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Cerrado ground-dwelling ants (Hymenoptera: Formicidae) as indicators of edge effects

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ABSTRACT. Large-scale agricultural production in Brazil preferentially occupies plateaus reclaimed from areas originally covered by Cerrado (savanna). Depending on the region, a percentage of the pristine vegetation coverage must be preserved by law, resulting in the creation of fragmented legal Cerrado reserves. The geometry of these relatively small legal reserves creates new habitat edges and ecotones, whose effects on the invertebrate fauna are poorly understood. This study aimed to assess the effects of abrupt edges resulting from soy production on ground-dwelling ant assemblages in the Brazilian Cerrado. The study sites are located within the Amazon region, in the state of Maranhão, northern Brazil, but were covered by Cerrado on a relatively low plateau, irregularly inter-spaced with gallery forests along streams. We compared species richness and species composition of ground-dwelling ants along eight transects set 0, 50, 100, 150, 200, and 250 m into the *sensu stricto* Cerrado and 50 and 100 m into the soy field. The collecting periods covered the wet and dry seasons. Effects on ant species richness were non-significant, although composition of the assemblages was significantly affected by edge effects, which were, in part, found to be species specific. We hypothesize that edge effects are probably greater than estimated because of the shape and complexity of reserves. Consideration of edge effects in the Cerrado Biome should enable the design of appropriate reserve sizes and shapes to meet conservation goals.

KEY WORDS. Consevation; diversity; legal reserves; savanna; soy production.

The Brazilian Cerrado (a savanna like vegetation) once occupied some 2 million square kilometers, representing about 21% of the Brazilian territory (Bridgewater *et al.* 2004). The Cerrado was recently recognized as one of the world hotspots for biodiversity conservation (Myers *et al.* 2000) because of its high endemism and rates of biodiversity loss due to recent human occupation and agricultural expansion; however, only 2.2% of its area is under legal protection (Klink & Machado 2005). The relatively high level of landscape conversion to agriculture is a major threat to the conservation of Cerrado's biodiversity. It is estimated that around 55% of the biome has been already deforested (Klink & Machado 2005, Silva *et al.* 2006).

Habitat edges are a ubiquitous feature of modern fragmented landscapes and have profound influences on the spatial distribution of many species (Ewers & Didham *2*008). Edge effects induce different micro-environmental conditions from those of the forest interior. These are mainly related to relative humidity, air and soil temperature, soil moisture, light incidence, soil organic matter, and pH (Marchand & Houle *2*006), which in turn influence species number, species composition, and population abundances of plants and animals (Laurance & Yensen 1991, Laurance 2000, Zheng & Chen 2000).

Abrupt edges, characterized by small spatial extensions between patches of different land use practices, are a major attribute of agricultural landscapes (Dauber & Wolters 2004), and some available studies suggest that sharp edges markedly impact the structure and distribution of faunal communities (Ingham & Samways 1996, French & Elliot 1999). In the Cerrado, abrupt edges have been created by agricultural expansion, including regions in the Brazilian Amazon that have been cleared for soybean production. The law dictates that at least 50% of these regions are protected and kept intact as conservation reserves. In Brazil, fragmentation and edge effects have been mainly reported for Amazonian forests (e.g. Malcolm 1994, Ferraz *et al.* 2003, Laurance *et al.* 2006) and Brazilian Atlantic forest (e.g. Viana *et al.* 1997, Tabarelli *et al.* 1999), but very few comparative data are available for Cerrado (Pivello *et al.* 1999). Due to its unique physiognomy and often open structure, which permits enough sunlight to reach the lower strata, Cerrado is likely to exhibit different edge effect responses when compared to other Neotropical forests and savannas (Pivello *et al.* 1999). Despite the ecological importance of this biome, there is no available study on the effects of abrupt edges, created by agricultural expansion, on the invertebrate fauna of the Cerrado.

In this study, we examine the edge response of ground-dwelling ants to recently created legal reserves of Cerrado. Our study aimed to understand the response of ant communities at the sharp edges between Cerrado areas exposed to soy bean land use. Ants have been successfully employed as ecological bioindicators because they are ubiquitous, relatively abundant, diverse, of great functional importance, easily surveyed by baiting and other quantitative techniques, readily collected in suitable numbers for statistical analysis, and are easily identified to morphospecies (Agosti *et al.* 2000, Andersen & Majer 2004). Further, ants are of special interest because they are an important part of the biodiversity, influencing other organisms and soil process (Agosti *et al.* 2000).

Specifically, we investigate (1) how species richness, assemblage composition, and species abundance respond at selected distances from the edge in two areas of the Brazilian Cerrado, and (2) the characteristic ant species of the soy culture, edge and interior habitat, revealing ant indicator taxa of edge effects.

MATERIAL AND METHODS

Study sites and ant sampling

Between 1995 and 2000, the PRODECER program, a joint venture of the Brazilian government, via the Ministério da Agricultura e Abastecimento and the Japanese Cooperation Agency, has funded 47 agroindustrial project areas, each at least 40,000 ha in size. Several of these areas are located in what is called by the Brazilian government as "legal Amazon", covering areas suitable and non suitable for mechanized agriculture, which includes different savanna habitats.

This study was carried out from 1999 to 2000 in the Colonization Project of the municipality of Balsas, state of Maranhão, northern Brazil. The study site lies within a structurally complex range known as Chapada das Mangabeiras, a system of low plateaus and low undulations that represent water catchments between the Tocantins and Parnaíba River Basins. The region is regarded as an important corridor between the Amazon forest and the peculiar Caatinga biome (Progea 1995). According to Embrapa soil maps (Jacomine 1986), the landscape is dominated by yellow latosols (sandy-argillaceous) with small patches of podozolic red-yellow soils and laterite. Because the legal reserves are mostly situated on sandy areas, the soil is well drained, dystrophic, and mostly acidic. Elevation in the study sites ranged from 520 to 560 m above sea level. The climate is seasonal, characterized by a well-defined dry season (May to September), with minimum monthly average rainfall close to 60 mm and average minimum temperature of 18°C (June to July). In the wet season (Semptember to April), the average rainfall is 1,118 mm and average maximum temperature is 26°C. The average annual rainfall in the municipality of Balsas is 1,216.7 mm.

The areas surveyed are all within, or neighboring, conservation reserves included in the PRODECER agroindustrial project area. Because they are usually delimited as to leave the best spots for agricultural use, these legal reserves have different sizes and shapes, often including steep slopes and lacking extensive flat areas. The original vegetation of all study areas can be classified as *sensu stricto* Cerrado, a predominantly tree and scrub phytophysiognomy presenting two strata of woody vegetation, with an herbaceous stratum; the upper-layer of vegetation is 2-6 m high and discontinuous. The bare soil was estimated to represent 10-25% of the area (Progea 1995). Although poorly studied, this area of Cerrado is very rich in at least two taxonomic groups: surveys lasting three years (1995-1998) in four sites found 773 moth species from 32 nocturnal Lepidoptera families (Camargo 1998); a floristic survey revealed 63 tree and 483 herb and shrub species (Joel L. de Queiroga, Universidade Estadual de Londrina, unpubl. data).

Edge effects on ground-dwelling ants were investigated at edges of two recently established legal reserves, hereafter called reserve 1 (08°37'27.1"S, 46°44'30.5"W) and reserve 2 (08°34'19.6S, 46°42'28.2"W). Soy culture dominates the plateaus adjacent to these reserves, and the abrupt edges are created by natural ravines. At the point where we recorded geographic coordinates, the distance between sites is 6.89 km.

Eight 200 m transects were set parallel to the edge between soy culture and preserved Cerrado at each study site. Each was randomly set along the edge lengths, spaced 0, 50, 100, 150, 200, and 250 m into *sensu stricto* Cerrado vegetation, and 50 and 100 m into the soy culture area (hereafter called -100 and -50 m). Within each 200 m transect, 20 sardine baits were distributed, with at least 10 m between them. Sardine baits were offered for 60 minutes, based on other studies in the Brazilian Cerrado (Brandão *et al.* 2000, Silva *et al.* 2004). The collecting period covered the wet and dry seasons in the region (respectively 6-9 November 1999 and 16-17 March 2000). Altogether we surveyed sixteen transects in the two areas, collecting 20 baits in each, thus totaling 640 baits.

All ants taken while visiting the sardine baits were sorted and up to three workers of each morphospecies, pin mounted and labelled. The specimens were identified to morphospecies based on characters previously established to be important at the species level for each genus. When possible, names were linked to these morphospecies using taxonomic descriptions and by comparison with identified material deposited in the Formicidae collection of the Museu de Zoologia da Universidade de São Paulo, Brazil, where voucher specimens were deposited.

Data analysis

We employed species richness and species composition analyses to evaluate the response of ground-dwelling ant species to edges in the Cerrado. Samples from two seasons were pooled for the numerical analysis because baiting in different seasons was conducted at the same points of the transects. The number of species occurrences at the baits was used to compare ant assemblages among transects because occurrence often yields a more accurate estimation of abundance than the total number of ant individuals collected at baits, since different species employ different systems of nestmates recruiting. Species occurrences and species richness were defined as the total number of species occurrences and the number of ant species occurring at transects, respectively. The number of ant species in each reserve was estimated using the Chao 2 index (Colwell 2008).

Because we did not consider the number of individuals at baits for the analysis, edge effects were tested using species presence-absence data. We applied three approaches to investigate patterns of species richness and composition at each edge distance. First, we evaluated the relationship between edge and species richness in each reserve using general linear models (GLMs), with distance of edge as an explanatory variable and species richness at baits as a response variable, taking into consideration Poisson errors (Crawley 2002). Second, detrended correspondence analysis (DCA) was used to show patterns in ant assemblages with respect to distance from edge. DCA is considered the best indirect ordination procedure to discern sample variation in response to environmental gradients (Pielou 1984). Lastly, indicator species analysis (Dufrêne & Legendre 1997) in the *labdsv* Package version 1.3-1 (Roberts 2009) assesses the habitat preferences of ant species for edge zones defined by NCAP analysis (results not showed; Anderson *et al.* 2005) as: interior (100, 150, 200, and 250 m), edge (0 and 50 m), and soy culture (-100 and -50 m). Indicator species analysis calculates an indicator value (%) for each species, where 0 represents no indication and 100 represents perfect indication of the habitat. The indicator value combines information about species relative abundance (specificity) and relative frequency of occurrence (fidelity) in each of the edge zones (Dufrêne & Legendre 1997, McGeoch *et al.* 2002).

RESULTS

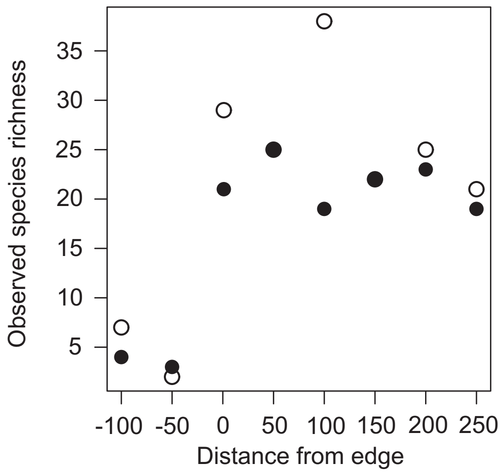
Overall species richness and species occurrence

A total of 938 records of 77 species were obtained in 640 baits (Tab. I). In total, 34 ant species were recorded in both sites, 60 in the Cerrado reserve 1 and 52 in the Cerrado reserve 2. The Chao 2 ± standard deviations estimated a species richness of 82 (±13.90) and 64 (±8.81) for Cerrado reserve 1 and Cerrado reserve 2, respectively. The six most common species made up 45.15% of all ants collected at baits and were encountered in both studied reserves: *Ectatomma brunneum* Smith, 1858 (96 occurrences), *Linepithema cerradense* Wild, 2007 (92), *Pheidole* sp. 1 (84), *Pheidole* sp. 4 (74), *Camponotus crassus* Mayr, 1862 (73), and *Dorymyrmex pyramicus* (Roger, 1863) (42) (Tab. I).

Edge-interior gradients in species richness and diversity

The relationships between distance from edge into the Cerrado and species richness or species occurrences generally increased (Figs 1 and 2). The largest values of observed species richness, occurrences and diversity occurred at 100 m from the edge in reserve 1, although the trend was less clear in reserve 2.

Ant species richness at baits did not differ significantly between edge and the interior transects in the Cerrado reserves (GLMs, p > 0.05). Only the 100 m transect in reserve 1 was significantly different, with higher mean species richness than the edge (z-value = 2.531, p = 0.0114, Tab. II). Inspection of the species list in each transect indicates the specific differences in species richness among habitats. In reserve 1, 52 ant species were found between edge and 100 m from the edge, while 36 species were found towards the interior of the reserve. In this case, the greater species richness in transects near the edge was related to the higher diversity of the Myrmicinae ant genera: *Crematogaster, Pheidole*, *Solenopsis*, and fungus-growers (Attini). However, there was no difference between species richness of edge and the interior in reserve 2 (35 and 37 species in edge and interior, respectively).



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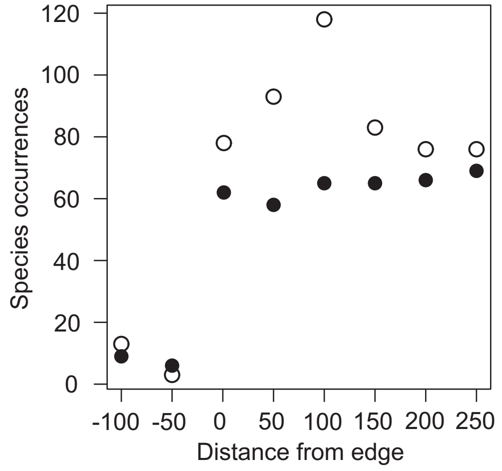

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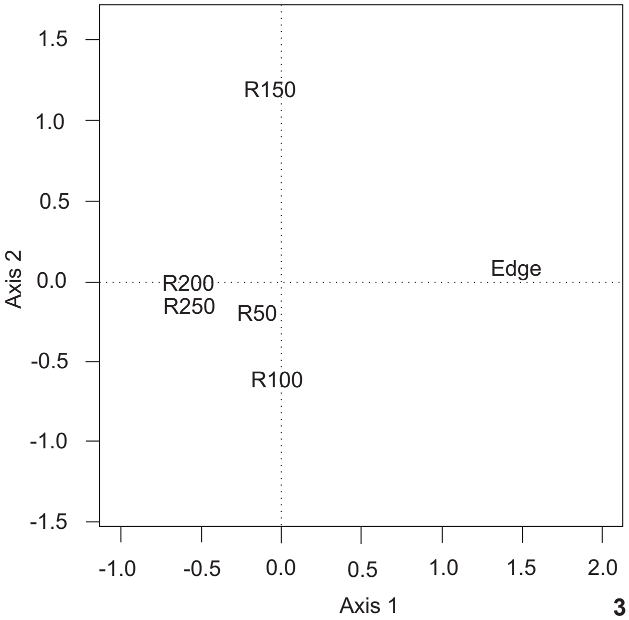
Figures 1-2. Relationships between distance from edge and: observed species (1) and species occurrences (2) for ground-dwelling ant assemblages in two surveyed Cerrado reserves. (○) reserve 1, (●) reserve 2, in Balsas, Maranhão, northern Brazil.

Table I. Ground-dwelling ant species recorded (total number of occurrences) at sardine baits (N = 320 per reserve; see Material and Methods) set along eight 200 m transects in two reserves of Cerrado in Balsas, Maranhão, northern Brazil.

	Reserve 1	Reserve 2	Total occurrences
Dolichoderinae			
Azteca alfari Emery, 1893	0	3	3
Dorymyrmex brunneus Forel, 1908	0	1	1
Dorymyrmex jheringi Forel, 1912	2	3	5
Dorymyrmex pyramicus (Roger, 1863)	28	14	42
Dorymyrmex spurius Santschi, 1929	0	4	4
Dorymyrmex thoracicus Gallardo, 1916	1	0	1
Dorymyrmex sp. 2	1	3	4
Dorymyrmex sp. 6	1	3	4
Dorymyrmex sp. 8	4	1	5
Gracilidris pombero Wild & Cuezzo, 2006	0	2	2
Forelius brasiliensis (Forel, 1908)	1	5	6
Forelius maranhaoensis Cuezzo, 2000	3	0	3
Forelius sp. 2	2	0	2
Linepithema cerradense Wild, 2007	51	41	92
Linepithema neotropicum Wild, 2007	5	5	10
Linepithema sp. 1	3	6	9
Linepithema sp. 2	0	1	1
Tapinoma melanocephalum (Fabricius, 1793)	3	9	12
Ecitoninae			
Labidus coecus (Latreille, 1802)	0	1	1
Ectatomminae			
Ectatomma brunneum Smith, 1858	66	30	96
Ectatomma edentatum Roger, 1863	7	1	8
Ectatomma muticum Mayr, 1870	8	0	8
Ectatomma opaciventre (Roger, 1861)	20	1	21
Ectatomma planidens Borgmeier, 1939	7	7	14
Gnamptogenys ammophila Lattke, 1990	3	1	4
Formicinae			
Brachymyrmex longicornis Forel, 1907	10	7	17
Brachymyrmex patagonicus Mayr, 1868	27	2	29
Camponotus blandus (Smith, 1858)	9	14	23
Camponotus crassus Mayr, 1862	46	27	73
Camponotus personatus Emery, 1894	17	14	31
Camponotus renggeri Emery, 1894	6	0	6
Nylanderia fulva (Mayr, 1862)	1	0	1
Paratrechina longicornis Latreille, 1802	0	1	1
Myrmicinae			
Acromyrmex landolti (Forel, 1885)	0	1	1
Acromyrmex rugosus (Smith, 1858)	1	0	1
Atta sexdens (Linnaeus, 1758)	6	2	8
Blepharidatta conops Kempf, 1967	0	4	4
Cardiocondyla emeryi Forel, 1881	0	3	3
Carebara (gr. Concinna) sp. 1	1	0	1
Cephalotes atratus (Linnaeus, 1758)	1	2	3
Cephalotes pavonii (Latreille, 1809)	2	0	2
Cephalotes pusillus (Klug, 1824)	0	13	13
Crematogaster abstinens Forel, 1899	2	14	16
Crematogaster acuta (Fabricius, 1804)	2	6	8
Crematogaster erecta Mayr, 1866	0	2	2
Crematogaster evallans Forel, 1907	2	7	9
Mycocepurus goeldii (Forel, 1893)	2	0	2
Nesomyrmex brasiliensis (Kempf, 1958)	1	0	1
Ochetomyrmex semipolitus Mayr, 1878	0	5	5
Pheidole sp. 1	35	49	84
Pheidole sp. 2	3	0	3
Pheidole sp. 3	0	1	1
Pheidole sp. 4	48	26	74
Pheidole sp. 5	8	2	10
Pheidole sp. 7	1	4	5
Pheidole sp. 8	11	0	11
Pheidole sp. 10	1	0	1
Pheidole sp. 11	1	0	1
Pheidole sp. 14	1	0	1
Pheidole sp. 15	8	0	8
Pheidole sp. 16	1	1	2
Pheidole sp. 18	5	0	5
Rogeria scobinata Kugler, 1994	1	0	1
Solenopsis sp. 1	11	14	25
Solenopsis sp. 2	20	7	27
Solenopsis sp. 3	1	7	8
Solenopsis sp. 4	1	0	1
Solenopsis sp. 5	1	0	1
Solenopsis sp. 6	6	0	6
Solenopsis sp. 7	3	0	3
Trachymyrmex bugnioni (Forel, 1912)	0	1	1
Wasmannia auropunctata (Roger, 1863)	12	13	25
Ponerinae			
Dinoponera gigantea (Perty, 1833)	5	0	5
Odontomachus bauri Emery, 1892	1	0	1
Pachycondyla villosa (Fabricius, 1804)	0	1	1
Pseudomyrmecinae			
Pseudomyrmex termitarius (Smith, 1855)	2	5	7
Pseudomyrmex flavidulus (Smith, 1858)	0	2	2
Total of records	539	399	938
Total of species	60	52	77

Table II. Model parameters (intercepts) for edge effects on ant ground-dwelling ant species richness at baits in two Cerrado legal reserves, as estimated from a generalized linear model, using Poisson errors (SE = standard error; parameter estimates given are on the log scale; note that positive/negative parameter estimates indicate positive/negative effects relative to the edge intercept, which represents average ant species richness at baits).

	Parameters	SE	z-value	P
Reserve 1				
Edge	1.348	0.114	11.829	0.000
50 m	0.178	0.154	1.152	0.249
100 m	0.375	0.148	2.531	0.011
150 m	0.075	0.158	0.474	0.635
200 m	-0.013	0.162	-0.081	0.936
250 m	-0.013	0.162	-0.081	0.936
Reserve 2				
Edge	1.100	0.129	8.510	0.000
50 m	-0.034	0.184	-0.184	0.854
100 m	0.065	0.180	0.359	0.719
150 m	0.033	0.181	0.181	0.856
200 m	0.049	0.180	0.270	0.787
250 m	0.110	0.178	0.621	0.535



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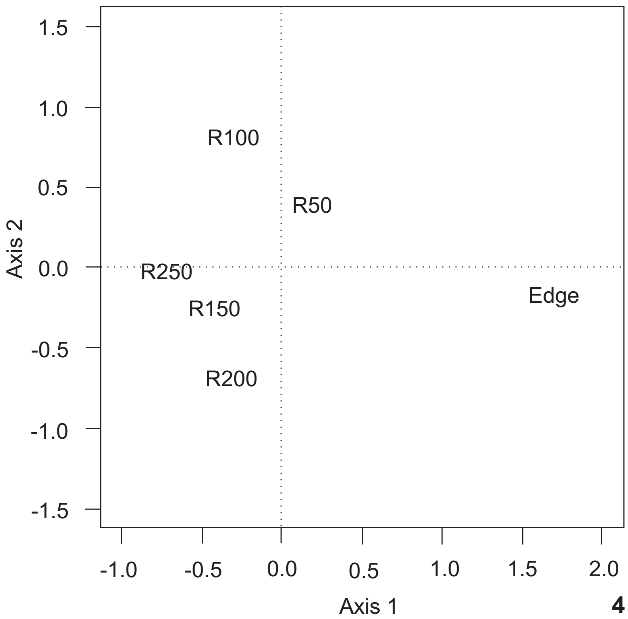

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Figures 3-4. Detrended correspondence analysis (DCA) of baited transects in Cerrado reserve 1 (3) and Cerrado reserve 2 (4) in Balsas, Maranhão, northern Brazil, according to their ground-dwelling ant species assemblages composition.

Edge-interior similarity in species composition

Results for DCA analysis suggest marked differences between edge and interior transects (the ordered transects along the first axis); further, in general, the first axis exhibited grouping of interior transects (150 to 250 m, at least for reserve 2). The second axis shows additional species turnover among 100, 150, and 200 m transects for reserve 1 (Fig. 3) and species turnover among 50, 150, and 200 m for reserve 2 (Fig. 4).

Indicator species analysis revealed the species-specific edge responses of ants for the three edge zones: field (-100 and -50 m), edge (0 and 50 m), and interior (100, 150, 200, and 250 m) of Cerrado. Five species, *Brachymyrmex patagonicus* Mayr, 1868, *Ectatomma opaciventre* (Roger, 1861), *C. crassus*, *L. cerradense*, and *Wasmannia auropunctata* (Roger, 1863) (reserve 2) were classified as indicator species characteristic of Cerrado interior. In contrast, two species were classified as characteristic of soy culture (*Cardiocondyla emeryi* Forel, 1881 and *Solenopsis* sp. 1). The edge showed the highest number of characteristic single habitat ant species (seven species) (Tab. III).

DISCUSSION

We found evidence of edge effects on species composition in the ground-dwelling ant communities of the studied reserves in the Cerrado biome. There was a significant difference in species composition in recorded baits scale (sampling unit). However, there was little evidence for a significant difference in overall species richness between the edge and the interior at the recorded scale transect or at baits scale, with relatively more species in the edge sites.

Table III. Indicator values for ground-dwelling ant species collected along transects set in the soy field (-100 and -50 m), Cerrado edge habitat (0 and 50 m) and Cerrado interior habitats (100, 150, 200, and 250 m) in Balsas, Maranhão, northern Brazil. Only the significant indicator species are included ($p < 0.05$).

	Field	Edge	Interior	P-value
Reserve 1				
Brachymyrmex patagonicus	–	–	0.240	0.024
Ectatomma brunneum	–	0.332	–	0.021
Ectatomma opaciventre	–	–	0.250	0.007
Reserve 2				
Camponotus crassus	–	–	0.275	0.007
Dorymyrmex pyramicus	–	0.258	–	0.002
Dorymyrmex spurius	–	0.121	–	0.009
Linepithema cerradense	–	–	0.410	0.003
Tapinoma melanocephalum	–	0.229	–	0.004
Cardiocondyla emeryi	0.200	–	–	0.001
Pseudomyrmex termitarius	–	0.109	–	0.030
Solenopsis sp. 1	0.375	–	–	0.001
Solenopsis sp. 2	–	0.169	–	0.010
Solenopsis sp. 3	–	0.169	–	0.004
Wasmannia auropunctata	–	–	0.171	0.020

Few comparative data exist on the faunal communities' response to edges in Neotropical savannas (Spector & Ayzama 2003). The Cerrado vegetation, being an open savanna habitat, may respond to edges in a different way than forests (Pivello *et al.* 1999). In fact, Joel L. de Queiroga (unpubl. data) did not detect edge effects on floristic composition (114 species of trees and shrubs) up to 400 m from the edge, as well as on microclimatic data (air humidity, air and soil temperature), in the same reserves we studied. Similarly, edge effects were not detected on richness or in species composition of dung beetles in a natural forest-Cerrado ecotone (Durães *et al.* 2005).

We have shown that the composition of ground-dwelling ants in the Brazilian Cerrado responds to habitat edges. The ants found at the edge are different from those found 50 m from it. However, as one moves further from the edge, this difference becomes insignificant. This finding is consistent with previous observations that the strongest influence of abiotic and biotic edge effects on invertebrates occurs within the first 50 m of the edges (Didham 1997), and that edges affect litter-dwelling ant species richness in a distance shorter than 50 m (Sobrinho & Schoereder 2007). For example, the invasive Argentine ant, *Linepithema humile* (Mayr, 1868), appears to suppress native ants within 50 m of abrupt edges in southwestern California (Holway 2005). Most empirical studies have found that edge effects penetrate less than 150 m into fragmented habitats – see e.g. Laurance (2000); but see Ewers & Didham (2008) for large-scale edge effects on invertebrate communities.

Differences in species composition along the edges could be related to changes in factors that affect suitability of nesting sites, including degree of shading (vegetation cover), availability of nesting materials, soil moisture, soil depth, temperature, and availability of food resources in the neighborhood (Braschler & Baur 2003). Thus, ant presence under edge-altered environments must be determined by the species physiological performance in disturbed environments.

By contrast, we did not find a consistent pattern for ant species richness or species occurrences responses from edge in the studied areas. Furthermore, there were obvious differences in community structure in soy field compared to edges and the interior of Cerrado. The indicator species analysis suggests that a few species occurred exclusively, or were more abundant at, certain points along the distances from the edge. Two highly generalist species, *C. emeryi* and *Solenopsis* sp. 1, were classified as soy species. *Cardiocondyla emeryi* is a cosmopolitan tramp species, widespread in the tropics (Seifert 2003), occurring in open areas and synanthropic habitats, feeding on dead insects, nectar or tending Hemiptera. *Tapinoma melanocephalum*, an edge species in our study, is also a widespread tropical tramp species, introduced by men throughout the world. *Dorymyrmex pyramicus* and *D. spurius* (edge classified species) prefer open habitats or highly disturbed areas where the soil is bare or covered by sparse grassy vegetation. Similarly, *E. brunneum* (an edge species) is widely distributed in Brazil, usually in areas with open vegetation such as forest edges or clearings, but also in cropland, pastures and secondary vegetation (Tofolo & Giannotti 2005).

It is interesting that *L. cerradense*, frequently associated with Cerrado habitats (Wild 2007), has been classified as an interior specialist species and may to be a trophic generalist. However, at least two species classified as interior specialists (*C. crassus* and *W. auropunctata*) are highly generalist species that inhabit a considerable range of Cerrado habitats (Silvestre *et al.* 2003). *Brachymyrmex patagonicus*, a tiny South American species, has been recently considered a matter of concern as it may represent a new ant pest in North America (MacGown *et al.* 2007). However, its biology is poorly known; workers tend hemipterous insects for honeydew and visit nectaries. *E. opaciventre*, another interior specialist species, is a common soil nester ant in Cerrado, primarily diurnal, preying mostly on termites and leaf-cutter ants (Pie 2004). In a Cerrado savanna in southeastern Brazil, the nests of *E. opaciventre* are most often found in more complex microhabitats, which may indicate nesting site choice by founding queens (Pie 2004).

Other studies have shown that ant communities might respond to edges, altering their species richness and/or composition, although there is no defined global pattern on how edges may affect ant communities (Sobrinho & Schoereder 2007). Ant abundance might increase (Vasconcelos 1999) or might be kept unaltered at the edges (Kotze & Samways 2001, Dauber & Wolters 2004). Species richness might decrease (Carvalho & Vasconcelos 1999, Kotze & Samways 2001), increase (Majer *et al.* 1997) or remain unaltered towards the interior of forests (Dauber *et al.* 2006, Sobrinho & Schoereder 2007).

Higher ant species richness at edges may be due to the invasion by alien species or habitat generalists (Sobrinho *et al.* 2003, Schoereder *et al.* 2004), or by colonization by species better adapted to open areas, which may come from altered areas adjacent to pristine Cerrado habitat. Invasion from surrounding landscape may actually increase the total species richness at the edges. The higher diversity of plants and animals associated with edges and ecotones is known as the edge effect principle, which is widely referred to as a fundamental concept of ecology (Malcolm 1994, Didham 1997).

The present study has shown the significant response of the ant communities of the Cerrado biome to edges in terms of species composition. When examining species separately, we found that certain species of ants were more sensitive to edge effects than others. A better knowledge of the mechanisms through which edge effects alter ant communities will be useful for the development of strategies to mitigate harmful edge effects and to improve methods that can be used to evaluate the conservation value of legal reserves in which ants are diverse and abundant.

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