



RESEARCH ARTICLE - ANTS

Do Bottom-up Effects Define The Structuring of Ant (Hymenoptera: Formicidae) Communities In A Restinga Remnant?

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Abstract

Restingas are lowland sandy ecosystems located between mountain ranges and the sea. For living organisms in this ecosystem, restingas can be seen as habitats formed by islands of vegetation separated by a sandy matrix. These organisms are highly influenced by the environmental conditions and physical characteristics of the landscape, including size, connectivity and environmental heterogeneity. Given the recognized effectiveness of ants as bioindicators, this study uses these organisms as a model to assess how do the physical characteristics of a landscape influence the structures of ant communities. The study was carried out in the Parque das Dunas, Salvador - Bahia, Brazil. Within this park, four categories of vegetation islands (Small, Medium, Large and Continuous) were delimited, where the ant fauna was sampled and the forms of vegetal life were analyzed, using the Raunkiaer analysis. A total of 69 ant species were collected from 31 genera and six subfamilies. We found a positive relationship between ant richness and diversity of plant life forms (Shannon index). In general, there was a significant difference in the composition of ant species between the areas of continuous vegetation and the different vegetation islands. We conclude that there is a bottom up effect mediating the ant community associated with dune vegetation, where the local richness of ant species responds to vegetation heterogeneity.

Introduction

The urbanization process is considered to be one of the main areas of concern in conservation biology. The creation and expansion of urban boundaries is responsible for the replacement of natural environments in various anthropogenic forms of land use (McKinney, 2002), resulting in a large loss of habitat and the fragmentation of natural environments in different shapes and sizes (Pacheco & Vasconcelos, 2007).

The remnants of a natural landscape (e.g. forest fragments and urban parks) represent important reservoirs of native biodiversity (Nielsen et al., 2013), since many organisms have niche requirements that do not allow them to survive in an urban matrix (Viana & Pinheiro, 1998). Thus, it is necessary to urgently develop strategies for the conservation

of biological diversity in these types of environment, for example through the implementation of strategies such as the execution of inventories, in order to record the fauna and flora of a certain place (Pearson, 1994), which can generate subsidies for conservation policies and biodiversity management programs.

Among the vegetal formations found in Brazil, the Rain Forest and its associated ecosystems are one of the environments most affected by the urbanization process (Myers et al., 2000). Restingas are lowland sandy ecosystems located in coastal zones (Mantovani, 2003). For living organisms in this ecosystem, restingas can be seen as habitats formed by islands of vegetation separated by a sandy matrix. These organisms are highly influenced by environmental conditions. According to MacArthur and Wilson (1967), the number of



species on an island is determined by a balance between species migration/colonization and extinction processes, with these factors being regulated by the physical characteristics of the landscape, such as size, connectivity and environmental heterogeneity.

Environmental heterogeneity can directly influence animal diversity, promoting conditions and resources for a greater coexistence of species (Corrêa et al., 2006, Resende et al., 2011, Silva et al., 2014). In this sense, studies have demonstrated positive relationships between environmental heterogeneity and ant diversity over time, by comparing areas with different phytophysiognomies (Kumar & Mishra, 2008; Resende et al., 2013) or relating vegetation structure to diversity of ants (Santana-Reis & Santos, 2001; Gomes et al., 2010; Vasconcelos et al., 2019).

Ants are excellent bioindicators, abundant and highly diverse in most terrestrial ecosystems (Holldobler & Wilson, 1990), performing several functions (Oliveira et al., 1999; Fernández, 2003). These organisms are highly dependent on habitat vegetation structure, as it provides food resources and nesting sites (Vasconcelos et al., 2019). Thus, this study answers the following question: How do the physical characteristics of a landscape influence the structures of ant communities? Our working hypotheses are: (i) ant species richness is positively correlated to environmental heterogeneity, because complex environments offer wider niches for species and (ii) ant species composition varies among different sized landscapes, since each island size presents a specific set of niches that can be realized for the species.

Material and methods

Study area

The city of Salvador is the fourth largest city in Brazil founded in the year 1549 and its administrative headquarters is located at the geographical coordinates 12.97°S 38.51°W. Located within the Atlantic Forest biome, its local climate is humid tropical, classified as Af (Köppen) and characterized by an annual average temperature of 17°C and 81% annual mean humidity (BDMEP, 2017).

The study was realized in Parque das Dunas (12°55'6.54"S, 38°19'5.83"W) located in the city of Salvador and inserted in the APA Lagoas e Dunas do Abaeté (State Decree nº 351 of September 22, 1987), comprising an area of approximately six million square meters.

The park is located in the neighborhood of Praia do Flamengo, situated in a restinga ecosystem. It is formed by a heterogeneous set of vegetation, with flooded areas, lagoons and dune areas covered by shrub, arboreal and herbaceous vegetation, which play an important role in fixing the dunes and protecting the soil against erosion (Britto et al., 1993).

Sample design

The samples were collected during April and July 2018. Four categories of vegetation islands were sampled along the Parque das Dunas: (1) small, (2) medium, (3) large and (4) continuous, which are treated as environments with different microhabitats in this study, since each island size presents a specific set of realizable niches.

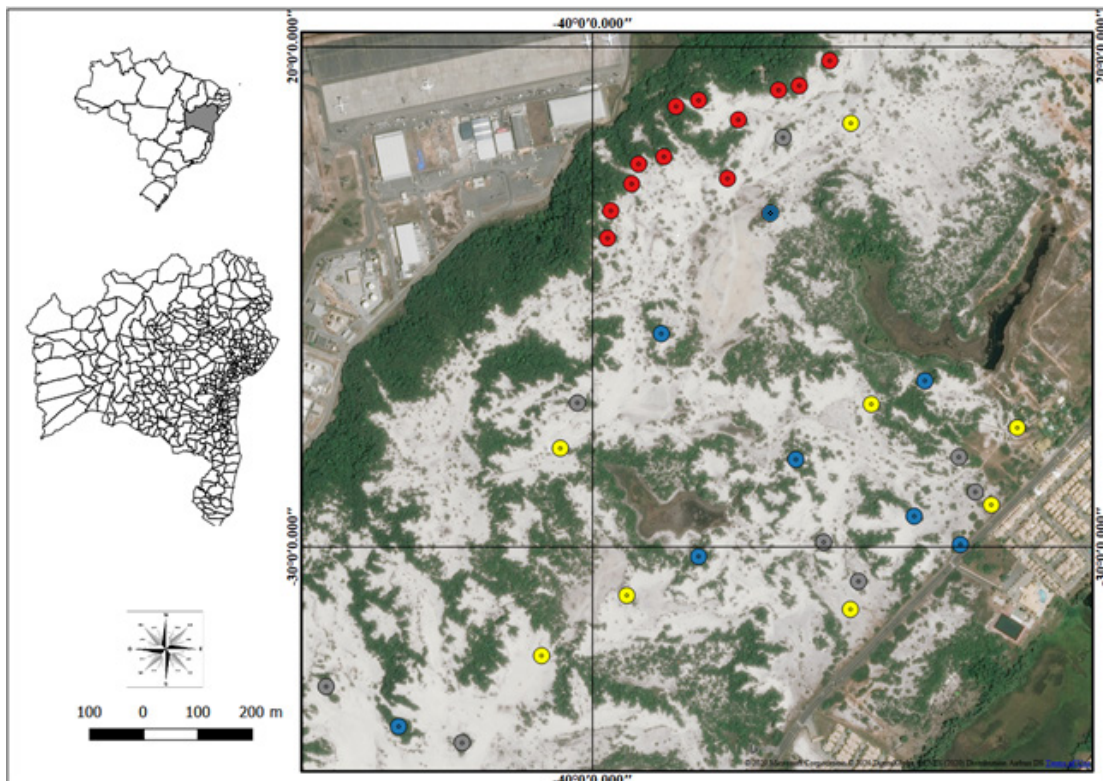


Fig 1. Map of Parque das Dunas and their respective sample points. Yellow = small microhabitats; Gray = medium microhabitats, Blue = large microhabitats and red = continuous microhabitats.

We selected and collected eight Sample Points (SPs) for the small (< 250m²), medium (≥ 250 m² and ≤ 1500 m²), large (≥ 1500 m²) microhabitats, and 12 SPs for the continuous area (Fig 1), with a minimum distance of 30 meters between them, totaling 36 SPs. At each sampling point, a 10 m² quadrant was delimited where we analyzed the ant communities and vegetation complexity.

In order to characterize the ant community, the soil and vegetation fauna were sampled at each SP for greater detection of the diversity of ants with different habits, using the following methods:

Winkler Extractor: for sampling the edaphic ants that inhabit the litter. In each SP, 1m² of litter was sampled, where the collected material was placed in winklers extractors for a period of 24 hours.

Pitfall trap: for sampling epigeous ants. Five pitfall traps (polystyrene cups 15cm high and 7cm in diameter, containing alcohol 70%) were installed in each SP and remained in the field for a period of 24 hours.

Entomological umbrella: for sampling understory ants. In each area, an umbrella sample was made, where each sample was composed of fauna from 10 shrubs (up to 3 meters high) shaken for 10 seconds on top of the umbrella.

Following the sampling procedure, the structural complexity of the vegetation was analyzed through the classification of the plant communities according to Raunkiaer (1934). All plants in each quadrant were analyzed and classified in Cactaceae (Ca), Creepers (Ce), Chamephytes (Cm), Cryptophytes (Cr), Epiphytes (Ep), Phanerophytes (Ph), Hemicryptophytes (Hm) and Therophytes (Te). The plants were not collected.

The collected ants were morphotyped and fixed. Some of these were sent to the collection of the Laboratory of Mirmecology (acronym CPDC), Itabuna, BA (curator: J. Delabie), Executive Committee of the Cocoa Plan (CEPLAC), where they were identified and deposited. The specimen collections received authorization n^o 61299-3 from MMA/SISBIO.

Data for species incidence in the collections were used to calculate the faunistic indexes of (1) frequency, (2) similarity and (3) richness, to characterize myrmecofauna (Marques et al., 2009).

Statistical analysis

Ants and plant community parameters were analyzed for each sampled point through a frequency matrix. The Shannon's (H') diversity index for plants and ants was analyzed using the Vegan package in program R version 3.4.3.

In order to compare the plant life form between each microhabitat we applied the Multiple Response Permutation Procedure (MRPP), using the Sorensen (Bray-Curtis) distance (McCune & Grace, 2002). In order to compare ant species composition between each microhabitat and for the peer-to-peer comparisons, we applied the Multiple Response Permutation Procedure (MRPP), using the Sorensen (Bray-Curtis) distance (McCune & Grace, 2002). A hierarchical clustering analysis was performed to evaluate how the environments are grouped according to ant species composition, using Sorensen's distance (Bray-Curtis) and the method of connection Average Method (McCune & Grace, 2002). Cluster analysis and MRPP were performed using the PC-ORD © 6.0 program (McCune & Mefford, 2011).

A normality test was performed for species richness using the Shapiro test and the data showed normal distribution ($p > 0.05$). The effect of plant structural diversity on the ant community was analyzed using a general linear model (GLM) using the R program version 3.4.3. Ant species richness was considered a dependent variable and the diversity of plant life forms (H') was an independent variable.

Results

The restinga phytophysognomy showed a high heterogeneity of plant life forms (Fig 2). This environment had areas with predominantly Chamephytes plants (frequency

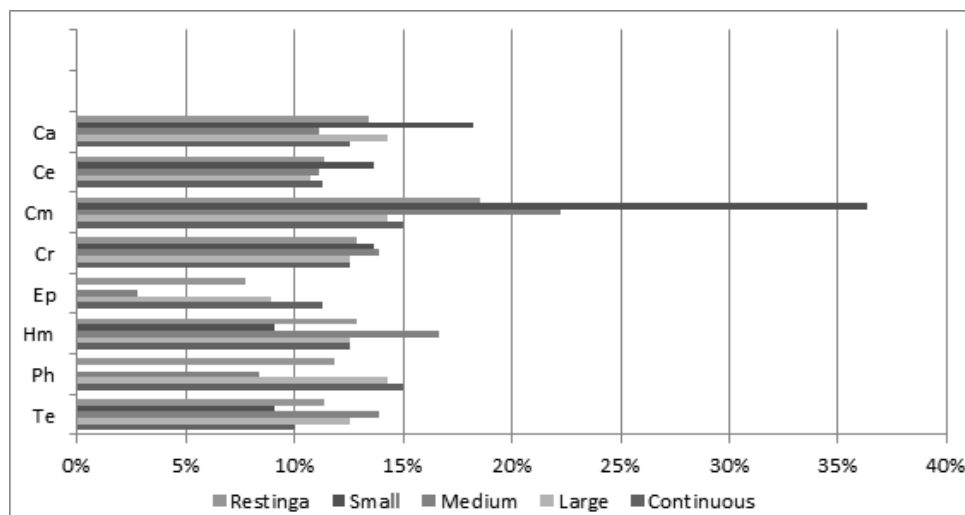


Fig 2. Spectrum of plant life forms found in Parque das Dunas. Ca = Cactaceae, Ce = Creepers, Cm = Chamephytes, Cr = Cryptophytes, Ep = Epiphytes, Ph = Phanerophytes, Hm = Hemicryptophytes, Te = Therophytes.

19%), while the plants Therophytes (11%), Creepers (11%) and Epiphytes (8%) were the least representative.

Among the studied microhabitats the small vegetation islands differed in the composition of life forms in relation to the other sampled habitats. The small vegetation island life forms were composed mainly of Chamephytes (36%) and Cactaceae (18%) with the absence of Phanerophytes and Epiphytes. The medium sized vegetation islands showed a higher formation of Chamephytes plants (22%) and Hemicryptophytes (17%). The large vegetation islands showed a higher formation of Phanerophytes, Chamephytes and Cactaceae plants (14% both). On the other hand, the continuous area presented the greatest fairness in the distribution of plant life forms among the microhabitats sampled, with the Chamephytes and Phanerophytes plants (15% both) being predominant (Fig 2).

Table 1. Pairwise comparison of plants life form community. T = variation between groups, A = intra-group variation, p = statistical significance. Significant p-values are in bold.

	Medium	Large	Continuous
	T = -1.0862	T = -6.0993	T = -8.0052
Small	A = 0.0445	A = 0.2704	A = 0.2584
	p = 0.1350	p = 0.0003	p < 0.00001
Medium		T = -1.9452	T = -2.4028
		A = 0.0694	A = 0.0718
		p = 0.0434	p < 0.0235
Large			T = 0.9840
			A = -0.0292
			p = 0.8476

In general, there was a significant difference in the plants life form between microhabitats (MRPP: $p < 0.000009$, A - intra-group variation = 0.1856, T - variation between groups = -6.3213). We found a significant difference between continuous vegetation and the small and medium microhabitats. However, we did not find significant differences in plants life form similarities between small/medium and large/continuous microhabitats (Table 1).

A total of 69 ant species were collected and distributed across 31 genera and six subfamilies. The most representative subfamilies were Myrmicinae (39 species), Formicinae (nine) and Ponerinae (seven) representing 76.8% of the species collected. The most representative genera were *Pheidole* (nine species), *Solenopsis* (six), *Camponotus* and *Pseudomyrmex* (five species each) representing 36.2% of the species collected (Table 2). In general, the species with the highest frequency of occurrence were: *Pheidole radoszkowskii* (F = 42%), *Brachymyrmex admotus* (F = 24%) and *Crematogaster erecta* (F = 16%). On the other hand, the species *Camponotus crassus*, *Cyphomyrmex costatus*, *Ectatomma muticum*, *Paratrechina longicornis*, *Megalomyrmex drifti*, *Monomorium floricola*, *Mycetophylax morschi*, *Nesomyrmex asper*, *Odontomachus brunneus*, *Pheidole midas*, *Rogeria lirata*, *Solenopsis geminata*,

Solenopsis saevissima, *Strumigenys alberti*, *Strumigenys subedentata* and *Thaumatomyrmex fraxini* showed frequencies of less than 1% (Table 2).

Table 2 . Ant frequency (0 - 100%), in small, medium large and continuous microhabitats in Parque das Dunas. SMA = Small, MED = Medium, LAR = Large, CON = Continuous Area.

SUBFAMILY	Habitat				%
	SMA	MED	LAR	CON	
Species					
DOLICHODERINAE					
<i>Dorymyrmex</i> sp. 1	12	7	5	13	0.15
<i>Dorymyrmex</i> sp. 2	13	8	10	10	0.16
<i>Dorymyrmex</i> sp. 3	10	11	12	10	0.17
<i>Dorymyrmex</i> sp. 4	1	0	0	0	0.01
<i>Dorymyrmex thoracicus</i> Gallardo, 1916	2	2	3	0	0.03
<i>Forelius brasiliensis</i> (Forel, 1908)	4	3	4	2	0.05
ECTATOMMINAE					
<i>Ectatomma muticum</i> Mayr, 1870	0	0	0	3	0.01
<i>Gnamptogenys moelleri</i> (Forel, 1912)	0	0	0	12	0.05
<i>Gnamptogenys striatula</i> Radoskowsky, 1884	1	3	7	13	0.10
FORMICINAE					
<i>Brachymyrmex admotus</i> Mayr, 1887	20	16	10	15	0.24
<i>Brachymyrmex heeri</i> Forel, 1874	4	3	2	4	0.05
<i>Brachymyrmex</i> sp. 1	1	0	0	5	0.02
<i>Camponotus arboreus</i> (Fr. Smith, 1858)	1	7	7	10	0.10
<i>Camponotus atriceps</i> (Fr. Smith, 1858)	1	2	6	0	0.04
<i>Camponotus crassus</i> Mayr, 1862	0	1	0	0	0.01
<i>Camponotus fastigatus</i> Roger, 1863	3	4	9	2	0.07
<i>Camponotus vittatus</i> Forel, 1904	1	2	4	2	0.04
<i>Paratrechina longicornis</i> (Latreille, 1802)	0	0	0	1	0.001
MYRMICINAE					
<i>Acromyrmex aspersus</i> (Smith, 1858)	0	1	0	3	0.02
<i>Acromyrmex</i> sp. 1	0	1	0	0	0.001
<i>Atta opaciceps</i> Borgmeier, 1939	1	3	3	0	0.03
<i>Carebara</i> sp. 1	0	0	0	1	0.001
<i>Cephalotes minutus</i> (Fabricius, 1804)	1	5	6	6	0.07
<i>Cephalotes pinelii</i> De Andrade, 1999	1	1	2	0	0.02

Table 2. Ant frequency (0 - 100%), in small, medium large and continuous microhabitats in Parque das Dunas. SMA = Small, MED = Medium, LAR = Large, CON = Continuous Area. (Continuation)

SUBFAMILY	Habitat				%
<i>Crematogaster erecta</i> Mayr, 1866	12	7	6	16	0.16
<i>Crematogaster victima</i> Fr. Smith, 1858	0	1	3	2	0.02
<i>Cyphomyrmex costatus</i> Mann, 1922	0	0	0	1	0.001
<i>Cyphomyrmex rimosus</i> (Spinola, 1853)	1	2	0	3	0.02
<i>Cyphomyrmex transversus</i> Emery, 1894	6	4	6	2	0.07
<i>Megalomyrmex drifti</i> Kempf, 1961	0	0	0	2	0.01
<i>Monomorium floricola</i> (Jerdon, 1852)	0	0	0	2	0.01
<i>Mycetophylax morschi</i> (Emery, 1888)	1	0	0	0	0.001
<i>Myrmicocrypta</i> sp. 1	2	0	0	2	0.02
<i>Nesomyrmex asper</i> (Mayr, 1887)	1	0	1	0	0.01
<i>Nylanderia fulva</i> (Mayr, 1862)	2	3	2	3	0.04
<i>Pheidole</i> (group <i>diligens</i>) sp. 2	0	0	0	1	0.001
<i>Pheidole</i> (group <i>fallax</i>) sp. 1	1	4	3	11	0.08
<i>Pheidole</i> (group <i>fallax</i>) sp. 2	0	0	1	0	0.001
<i>Pheidole</i> (group <i>flavens</i>) sp. 3	3	2	1	4	0.04
<i>Pheidole</i> (group <i>tnistis</i>) sp. 4	0	1	0	1	0.01
<i>Pheidole</i> (group <i>tnistis</i>) sp. 5	0	0	1	4	0.02
<i>Pheidole</i> (group <i>tnistis</i>) sp. 6	0	0	1	2	0.01
<i>Pheidole midas</i> Wilson, 2003	0	0	0	1	0.001
<i>Pheidole radoszkowskii</i> Radoskowsky, 1884	29	23	21	32	0.42
<i>Rogeria lirata</i> Kugler, 1994	1	0	0	1	0.01
<i>Solenopsis geminata</i> (Fabricius, 1804)	0	0	0	1	0.001
<i>Solenopsis saevissima</i> (Smith, 1855)	0	0	1	0	0.001
SUBFAMILY	Habitat				%
<i>Solenopsis globularia</i> (Fr. Smith, 1858)	6	3	3	0	0.05
<i>Solenopsis</i> sp. 1	0	1	1	2	0.02
<i>Solenopsis</i> sp. 2	3	3	3	8	0.07
<i>Solenopsis</i> sp. 3	1	0	1	1	0.01
<i>Strumigenys alberti</i> Forel, 1893	0	0	0	1	0.001
<i>Strumigenys subdentata</i> Mayr, 1887	0	0	1	0	0.001
<i>Strumigenys</i> sp. 1	1	0	0	0	0.001
<i>Strumigenys</i> sp. 2	0	0	1	0	0.001
<i>Trachymyrmex</i> sp. 1	1	0	4	10	0.06
<i>Wasmannia auropunctata</i> (Roger, 1863)	1	6	0	0	0.03
PONERINAE					
<i>Anochetus diegensis</i> Forel, 1912	2	1	4	0	0.03
<i>Hypoponera</i> sp. 1	0	0	0	2	0.01
<i>Hypoponera</i> sp. 2	0	0	0	5	0.02
<i>Neoponera bactromica</i> (Fernandes, 2014)	2	1	4	4	0.04
<i>Odontomachus bauri</i> Emery, 1891	9	12	10	2	0.13
<i>Odontomachus brunneus</i> (Patton, 1894)	1	1	0	0	0.01
<i>Thaumatomyrmex fraxini</i> D'Esquivel & Jahyny, 2017	0	0	0	1	0.001
PSEUDOMYRMECINAE					
<i>Pseudomyrmex elongatus</i> (Mayr, 1870)	0	2	1	5	0.03
<i>Pseudomyrmex</i> (group <i>pallidus</i>) sp. 1	1	1	1	0	0.01
<i>Pseudomyrmex</i> (group <i>pallidus</i>) sp. 2	2	0	0	1	0.01
<i>Pseudomyrmex</i> (group <i>pallidus</i>) sp. 3	3	1	1	0	0.02
<i>Pseudomyrmex</i> (group <i>pallidus</i>) sp. 4	1	0	1	0	0.01
RICHNESS	42	38	41	48	

The characterization of the ant communities showed that each sample point has specific ants richness. 48 species of ants were collected in the area of continuous restinga, with 13 species occurring exclusively in this environment; 42 species were collected in the small vegetation islands; 38 species in medium sized vegetation islands and 41 species in large vegetation islands (Table 3).

The Shannon's diversity ranged between 3.12 +/- 3.37, with the continuous area showing the greatest ants species diversity among the studied microhabitats (Table 3). The studied microhabitats presented high species similarity, with values varying between 0.55 +/- 0.77 (Table 4).

Table 3. Average number of species per sample point, Species richness (S) of ants and ants Shannon diversity (H') in the four different microhabitats.

Microhabitats	Average number of ants species	Species richness (S)	Diversity (H')
Small	12	42	3.12
Medium	13	38	3.21
Large	14	41	3.36
Continuous	14	48	3.37

Table 4. Ants similarity index among the studied microhabitats. SMA = Small island, MED = Medium island, LAR = Large island, CON = Continuous area.

	SMA	MED	LAR	CON
SMA	1			
MED	0.730	1	0.772	0.633
LAR	0.678	0.772	1	0.616
CON	0.557	0.633	0.616	1

In general, there was a significant difference in the composition of ant species between microhabitats (MRPP: $p < 0.0005$, A - intra-group variation = 0.0276, T - variation between groups = -3.8002). We found a significant difference between continuous vegetation and the other three microhabitats. However, we did not find significant differences in ant species similarities between small, medium and large habitats (Table 5).

Table 5. Pairwise comparison of ant communities similarity. T = variation between groups, A = intra-group variation, p = statistical significance. Significant p-values are in bold.

	Medium	Large	Continuous
Small	T = 0.2251	T = -1.3906	T = -5.6366
	A = -0.0021	A = 0.0146	A = 0.0423
	p = 0.5645	p = 0.0936	p < 0.0001
Medium		T = 1.7167	T = -2.7170
		A = -0.0163	A = 0.0201
		p = 0.9670	p < 0.0100
Large			T = -4.2035
			A = 0.0302
			p < 0.0004

The one-way cluster analysis between microhabitats indicated the presence of three distinct groups, where the continuous area separated sharply from the others (70% similarity), and the large and medium areas were very similar to each other (100% similarity). Finally, medium and large vegetations showed about 75% of similarity with small microhabitat.

A positive relationship was found between ant richness and the diversity of plant life forms (H') (Fig 3). Many ant species were common to several dunes, regardless of the type of vegetation, however, the diversity of plant life forms explains 12% of the variance in the species richness of ants (GLM: DF= 34, $p < 0.03$, $r^2 = 0.123$).

Discussion

Among Brazilian habitats, the restinga is composed of a mosaic of vegetation types with great variations in their life forms. In this sense, this ecosystem is considered to be one of the most complex and heterogeneous ecosystems in Brazil (Mantovani, 2003), thus enabling a high number of realizable niches and the coexistence of a large number of species.

The restingas are naturally fragmented with obvious differences between areas; however, they demonstrate high similarity in the composition of life forms. Only small and medium dunes, as observed on oceanic islands, differ from dunes of other sizes due to a lack of space required to support a wider range of life forms.

Overall, studies have shown that restinga environments have a high diversity of ants. Cardoso and Schoereder (2014) collected a total of 71 ant species for a restinga environment in Santa Catarina; while Vargas et al. (2007) collected 92 species in a restinga environment in Rio de Janeiro. The results of our study were not different. We found a high diversity of ants (69 species) for the restinga areas sampled, thus suggesting

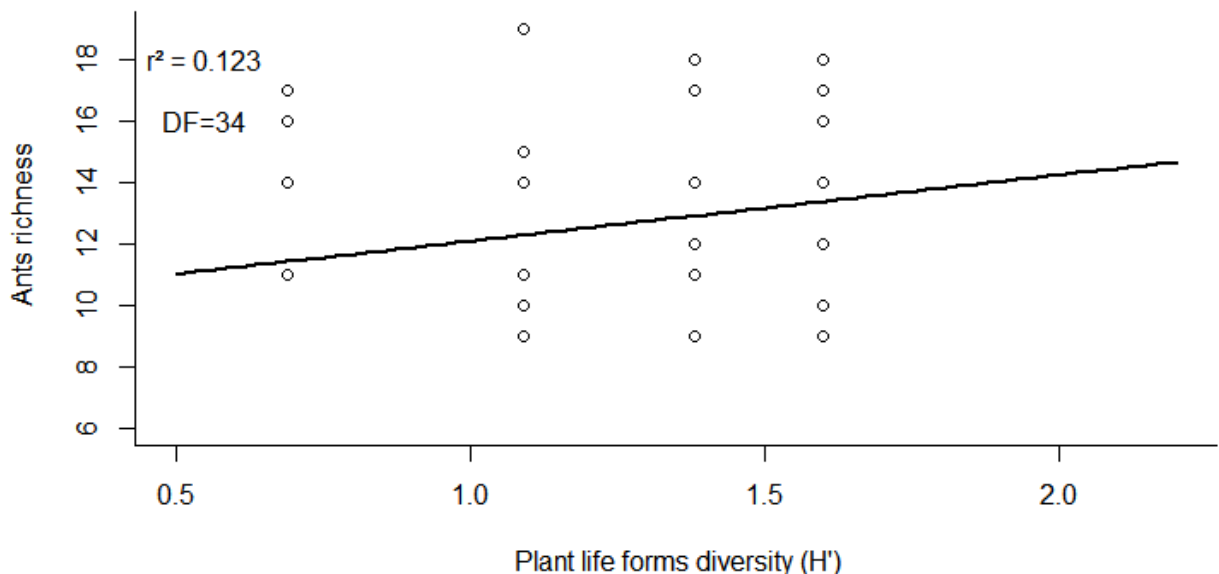


Fig 3. Positive relationship between ant richness and diversity of plant life forms (H'). Curve equation ($9.9414 + 2.1449 * x$). Analyses based on sample points. Thirty-six sample points are not seen in the graph due to data overlap.

the necessity of the expansion of studies on invertebrate biodiversity in these environments and reinforcing the importance of forest remnants as environments capable of maintaining a high diversity of organisms.

The high relative ant richness of the Myrmicinae and Formicinae subfamilies was expected as they have the highest species richness among ant subfamilies around the world (Bolton, 2019). In turn, the species belonging to these subfamilies make up communities of stressed environments, natural or anthropic. Restingas are naturally fragmented environments and are subjected to high thermal amplitudes at ground level, which favor the presence of xerophilous and opportunistic species. This fact supports the highest frequency of occurrence found for the species *Pheidole radoszkowskii*, *Brachymyrmex admotus* and *Crematogaster erecta* in this study. In view of this fact, the existence of 13 species of ants exclusive to the continuous area is explained by greater soil cover, a greater number of plant species, greater vertical structure and, consequently, the greater buffering of climatic factors such as soil temperature and incidence luminosity.

Despite the high richness found in the environment as a whole (gamma diversity), we observed small variations in ant richness among the studied microhabitats (beta diversity). These fluctuations may be due to physical differences present in each sampled environment, where structural differences are responsible for several changes in animal communities, directly influencing species diversity and consequently, modifying the distribution and richness of organisms (Lach et al., 2010).

In our study, a significant relationship was found between ant richness and plant life diversity, showing a bottom up effect. The use of the Raunkiaer scale can be considered as an important substitute for assessing and characterizing the structural complexity of a habitat (Santos et al., 2007). Several studies have shown that vegetation structure is one of the main factors that can influence the structure of ant communities (Corrêa et al., 2006; Resende et al., 2011; Silva et al., 2014; Vasconcelos et al., 2019). Thus, complex environments with high environmental heterogeneity are able to act directly on the realizable and fundamental niches of species, allowing for the coexistence of a large number of species by providing nesting structures, food resources or foraging areas.

The composition of ant species was significantly different between the studied microhabitats and between the continuous area and the different vegetative islands. It is common and expected that ant communities from different habitats, although in close proximity or even bordering each other, present distinct compositions (Guimarães et al., 2013; Lutinski et al., 2013; Achury & Suarez, 2018). This disparity is mainly expressed through the presence of species unique to each habitat. However, ant communities from similar ecosystems are also expected to have similar compositions, at least at the generic level, even if they are geographically separate (Resende et al., 2011), while distinct ecosystems (Cerrado, Caatinga, Atlantic Forest) have a set of species that characterize them.

The existence of differences between types of dune vegetation phytophysiognomies reinforces the mosaic system structure of this environment. This difference is most exacerbated when comparing the different vegetation island sizes with the continuous area. Thus, this suggests that the sampled environments present a great variety in habitat structure and that it is a completely heterogeneous environment, a fact proven by the presence of species exclusive to both habitats.

However, although each island has unique species, we found no significant differences in species similarities between islands of different sizes. In island systems such as sandbanks, factors such as the shape, size and degree of isolation of a habitat can influence the composition of component species (McArthur & Wilson 1967). Thus, variations in species composition should be related to the characteristics of the studied landscapes.

Among landscape metrics, connectivity acts directly on the migration and dispersal processes of biological communities (Magle et al., 2009). These mobility rates influence the similarities of species assemblages between habitats (Magura et al., 2001) and can be explained by the island biogeography theory (MacArthur and Wilson, 1967), which postulates the importance of the size of the species' receiving areas and the distance of these areas from source areas, in explaining these similarities. Ecological community theory highlights habitat isolation as one of the most significant explanations for differences and similarities in species richness and composition in a community (Pacheco & Vasconcelos, 2007; Öckinger et al., 2009; Lizée et al., 2012), since isolated habitats tend to be more easily colonized.

Conclusion

There is a bottom up effect mediating the ant community associated with dune vegetation, where the local ant species richness responds to the heterogeneity of the vegetation. Diversity of plant life affects ant richness. Different plant life allows for the establishment of ants with different niches, directly influencing the richness of ant species across habitats. Restinga has high ant richness and diversity and should be preserved as a refuge for ants and associated communities, and is therefore important for the preservation, maintenance and conservation of arthropod biodiversity in urban environments.

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