall) and a different environment, Oliveira *et al*. (2016), when comparing the edaphic myrmecofauna in three successional stages of Atlantic forest (forest, scrub and pasture), they identified 1,157 ants, distributed in 14 genera. Myrmicinae presented a total of 283 (24.46%) ants, grouped into five genera, nevertheless, Formicinae subfamily was the most abundant, with 371 (32.06%) individuals, represented by *Camponotus* genus (Table 1). Baiotto *et al*. (2015) carried out a study in three points of Northwest Regional University of State of Rio Grande do Sul. The area close to the Veterinary Hospital entrance, one of the points, had the highest number of ants. A total of 274 ants were registered, with 84 (30.65%) representing Myrmicinae subfamily and 92 (33.57%), Formicinae. This area presented greater availability as food source and nesting site. The study was conducted over an 11-day period, with 3-4 days intervals between collections, which may justify the discrepancy with the current study (Table 1). Baccaro *et al*. (2015) explain that Formicinae is a subfamily that holds genera with a wide abundance of individuals and that these are extremely easy to be collected. Such characteristics may justify the high diversity of Formicinae in the present study.

According to some authors (Ramos *et al*. 2003; Dorval *et al*. 2017), in areas of Cerrado, the presence of Myrmicinae ants has a high occurrence rate, followed by the subfamily Formicinae. This abundance is due to the fact that they are two subfamilies with easy adaptation to different types of

Table 1. Absolute (F. A.) and relative (F. R.) frequency of collected insects in housing environments in Riachinho and Renato Gonçalves neighborhoods, Barreiras-BA municipality, throughout the period of November 2016 and April 2017.

Subfamily	Genus	Riachinho		Renato Gonçalves		Total F.A.	Total F.R.
		F. A.	F.R.	F.A.	F.R.		
Formicinae	*Camponotus*	118	2.28	53	0.54	171	1.15
	Nylanderia	3	0.05	2	0.02	5	0.03
	Brachymyrmex	85	1.65	5,273	54.40	5,358	36.09
	Paratrechina	4,402	85.32	4,009	41.35	8,411	56.65
Total	**04 genus**	**4,608**	**89.3**	**9,337**	**96.31**	**13,945**	**93.92**
Dolichoderinae	*Tapinoma*	238	4.62	221	2.25	459	3.10
Total	**01 genus**	**238**	**4.62**	**221**	**2.25**	**459**	**3.10**
Myrmicinae	*Monomorium*	35	0.68	2	0.02	37	0.02
	Wasmannia	166	3.21	1	0.01	167	1.13
	Tetramorium	113	2.19	-	-	113	0.76
	Ochetomyrmex	-	-	115	1.18	115	0.78
	Pheidole	-	-	10	1.03	10	0.07
Total	**05 genus**	**314**	**6.08**	**128**	**2.24**	**442**	**2.76**
Total		**5,160**	**100**	**9,686**	**100**	**14,846**	**100**

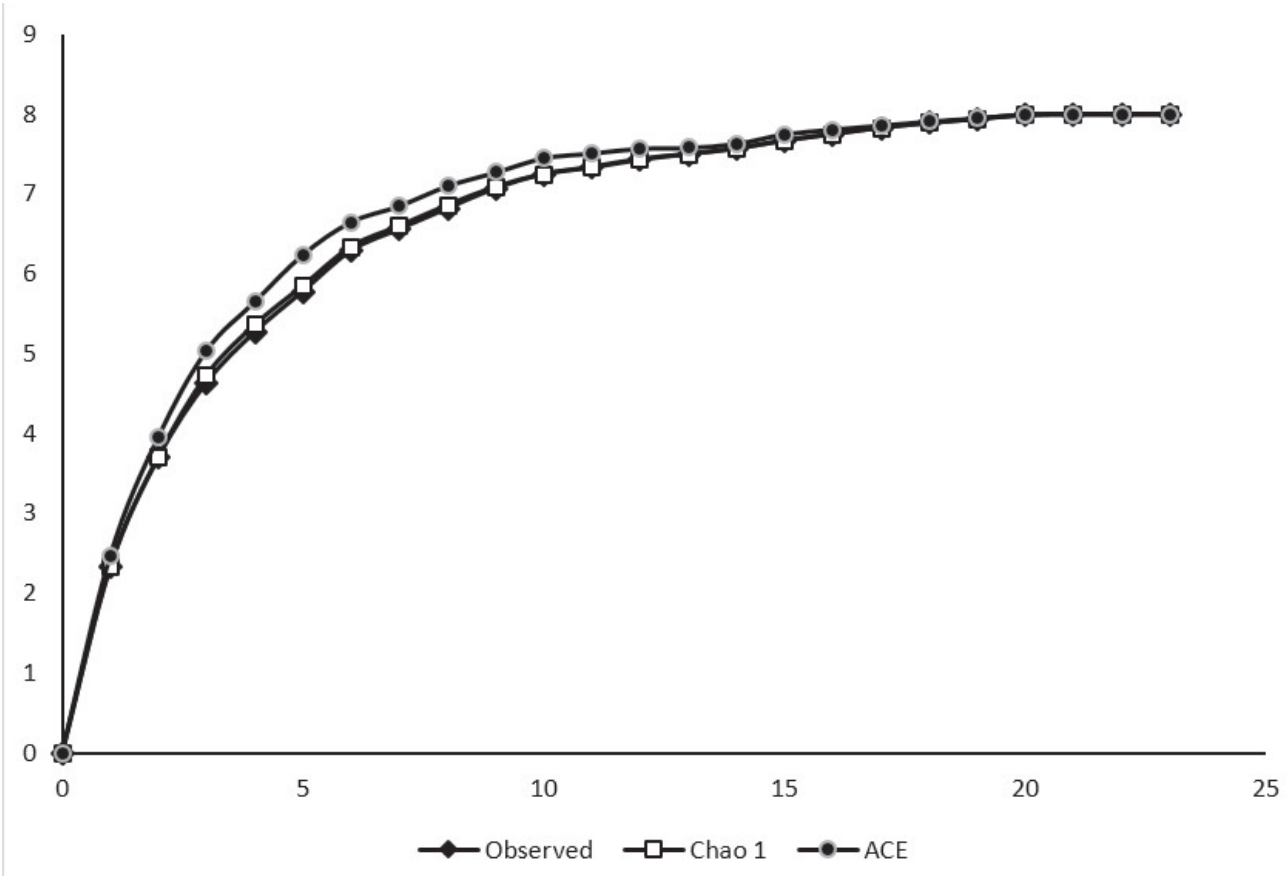

Figure 5. AntAnt collection accumulation curve in Riachinho neighborhood, 2016/17 in Barreiras-BA municipality. The curve was produced by EstimateS software (Colwell *et al.* 2012).

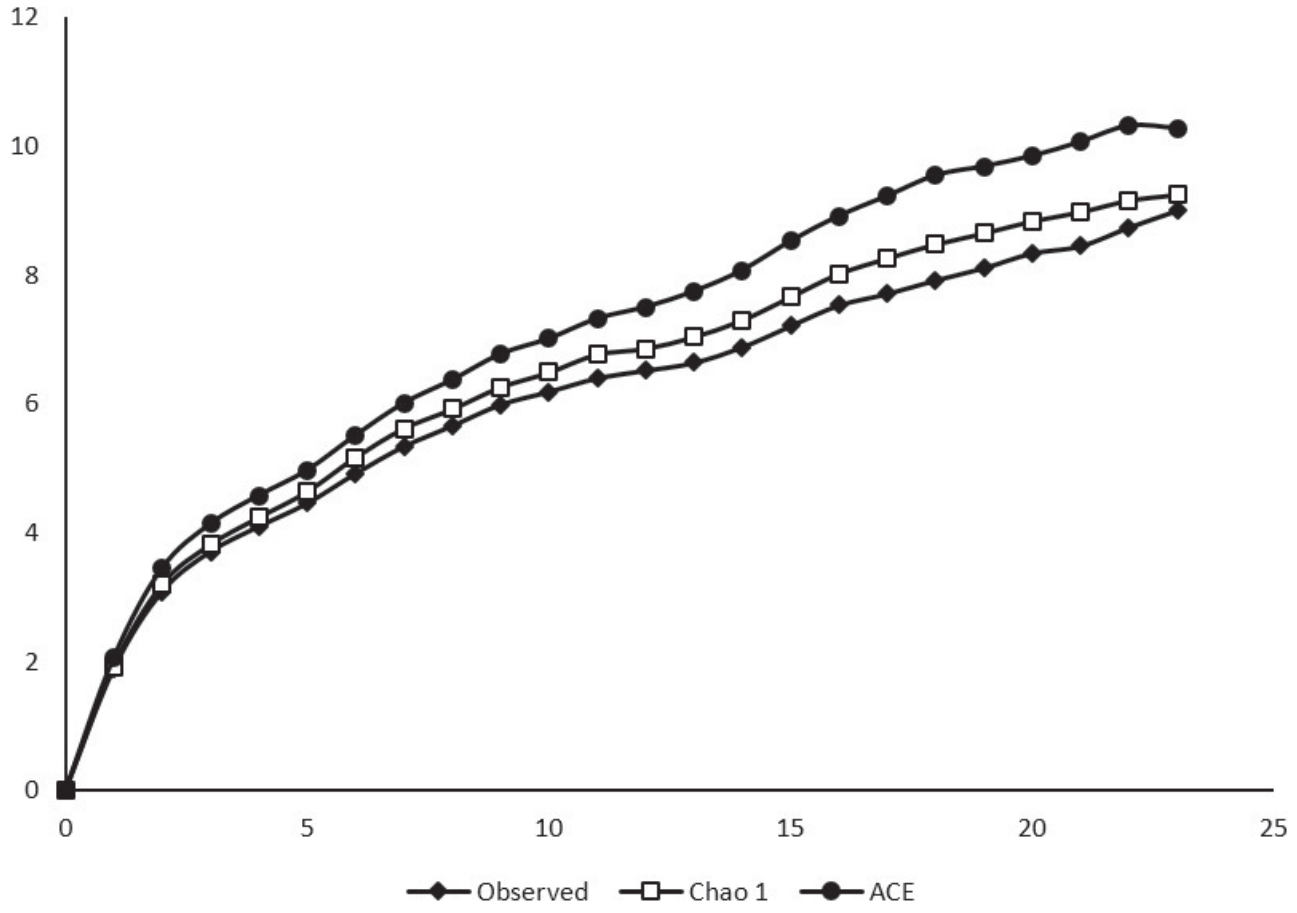

Figure 6. Ant collection accumulation curve in Renato Gonçalves neighborhood, 2016/17 in Barreiras-BA municipality. The curve was produced by EstimateS software (Colwell *et al.* 2012).

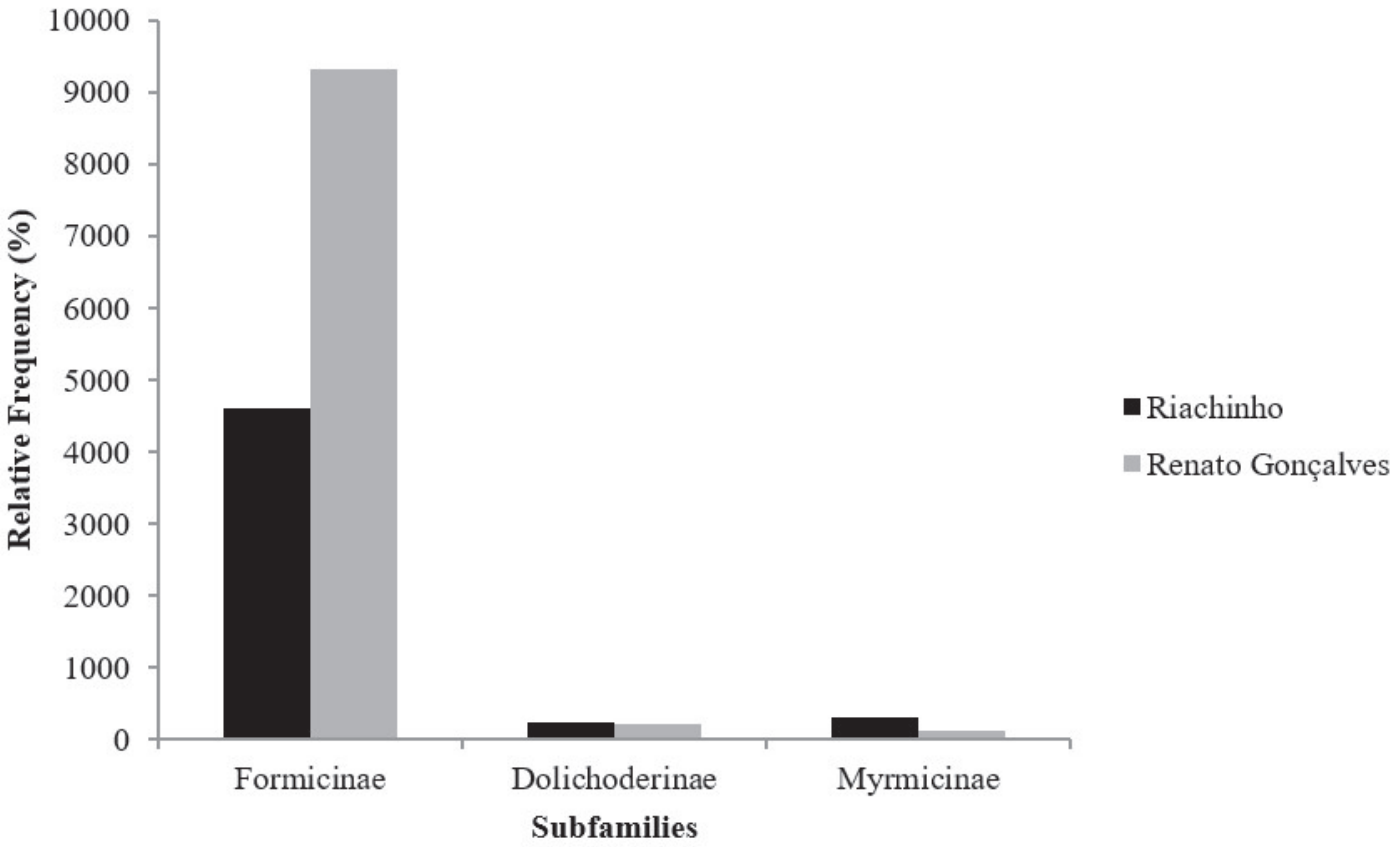

Figure 6. Ant subfamilies relative frequency (%) in Riachinho and Renato Gonçalves neighborhoods, Barreiras-BA, throughout the period of November 2016 and April 2017.

environments. Just as this study identified Myrmicinae and Formicinae standing out in numbers of individuals, a survey carried out by Oliveira & Campos-Farinha (2005) pointed out these taxo groups as being the most frequent in household areas. According to Bueno & Campos (2017), the urban environment has its own abiotic factors, which biologically benefits the appearance of many animal species, including hundreds of ant species, mainly due to the high human concentration and water and food availability.

The genera with the highest relative frequency were *Paratrechina* (56.65%), *Brachymyrmex* (36.09%) and *Tapinoma* (3.10%) (Table 1), which are characterized as opportunistic and even urban pests (Castro *et al*. al. 2014; Baccaro *et al*. 2015). In addition to the wide food supply, other factors contribute to the occurrence of these insects inside residences, such as size, number of workers in recruitment, nesting space and ease of inhabiting different types of environments (Cintra-Socolowski & Bueno 2017). The presence of *Paratrechina*, *Brachymyrmex* and *Tapinoma* in the housing environment was also described by Soares *et al*. (2006), when carrying out a survey of ants' diversity in the municipality of Uberlândia, in Minas Gerais State. These individuals are easy to adapt to highly anthropized areas and can be found both in low-vegetated forest environments and in households (Baccaro *et al*. 2015; Rocha *et al*. 2015).

According to Baccaro *et al*. (2015) and Bueno (2017), *Paratrechina*, which in the present study showed the highest relative frequency (Table 1), is a cosmopolitan genus that inhabits both disturbed natural environments and urban spaces. These insects usually build their nests outside infested places, such as in home gardens, recruiting large numbers of workers and a colony can comprise several queens (Cintra-Socolowski & Bueno 2017; Herrera *et al*. 2020). According to Júnior (2017), its presence is common in environments such as soil, vegetation in houses, parks and urban fragments. As for Baccaro *et al*. (2015), these are opportunistic ants, which feed on leftover fruit and household food.

Cintra-Socolowski & Bueno (2017) highlight that *Brachymyrmex* are reduced-size ants (0.2 to 0.4 mm; Suguituru *et al*. 2015), as well as the genus *Paratrechina* (0.2 to 0.5 mm; Baccaro *et al*. 2015). They are insects with several queens and also recruit a large number of workers. *Brachymyrmex* nests can be found on tiles or on cabinet and/or door frames. Due to their easy adaptation in different environments, the occurrence of these insects is common both in vegetation areas with different levels of degradation, as well as in an urban environment (Rocha *et al*. 2015; Lutinski *et al*. 2017). Silva & Loeck (1999) pointed out this same genus with a high rate of infestation inside the sampled households in the city of Pelotas, Rio Grande do Sul State. According to the authors, among the genera collected in the research, *Brachymyrmex* stood out, being found indoors and outdoors. It is noteworthy that in the present study, the collections were carried out only inside the houses. Lutinski *et al*. (2017) explain that the size of these insects and the foraging activity in large numbers of individuals favors dominance by food source and nesting in indoor and outdoor areas of urban environments.

The genus *Tapinoma* for having a tiny size, ranging from 0.1 to 0.5 mm and due to the colorless gaster coloration, they can go unnoticed (Carvalho *et al*. 2011; Cintra-Socolowski & Bueno 2017) indoors, which explains the frequency of these insects in the areas studied. According to Melo & Dellabie (2017), *Tapinoma* ants occur in more than 50% of cities and are considered invasive, due to the ease of being found in a greater number of habitats.

As for the samples collected in Riachinho and Renato Gonçalves neighborhoods (U=47; p >0.001), there was no significant difference, that is, the location (neighborhoods) did not influence the occurrence of ants during the study. In a survey carried out in the urban perimeter of Juiz de For a city Minas Gerais State, with the same statistical test used (Mann-Whitney U Test), it also showed that there was no significant difference for the samples taken. The research took place in urban areas where a comparison was made between three squares close to the urban center and another three in more

distant places (Vital 2007). Ant diversity in paved areas is probably due to species considered opportunistic, sensitive to disturbance from urbanization (Morini *et al*. 2007; Vital 2007).

Thus, even if the homes have different physical structures, nesting construction inside housings will not be affected, as a significant number of ants was found between the neighborhoods. Thus, the location of the studied areas does not interfere with the occurrence and propagation of these insects within the residences (Soares 2005).

Riachinho neighborhood (H´= 0.663), presented lower diversity than Renato Gonçalves neighborhood (H´= 0.875). Roani *et al*. (2019), explain that the result of diversity is due to the sampling effort. This and other factors such as the used methodology, and the environment for collection can interfere in the ant richness. Here, the sampling effort was sufficient (Figures 5 and 6), which highlights the low diversity of urbanized environments.

According to Prezoto *et al*. (2017), many animals are forced to live off the resources offered by anthropized environments. This fact is due to the partial or complete loss of their habitats, whether conserved or restored urban areas, where they take full advantage of the shelter and food provided by human beings.

Renato Gonçalves neighborhood was the one presenting the highest number of genera, probably because of the offer of shelter and food in the same area. The presence of gardens around the houses, as well as the availability of food inside the houses, may be factors that contribute to the growth of the ant population.

Pacheco *et al*. (2017), report that the lack of natural predators facilitates the spread of these insects in urban spaces. This characteristic can justify the result found in the studied areas, where, in Renato Gonçalves neighborhood, as it is an area located in the center of the city, the presence of natural enemies may be smaller. Riachinho neighborhood, where the number of ants found was lower, has a high level of secondary vegetation, which facilitates the presence of natural enemies, and consequently may lead to a low occurrence of ants.

Bueno & Campos (2017), also point out that many urban ants inhabit extremely clean spaces, having difficulties to live in dirty environments, which characterizes them as indicators of cleanliness. This may justify the greater number of ants in Renato Gonçalves neighborhood, since, as this is an area located in the central region of the city, solid waste collection takes place more frequently (three times a week), while that in Riachinho neighborhood, where collection is carried out once a week, according to the locals.

Another aspect that can be considered is the use of chemical products in an attempt to reduce insect infestation problems. On the other hand, it is important to know the feeding habits of a given species of ant, as some genera such as *Paratrechina* and *Bachymyrmex* are hardly controlled with the use of insecticides (Cintra-Socolowski & Bueno 2017).

Some genera described in this research, such as *Paratrechina*, *Monomorium*, *Nylanderia*, *Pheidole* and *Wasmannia* have species considered invasive, tolerant to disturbances and can be commonly found in urban environments (Lutinski *et al*. 2014). Jaime (2010) points out that the lack of asphalt pavement and the presence of gardens can increase ant species richness. Differing to this study, the most diverse neighborhood observed in this research, Renato Gonçalves, has gardening and asphalt paving, while Riachinho, less diverse, the streets are not yet paved.

Studies that address myrmecofauna can be essential not only for understanding their natural histories, but also for collaborating with conservation practices both in the case of endangered species and for pest control practices, such as invasive species.

Caldart *et al*. (2012) emphasize that studies on urban ants are of special interest, as they make it possible to list the species that live in these environments, and to assess the impact of urbanization process on myrmecofauna. Thus, the results of this study show the importance of keeping myrmecological research in an urban area in the city of Barreiras-BA, contributing to greater information and understanding about ant communities.

ACKNOWLEDGEMENTS

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