Contrasting "Carrasco" and Forest Ant Communities in the Chapada Diamantina, Bahia, Brazil

by

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ABSTRACT

This study contrasts the structure of ant communities of the "carrasco" (deciduous forest) and forest (semideciduous forest) remnants in the buffer zone of the Chapada Diamantina National Park, Bahia, Brazil. Our aim was to compare the richness, composition, vertical partitioning and guild organization at the level of leaf-litter, ground-surface and lower vegetation between the habitat types. Ants were sampled at six sites within each habitat by manual extraction in the leaf-litter, pitfall traps at ground level and baited pitfall traps on tree-trunks and shrubs 1.5 m above the soil surface. A total of 132 ant species was collected belonging to 34 genera and seven subfamilies. According to the analyses performed, the habitat types had equivalent species richness and a distinct species and functional composition at the vertical strata level. Furthermore, a greater vertical partitioning was observed in the forest ant community than in the carrasco ant community. The results indicated a distinct biogeographical association between the ant fauna of the two habitat types and suggested that ant communities in carrasco and forest remnants in the buffer zone of the Chapada Diamantina National Park are especially interesting for conservation and ecological research.

Key Words: ant communities, "carrasco" vegetation, Chapada Diamantina.

INTRODUCTION

In the central region of the Chapada Diamantina, Bahia, Brazil, "carrasco" (deciduous forest) and forest (semideciduous forest) remnants occur as isolated fragments surrounded by other vegetation formations, especially those associ-

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ated with "Caatinga" (tropical dry forest) and "Cerrado" (tropical savanna) biomes, and by an anthropogenic matrix, mainly dominated by agricultural activities (MMA 2007). They are of high biogeographic and conservation interest because their peculiar physiognomy and floristic composition are so dramatically different from that in other vegetation formations in Brazilian semi-arid domains (Funch *et al.* 2005, Queiroz *et al.* 2005).

Apparently carrasco and forest support a highly distinctive ant community because the habitat structure differs markedly between them, while in the carrasco the aspect of more open vegetation should create an arid microclimate for the ant assemblages of different strata, favouring the persistence of tolerant species, similar to those found in warm and open habitats (Andersen 2000). In the forest, the greater vegetation stratification, with well-defined canopy and understory, should soften the microclimate on the ant foraging surface, favouring the existence of an ant community more sensitive to the higher insolation levels of the habitat. Furthermore, considering the fact that ant species in local communities may differ markedly in their preferences with regard to food and nesting and foraging substrates (Yanoviak & Kaspari 2000), it is expected that differences in ecological properties of the vertical strata between the carrasco and forest range constrain the types of ants and guilds that may occur in them.

This study contrasts the structure of ant communities of the carrasco and forest remnants in the buffer zone of the Chapada Diamantina National Park, Bahia, Brazil. Our aim was to compare the richness, composition, vertical partitioning and guild organization at the level of leaf-litter, ground-surface and lower vegetation between the habitat types. The following hypotheses were tested: 1) the species richness of ants in the vertical strata differs between the carrasco and the forest; 2) the vertical strata of the habitat types have a distinct species composition of ants; 3) in the forest, due to higher habitat structural heterogeneity, there is greater vertical partitioning in ant community; 4) the guild composition of ants in the vertical strata differs between the habitat types.

METHODS

Study area

The study was carried out at 12 sites located in Cascavél, county of Ibicoara, in the buffer zone of the Chapada Diamantina National Park, State of Bahia, Brazil (13°10'-13°16'S 41°21'-41°23'W). The sites studied currently comprise the legal reserves of two farms in the region (Caraíbas farm and Londres farm), which are characterized by the occurrence of two vegetation types: carrasco (deciduous forest) and forest (semi-deciduous forest), both at an interface between the Caatinga (tropical dry forest) and the Cerrado (tropical savanna) biomes. The climate of the region is tropical semi-arid, ranging from sub-humid to dry and is marked by two defined seasons: dry (May-September) and rainy (October-April). The mean annual rainfall is approximately 1.062 mm and the average annual temperature is 20°C (MMA 2007).

Carrasco is a shrub-dominated vegetation type of the Brazilian semi-arid domain, which is derived from a natural process of ecological succession slowly adjusted to the xeric environment, in line with climate changes, possibly from the Pliocene (Fernandes 1998). It can be characterized as a deciduous, closed, and unistratified shrubland intermingled with lianas, with an irregular canopy and sparse emergent trees rarely reaching 6-8 m (Araújo & Martins 1999, Queiroz *et al.* 2005). The trees *Eremanthus capitatus* (Spring.) Macleish, *Bowdichia virgilioides* Kunth, *Jacaranda irwinii* A.H. Gentry, *Himatanthus lancifolius* (Müll. Arg.) and *Pouteria ramiflora* (Mart.) Radlk. are characteristic of this vegetation formation in the region.

The forest studied is part of a group of remnants of semi-deciduous forest associated with the Brazilian Atlantic Forest biome that occurs in this region, especially at altitudes above 800 m, where the moist and sandy soils favour the occurrence of canopy trees generally larger than in other vegetation formations of the Chapada Diamantina (10-20 m) (Funch *et al.* 2005). In general, these remnants have diverse floristic composition and most species have wide geographical distribution, occurring in various formations, from northern South America to southern Brazil (e.g. *Aspidosperma discolor* A.DC., *Copaifera langsdorffii* Desf., *Tapirira guianensis* Aubl., *Schoepfia obliquifolia* Turcz. and *Terminalia brasiliensis* Cambess.).

Sampling

Ants were collected in April 2010, at the end of the rainy season in the region. Within each habitat type, six sites were sampled at least 500 m distant from each other to ensure the independence of the data collected. In addition, 10 sampling points were established for each site at 50 m intervals to facilitate the sampling of individuals from different colonies on the leaf-litter, ground-surface and lower vegetation.

For the sampling of the leaf-litter ants, 0.5 m^2 samples were manually extracted from the soil surface. The collected material was placed in plastic bags for the manual processing of each sample. The screening was performed using sieves of 55 mm mesh attached to white plastic containers to facilitate the detection of organisms captured that were later removed with forceps and brushes (Sarmiento 2003). The non-particulate material retained in the sieves (e.g. leaves, branches and twigs) was transferred to other containers and inspected in detail in order to enhance the effectiveness of the screening.

Ground-foraging ants were sampled using pitfall traps installed at ground level. The traps consisted of standard volume and diameter plastic containers partially filled with ethylene glycol to preserve the organisms collected. The containers were covered with plastic dishes supported by toothpicks to prevent flooding by rain and were left in the field for 24 h (Andersen 1990).

Arboreal-foraging ants were sampled using baited pitfall traps on tree-trunks and shrubs 1.5 m above the soil surface. Smaller plastic containers were attached inside the pitfall traps containing small quantities of honey and sardine as an ant attractive (Bestelmeyer *et al.* 2000). The larger compartment of the containers also was partly filled with ethylene glycol to preserve the specimens collected. The baited pitfall traps operated in parallel with the pitfall traps installed at ground level.

The ants were identified to specific level according Bolton (1995, 2003). Species that could not be confidently named were identified to morphospecific level. Voucher specimens were deposited at the Hymenoptera collection of the Museum of Zoology, Federal University of Bahia (MZUFBA) and at the Myrmecology Laboratory of the Cocoa Research Center (CPDC) in Brazil.

Data analysis

The observed species richness in the carrasco and forest was determined by the rarefaction curve (Mao Tau) (Colwell *et al.* 2004), and expected species richness was estimated using the 1st order Jackknife estimator (Heltshe & Forrester 1983), calculated with Program EstimateS version 7.5.2 (50 randomizations) (Colwell 2006). The effects of habitat type on the mean species richness of ants in the vertical strata were examined using the Student t-test in the BioEstat version 5.0 (Ayres *et al.* 2007).

The effects of habitat type on the ant species composition in the vertical strata were examined using Analysis of Similarity (ANOSIM) in PRIMER version 5.0 (Clarke & Gorley 2001). The Similarity Percentage procedure (SIMPER) was then used to determine which species were good difference discriminators among the sample groups analyzed (Clarke & Warwick 2001). The presence/absence data of ant species in the vertical strata of each site were submitted to analysis of Non-metric Multidimensional Scaling (nMDS) using the Bray-Curtis index as a measure of association to order the ant assemblages of habitat types in a two-dimensional space.

The relative abundance of ant species in the vertical strata of each habitat type (leaf-litter: n = 60, ground-surface, n = 60, lower vegetation, n = 60) was measured from the species occurrence frequency in the sample sets. The number of individuals was not used as a measure of abundance because this estimate is greatly influenced by the patterns of nesting and foraging strategies of ant species (Bestelmeyer *et al.* 2000).

The vertical partitioning of ant communities was characterized by obtaining the proportion of species that occupied an only one stratum and the proportion of species that occupied more than one vertical stratum in the set of sites for the same habitat type. ANOSIM was used to examine the similarity in ant species composition among samples from different vertical strata. In addition, a cluster analysis was carried out using the Bray Curtis index as a measure of association to produce a similarity dendrogram.

The functional composition of ant communities was compared by assigning species to guilds based on the model proposed by Brandão *et al.* (2009). In this model, species that share the same food resources and use the same strategies to occupy their niches are grouped in the same guild based on a series of ecological, morphological and behavioral attributes adopted by the authors in range habitat types of the Neotropics (e.g. body size, diet, foraging activity and substrate nesting). The adoption of this classification approach has allowed a greater understanding of the structure of ant communities and the factors that determine their organization in habitats of different biogeographic regions (Andersen 1995, Brandão *et al.* 2009, Silvestre *et al.* 2003).

The ant guild organization was characterized by calculating the percentage amplitude (the proportion of the total number of species) in the vertical strata of each habitat type. The functional similarity was assessed using the Functional Similarity Index, which considers how many guilds are in each location and how many are common between them, the number of species recorded by location and number of shared species within the guilds, by observing the minimum number of species in each guild in each locality (Silvestre *et al.* 2003).

RESULTS

A total of 132 ant species belonging to 34 genera and seven subfamilies was collected in the 12 sites sampled, including two exotic species, *Tetramorium simillimum* and *Paratrechina longicornis* (Appendix 1). The most species-rich genus was *Pheidole* with 26 species (19.7% of the total) and *Camponotus* with 20 (15.2%). In the carrasco, 83 species of 30 genera were observed against 81 species of 25 genera in the forest. Despite the equivalence in the ant species richness between the carrasco and the forest, only 32 species were common

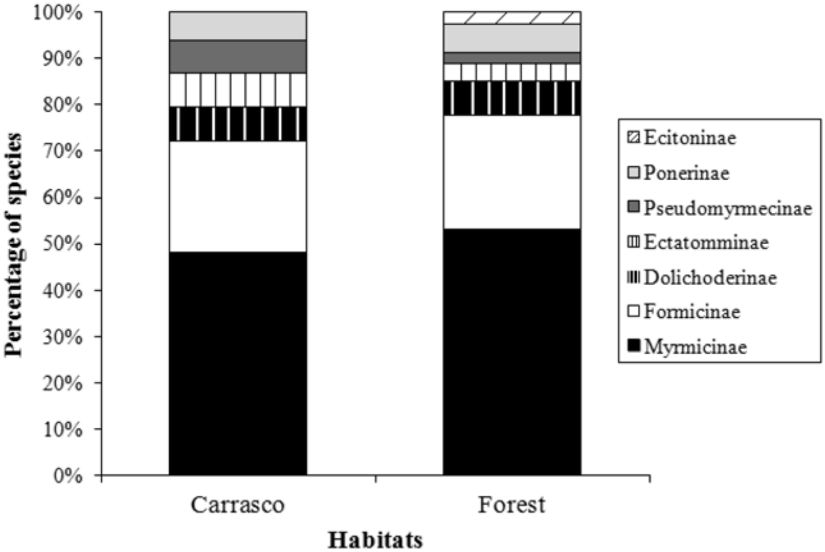

Fig. 1. Percentage of ant species for subfamilies in the carrasco and forest in the buffer zone of the Chapada Diamantina National Park, Bahia, Brazil. Stacked bars show cumulative proportions of total species records from different subfamilies of ants.

to both habitats. It means that 75.7% of the total species collected in this study occurred in a single habitat type.

The carrasco and forest showed little variation in the percentage distribution of ant species by subfamilies. Myrmicinae was the dominant subfamily with approximately 50% of the species collected, while Ecitoninae had the lowest percentage of species, occurring only in the forest (Fig. 1).

Despite considerable sampling effort in this study, the species accumulation curves for the two habitat types showed no indication of reaching a plateau, and therefore many more species are likely to be found in them (Fig. 2). The observed and expected ant species richness was similar between the carrasco and the forest. Furthermore, with the exception of lower vegetation, where a statistically significant difference was observed, the mean species richness of

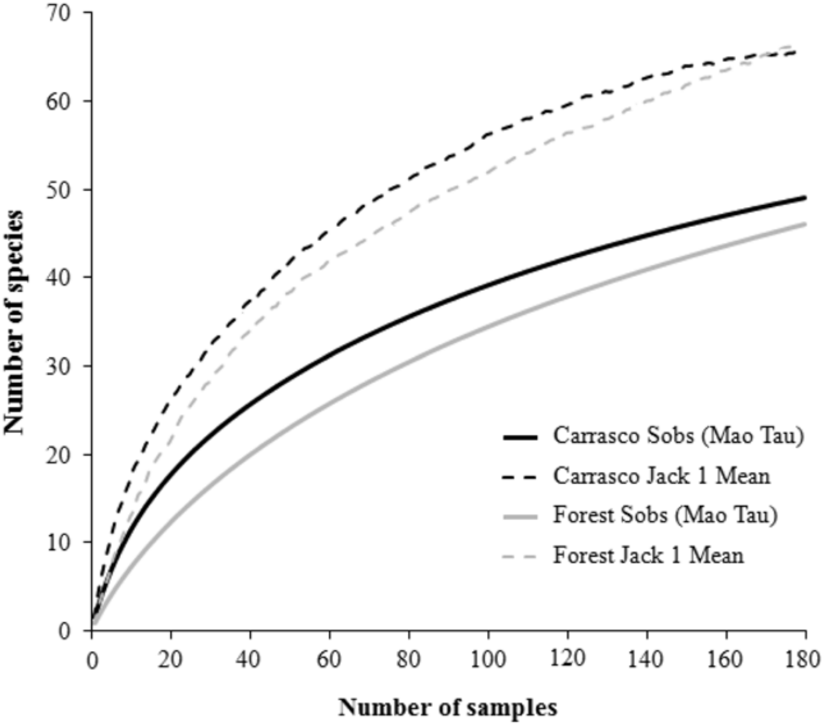

Fig. 2. Observed (Mao Tau) and expected (Jack1) richness curves of ant species in the carrasco and forest in the buffer zone of the Chapada Diamantina National Park, Bahia, Brazil. A total of 180 samples (60 samples of 0.5 m^2 of leaf-litter, 60 ground pitfall traps and 60 baited pitfall traps) were collected in each habitat type, April 2010.

ants in the vertical strata did not differ among the habitat types (leaf-litter: t = -0.72, df = 10, p = 0.49; ground-surface: t = 0.59, df = 10, p = 0.57; lower vegetation: t = 2.51, df = 10, p = 0.03; and all strata combined: t = 0.91, df = 10 , p = 0.38) (Fig. 3 a-d).

Multivariate analysis according to the ant presence/absence data showed a clear separation between the carrasco and forest sites. Vertical strata of habitat types showed a distinct species composition of ants, particularly at the lower vegetation level (ANOSIM, leaf-litter: Global R = 0.48, p = 0.002; ground-surface: Global R = 0.41, p = 0.002; lower vegetation: Global R =

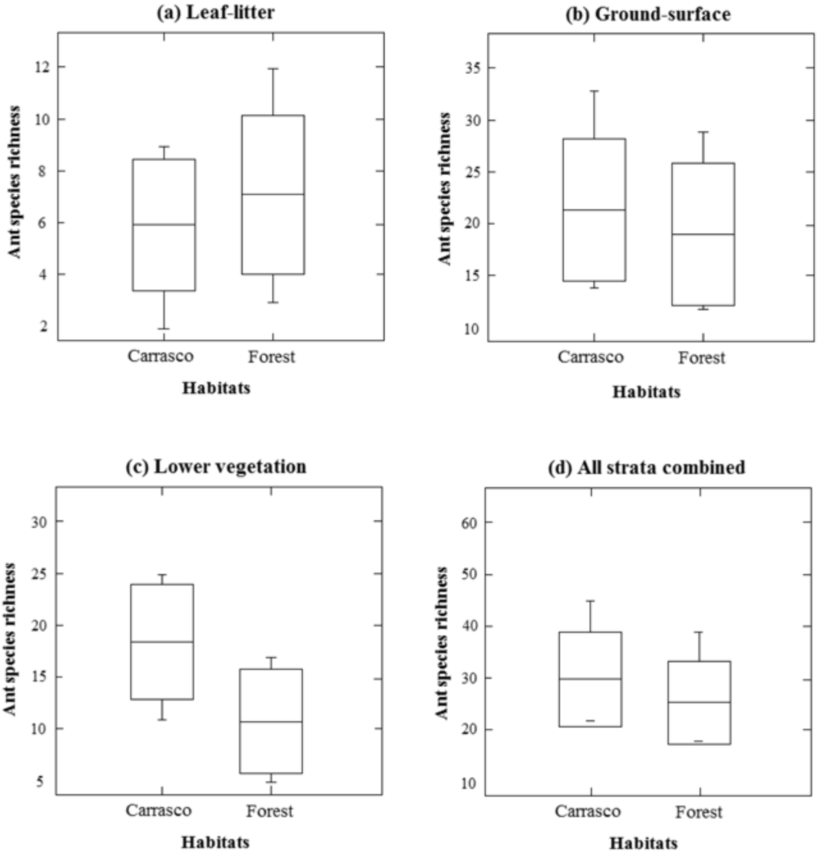

Fig. 3. Mean (± SD) species richness of ants in the vertical strata (a: leaf-litter, b: ground-surface, c: lower vegetation, d: all strata combined) per site in the carrasco (n = 6, in each case) and forest (n = 6, in each case) in the buffer zone of the Chapada Diamantina National Park, Bahia, Brazil, April 2010.

0.73, p = 0.002; and all strata combined: Global R = 0.56, p = 0.001). The ordinations produced by nMDS showed that ant assemblages sampled in sites of the same habitat type are more similar to each other than those from other habitat types (Fig. 4 a-d).

SIMPER analysis indicated that the ant species that contributed most to the dissimilarity in the assemblage compositions among habitat types were: *Odontomachus chelifer*, *Crematogaster distans* and *Tetramorium simillimum* at the leaf-litter level; *Pheidole* sp.18 gp. Flavens, *Solenopsis* sp.3 and *Odontomachus chelifer* at the ground-surface level; and *Pheidole* sp.18 gp. Flavens, *Linepithema pulex* and *Ectatomma muticum* at the lower vegetation level (Table 1).

Within the two habitats, more than half the species were found in only one stratum (carrasco 67.4% and forest 70.5%), and the number of species exclusive to the ground-surface level was greater than in the lower vegetation

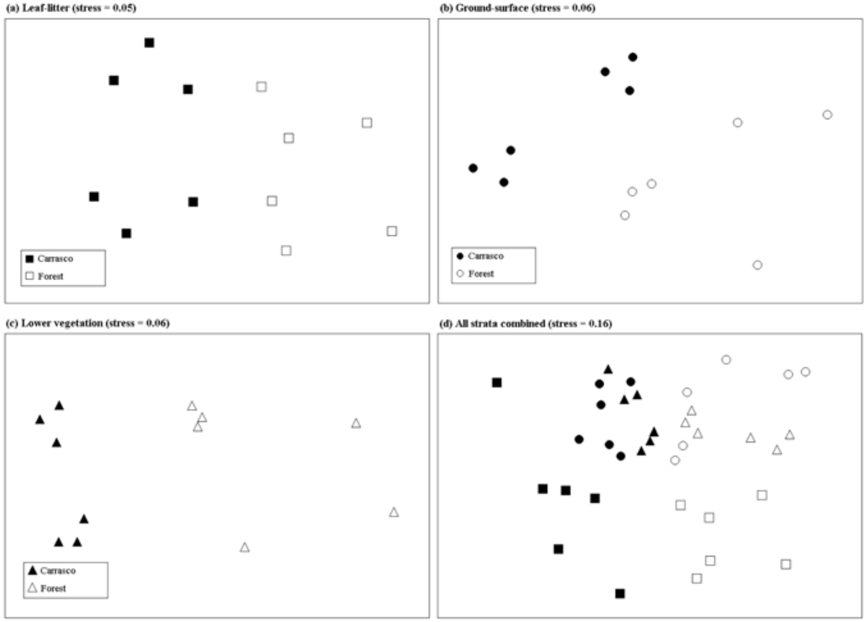

Fig. 4. Non-metric multidimensional scaling (nMDS) showing differences in the species composition of ants of the vertical strata sampled (a: leaf-litter, b: ground-surface, c: lower vegetation, d: all strata combined) in the carrasco sites and forest sites in the buffer zone of the Chapada Diamantina National Park, Bahia, Brazil, April 2010.

Table 1. Species contributing most to percentage dissimilarity in the species composition of the vertical strata between the carrasco and forest in the buffer zone of the Chapada Diamantina National Park, Bahia, Brazil.

Vertical strata	Species	Percentage contribution to dissimilarity
Leaf-litter	*Odontomachus chelifer*	8.37
	Crematogaster distans	4.76
	Tetramorium simillimum	4.20
	Solenopsis sp.1	4.12
	Pheidole sp.8 gp. Fallax	4.12
Ground-surface	*Pheidole* sp.18 gp. Flavens	3.13
	Solenopsis sp.3	2.51
	Odontomachus chelifer	2.20
	Linepithema neotropicum	2.19
	Wasmannia auropunctata	2.09
Lower vegetation	*Pheidole* sp.18 gp. Flavens	4.35
	Linepithema pulex	4.35
	Ectatomma muticum	4.35
	Crematogaster victima	3.78
	Wasmannia auropunctata	2.98

Table 2. Number and percentage of stratum-specialists species of ants in the vertical strata of the carrasco and forest at the buffer zone of the Chapada Diamantina National Park, Bahia, Brazil.

Vertical strata	Carrasco	Forest
Leaf-litter	5 (6.0%)	5 (6.4%)
Ground-surface	30 (36.1%)	35 (44.9%)
Lower vegetation	21 (25.3%)	15 (19.2%)
Total	56 (67.4%)	55 (70.5%)

and leaf-litter, respectively (Table 2). ANOSIM based on presence/absence data showed a greater similarity in the species composition between the vertical strata of the carrasco (Global R = 0.38, p = 0.001) than of the forest (Global R = 0.51, p = 0.001). Furthermore, the cluster analysis showed that

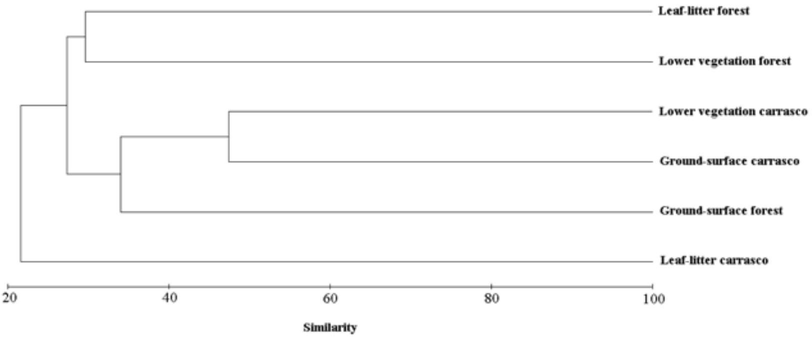

Fig. 5. Similarity dendrogram (Bray Curtis index) showed the similarity relations in the species composition of ants of the vertical strata in the carrasco and forest in the buffer zone of the Chapada Diamantina National Park, Bahia, Brazil, April 2010.

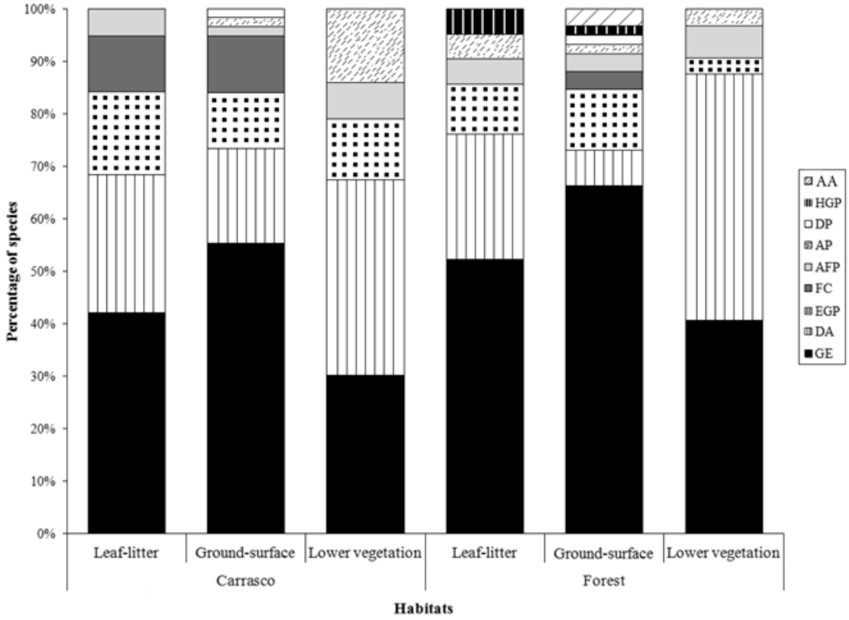

Fig. 6. Percentage of species for ant guilds in the vertical strata of the carrasco and forest in the buffer zone of the Chapada Diamantina National Park, Bahia, Brazil, April 2010. Stacked bars show cumulative proportions of total species records from different ant guilds: (AA) Army ants, (AFP) Arboreal Feeding on Pollen, (AP) Arboreal Predators, (DA) Dominant Arboreal, (DP) Dacetini Predators, (EGP) Epigaeic Generalist Predators, (FC) Fungus Collectors, (GE) Generalists and (HGP) Hypogaeic Generalist Predators.

the ant species composition on the ground-surface and lower vegetation was more similar in the carrasco than in the forest (Fig. 5). On the other hand, the ant species composition in the lower vegetation and leaf-litter was more similar in the forest than in the carrasco (Fig. 5).

In both habitat types, the vertical strata varied markedly in guild composition (Fig. 6). The most frequently recorded guilds were Generalists (mostly species of *Pheidole*, *Dorymyrmex* and *Linepithema*) in the leaf-litter and ground-surface, and Dominant Arboreal (mostly species of *Camponotus* and *Crematogaster*) on the lower vegetation. Furthermore, the ant community functional organization in terms of vertical strata differed markedly between the carrasco and forest. The Functional Similarity Index for the leaf-litter ant assemblages was 21.4%, while for the ground-surface ant assemblages it was 35.3% and 34.7% for the lower vegetation ant assemblages.

DISCUSSION

Although the sampling methods used in this study did not provide exhaustive information on ant communities in the habitats studied, they were enough to perform comparative analysis. The adoption of complementary collecting methodologies (Bestelmeyer *et al.* 2000, Sarmiento 2003) and planning of a larger sampling period (Delabie *et al.* 2000) are necessary to obtain a more complete and exhaustive picture of the ant communities from the carrasco and forest remnants in the buffer zone of the Chapada Diamantina National Park, Bahia, Brazil.

The Myrmicinae taxonomic dominance can be attributed to the fact that this subfamily has the greatest generic and specific diversity between subfamilies of ants in the Neotropics (Brown 2000). *Pheidole*, for example, comprises one of the ant genera with the greatest number of species around the world, a phenomenon known as hyperdiversity (Wilson 2003). Some of the more well-founded explanations for the existence of this phenomenon are related to a successful combination of small size, population factors and an appropriate set of adaptations to occupy new niches and exclude competitors (Wilson 2003).

The occurrence of exotic species in the habitats studied alerts to the danger of biological invasions, which have produced significant impacts on the ecological integrity of many natural habitats (Mikissa *et al.* 2008). *Tetramorium simillimum* and *Paratrechina longicornis* are species from the Old World that are widely distributed in savannas and forests in Brazil (Delabie *et al.* 2007, Silvestre *et al.* 2003). *Paratrechina longicornis* also been recorded in grassland in Mexico (Gove *et al.* 2009) and in Australian savannas (Andersen *et al.* 2007). Although these taxa have shown a low relative abundance in the collection sites, it is of fundamental importance to carry out an effective ecological monitoring to assess the expansion of these species in the region.

The results of this study showed that ant communities inhabiting the carrasco and forest remnants have equivalent species richness, contradicting the results of the literature from different biogeographic regions, which have suggested that the species richness for these taxa differs markedly between vegetation formations with deciduous and semi-deciduous features (Vasconcelos & Vilhena 2006, Andersen *et al.* 2007). In spite of this equivalence, the greater number of ant species found in the lower vegetation of the carrasco can be attributed to greater availability of the food supply and nesting sites for ants in this stratum, due to the high density of shrub and emergent trees (Ribas *et al.* 2003). In fact, the carrasco has a dense shrubland capable of supporting a greater number of ant species in the lower vegetation than the forest, where the greater stratification of the vegetation, mainly in the upper strata, usually maintains an arboreal ant fauna more associated with the canopy (Brühl *et al.* 1998, Delabie *et al.* 2007).

Despite the differences in the sampling effort and collecting methods employed, the diversity of ants observed in the forest sites was lower than that found by Martins *et al.* (2006) in four remnants of semi-deciduous forest in the same region, and by surveys carried out in the Atlantic Forest in southern Bahia, where the ant fauna inhabiting especially the leaf-litter is much greater (Alves *et al.* 2008, Delabie *et al.* 2007, Delabie & Majer 1999). On the other hand, the ant diversity observed in the carrasco sites was greater than that documented by other authors in open habitats, such as in vegetation types related to the Caatinga biome in the Brazilian semi-arid region (Leal 2003, Santos *et al.* 1999, Soares *et al.* 2003).

In this study, several species presented a strong association with a particular habitat. In fact, the carrasco and forest shared only about one-quarter of the ant species. This result, associated with the discontinuity in species composition observed in the multivariate analysis, indicated a distinct biogeographical association between the ant fauna of the two habitat types. While in the carrasco there was a higher prevalence of open habitat taxa of ants related with the semi-arid zone (e.g. *Ectatomma*, *Dorymyrmex*, *Pseudomyrmex* and *Solenopsis*), in the forest, a considerable prevalence of forest-associated fauna related with remnants of Brazilian Atlantic Forest was observed (e.g. *Strumigenys*, *Pachycondyla*, *Labidus* and *Crematogaster*).

The greater overlap of species between vertical strata within the carrasco was due to the presence of a group of species with generalist and tolerant habits. For example, *Ectatomma brunneum*, *Odontomachus chelifer*, *Camponotus cingulatus*, *Pheidole* sp.18 gp. Flavens and *Linepithema pulex* had favored their distributions probably due to better competitive strategies in obtaining food resources and occuping nesting substrates (Brandão *et al.* 2009, Fernández 2003, Lattke 2003, Silvestre *et al.* 2003). Thus, the plasticity of foraging and nesting of these species contributed to homogenizing the composition of ant assemblages between the vertical strata.

The data obtained by Vasconcelos & Vilhena (2006) and Campos *et al.* (2008) in savannas reinforce the results of this study that in simplified structure habitats the ant species composition varies less between the vertical strata, especially between the ground-surface and lower vegetation. In contrast to this pattern, in the forest, the ant community was characterized by a greater vertical partitioning, with more than 70% of species associated with only one habitat stratum. This pattern was similar to that reported by Brühl *et al.* (1998) in a primary forest in Malaysia, suggesting that greater vegetation stratification in forests provides a broad spectrum of permanent habitats for ant species allowing a greater vertical partitioning.

Analysis performed applying the guild model indicated that the functional composition of ant communities in terms of vertical strata was significantly different between the carrasco and forest remnants in the same region. This result suggested that possible differences in the intrinsic properties of the strata of the habitat types may determine the amplitude and species composition of ants within the guilds. For example, the Dominant Arboreal ant guild presented high percentage amplitude in the forest lower vegetation that might limit the ant species distribution in this stratum of other guilds. This pattern is well documented in tropical forests, where ant colonies with high numbers of individuals can become dominant, because of the potential to raise territory defense (Dejean *et al.* 2007). On the other hand, in the carrasco lower vegetation, the persistence of other ant guilds typical of vegetation (e.g. Arboreal Predators and Arboreal Feeding on Pollen) together with the expansion of ant guilds typical of the ground-surface (Epigaeic Generalist Predators) in this stratum, seem to decrease the percentage amplitude of the Dominant Arboreal ant guild.

Correlation tests between different ant guild traits and ecological properties associated with habitat vertical strata are encouraged in future studies to assess the real contribution of these properties in determining species patterns and functional composition in ant communities. For example, supply and distribution of extrafloral nectaries in the habitat and the Dominant Arboreal ant guild amplitude; availability and variety of prey and the Epigaeic Generalist Predator, Specialists and Dacetini Predator ant guild amplitude.

Although the lack of information about the insect diversity of the Brazilian semi-arid region has not yet attracted the attention of most researchers (Bravo & Aguiar 2005), the findings of this study suggest that ant communities in carrasco and forest remnants in the buffer zone of the Chapada Diamantina National Park have great potential for conservation and ecological research.

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APPENDIX

Appendix 1. Frequency of occurrence of ant species in the vertical strata of the carrasco and forest in the buffer zone of the Chapada Diamantina National Park, Bahia, Brazil. A total of 180 samples (60 samples of 0.5 m^2 of leaf-litter, 60 ground-surface pitfall traps and 60 baited pitfall traps in the lower vegetation) were collected in each habitat type. The guild of each species is also given: (AA) Army Ants, (AFP) Arboreal Feeding on Pollen, (AP) Arboreal Predators, (DA) Dominant Arboreal, (DP) Dacetini Predators, (EGP) Epigaeic Generalist Predators, (FC) Fungus Collectors, (GE) Generalists, and (HGP) Hypogaeic Generalist Predators.

Species		Carrasco			Forest		
	Guild	Leaf litter	Ground surface	Lower vegetation	Leaf litter	Ground surface	Lower vegetation
Dolichoderinae							
Azteca sp.	DA	0	0	3	0	0	0
Dorymyrmex thoracicus Gallardo, 1916	GE	0	0	0	0	3	0
Dorymyrmex sp.1	GE	0	0	0	0	2	0
Dorymyrmex sp.2	GE	0	0	0	0	1	0
Dorymyrmex sp.3	GE	0	1	0	0	0	0
Dorymyrmex sp.4	GE	0	1	1	0	0	0
Dorymyrmex sp.5	GE	0	0	0	0	1	0
Linepithema aztecoides Wild, 2007	GE	0	7	1	0	0	0
Linepithema cerradense Wild, 2007	GE	0	1	1	0	0	0
Linepithema pulex Wild, 2007	GE	0	15	0	0	33	2
Linepithema neotropicum Wild, 2007	GE	0	0	0	0	4	0
Ecitoninae							
Labidus praedator (Fr. Smith, 1858)	AA	0	0	0	0	2	0
Labidus coecus (Latreille, 1802)	AA	0	0	0	0	2	0
Ectatomminae							
Ectatomma brunneum Smith, 1858	EGP	1	19	13	8	1	0

Ectatomma muticum Mayr, 1870	EGP	0	36	7	9	0	0
Ectatomma opaciventris Roger, 1861	EGP	0	18	1	0	0	0
Ectatomma tuberculatum (Olivier, 1792)	AP	0	0	1	0	0	0
Gnamptogenys moelleri (Forel, 1912)	EGP	0	0	0	1	0	0
Gnamptogenys regularis Mayr, 1870	EGP	0	1	0	0	0	0
Gnamptogenys sulcata (Fr. Smith, 1858)	EGP	0	0	1	0	0	0
Formicinae							
Brachymyrmex heeri Forel, 1874	GE	3	0	0	0	0	0
Brachymyrmex patagonicus Mayr, 1868	GE	0	0	0	0	0	1
Brachymyrmex sp.1	GE	0	0	0	0	0	0
Brachymyrmex sp.2	GE	0	0	0	0	1	0
Brachymyrmex sp.3	GE	0	0	0	1	1	0
Camponotus agra (F. Smith, 1858)	DA	0	0	0	0	0	3
Camponotus arboreus (F. Smith, 1858)	DA	0	0	1	0	0	1
Camponotus blandus (F. Smith, 1858)	DA	0	1	0	0	0	0
Camponotus cingulatus Mayr, 1862	DA	0	3	15	0	0	1
Camponotus crassus Mayr, 1862	DA	0	0	3	2	2	3
Camponotus fastigatus Roger, 1863	DA	0	2	6	0	0	0
Camponotus leydigi Forel, 1886	DA	0	1	3	0	1	0
Camponotus melanoticus Emery, 1894	DA	0	2	7	0	0	0
Camponotus novogranadensis Mayr, 1870	DA	0	6	2	0	0	0
Camponotus punctulatus andigenus Mayr, 1868	DA	0	1	0	0	0	0

Camponotus renggeri Emery, 1894	DA	0	2	8	0	2	10
Camponotus rufipes (Fabricius, 1775)	DA	0	0	2	0	0	0
Camponotus (*Myrmaphaenus*) sp.1	DA	0	0	1	0	0	0
Camponotus (*Tanaemyrmex*) sp.2	DA	0	0	3	0	0	1
Camponotus (*Myrmaphaenus*) sp.3	DA	0	0	1	0	0	0
Camponotus (*Myrnothrix*) sp.4	DA	0	0	0	1	2	1
Camponotus sp.5	DA	1	0	0	0	0	0
Camponotus sp.6	DA	0	0	0	0	0	1
Camponotus sp.7	DA	0	0	0	0	0	3
Camponotus sp.8	DA	0	0	0	0	0	3
Myrmelachista sp.1	GE	0	0	1	0	0	0
Myrmelachista sp.2	GE	0	0	0	0	8	1
Myrmelachista sp.3	GE	0	0	0	1	0	1
Nylanderia fulva (Mayr, 1862)	GE	0	2	0	0	0	0
Nylanderia guatemalensis (Forel, 1885)	GE	0	0	0	0	1	0
Nylanderia sp.1	GE	0	0	0	0	2	0
Nylanderia sp.2	GE	0	0	0	0	1	0
Nylanderia sp.3	GE	0	0	0	0	2	0
Paratrechina longicornis Latreille, 1802	GE	2	0	0	0	0	0
Myrmicinae							
Acromyrmex balzani Emery, 1890	FC	0	1	0	0	0	0
Acromyrmex subterraneus molestans Santschi, 1925	FC	0	2	0	0	0	0
Atta sexdens (Linnaeus, 1758)	FC	0	1	0	0	0	0
Cephalotes atratus (Linnaeus, 1758)	AFP	0	0	0	0	0	4
Cephalotes minutus (Fabricius, 1804)	AFP	0	0	1	0	0	0

Cephalotes pallidus Andrade, 1999	AFP	0	0	0	0	1	0
Cephalotes pavonii (Latreille, 1809)	AFP	0	0	4	0	0	0
Cephalotes pusillus (Klug, 1824)	AFP	1	3	22	0	2	3
Cephalotes sp.	AFP	0	0	0	1	0	0
Crematogaster curvispinosa Mayr, 1862	AD	1	0	1	1	0	1
Crematogaster distans Mayr, 1870	DA	4	2	2	4	0	1
Crematogaster victima Smith, 1958	DA	1	1	9	0	0	0
Crematogaster sp.1	DA	0	0	0	0	0	3
Crematogaster sp.2	DA	0	0	0	1	0	0
Crematogaster sp.3	DA	0	0	0	2	0	0
Cyphomyrmex salvine Forel, 1899	FC	2	0	0	0	0	0
Cyphomyrmex sp.1 gp. Strigatus	FC	0	3	0	0	0	0
Cyphomyrmex sp.2	FC	0	0	0	0	3	0
Hylomyrma balzani (Emery, 1894)	FC	0	0	0	1	3	0
Mycetophylax sp.	FC	0	0	0	0	1	0
Nesomyrmex sp.	GE	0	0	1	0	0	0
Oxyepoecus sp.1	GE	0	2	0	0	0	0
Oxyepoecus sp.2	GE	0	3	0	0	0	0
Pheidole sp.1 gp. Diligens	GE	0	1	0	0	1	0
Pheidole sp.2 gp. Diligens	GE	0	0	0	0	0	1
Pheidole sp.3 gp. Diligens	GE	0	8	0	0	13	1
Pheidole sp.4 gp. Diligens	GE	0	18	3	0	9	11
Pheidole sp.5 gp. Diligens	GE	0	4	10	0	3	0
Pheidole sp.6 gp. Diligens	GE	1	1	0	0	0	0
Pheidole sp.7 gp. Flavens	GE	0	7	0	1	2	0
Pheidole sp.8 gp. Fallax	GE	0	11	0	2	6	1
Pheidole sp.9 gp. Fallax	GE	0	1	0	0	0	0
Pheidole sp.10 gp. Diligens	GE	0	0	1	0	0	0

Pheidole sp.11 gp. Diligens	GE	0	0	0	0	1	0
Pheidole sp.12 gp. Tristis	GE	0	6	0	0	0	0
Pheidole sp.13 gp. Fallax	GE	0	0	0	0	1	0
Pheidole sp.14 gp. Diligens	GE	0	1	0	0	0	1
Pheidole sp.15 gp. Diligens	GE	0	2	0	0	0	0
Pheidole sp.16 gp. Fallax	GE	0	1	0	0	2	0
Pheidole sp.17 gp. Diligens	GE	0	5	0	0	1	0
Pheidole sp.18 gp. Flavens	GE	1	17	2	1	2	0
Pheidole sp.19 gp. Tristis	GE	0	4	1	1	9	0
Pheidole sp.20 gp. Flavens	GE	0	2	0	0	5	0
Pheidole sp.21	GE	0	0	0	0	1	0
Pheidole sp.22	GE	0	0	0	0	0	1
Pheidole sp.23 gp. Diligens	GE	0	0	0	0	3	0
Pheidole sp.24 gp. Diligens	GE	0	0	0	1	4	0
Pheidole sp.25 gp. Diligens	GE	0	0	0	0	1	0
Pheidole sp.26	GE	0	0	0	0	1	0
Pogonomyrmex naegelii (Forel, 1878)	GE	0	1	0	0	2	0
Procryptocerus sp.	DA	0	0	0	0	0	1
Sericomyrmex sp.	FC	0	2	0	0	0	0
Solenopsis globularia (Smith, 1858)	GE	0	1	0	0	0	0
Solenopsis sp.1	GE	0	2	1	3	2	9
Solenopsis sp.2	GE	0	0	0	3	0	1
Solenopsis sp.3	GE	0	0	0	0	5	1
Solenopsis sp.4	GE	0	0	0	0	1	0
Strumigenys appretiatus (Borgmeier, 1954)	DP	0	1	0	0	0	0
Strumigenys denticulata (Mayr, 1887)	DP	0	0	0	0	1	0

Tetramorium simillimum (F. Smith, 1851)	GE	3	0	0	2	0	0
Trachymyrmex fuscus Emery, 1834	FC	0	10	0	0	0	0
Wasmannia auropunctata Roger, 1863	GE	3	7	2	0	2	0
Wasmannia rochai Forel, 1912	GE	2	4	0	4	1	0
Ponerinae							
Anochetus oriens Kempf, 1964	EGP	0	1	0	0	0	0
Hypoponera sp.1	HGP	2	0	0	0	0	0
Hypoponera sp.2	HGP	0	0	0	1	0	0
Hypoponera sp.3	HGP	0	0	0	0	1	0
Odontomachus chelifer (Latreille, 1802)	EGP	0	4	2	4	39	0
Odontomachus meinerti Forel, 1905	EGP	3	1	0	0	0	0
Pachycondyla bucki (Borgmeier, 1927)	EGP	0	0	0	0	2	0
Pachycondyla harpax (Fabricius, 1804)	EGP	0	3	0	0	1	0
Pseudomyrmecinae							
Pseudomyrmex gracilis (Fabricius, 1804)	AP	0	0	7	0	0	0
Pseudomyrmex oculatus (F. Smith, 1855)	AP	0	0	9	0	0	0
Pseudomyrmex schuppi (Forel, 1901)	AP	0	0	1	0	0	0
Pseudomyrmex tenuis (Fabricius, 1804)	AP	0	3	0	0	0	0
Pseudomyrmex termitarius (F. Smith, 1855)	AP	0	0	0	1	1	0
Pseudomyrmex sp.1 gp. Pallidus	AP	0	0	1	0	0	0
Pseudomyrmex sp.2 gp. Pallidus	AP	0	0	2	0	0	1