Litter as an Important Resource Determining the Diversity of Epigeic Ants in the South-Central Part of Bahia State, Brazil

by

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ABSTRACT

This study evaluates the richness and composition of the epigeic ant fauna in two Caatinga areas (site 1: Brejo Novo and 2: Frizuba) within a transitional region (between the Caatinga and the Decidual Atlantic Forest) in the Municipality of Jequié, state of Bahia, Brazil. Ants were sampled using pitfall traps and Winkler extractor method in 50 randomly chosen points, totalizing a sampling area of 12.5 ha per site. Overall, we identified 60 species belongingto 27 genera. The most speciose genera were *Pheidole*, *Camponotus*, and *Solenopsis* (with five species each) followed by *Wasmannia* and *Cephalotes* (four species each). *Pheidole* sp1. was the most frequent species (occurring in approximately 60% of the samples). Since site 1 did not possess a litter layer (and therefore could not be sampled by the Winkler extractor) comparisons between the two areas were made using only the data provided by the pitfall-trap method. The Simpson diversity indexes calculated for sites 1 and 2 were 0.87 and 0.89, respectively, and showed no statistically significant differences ($p \leq 0.417$). The Jaccard coefficient revealed only 35.5% similarity in species composition between the two areas. The results suggest that the presence of litter contributed to increased species richness (the Winkler method added 28 species in the sum total of species collected) and "shaped" a distinct faunal composition of the area. The present study is the first ant fauna inventory in the region and reveals an unexplored conservation potential for the Decidual Forest and the Caatinga of northeastern Brazil.

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INTRODUCTION

There are approximately 3,000 described species of ants in the Neotropics (Bolton 2003). However, it is estimated that the same amount still remains to be discovered or described (Bolton 2003). Thus, studies of ant communities are an important tool for conservation of biodiversity, especially in Brazil, a country recognized as "mega-diverse" (Brandon *et al*. 2005, MMA 2008), harboring approximately 13.2% of the world's biota (Lewinsohn & Prado 2006).

In this context, the Caatinga deserves to be highlighted as it is the main domain of northeastern Brazil, covering about 7% of the country (Leal *et al.* 2003b).Although the ant fauna of the Caatinga has been recently receiving more attention, as indicated by the publication of studies conducted in this domain (e.g. Brandão, 1995 in the states of Bahia and Piaui; Quinet & Tavares 2005; Nunes *et al.*, 2008 in the state of Ceará; Leal, 2003a, 2003b in the states of Alagoas and Sergipe; Santos *et al.*, 1999, Silva, 2011, Soares *et al.* 2003 and Oliveira *et al.*, 2009 in the state of Bahia), transitional areas between the Caatinga and the Atlantic Rainforest or the Caatinga and the Cerrado are still under sampled. One reason for the small number of studies in these areas lies in the fact that few are located in protected areas and most of them are already largely impacted by human activities. Moreover, questions about transitional areas that pervade current studies on priority areas for conservation (i.e. are levels of endemism and species concentration higher in transitional areas?) remain unknown for many animal groups (Kark *et al.* 2007).

The state of Bahia is a perfect locality to study transitional areas, since it harbors three different domains (Caatinga, Cerrado and Atlantic Rainforest). However, except for the literature cited above, the ant fauna of the state is still under sampled and this situation is even more dramatic for the transitional zones, which, with the exception ofthe studies published by Soares *et al.* (2003) and Carvalho *et al.* (2004), with ant communities in forests under the influence of the Caatinga, are neglected by the scientific community.

Surveys focusing on basic ecological parameters, such as composition, richness, and abundance of species, are essential not only to understand the

ecological traits that modeled a community, but also to subsidize conservation acts. In this sense, in order to increase the existing knowledge on the ant fauna inhabiting transitional areas we compared the epigeic ant communities in areas between the Caatinga and the Atlantic Rainforest in the central south of Bahia state.

MATERIALS AND METHODS

Study Area:

Samples were collected in February 2003 in sites in the municipality of Jequié, BA, Brazil. The region of Jequié is located on the watershed of the Contas River and is marked by different phyto-physiognomies of Atlantic Rainforest (Deciduous Forest) and Caatinga. In the region there are patches of Caatinga vegetation which provide a great variety of landscapes, remarkable biological richness, and certain amounts of endemism (Ibama 2011).

The areas used for collections were randomly chosen and named by their location as follows: Site 1 - Brejo Novo (13º56'34.5"S; 40º06'31.6"W) and Site 2 - Frizuba (13°55'33.81'' S; 40°01'24.66'' W), 10 km distant from one another.

Ant Samples:

The sampling of ants followed the standard protocol (ALL Protocol: Ants of the Leaf Litter, Agosti *et al.*, 2000) for soil and litter species. Fifty points were randomly selected fromthe sampling area in each site (Brejo Novo and Frizuba). Each point was separated from the others by intervals of 50 m, totalizing an area of 12.5 ha per site (for details see Agosti & Alonso, 2000).

At each sampling point a pitfall trap was installed containing water and detergent-based solution, which remained in the field for 24 hours. After this period, the specimens were fixed in alcohol 70%and taken to the laboratory for further identification. At the same points, samples were taken fromthe leaf litter of a $1m^2$ area, sieved and separated into bags for the extraction of the specimens by means of Winkler extractors. Due to a lack of litter to be extracted by the Winkler method in Frizuba, this method was carried out only in Brejo Novo. The extractors remained active for 48 hours. During this period the ants migrated into the containers with alcohol 70% attached to

the base of the extractors. The specimens were mounted and identified according to Bolton (2003).

The identification of ants was carried out at the Laboratory of Invertebrate Zoology in the Universidade Estadual do Sudoeste da Bahia, UESB, Municipality of Jequié, state of Bahia, Brazil. The species identifications were conducted using taxonomic keys and by comparison with the collections of the Laboratório de Mirmecologia of the Centro de Pesquisa do Cacau CEPEC/CEPLAC in Itabuna, state of Bahia.Feeding habit and nesting sites were categorized according to the literature available.

Data Analysis:

The expected richness was calculated based on the estimators Chao I, Jackknife I, and Bootstrap. The composition and diversity of species between the different sites were evaluated by using the diversity index (Simpson) and the similarity index (Jaccard).

In order to calculate the diversity index, the frequency levels of the species were used instead of the abundance levels, due to differences in the efficiency of recruitment among ant species.

When comparing the richness and the similarity between ant species, we considered only the results obtained with the pitfall trap, since this method was implemented in both sites.

Astudent t test was used to compare the values of the diversity index obtained for both studied sites. We considered significant values of $P<0.05$.

Data analyzes was carried out using the softwares EstimateS (version 7.5.2) and Systat (version 12).

RESULTS

In total, we surveyed 60 species of ants belonging to 27 genera and seven subfamilies (Table 1). The most common subfamily, with over half of all species of ants collected (63.3%) was Myrmicinae. The second most common subfamily was Formicinae (15%) followed by Ponerinae (8.3% of species) (Table 1).

The most diverse genera were *Pheidole*, *Camponotus*, and *Solenopsis* (with five species each) followed by *Wasmannia* and *Cephalotes* (four species) (Table 1).

Pheidole sp1.was the most frequent species in the samples, representing more than half of all species surveyed in site 1and 2. *Solenopsis* sp.1 and

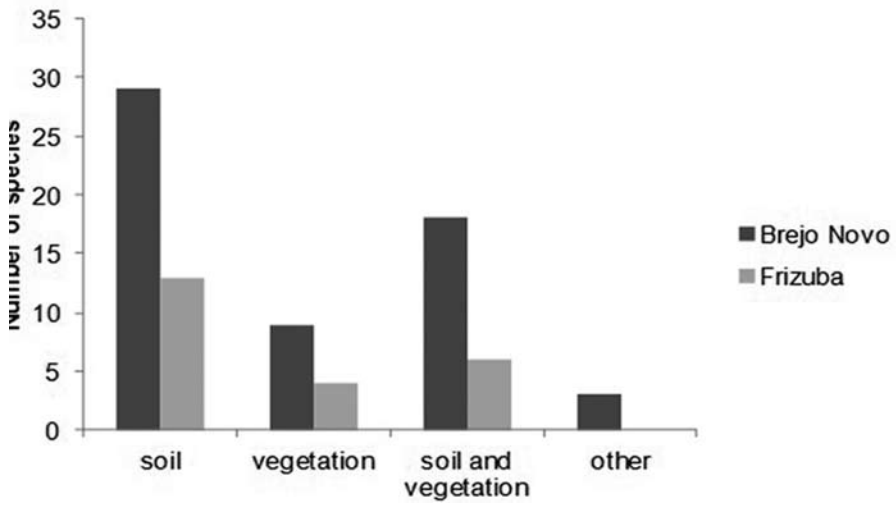

Fig. 1. Nesting site of ants collected in two sites (Brejo Novo and Frizuba) in the Municipality of Jequié, BA, Brazil.

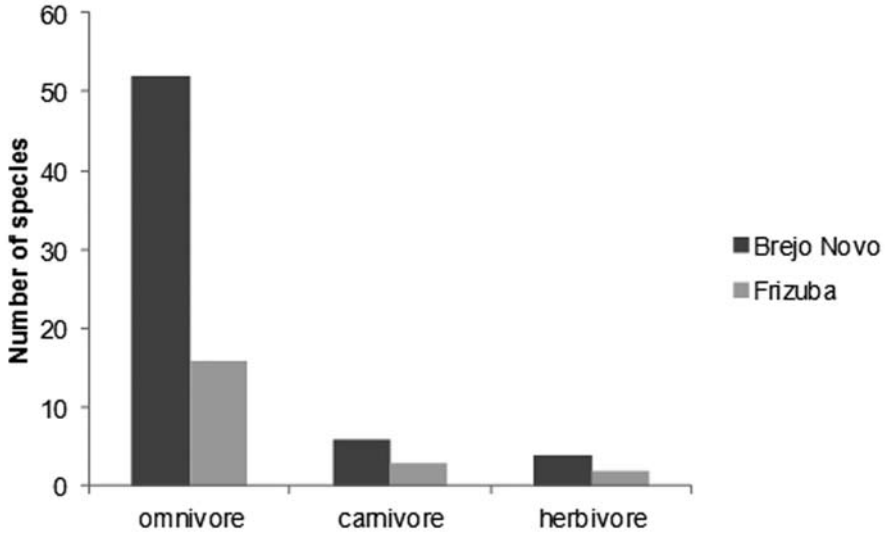

Fig. 2. Feeding habits of ants collected in two areas (Brejo Novo and Frizuba) in the region of Jequié, BA, Brazil.

Nylanderia sp.1 also presented high values of frequency of occurrence (Table 1, see appendix.).

In general, the species of ants recorded in both sites nested more frequently in the soil than in the vegetation (Figure 1). Microhabitats used for nesting may be rotting trunks, fruit and seeds in the litter. The frequency of feeding habits was similar between both sites, being the omnivore habit more common than the carnivore and herbivorehabits (Figure 2).

Species richness:

In site 1 (Brejo Novo) 58 species were recordedby both methods combined (pitfall traps and Winkler). Over half (65.5%) of all species collected in Brejo Novo were recorded with the Winkler method (1m^2 litter).The estimated number of species ranged from 69.9 (±0) to 89.5 (± 15.9). Considering the separate methods, with thepitfall traps, the estimated richness ranged from 21.7 (± 0) to 29.5 (± 10.5), and for the Winkler method the values ranged from 58.18 (± 0) to 75.6 (± 15.1) (Table 2). These values were higher than the richness observed.

In site 2 (Frizuba), 25 species were recordedandthe estimators of richness ranged from 28.0 (± 0) to 32.8 (± 2.9) (Table 2). Also, the richness estimators showed higher values than the observed richness.

Diversity and similarity in species composition:

The results of the Simpson diversity index calculated for Sites 1 and 2showed no statistically significant differences (p =0.42) (Table 1, appendix).

The correlation coefficient of Jaccard revealed only 35.5% of similarity in species composition between the two studied sites.

DISCUSSION

The diversity of Formicidae recorded in the two sites surveyed in this study follows the same pattern already known for other Neotropical domains, with the Myrmicinae subfamily being more diverse thanall other subfamilies (Bolton *et al.* 2005). With the exception of *Camponotus* (that belongs to the second most common subfamily in this study) all genera recorded in the present study that presenta high number of species richness belong to the Myrmicinae subfamily, such as *Pheidole*, *Solenopsis,* and *Crematogaster*. According to Wilson (1976) these genera may be considered to be prevalent

worldwide. The high number of species, as well as a variety of adaptations that allows the species of these genera to occupy different environments, may be the factors responsible for their abundance and prevalence in most Neotropical ant communities (Wilson 1976).

When compared with the ant fauna of the Caatinga, the species richness recorded in the present study can be considered relatively high (Santos *et al.* 1999: 50 species; Oliveira *et al.*, 2009: 32 species). However it is equivalent to thatfound by Leal (2003) (61) and lower when compared to the resultsof Silva (2011) (143 species). Nevertheless, differences related to sampling methods should be taken into account. Additionally, as the values of observed richness showed, the total richness was not reached in both studied sites. More sampling effort should be implemented as this would probably increase the number of recorded species. On the other hand, this result is very common in Neotropical environments for insect fauna.

When compared with the ant fauna of other transitional zones in the state, the present study showed the highest number of species (Carvalho *et al.*, 2004: 55 species belonging to 23 genera). The Deciduous forest (Mata de Cipó) is characterized by shrubby understory trees and xerophytic species and occurs in areaswhere thereinfall is usually between 800-1000 mm/year and which havewell-defined rainy and dry periods (Thomas 2003). Although this physiognomy is subject to a high degree of degradation, according to Carvalho *et al.* (2004), transitional areas between the Caatinga and the Deciduous Forest revealed an interesting biological diversity with a probable endemism.

Most species of ants found in the two areas followed the same pattern: omnivorous (or generalists) with nests in the soil. Theseresults may be related to the sampling methods, since the combination of pitfall traps and Winkler is considered the best way to capture soil and leaf litter ants (Agosti & Alonso 2000). The predominantly generalist life, however, may be related to food shortages in highly seasonal environments, such as the Caatinga. Similarly, the low frequency of species that cultivate fungus (Attini) is probably related to the lack of sufficientvegetation to maintainthe colonies of these ants (Leal 2003).

Structural differences related to vegetation traits may explain the low values of similarity between the two studied sites despite the short distance between them. The spatial heterogeneity between the sites may be due to the

presence (Site 1) and absence (Site 2) of litter, a resource that, according to Hölldobler and Wilson (1990), increases the number of available habitats for nesting and foraging. This statement is supported by the fact that the total richness recorded in Brejo Novo was obtained in 1m^2 litter.

These results corroborate other studies of ants in tropical forests, where the heterogeneous distribution of resources such as litter is one of the most important factors in determining the foraging, nesting and diversity of these insects (McGlynn & Kirksey 2000; Armbrecht *et al.*2004; McGlynn 2006; Bastos & Harada 2011).

Although this study has not quantified or measured vegetation structure, we can infer that the species of ants found in two areas reflect the composition of the ant fauna of the region and can be correlated with the premise of the literature, that species diversity increases with increasing environmental complexity, since more complex environments support a greater diversity of ecological niches, resulting in a greater amount of foraging and nesting sites, reducing the competition between coexisting species. In fact, the presence of litter contributed both to increase the species richness, since the Winkler method added 28 species (or 46.6%) tothe total sum of species collected, and "shaped" a differentiated faunal area in sites that lacked this feature.

The present study represents the first survey of ants in a transitional zone between the Caatinga and the Atlantic Rainforest in the center south of the state of Bahia and one of few published data about ecotonal areas in the country. Using ants as ecological indicators, we suggest that there may be an expressive potential for studies in transitional areas, and also that these areas may represent important spots for conservation, harboring high species richness levels.

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The Appendix with both tables begins on page 1385.

Table 1. Frequency of occurrence of epigeic ant species collected at two sites in the Municipality of Jequié, BA, Brazil. Site 1 = Brejo Novo, Site 2 = Frizuba,W = Winklermethod, and P = Pitfall traps method.

	Frequency of Occurrence(%)		
Subfamily/species	Site 1		Site 2
	W	P	P
Ecitoninae			
Labidus coecus	0.0	2.0	2.0
Odontomachus bauri	8.0	0.0	4.0
Odontomachus sp.1	0.0	6.0	0.0
Ectatominae			
Ectatomma suzanae	0.0	0.0	12.0
Ectatomma sp.1	6.0	50.0	0.0
Formicinae			
Brachymyrmex sp.1	2.0	0.0	0.0
Camponotus (*Myrmobrachys*) sp.1	12.0	42.0	0.0
Camponotus crassus	2.0	0.0	0.0
Campontus sp.1	12.0	42.0	4.0
Camponotus sp.2	4.0	16.0	2.0
Camponotus sp3	0.0	4.0	0.0
Nylanderia sp.1	32.0	16.0	30.0
Nylanderia sp.2	6.0	0.0	4.0
Nylanderia sp.3	2.0	0.0	0.0
Myrmicinae			
Acromyrmex subterraneus brunneus	0.0	6.0	2.0
Atta cephalotes	0.0	2.0	0.0
Cephalotes pusillus	2.0	0.0	0.0
Cephalolotes persimilis	0.0	2.0	0.0
Cephalotes sp.1	8.0	0.0	2.0
Cephalotes sp.2	2.0	0.0	0.0
Crematogaster sp.1	6.0	10.0	12.0
*Crematogaster*sp.2	2.0	0.0	0.0
Crematogaster sp.3	6.0	0.0	0.0
Dorymyrmex sp.1	0.0	26.0	10.0

Table 1 (continued). Frequency of occurrence of epigeic ant species collected at two sites in the Municipality of Jequié, BA, Brazil. Site 1 = Brejo Novo, Site 2 = Frizuba,W = Winklermethod, and P = Pitfall traps method.

Pheidole sp.4grupo diligens	12.0	0.0	4.0
Pheidole sp.5grupo tristis	6.0	0.0	0.0
Pyramica denticulate	14.0	0.0	0.0
Rogeria besucheti	2.0	0.0	0.0
Rogeria blanda	2.0	0.0	0.0
Rogeria sp.1	2.0	0.0	0.0
Solenopsis globularia	2.0	0.0	0.0
Solenopsis sp.1	30.0	20.0	44.0
Solenopsis sp.2	4.0	0.0	8.0
Solenopsis sp.3	0.0	0.0	2.0
Solenpsis (*Diplorhoptrum*) sp.2	2.0	0.0	0.0
Strumigenys mandibulata	2.0	0.0	0.0
Strumigenys sp.1	0.0	0.0	2.0
Wasmannia auropunctata (Roger, 1863)	2.0	0.0	0.0
Wasmannia sp.1	36.0	0.0	10.0
Wasmannia sp.2	4.0	0.0	2.0
Wasmannia sp.3	2.0	0.0	0.0
Cerapachynae			
*Cerapachys*sp.1	0.0	2.0	0.0
Ponerinae			
Anochetus simony	4.0	0.0	0.0
Hypoponera sp.2	2.0	0.0	0.0
*Hypoponera*sp.1	2.0	0.0	0.0
Hypoponera sp.3	4.0	0.0	0.0
Thaumatomymex sp. prox. *mutilatus*	4.0	0.0	0.0
Proceratinae	0.0	0.0	0.0
Discothyrea sexarticulata	4.0	0.0	0.0
Pseudomyrmecinae			
Pseudomyrmex oculatus	2.0	0.0	0.0
Pseudomyrmex sp.1	4.0	2.0	6.0

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Table 1 (continued). Frequency of occurrence of epigeic ant species collected at two sites in the Municipality of Jequié, BA, Brazil. Site 1 = Brejo Novo, Site 2 = Frizuba,W = Winklermethod, and P = Pitfall traps method.

Cyphomyrmex transversus	2.0	0.0	2.0
Hylomyrma sp	0.0	0.0	6.0
Nesomyrmex sp.1	0.0	2.0	0.0
Nesomyrmex itinerans	2.0	0.0	0.0
Basiceros rugifera(Mayr, 1887)	10.0	0.0	0.0
Basiceros stenognatha	2.0	0.0	0.0
Basiceros jheringi	2.0	0.0	0.0
Pheidole sp.1	0.0	58.0	56.0
Pheidole sp.2	4.0	12.0	22.0
Pheidole sp.3grupo diligens	18.0	0.0	0.0

Table 2. Richness (estimators and indexes) of epigeic ant species in two sites in the Municipality of Jequié, BA, Brazil.

	Brejo Novo			Frizuba
	Sampling method			
	Pitfall	Winkler	Combined	Pitfall
Observed richness (Mao Tau)	19	48	58	25
Estimated richness:				
Chao I	29.50 ± 8.8	75.60 ± 15.1	89.5 ± 15.9	29.6 ± 4.4
Jackknife I	24.73 ± 2.98	71.52 ± 7.95	85.44 ± 7.4	32.8 ±2.9
Bootstrap	21.78+ 0	58.18 +0	69.98 +0	28.7 +0
Simpson Diversity Index	0.87			0.89