

Reduced ant diversity along a habitat regeneration gradient in the southern Brazilian Atlantic Forest

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Abstract

This study evaluates the response of the ant communities along a habitat regeneration gradient in the south Atlantic Forest comparing it with the ant fauna from a mature forest at the same biome. The survey was conducted according to standard collecting protocols, employing sardine baits and mini-Winkler apparatuses. The structure of the ground and litter-foraging ant community was compared in five habitats, representing a regeneration gradient within the Atlantic Forest. Furthermore, the composition of the leaf-litter ant fauna and the species richness were compared between the regeneration gradient and an area of mature forest. The results showed a higher number of leaf-litter ant species in the mature forest in comparison with the regeneration gradient habitat, as well a distinct species composition. There was a significant loss of ant diversity in the regrowth forest, compared to the mature Atlantic Forest. The composition of the ground-dwelling ant fauna does not consistently separate the sites of forest succession; but a gradient of ant species richness and composition was revealed when the leaf-litter ant fauna data set was included in the analysis. In this sense, the leaf-litter ant fauna is an important segment to characterize habitats also playing an important role as bio-indicators. The data suggest that only primary forests (our data) and old secondary forests (*in litt.*) are capable of maintaining a substantial proportion of the biodiversity in areas of the Atlantic Forest.

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1. Introduction

Due to the dramatic loss of tropical rain forests, an increasing number of studies have focused on the effects of modification and clearance of this habitat on tropical rain forest biodiversity (Schulze et al., 2004). Understanding how much of its original species richness in a modified forest is maintained is an important question in conservation biology. Assessing the conservation value of secondary habitats in the tropics is a topic of growing interest (New, 2000; Watt et al., 2002; Beck et al., 2002; Dunn, 2004). The danger of significant loss of species is particularly acute in hotspots such as the Brazilian Atlantic Forest (Myers et al., 2000), where only approximately 7.6% of the original forest remains (Morellato and Haddad, 2000).

Ants are widely used as ecological indicators in studies on forest clearing (Majer et al., 1997), land management (Majer

and Nichols, 1998; Andersen et al., 2002; Andersen and Majer, 2004; Coelho and Ribeiro, 2006), agroecosystems (Armbrecht et al., 2004), habitat fragmentation (Carvalho and Vasconcelos, 1999; Brühl et al., 2003; Ribas et al., 2005), and general anthropogenic disturbances (Floren and Linsenmair, 2001).

However, much less is known about the changes of the ant communities along habitat gradients in the Atlantic Forest, representing different stages of forest succession and land use after logging. Such habitat gradients can be used to assess effects of habitat disturbance on faunal communities (Beck et al., 2002; Dunn, 2004). The understanding of successional changes in species richness and community composition of faunal communities is central to many aspects of nature conservation (Dunn, 2004; Dauber and Wolters, 2005).

In this study, we compared the species composition of the leaf-litter ant fauna between an intact forest and an area representing a regeneration gradient in the Atlantic Forest. Our first goal was to assess changes in species richness and composition between relatively pristine habitat and along the forest regeneration gradient. We asked how much diversity was

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lost with forest modification. Further, we explored the use of ground-dwelling ant fauna to characterize the regeneration gradient in Atlantic Forest. Our second goal was to define the ant diversity throughout the recognized stages in the regeneration gradient forest. We asked whether changes in forest structure correlate with changes in ant species richness and assemblage composition. In general, we expected to see that stages considered as more heterogeneous might support relatively higher diversity and similar ant communities.

2. Methods

2.1. Sampling site

We surveyed one primary area and a successional gradient in the Brazilian Atlantic Rain Forest in the Parque das Nascentes, Santa Catarina state, South Brazil (27°01'06"S e 49°01'W; Fig. 1). The Brazilian Atlantic Rain Forest covers mostly low to medium elevations (1000 m altitude) of the eastern slopes of the mountain chain that runs along the coastline from southern to northeastern Brazil, with a warm, wet climate without a dry season (Oliveira-Filho and Fontes, 2000). The Park encompasses 5800 ha and has boundaries with two other conservation areas amounting to ca. 10,000 ha. The average annual temperature is 20 °C (ranges from 37 to –3 °C) with occurrences of frost in wintertime (June to September), and total annual precipitation ranges from 1600 to 1800 mm, distributed between 120 and 140 days along the year (Gaplan, 1986). According to the altitudinal categories (300–700 m), this area can be considered as submontane Atlantic rain forest (Oliveira-Filho and Fontes, 2000).

The disturbance gradient is localized in a slope with approximately 1000 m × 500 m, with altitudes ranging from 530 to 580 m. This area was formerly pasture (transformed

either for farming or timber harvesting) and was abandoned about 25 years ago. It is more categorized as a mosaic of successional stages with roughly four stages that could be identified, referred to here as “brush 1”, “brush 2”, “brush 3” and “secondary forest 1”. One further supplementary plot was selected and it is referred as the “secondary forest 2”.

The primary area is considered the forest control plot and its conservation status is considered very good, based on understory and canopy characteristics (Silva, *pers. obs.*). This site is at an elevation of 630 m, ca. 20 km from the regeneration forest plots and about 600 ha in size. The primary forest area studied was chosen by the use of 1:3,500,000 scale maps of the whole Atlantic Forest biome, including maps of the remnants and conservation units already settled (Brandão et al., 2005).

We conducted the sampling in an unique regeneration gradient plot, because this site was selected by Centro de Ciências da Universidade Regional de Blumenau, to examine the responses of ants, rodents, bats, birds and plants communities to small-scale structural changes in the Atlantic Forest. Therefore, the present study focused on a single example of each stage. A description of five stages of regeneration gradient in the plot, listed from lowest to highest, is given below:

1. Brush 1 – located at the beginning of the slope, this site was formed after a pasture was abandoned, and at present it is covered by *Pteridium aquilinum* and grasses. There are scattered individuals of *Myrsine coriacea*. This situation is characteristic of an initial recovery from intense forest modification. This site was classified as “highly simplified”, with lowest structural heterogeneity in the habitat regeneration gradient. There are not shrubs or trees.
2. Brush 2 – contiguous to Brush 1, the site was also formed after a pasture was abandoned, but structural heterogeneity is

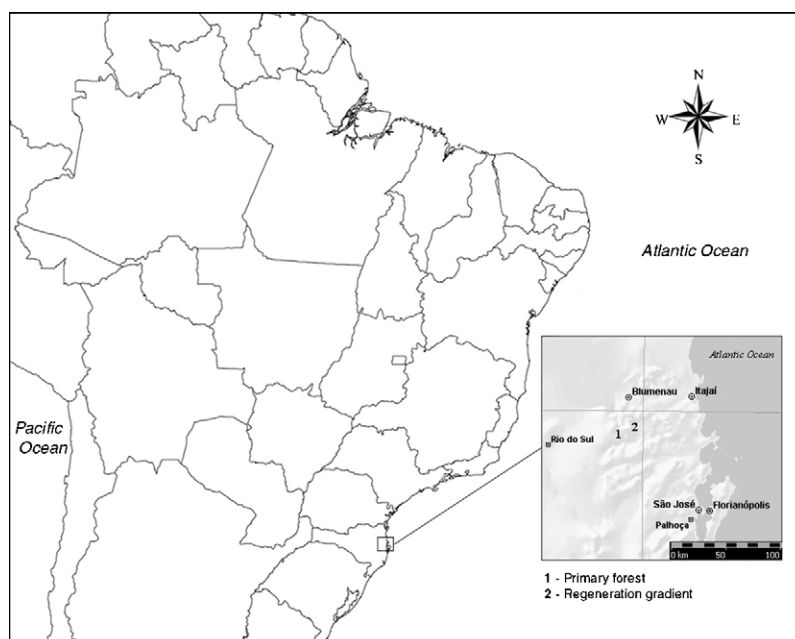


Fig. 1. Map of the studied region showing the position of the two study sites in the southern Brazilian Atlantic Forest, Blumenau, Brazil.

higher compared with Brush 1. This area had more shrub cover, and some trees and grasses that were restricted to small patches. The soil is covered by *Pteridium aquilinum*, *Miconia cabussu*, and some individuals of *Myrsine coriacea*, along with scattered individuals of *Miconia* sp., *Platimycium floribundum*, *Cibistax anthesisiphylitica*, *Casearia sylvestris*, and *Cecropia glazioui*.

3. Brush 3 – in the third area of the slope, the trees grew up to 15 m in height and there is no dominance of *Pteridium aquilinum*. Vegetation is characterized by the presence of trees, as *Miconia cinnamomifolia*, *Cecropia glazioui*, *Cabranea canjerana*, *Nectandra oppositifolia*, *Myrsine coriacea*, and *Miconia cabussu*, and scattered and young individuals of *Euterpe edulis*, *Virola bicuhyba*, *Cyathea delgadii*, and *Alsophila setosa*.
4. Secondary forest 1 – restricted to the highest point of the slope, this area has a developed arboreous vegetation up to 18 m in height and a thick layer of leaf-litter. It was characterized as the least disturbed site and this site experienced only timber extraction. Vegetation is characterized by the presence of a more diverse assemblage of trees, including *Didimopanax angustissimum*, *Persea alba*, *Ocotea odorifera*, *Podocarpus sellowii*, *Myrcia pubipetala*, *Aspidosperma parvifolium*, *Alsophila corcovadensis*, *Cyathea delgadii*, and *Euterpe edulis*.
5. Secondary forest 2 – this area is located near a stream, approximately 500 m from the succession plot. Vegetation is similar to secondary forest 1 site representing a replication of the secondary forest. This extra plot was included in order to increase the number of sites in regeneration studied, and to reach an equal number of leaf-litter samples between the primary and regeneration areas.

2.2. Sampling ants

The work started in December 2000 with the investigation of the leaf-litter ant fauna in the primary area, and then from January to February 2001 we surveyed the five successional sites. At the primary area, a 1250 m long line transect was selected for the ant survey, beginning 500 m from the forest edge. The transect contained 25 collection points at intervals of 50 m. At each point, two samples were collected, 25 m to the left and 25 m to the right of the point. At each of the 50 sampling points a 1-m² plot was established on the ground. The leaf-litter inside the plot was collected, sifted and put in a bag. The sifted material was brought to the field-laboratory and its fauna extracted with mini-Winkler apparatuses (Fisher, 1999) for 48 h.

In each succession site, we established two parallel 200 m transects, 100 m distant from each other, and sardine baits were placed in the soil at 10 m intervals (total of 20 sampling points per transect). We collected all ant species attracted to the baits after 1 h of exposure. In addition, 10 leaf-litter samples were collected at intervals of 50 m in the five succession sites. Overall, 40 baits were distributed in each site and 50 leaf-litter samples were taken in the regeneration gradient.

Although the leaf-litter sampling occurred in different years, the collections were performed in the warm and wet season

(year period with the highest ant activity) thus, a significant change in species richness is not likely to occur within the plots between the 2 years of sampling. Studies on leaf-litter ant fauna with temporal replication of plots, shows that plots are generally situated adjacent to each other in ordination of community similarity (see for example, Brühl et al., 2003).

The ant specimens collected were preserved in 70% alcohol. Once in the laboratory, the ants were sorted to species level, otherwise they were assigned to morphospecies. A full voucher collection is housed in the Museu de Zoologia da Universidade de São Paulo.

2.3. Data analysis

The analyses were based on species occurrence in samples rather than the number of individuals, a better parameter for social insects, which employ different recruiting techniques (Longino et al., 2002).

To estimate species richness we used Chao 2, an incidence-based estimator commonly used in ant studies (Longino et al., 2002; Leponce et al., 2004), which has performed well at low sample sizes and at a moderate degree of patchiness (Chazdon et al., 1998; Brose, 2002). Chao and Jackknife estimators usually perform better than the other methods (Walther and Moore, 2005). Species accumulation curves (sample-based), using the Coleman method (Coleman et al., 1982), were used to compare the species density of sampled sites (Gotelli and Colwell, 2001; Colwell et al., 2004). We used species density as measure because we are particularly interested in differences in the structure within the regeneration gradient and between areas. We expected that there will be fewer ant colonies nesting in the areas with lowest structural heterogeneity.

Comparisons among the ant fauna in the succession sites and the primary area are based exclusively on the leaf-litter ant fauna. Differences in composition among samples collected in each area are presented using non-metric multidimensional scaling (NMDS) and tests of Analysis of Similarity (ANOSIM; Clarke and Green, 1988), based on 1000 permutations. NMDS and ANOSIM were computed using the Bray–Curtis distance index on qualitative (presence-absence) data.

We used detrended correspondence analysis (DCA) to evaluate the ant fauna composition along the successional gradient. This model assumes that species abundances are distributed unimodally, resulting from some underlying ecological patterns (ter Braak and Prentice, 1988; Legendre and Legendre, 1998) and for data taken from more or less continuous, unimodal species' distributions along gradients, DCA summarizes those data with less distortion than any of the other commonly used multivariate algorithms (Gauch et al., 1981). We performed DCA on squared root abundance (frequency of occurrence of species) for three data sets: (1) for those species that forage in the surface (collected by baits), (2) for those species that forage in the leaf-litter (collected in the leaf-litter samples), and (3) for the full data set (baits + leaf-litter).

The statistical analyses were performed using the software R version 2.3.1 (R Development Core Team, 2006) with the

add-on library *Vegan* version 1.8-3, all available at <http://www.r-project.org>.

3. Results

3.1. The ant fauna

In total, we recorded 124 species or morphospecies from 40 genera in all the six areas (five in the disturbance gradient and one in primary forest), including the ground-dwelling and the leaf-litter ant fauna (see [Appendices A and B](#) for complete list of species). A total of 89 species were sampled in the primary forest (leaf-litter samples) and 76 in the disturbance gradient (baits + leaf-litter samples).

3.2. Comparisons between primary area and the regeneration gradient

A total of 120 leaf-litter ant species were sampled in the two areas ([Appendix B](#)). Of these, 89 were collected in the primary area and 69 in the regeneration gradient area. The least disturbed habitat (primary) had the highest number of unique species (50), while the regeneration area contained 31 unique species. The dissimilarity index between them is equal to 0.55 (Bray–Curtis). Thirty-eight ant species were common between the two areas (31.6% shared species). Most of these species can be characterized as generalists and widespread species, as *Camponotus* spp., *Brachymyrmex* spp., *Crematogaster* spp., *Paratrechina* spp., *Pachycondyla striata*, *Pyramica denticulata*, *P. subdentata*, *Strumigenys elongata* and *Odontomachus affinis*. In contrast, the missing species in the regeneration area are in the most cases, specialist species of following genera: *Acanthognathus* (2 species), *Amblyopone* (1), *Carebara* (1), *Oxyepoecus* (3), *Proceratium* (1), *Pyramica* (4), *Sphinctomyrmex* (1), *Stegomyrmex* (1), *Typhlomyrmex* (2), besides several *Gnamptogenys* (4) and Attini (7).

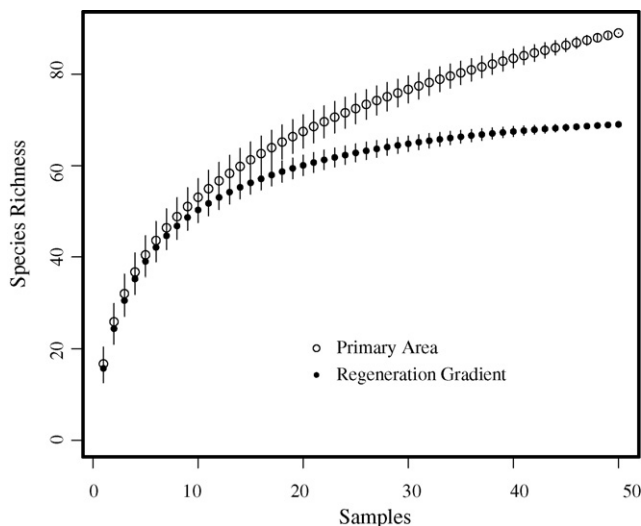


Fig. 2. Sample-based accumulation curves using the Coleman method (Coleman et al., 1982) for ant species from litter samples in a habitat gradient and a primary area in the Atlantic Forest. Vertical lines at each value are standard deviations.

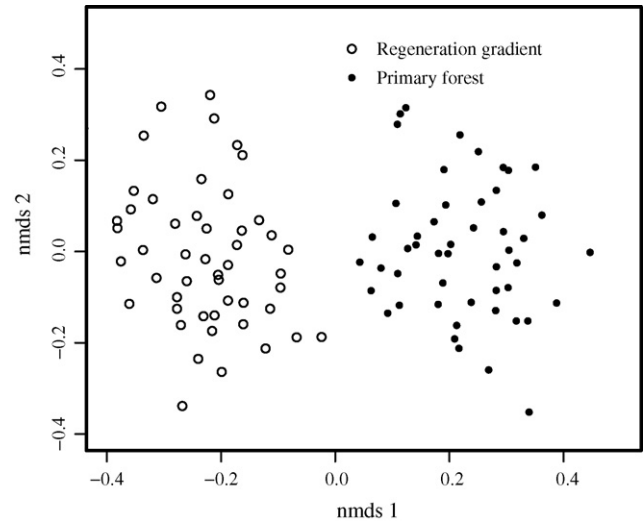


Fig. 3. Non-metric multidimensional scaling ordination in two-dimensions of the leaf-litter ant community inhabiting a primary area and a habitat regeneration gradient in the southern Atlantic Forest. Ordination was based on species presence/absence data (Bray–Curtis dissimilarity index). Stress = 22%.

Visual inspection of species accumulation curves showed that the primary area had a higher rate of species accumulation and species density than the gradient area ([Fig. 2](#)). In addition, the non-metric multidimensional scaling showed strong differences between the samples from the two areas ([Fig. 3](#)). The difference in ant species composition is highly significant (ANOSIM, Global $R = 0.793$, $P < 0.001$). Therefore, our comparisons suggest significant differences between the leaf-litter ant fauna in the primary and the regeneration areas.

3.3. Ant response to the disturbance gradient

In the disturbance gradient, 37 species were sampled with baits and 69 in the leaf-litter (see [Appendix B](#)). The order ranking of species richness among disturbance gradient areas was not generally consistent ([Table 1](#)). This is also observed in the accumulation curves of the ant fauna visiting baits. The intermediate areas showed the highest species density (the number of species per sample), whereas the secondary area showed the smallest species density (SF 1; [Fig. 4](#)). The secondary forest 2 (SF 2) and brush 1 were very close in response to disturbance. In fact, these plots showed similar responses in the average species richness (brush 1 = 1.5, S.D. = 1.01; SF 2 = 1.6, S.D. = 0.98), number of species (brush 1 = 19; SF 2 = 20), and number of occurrences at baits (brush 1 = 60; SF 2 = 64) ([Fig. 4](#)).

The correspondence analysis indicates that the succession gradient of the vegetation structure is revealed when the ant leaf-litter species composition is included in the data set. The DCA performed only for species visiting baits do not indicate clearly the gradient; however, the total data set (baits + leaf-litter samples) suggests a discrimination in species composition among Brush 1, intermediate areas (Brush 2 and Brush 3) and the secondary areas ([Fig. 5](#)).

Table 1

Ant species richness along a successional gradient of regeneration in the Atlantic Forest, partitioned by sampling technique.

	Baits (n = 40)		Winkler (n = 10)		Total
	Observed	Expected (S.D.)	Observed	Expected (S.D.)	Observed
Brush 1	19	23 (4.8)	38	50 (8.8)	46
Brush 2	26	39 (12.4)	52	62 (7.0)	60
Brush 3	25	28 (3.5)	48	57 (6.0)	57
Secondary forest 1	13	19 (7.5)	48	96 (36.9)	51
Secondary forest 2	20	24 (4.8)	44	46 (2.8)	53

Expected species richness according to Chao 2.

4. Discussion

Despite the absence of replication areas in this study may preclude us from drawing any strong conclusions regarding the effects of the habitat modification on ant communities in the southern Brazilian Atlantic Forest, two preliminary conclusions may be drawn. One is that disturbed Atlantic Forest sites have shown a relatively lower richness in their leaf-litter ant fauna than those primary areas. The second conclusion is that the ground ant fauna which visits baits do not discriminate clearly the contiguous sites in the succession stages studied, and in this case, it was important to include the leaf-litter ant fauna in the sample protocol. This suggests that the leaf-litter ant fauna is highly site specific and reflects significantly the differences in habitat features.

4.1. The primary forest × The regeneration gradient forest

The comparison between the primary forest and the sum of gradient successional habitats indicates that the loss of ant diversity was significant, and that only 31% of species are shared between these areas. After 25 years of forest

regeneration, the number of species and the composition profile between the primary forest and the disturbed area still show great differences. These figures are similar to the situation seen in central Amazonian forests, where ant species richness decreases between half to one-third of its original level along succession gradients (Carvalho and Vasconcelos, 1999; Vasconcelos, 1999; Vasconcelos et al., 2000). Recent studies suggest that environmental disturbance may cause severe and long-lasting modification in the ant communities (Armbrrecht et al., 2004). In tropical areas, the complete recovery of ant species richness is estimated to occur after 39 years land abandonment. However, recovery of species composition appears to take substantially longer than recovery of species richness (Dunn, 2004).

Except for the highly diverse, generalist genera (e.g., *Camponotus*, *Crematogaster*, *Paratrechina*, *Brachymyrmex*), the disturbed sites lack a relatively high percentage of species. Therefore, the leaf-litter ant communities of the regeneration gradient forest differed distinctly in species richness and composition from the primary forest. These results are commonly found in studies on the importance of forest regeneration for ant diversity conservation (Roth et al., 1994; Moutinho, 1998; Vasconcelos, 1999) or ant recolonization of

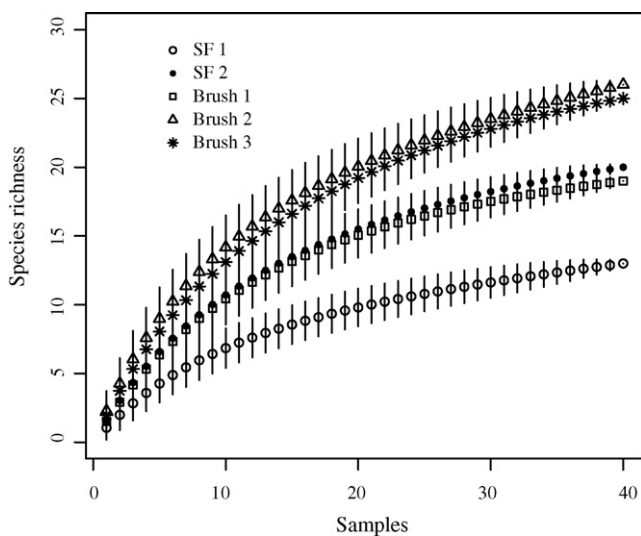


Fig. 4. Sample-based accumulation curves using the Coleman method (Coleman et al., 1982) for ant species from bait samples in five vegetation types along a habitat regeneration gradient in the Atlantic Forest. Vertical lines at each value are standard deviations.

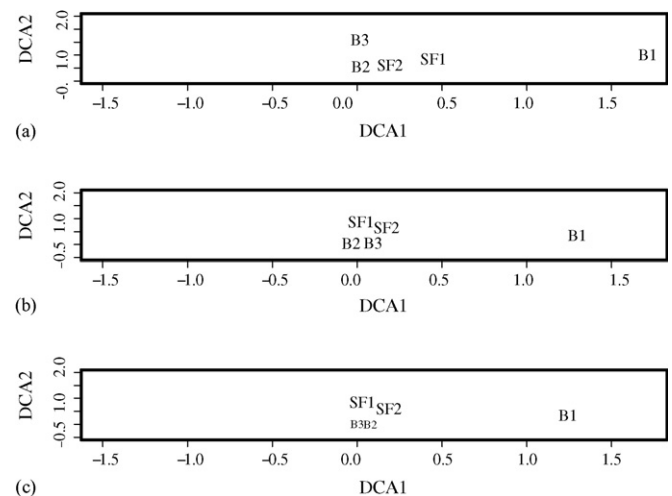


Fig. 5. Detrended correspondence analysis (DCA) of ant assemblages occurring in the different vegetation types across a habitat regeneration gradient in the Atlantic Forest. Letters show DCA for (a) species that foraging in the surface, collected by tuna baits; (b) species that foraging in the leaf-litter; and (c) for both sampling methods combined. B1 = Brush 1, B2 = Brush 2, B3 = Brush 3, SF1 = Secondary forest 1, SF2 = Secondary forest 2 (see Section 2).

rehabilitated areas (Majer, 1992, 1996), specially those that have evaluated forests at different disturbance levels (Floren and Linsenmair, 2001; Watt et al., 2002; Coelho and Ribeiro, 2006).

Therefore, results from many ant studies have showed that ant species composition had not recovered in secondary forests (Dunn, 2004). Furthermore, Armbrrecht et al. (2004) have demonstrated that loss of ant diversity in the leaf-litter on coffee agroecosystems occurs not only in terms of specific species identities but also in terms of ecological association and complexity.

4.2. Ant species richness along the regeneration gradient

The structure and composition of arthropod assemblages are generally associated with habitat complexity (Lassau and Hochuli, 2004; Lassau et al., 2005). Positive associations between arboreal ant species richness and vegetation density or vegetation structural heterogeneity have been described in the Brazilian savanna (Ribas et al., 2003) and in the Brazilian Pantanal (Ribas and Schoederer, 2006), respectively. However, the ground-dwelling ant diversity may be negatively associated with forest complexity in some habitat types (Lassau and Hochuli, 2004).

In the area studied here, the ground-dwelling ant fauna do not discriminate clearly the contiguous stages of forest succession. The more probably cause may be: the different stages of forest succession studied here are in such close proximity that the ground-dwelling ant fauna may have been transient individuals passing among sites or, the generalist ant fauna even use of the sites. In other words, the fact that the study sites were adjacent, resulted in a substantial spatial auto-correlation among the sites, defaulting the sites characterization by the study of the ground-dwelling ant species composition. It is known that low complexity habitats most likely present a more traversable surface at the scale of a foraging ant (Kaspari and Weiser, 1999; Lassau et al., 2005).

This conclusion is reinforced when the leaf-litter ant fauna data set was considered in combination with the ground-dwelling ant fauna in analysis. With only ten samples of leaf-litter, the sites ordination is close to the expected relationship between ant species composition and habitat complexity sites. The performed analysis suggests that the regeneration gradient can be grouped in three distinct groups: highly simplified, intermediate stages and secondary forests. Therefore, with progressing forest succession, changes in species richness and composition in ant communities occurs. We are aware that in each succession site, the minimum number of samples to characterize the most common leaf-litter species, as suggested by ALL protocol (Agosti and Alonso, 2000; Leponce et al., 2004), was not reached. In our case, the main goal was to standardize the leaf-litter sampling protocol based on an equal effort employed in the primary area, and to assess how much leaf-litter ant diversity is lost in a gradient of habitat regeneration.

We believe that the results raised in this study imply that, at least for contiguous sites, surveys that include the ground-

dwelling and leaf-litter ant fauna in an assessment protocol, will perform better as descriptors or habitats indicators, because the leaf-litter ant fauna showed a high indicator value.

In conclusion, this study has documented differences between primary and simplified Atlantic Forest, and how forest disturbance affects the diversity and community structure of ants. In agreement with previous investigations (Majer, 1992, 1996; Schulze et al., 2004), this study reinforce the utility of ant communities as surrogate to habitat characterization, and also supports the conclusion that only primary forests and old secondary forests are capable of maintaining a substantial proportion of biodiversity.

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Appendix A

List of ant species sampled at baits along a habitat gradient in a southern Atlantic Forest, Brazil

Species	Brush 1	Brush 2	Brush 3	Sec. 1	Sec. 2
<i>Brachymyrmex coactus</i>	0	3	2	1	0
<i>Brachymyrmex</i> sp.1	1	0	0	0	0
<i>Brachymyrmex</i> sp.2	1	0	1	0	0
<i>Camponotus</i> sp.1	4	0	2	0	0
<i>Camponotus</i> sp.2	0	1	0	0	0
<i>Crematogaster</i> sp.2	0	3	6	0	1
<i>Crematogaster</i> sp.3	0	1	1	0	0
<i>Crematogaster</i> sp.4	2	1	0	0	2
<i>Crematogaster</i> sp.5	3	0	0	0	0
<i>Ectatomma tuberculatum</i>	0	1	5	0	0
<i>Gnamptogenys striatula</i>	0	8	2	1	4
<i>Hylomyrma reitteri</i>	0	1	0	0	1
<i>Hypoponera</i> sp.8	0	0	0	0	1
<i>Linepithema</i> sp.	6	7	2	1	0
<i>Megalomyrmex goeldii</i>	3	0	0	0	0
<i>Odontomachus affinis</i>	0	0	0	0	3
<i>Odontomachus chelififer</i>	0	2	1	0	4
<i>Pachycondyla striata</i>	1	7	7	6	3
<i>Paratrechina</i> sp.1	0	7	8	0	4
<i>Pheidole</i> sp.1	1	7	3	3	1
<i>Pheidole</i> sp.2	0	0	2	0	0
<i>Pheidole</i> sp.5	4	1	0	1	1
<i>Pheidole</i> sp.6	2	2	1	3	2
<i>Pheidole</i> sp.7	2	3	3	9	9
<i>Pheidole</i> sp.9	3	4	3	2	7
<i>Pheidole</i> sp.13	3	12	11	6	7
<i>Pheidole</i> sp.20	0	5	4	5	6
<i>Pheidole</i> sp.21	6	1	1	1	3
<i>Pheidole</i> sp.22	7	3	3	0	2
<i>Pyramica denticulata</i>	0	1	0	0	0
<i>Solenopsis</i> sp.1	0	1	0	0	0
<i>Solenopsis</i> sp.2	1	3	2	0	1

Appendix A (Continued)

Species	Brush 1	Brush 2	Brush 3	Sec. 1	Sec. 2
<i>Solenopsis</i> sp.5	0	2	2	0	0
<i>Solenopsis</i> sp.6	0	0	1	0	0
<i>Solenopsis</i> sp.10	3	0	0	0	0
<i>Strumigenys elongata</i>	0	0	1	0	0
<i>Wasmannia auropunctata</i>	8	4	5	4	2
Number of species	19	26	25	13	20
Number of occurrences	61	91	79	43	64

Numbers represent their occurrences in the 40 samples collected in each transect. Sec = secondary areas.

Appendix B

List of leaf-litter ant species recorded in a primary area and along a regeneration gradient in a southern Atlantic Forest, Brazil

	Primary area	Regeneration gradient
<i>Acanthognathus ocellatus</i>	4	0
<i>Acanthognathus rudis</i>	2	0
<i>Acanthognathus brevicornis</i>	0	10
<i>Acromyrmex</i> sp.	0	2
<i>Amblyopone elongata</i>	3	0
<i>Amblyopone armigera</i>	0	4
<i>Apterostigma</i> sp.1	1	0
<i>Apterostigma</i> sp.2	0	5
<i>Apterostigma</i> sp.3	0	7
<i>Basiceros disciger</i>	3	16
<i>Brachymyrmex coactus</i>	0	7
<i>Brachymyrmex</i> sp.1	9	16
<i>Brachymyrmex</i> sp.2	0	24
<i>Brachymyrmex</i> sp.3	0	13
<i>Brachymyrmex</i> sp.5	1	0
<i>Camponotus</i> sp.1	0	3
<i>Camponotus</i> sp.3	0	1
<i>Carebara</i> sp.1	3	0
<i>Cerapachys splendens</i>	4	1
<i>Crematogaster</i> sp.1	1	0
<i>Crematogaster</i> sp.2	0	3
<i>Crematogaster</i> sp.3	0	3
<i>Crematogaster</i> sp.4	0	2
<i>Cyphomyrmex olitor</i>	4	0
<i>Cyphomyrmex plaumanni</i>	3	0
<i>Cyphomyrmex strigatus</i>	4	11
<i>Cyphomyrmex</i> (gr. rimosus) sp.1	19	0
<i>Cyphomyrmex</i> (gr. rimosus) sp.2	0	16
<i>Cyphomyrmex</i> (gr. rimosus) sp.3	3	0
<i>Cyphomyrmex</i> (gr. strigatus) sp.1	3	0
<i>Discothyrea neotropica</i>	11	8
<i>Discothyrea sexarticulata</i>	2	0
<i>Gnamptogenys continua</i>	1	0
<i>Gnamptogenys rastrata</i>	8	7
<i>Gnamptogenys reichenspergeri</i>	3	0
<i>Gnamptogenys</i> pr. <i>reichenspergeri</i>	1	0
<i>Gnamptogenys striatula</i>	32	23
<i>Gnamptogenys</i> pr. <i>striatula</i> sp.1	6	0
<i>Gnamptogenys</i> pr. <i>striatula</i> sp.2	4	0
<i>Heteroponera dentinodis</i>	4	9
<i>Heteroponera mayri</i>	3	4
<i>Hylomyrma reitteri</i>	34	36
<i>Hypoconerops</i> sp.1	0	17
<i>Hypoconerops</i> sp.2	20	0
<i>Hypoconerops</i> sp.8	27	47
<i>Hypoconerops</i> sp.12	1	0
<i>Hypoconerops</i> sp.14	13	2

Appendix B (Continued)

	Primary area	Regeneration gradient
<i>Hypoconerops</i> sp.17	1	0
<i>Hypoconerops</i> sp.19	35	0
<i>Hypoconerops</i> sp.20	6	0
<i>Hypoconerops</i> sp.21	14	0
<i>Hypoconerops</i> sp.22	39	1
<i>Hypoconerops</i> sp.23	10	15
<i>Hypoconerops</i> sp.24	0	6
<i>Hypoconerops</i> sp.25	0	17
<i>Hypoconerops</i> sp.26	0	17
<i>Lachnomyrmex plaumanni</i>	5	17
<i>Linepithema</i> sp.	28	10
<i>Megalomyrmex drifti</i>	2	2
<i>Megalomyrmex goeldii</i>	2	0
<i>Neivamyrmex</i> sp.	0	1
<i>Octostruma rugifera</i>	18	23
<i>Octostruma stenognatha</i>	42	20
<i>Odontomachus affinis</i>	0	1
<i>Oxyepoecus plaumanni</i>	1	0
<i>Oxyepoecus rastratus</i>	1	0
<i>Oxyepoecus</i> sp.1	1	0
<i>Oxyepoecus</i> sp.2	1	3
<i>Pachycondyla bucki</i>	17	0
<i>Pachycondyla ferruginea</i>	0	2
<i>Pachycondyla harpax</i>	1	3
<i>Pachycondyla striata</i>	0	3
<i>Paratrechina</i> sp.1	9	23
<i>Paratrechina</i> sp.2	0	2
<i>Paratrechina</i> sp.3	0	4
<i>Pheidole</i> sp.1	44	44
<i>Pheidole</i> sp.2	15	10
<i>Pheidole</i> sp.3	4	0
<i>Pheidole</i> sp.4	2	8
<i>Pheidole</i> sp.5	9	2
<i>Pheidole</i> sp.6	1	0
<i>Pheidole</i> sp.7	11	7
<i>Pheidole</i> sp.7.1	1	0
<i>Pheidole</i> sp.7.2	1	0
<i>Pheidole</i> sp.9	17	3
<i>Pheidole</i> sp.13	12	9
<i>Pheidole</i> sp.15	1	0
<i>Pheidole</i> sp.19	2	0
<i>Pheidole</i> sp.20	0	3
<i>Pheidole</i> sp.21	0	5
<i>Pheidole</i> sp.22	0	4
<i>Prionopelta punctulata</i>	0	15
<i>Proceratium</i> sp.	4	0
<i>Procryptocerus</i> sp.	1	1
<i>Pseudomyrmex</i> sp.	1	0
<i>Pyramica appretiata</i>	2	0
<i>Pyramica crassicornis</i>	27	10
<i>Pyramica denticulata</i>	0	37
<i>Pyramica lygatrix</i>	1	0
<i>Pyramica rugithorax</i>	1	0
<i>Pyramica subdentata</i>	0	14
<i>Pyramica</i> sp.	1	0
<i>Rogeria</i> sp.	1	2
<i>Solenopsis</i> sp.1	33	14
<i>Solenopsis</i> sp.2	21	19
<i>Solenopsis</i> sp.4	23	0
<i>Solenopsis</i> sp.5	13	44
<i>Solenopsis</i> sp.6	32	11
<i>Solenopsis</i> sp.7	5	0
<i>Solenopsis</i> sp.9	11	0
<i>Solenopsis</i> sp.10	4	0
<i>Sphinctomyrmex stali</i>	1	0

Appendix B (Continued)

	Primary area	Regeneration gradient
<i>Stegomyrmex vizzotoi</i>	1	0
<i>Strumigenys elongata</i>	0	9
<i>Strumigenys louisianae</i>	33	5
<i>Strumigenys</i> sp.	1	0
<i>Trachymyrmex zeteki</i>	1	0
<i>Typhlomyrmex major</i>	2	0
<i>Typhlomyrmex pusillus</i>	4	0
<i>Wasmannia auropunctata</i>	23	44
Number of species	89	69

Numbers represent their occurrences in the 50 samples collected in each site.

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