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Formigas da serapilheira do Parque Estadual Papagaio Charão, Rio Grande do Sul, Brasil.

Litter ants of the Parrot Charão State Park, Rio Grande do Sul, Brazil

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Resumo

A fragmentação conduz à perda de espécies nas comunidades biológicas, o que faz com que a seja considerada uma das maiores ameaças à biodiversidade. As formigas, presentes em praticamente todos ambientes terrestres, contribuem para o equilíbrio dos ecossistemas. O nosso objetivo foi verificar se existem diferenças na composição de formigas de serrapilheira em um gradiente da borda para o centro do fragmento. O estudo foi realizado no Parque Estadual Papagaio Charão, localizado em uma região de Mata Atlântica. Selecionamos cinco áreas, iniciando da borda do fragmento ao centro, para a instalação dos coletores de insetos de solo (pitfall). Em cada área dispomos de quatro conjuntos contendo três coletores, totalizando 60 amostras. Cada área se distanciou 100 m uma da outra. Dispomos, em cada área, aleatoriamente 10 amostradores para a coleta da serrapilheira. Registramos 549 formigas, distribuídas em 34 espécies e em seis subfamílias. Myrmicinae apresentou maior riqueza e abundância. A predominância funcional foi de espécies onívoras. A composição de espécies diferiu entre as áreas amostradas, entretanto a serrapilhaira não diferiu. Maior riqueza e abundância de espécies relacionadas a áreas perturbadas pode ser um indicador do estado de conservação da área de estudo.

Palavras-chave

Dieta. Formicidae. Mata Atlântica. Mirmecofauna.

Abstract

Litter ants of the Parrot Charão State Park, Rio Grande do Sul, Brazil.Fragmentation leads to loss of species in biological communities, which is considered one of the greatest threats to biodiversity. The ants contribute to the balance of tropical ecosystems, once they are present in all terrestrial environments. Our goal was to check whether there are differences in the composition of ants of the litter in a gradient from the edge to the nucleus of the forest fragment. The study was conducted at Parrot Charão State Park located in a region of the Atlantic Forest. We selected five areas, starting from the edge of the fragment to the nucleus, for the installation of the pitfalls. In each area we have four sets containing three collectors, totaling 60 samples. These areas were separated 100 m apart from each other. We had, in each area, randomly 10 samplers for litter collection. We recorded 549 ants, distributed in 34 species and six subfamilies. Myrmicinae showed the highest richness and abundance. The predominance of omnivorous species was functional. The species composition differed among the sampled areas, however the litter did not differ. The richness and abundance of species related to disturbed areas can be an indicator of the state of conservation of the studied area.

Keywords

Atlantic forest. Diet. Formicidae. Mirmecofauna.

1. Introduction

The fragmentation leads to loss of species in biological communities, which is considered one of the greatest threats to biodiversity (Fahrig, 2003). This habitat loss is responsible for a number of negative impacts, such as increased extinction probability, decreased richness and abundance, and changes in species distribution in forest fragments (Fahrig, 2003), and may affect the communities through changes in interactions among species (Schultz and McGlynn, 2000). The interior of the fragments can provide microhabitats with climatic and trophic conditions more appropriate for species survival than surrounding areas (Staab et al., 2014; Andersen 2018).

Currently, 27.000 ant species are described, being 6.160 recorded for the Neotropical region (Bolton, 2019). Ants contribute to the balance of tropical ecosystems, once they are present in practically every terrestrial environment, but it is in the Neotropical region that this group presents greater abundance, frequency and diversity (Baccaro et al., 2015; Bolton, 2019). Due to their diversified diet and innumerable interactions with animals, plants and fungi, ants actively participate in ecological relations with other organisms, as well as in the processes of energy flow and nutrient cycling (Schultz and McGlynn, 2000; Rosumek, 2017). Ants can also be considered bioindicators of environmental quality because they have high local and global species richness, are easily sampled in a standard way, have ecological importance, and have their diversity related to several other biotic components (Ribas et al., 2012; Tibcherani et al., 2018). The species of Formicidae are highly diversified, have numerical and biomass dominance in almost all terrestrial habitats, are easily identified in terms of species/morphospecies and usually have stationary nests that allow for resampling over time (Alonso and Agosti, 2000; Blüthgen and Feldhaar, 2010).

Theoretically, environments with greater structural complexity harbor greater species richness because they provide greater diversity of ecological niches, related to the availability of food resources and nesting. In tropical environments, factors such as vegetation structure, litter biomass, climatic and microclimatic conditions and environmental degradation, have been related to the richness and abundance of ant communities (Pianka, 2012; Suguituru et al., 2013; Cantarelli et al., 2015; Rocha et al., 2015; Silva et al., 2017) . Ants in general are considered omnivores, eeding on a combination of live prey, dead animals, seeds and plant exudates, with some specialized behaviors such as fungus cultivation and pollen consumption (Blüthgen and Feldhaar, 2010).

The litter heterogeneity can influence the ant community in different ways, depending on the type of habitat, such as edge or forest interior (Silva et al., 2011). Forest edges provide microclimatic changes that affect the structure of fragments (Magnago et al., 2015). Heterogeneity of the vegetal community, provides a litter more rich, with higer food abundance between fruits, seeds, microorganisms and preys (Staab et al., 2014).

Therefore, we expect the litter composition to reflect differences in ant species composition found on a gradient of the forest edge toward the nucleus of the fragment. In this way, the objective of this study was to compare the composition of ant species in the litter, from its edge to its nucleus of a fragment of Mixed Ombrophilous Forest in the middle north of the state of Rio Grande do Sul, southern Brazil.

2. Materials and methods

Study area

Our study was realized in the Parrot Charão State Park (PCSP) (27°54'49''S, 52°48'52''W), a phytoecological region of the Mixed Ombrophilous Forest (MOF) inserted in the Atlantic Rainforest biome. The Park is located 14 km from the municipality of Sarandi and has 1000 hectares. The climate of the region is humid temperate with hot summers (Cfa/Köppen-Geiger). The mean annual temperature is 19.4°C, the mean annual rainfall is 1765 mm (Wrege et al., 2011) and the mean altitude of the region is 508 m.

The park is located in a region of slightly undulating ground, having larger slopes close to water bodies. In sampled environments, flat to slightly undulated grounds were predominant, being chosen by the presence of a vegetation cover typical of MOF, with different vegetative strata in good phytosanitary status, and described as follows: Area 1 (A1): edge of the Park with presence of arboreal canopy (with araucarias and juvenile trees), scarce sub-forest and herbaceous stratum with characteristics of anthropic pressure through selective removal of arboreal species. This area was located in the bordering portion of the Park, next to an access road to neighboring farms (dirt road). On the other side of the road there was a soybean crop. Area 2 (A2): MOF, similar to area 1. Area 3 (A3): open (possible previous disturbance) with sparse large trees, with no bushy stratum. Soil covered with herbaceous stratum of non-forest grasses (formed almost exclusively from a species of Poaceae). In most of this area there was little shading and the sunlight was present up to the herbaceous stratum. Area 4 (A4): composed almost exclusively of large and old bamboos. This was the shadiest area. Area 5 (A5): central region of the forest, presence of characteristic MOF, with arboreal canopy, sub-forest more developed than area 1, and herbaceous stratum even more scarce, characterizing interior forest.

Sampling procedures were conducted for six days in January 2016. In each area a line was drawn where the pitfalls were inserted. Soil insect collectors were installed in each line in the five areas previously defined, which were spaced 100 m from each other in an edge-nucleus orientation. Four sets containing three insect collectors were placed in each line, totaling 60 pitfalls. These sets were 25 m apart, and the collectors of each set were at a distance of 50 cm (Figure 1). Pitfalls were made using 5 L plastic bottles, that were cut in the top portion, which was placed face down, forming a funnel in the body of the bottle. Then, bottles were buried into the ground, filled with 250 ml of alcohol 70% and left exposed for 24 hours. On the first day of collection a pitfall set was installed. On the second day the biological material from this set was removed and the second line set was installed. This procedure was repeated until the collection of the fifth set of insect collectors in the core of the fragment. During the sampling period the average temperature was 22.9ºC and the rainfall was 17 mm.

The collected material (authorization Sisbio 34807-2) was identified using specialized bibliography (Baccaro et al., 2015) and the aid of specialist taxonomists. Ant specimens were deposited in the Entomological Collection (CEUPF) of the Augusto Ruschi Zoobotanic Museum, at the University of Passo Fundo.

Litter samples

In each area, 10 wood frames (with internal area of 0,5 m x 0,5 m) were randomly disposed, totaling 50 samplings. Each set of two wood frames was distant from another set in

25 m, this distance was used to reduce a potential effect of pseudo spatial repetitions, maintaining a minimum of 10 m of streams or pools to avoid their effect on the ant community. All the litter contained inside the frames where collected using garden shovels. The litter was accommodated in a bag and identified for later drying. Drying was performed in an oven at 65°C until dry weight stabilization. Before and after drying all samples were weighed using a digital scale. After drying the soil present in samples was discarded. The collection of litter was concomitant with ant samplings.

Data analysis

To analyze the richness of the ant species collected in pitfalls, the following procedures were used: non-parametric estimators ICE, CHAO 1 and Jacknife of the first-order and species rarefaction curves, with 1000 randomizations, run in EstimateS 9.1 (Colwell, 2013). For this, each pitfall was considered a sample unit.

In order to evaluate possible differences in ant species composition among the different sampled areas and the measured litter mass, a multivariate analysis of variance by permutation (PERMANOVA) with paired test was used, based on Bray Curtis distance, with 10.000 permutations and level of significance of 5% ($\alpha = 0.05$). Bonferroni correction method was used for the paired test. All these analyzes were performed in R environment using the Vegan package.

3. Results

A total of 549 ant specimens were collected, distributed in 34 species and six subfamilies (Table 1). Myrmicinae showed higher richness (n = 13, 38.2%), Formicinae presented 10 species (29.4%), Ponerinae six species (17.6%), Dolichoderinae and Pseudomyrmecinae with two species each (5.8%) and Ectatomminae with a single species (2.9%). Myrmicinae also presented higher abundance (n = 170). We sampled 29.4% of species with only one individual, 12% of which were found in area 2, where the largest number of species was recorded (n = 19). The richness of ants was descending from the edge to the central region (n=7), being that the area 2 (n=19) showed the bigger richness (Table 1).

The functional predominance was of the omnivorous (50%) and predatory/omnivorous species (35%). We recorded 64.7% of species with a single trophic guild (Table 1). The species composition was significantly different among sampled areas, and area 5 differed from areas 1, 2 and 4 ($p < 0.05$), but did not differ from area 3 (Table 2).

The litter showed a humid weight of the 49.343 kg and dry weight of the 14.143 kg, representing 28.66% of the original weight. Leaves and twigs totaled 11.033 kg (78.01%) and 3.110 kg (21.99%), respectively. Seeds, fruits and flowers, were added to leaves once their representativeness in litter was insignificant (99 grams), being identified in only 16% of the samples. The litter showed no significant difference among the sampled areas ($p < 0.05$).

The rarefaction curves did not reach the asymptote (Figure 2), indicating the possibility of increased richness in the area with increased sample effort. The ICE estimated 55.33 species, Chao 1 estimated 45.23 species and Jacknife 1 estimated 48.75.

4. Discussion

The fauna of ants registrated by us contrast with others studys in the southern Atlantic Forest biome, that presented the rich and abundance of ants highr than found in PEPC (Martins et al., 2011; Cantarelli et al., 2015). However, Myrmicinae was dominant, with similar pattern observed in other studies (Suguituru et al., 2013; Lutinski et al., 2018). The species of this subfamily have a wide diversity of feeding habits and nesting, which explains the success of the group (Baccaro et al., 2015). We also verified that the dominant species (*Acromyrmex* sp.1) presented high abundance at the edge of the fragment. Some of the species with the greatest potential to cause economic damage are in this genus, once they are associated to environmental disturbed areas that leads to population disturbance, and an increase in vegetative mass cut (Fernández, 2003). This would explain the greater abundance in the border, once ants can transit between the agricultural matrix and the forest fragment.

Rare species were recorded in several studies with ants (Martins et al., 2011; Holdefer et al., 2017; Guarda et al., 2018). *Cyphomyrmex rimosus* was found in MOF and anthropic environments, as in this study (Rosumek, 2017; Holdefer, et al. 2017; Guarda et al., 2018), possibly having a solitary habit. In the genus *Dinoponera* are the largest Brazilian ants (Baccaro et al., 2005). *Dinoponera australis*, the largest ant recorded in this study, forage alone (Tillberg et al., 2014). *Pseudomyrmex termitarius* is found in anthropic areas with low abundance (Holdefer et al., 2017; Guarda et al., 2018) and was also considered rare in this study.

The rarefaction curve did not stabilize, demonstrating that we could find more ant species, as verified in other studies (Montine et al., 2014; Cantarelli et al., 2015; Guarda et al., 2018). In addition to the high percentage of species with only one representative individual, the duration of the sampling period may also have influenced the curves. This suggests that more ant species could be added with greater sample effort or with the addition of other sampling methods (Montine et al., 2014). However, studies with a longer sampling period show curves that do not stabilize (Ribeiro et al., 2012; Lutinski et al., 2017). Richness estimates are highly influenced by rare species, thus this result is expected in tropical areas due to the large number of rare species in the samples (Longino et al., 2002).

The predominance of omnivorous ant species in this study may be due to the availability of resources in the environment. Studies show that this guild is prevalent in fragmented environments (Leal et al., 2012; Groc et al., 2013; Pereira et al., 2016). Forest fragmentation often favours common, generalist species over rare and specialised species (Tabarelli et al., 2010; Filgueiras et al., 2011) and vegetation structure in heterogeneous environments influence the composition of ant communities (Pacheco and Vasconselos, 2012). Specialist ants, on the other hand, may also be affected by habitat changes. The use of fungi by some of the registered species is due to the food specialization of Myrmicinae, especially the Attini tribe (Santos and Cazetta, 2016; Ješovnik and Schultz, 2017). The mutual association between ants and cultivated fungi allows the use of this resource as part of the diet of both larvae and adults and is an extremely strong relationship (Santos and Cazetta, 2016).

In this study, the most conserved environments (central region of the forest = A5) presented lower richness than areas impacted. We relate this result to the type of impacts this fragment has received over the past decades, with changes in vegetation structure. Despite being in a state of regeneration and with reduced impacts, it still has clearings and exotic vegetation (bambuzal) that may be impacting the ant community. The richness of ant species may be related to the structural complexity of the habitats (Vargas et al., 2007), and the differences we find may be reflecting that ants may function as bioindicators of habitat quality. Ants have potential to serve as bioindicators due to intimate associations with vegetation, providing estimation of the degree of environmental preservation (Lutinski et al., 2017; 2018), and habitat disturbance favoured opportunists ants (King et al., 1998). In relation to the disturbances, the response of the ant community occurs primarily as a result of indirect effects caused by these factors, leading to modifications in the microclimate, resources and interspecific relationships (Andersen, 2018). However, others factors can be related with the low rich of the central region of fragment in your study, such as the short period of sample that can be masked the results. Lutinski et al. (2017), considering the environmental of a Permanent Preservation Area in southern Brazil, provides that the rich sample of ants would be higher with the samples subsequent records of species in the area. Although some authors did not record differences in ant composition among different areas, suggesting that they closely share the same regional pool of species (Vargas et al., 2007; Oliveira et al., 2016), in this study differences among sampled areas were recorded. The similarity among areas 1, 2 and 4, shows that some species may present greater competitive success in the most simplified habitats, which is the case in these areas due to their low ecological requirements, as observed for invasive ant species of more generalist habit (Delabie et al., 2006), as opposed to the areas 3 (open but with vegetation cover) and 5 (typical interior of MOF). We expected, in these areas, greater richness and abundance of ants due to their ecological characteristics, with greater structural heterogeneity. Some authors consider that the divergence in the distribution of ants can be caused by methodological bias, the type of forest environment or open areas and disturbances in the environment, conditioning the ant community structure (Andersen, 2018). Interactions within the community, such as interspecific competition, predation and symbiosis (Schultz and Mcglynn, 2000), which may be influencing distribution in the environment, should also be considered.

Seeds, fruits and flowers, present in the litter, are important food items for omnivorous species. The bamboo and inland areas of MOF were responsible for 48.2% of the total litter, favoring, in the bamboo area (area 4), omnivorous ants such as *Linepithema micans* and *Gnamptogenys striatula* and the predator *Pachycondyla* sp. 1, which were the most abundant in this area. Increased litter is associated with the potential increase in ant richness and abundance, once it suggests diversification of nesting and foraging potential (Silva et al., 2017). However, this was not possible to relate in this study, once the difference in litter values was not significant. *Acromyrmex* sp.1, of leaf-litter ants group, belongs to a genus that builds subterranean nests and is considered agricultural pest (Baccaro et al., 2015). These ants have aggregated distribution and construct numerous nests (sauveiros). These characteristics make it possible to relate areas with large numbers of individuals to the anthropogenic disturbances they receive. *Pachycondyla striata* and *Pachycondyla* sp.1 were recorded in all areas. They are predominantly predatory, but may also use dead arthropods, fruits and soil seeds from moist forests and in urban environments (Baccaro et al., 2015). *Pachycondyla striata* nests in the soil and prefers areas with tree cover (shade) (Cantone and Campos, 2015), which may be related to its occurrence in all areas. *Camponotus* is also related to open areas and disturbed environments (Baccaro et al., 2015; Silva et al., 2017). This genus contributed with 11% of abundance, is characterized by foraging day and night, presents a large number of species identified (Bolton, 2019), has a wide geographic distribution (Martins et al., 2011), and a high diversity of ecological adaptations (Baccaro et al., 2015), which justifies its high abundance, especially in area 4 (open). The individuals of the species *Linepithema micans* and *Linepithema* sp. 1 were also numerous. These species have neotropical occurrence and forage in rainforest soil and vegetation (Rosumek, 2017).

Although the sampling period was short our results contribute to studies of ant communities in the Atlantic Rainforest and we recorded greater richness in edge environments. Ant richness may be related to distinct environmental factors and greater abundance of ant species related to disturbed areas may be an indicator of the conservation status of the PCSP. The park, which is a currently regenerating conservation unit, receives anthropogenic influence, especially on the edge, which may be influencing the composition of this community.

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