

## Can clay banks increase the local ant species richness of a montane forest?

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**RESUMEN:** Observaciones recientes de hormigas anidando en paredes verticales sobre bancos de arcilla sugieren que este sustrato —común en áreas montañosas— mantiene una mirmecofauna especializada, contribuyendo así a incrementar la riqueza local de hormigas. Usando extractores Winkler, se comparó la estructura de las comunidades de hormigas de los bancos de arcilla con las de la hojarasca circundante, en un bosque pie-montano de los andes ecuatorianos. Se encontraron menos individuos y especies por m<sup>2</sup> en los bancos de arcilla que en la hojarasca circundante. Cuatro especies de hormigas (*Octostruma* sp1, *Octostruma*. sp3, *Cyphomyrmex* sp3 y *Crematogaster* sp1) se encontraron preferentemente en la hojarasca. No se encontró ninguna especie presente consistentemente en los bancos de arcilla. Mientras que el 60% de las especies se encontraron en ambos hábitats, las especies de hormigas de los bancos de arcilla se distribuyeron irregularmente, con una comunidad más heterogénea. Algunas de las características de los bancos de arcilla que les permitirían mantener un set de especies especializadas, diferentes de las hormigas que habitan en la hojarasca, y las adaptaciones que dichas especies presentarían para vivir en éste hábitat son discutidas. En suma, este estudio sugiere que los bancos de arcilla podrían contribuir en parte a mantener los altos niveles de riqueza de especies de hormigas de los bosques tropicales de media altitud de la región.

**PALABRAS CLAVE:** *Stenamma*, heterogeneidad, bancos de arcilla, hojarasca, Otongachi.

**ABSTRACT:** Recent observations of ant species nesting on vertical walls of clay banks suggest that this substrate —common on mountain areas— may sustain a specialized ant fauna, thus contributing to local ant species richness. Using Winkler extractors, we compared the structure of ant communities from clay banks with that of nearby leaf litter, on a pre-montane forest in Andean Ecuador. We observed fewer individuals and species per m<sup>2</sup> in clay banks, in comparison to the surrounding leaf litter. Four ant species (*Octostruma* sp1, *Octostruma*. sp3, *Cyphomyrmex* sp3 and *Crematogaster* sp1) were found preferentially on leaf litter. No ant species was consistently present at clay banks. While 60% of all species were common to both habitats, the ant species of clay banks were more patchily distributed and composed of more heterogeneous communities. We discuss some of the characteristics of clay banks that may allow them to host a specialized set of species, and the adaptations these may present to live here. Overall, our study suggests that clay banks may contribute in part to the high levels of ant species richness typical of mid-elevation tropical forests of the region.

**KEY WORDS:** *Stenamma*, heterogeneity, clay banks, leaf litter; Otongachi

## INTRODUCTION

Biodiversity has a heterogeneous global distribution, with greater numbers of species at the tropics than anywhere else (Gaston 2000). Many hypotheses have been proposed to explain this phenomenon (i.e. Kaspari *et al.* 2000, Wright 2002). One of these, the habitat heterogeneity hypothesis states that the number of species on an area is proportional to the number of limiting resources present there (Tilman & Pacala 1993). Thus, we can predict that heterogeneous habitats are richer than homogeneous ones because they have a wider variety of nutrients, environmental conditions and foraging and nesting sites on which species can specialize (Grant & Grant 2003, Bestelmeyer & Wiens 2001, John *et al.* 2007). For example, a study by Kilmes *et al.* (2012) assessed the factors structuring the arboreal ant community on two plots, one within a primary forest and one in a 10 year succession forest, by surveying all nests from recently cut trees. Their results suggested that the lower species richness found at the secondary forest plot was due to the similarity in nesting microhabitats between trees but mostly to the less complex vegetation structure of the secondary forest.

A central tenet of sociality is nest building (Hölldobler & Wilson 1990). But before building a nest, choosing a location is paramount to the life of an ant colony because activities such as colony growth, rearing of eggs and larvae, feeding and the maintenance of the nest itself all will depend on the chosen place (Penick & Tschinkel 2008, Soare *et al.* 2011). Once a nest site is found, nests must maintain the right conditions, protect ants from predators, and guarantee access to food sources (Hölldobler & Wilson 1990). Several ant species are known to nest on clay banks. For example, two *Stenamma* species nesting on

natural clay banks –that form near water streams or ravines– were recently discovered in Costa Rica (Longino 2005). Three hypothesis have been proposed for the origin of this behaviour: (1) the elevated nest site reduces colony odour accumulation which helps the colony evade the attention of army ants (Ecitoninae); (2) elevation prevents the nest from flooding after heavy rains and (3) the nest entrance could serve as a signal to help flying males find females. A quick literature survey revealed eleven ant species nesting exclusively or preferentially on clay banks (Table 1). All the species that nest at banks inhabit rainforests and montane forests and, with the exception of *Harpegnathos venator*, all belong to the subfamily Myrmicinae. The preferred nest location is near permanent streams and/or at vertical surfaces and almost all of them prefer clay as a building material (Mueller & Wcislo 1998; Longino 2005). Preference for this substrate has appeared independently on several ant genera.

Ants are an important component of tropical fauna, both in terms of abundance and biomass, and about 75% of the ant species on tropical communities are associated with a strata to which they are adapted for nesting and foraging —i.e. canopy, understory, leaf litter, underground— (Longino & Nadkarni 1990, Delabie & Fowler 1995, Basset *et al.* 2012). The recent discovery by the authors of *Stenamma alas* nesting on clay banks, on a species-rich Ecuadorian montane forest (Donoso & Ramón 2009), suggests that clay banks may increase habitat heterogeneity; allowing the coexistence of more species (Tilman y Pacala, 1993; Ambrecht *et al.* 2004). Are these species the only ones adapted to nesting on this habitat, or is there a whole undescribed community living on this strata? This study tests the hypothesis that there is a community of ant species adapted to nest and forage on clay banks, and that this community differs from that of the leaf litter. If

so, clay banks on Andean forests, a world biodiversity hot-spot (Myers et al. 2000) could be responsible for part of this mega-diversity.

## MATERIALS AND METHODS

### Study site

Our study site is located within the Otongachi reserve ( $0^{\circ}18'59.82''$  S;  $78^{\circ}57'15.32''$  W, 830 masl), a 20 ha secondary forest, near “La Unión del Toachi” village, Pichincha province, Ecuador. Average precipitation here is 1500 mm/year with increased rains from December to May. The average temperature is  $21^{\circ}\text{C}$  (max= $27^{\circ}\text{C}$ , min=  $16^{\circ}\text{C}$ ) (for a detailed description of this site see Donoso & Ramón, 2009).

### Sampling Methods

We sampled two habitats from August 5 to 10, 2009: clay banks (hereafter “banks”) and the leaf litter. Banks were defined as surfaces with a slope greater than  $50^{\circ}$  with respect to the horizontal plane, and that did not accumulate litter. Banks, however, were partially covered with mosses, bryophytes, ferns and seedlings. Twenty  $1\text{m}^2$  samples were taken from each habitat, along a transect, and were spaced at least 20 m apart ( $n=40$ ). Each litter sample was taken within 4 metres of a corresponding bank sample. Samples consisted of soil and leaf litter detritus that were put on a  $1\times 1\text{cm}$  wire-mesh sifter. The siftate was then passed to a Winkler extractor (Bestelmeyer et al. 2000) for 72 h.

Identification to species/morphospecies level was made with standard keys or by comparing material with specimens deposited at QCAZ museum, where all the specimens were deposited.

### Data analysis

To determine the completeness of our survey we drew species accumulation curves (Mao Tau) (Colwell & Coddington 1994). We used two-

sample “t” tests, over logarithmic (log+1) transformed data, to determine if ant abundance and richness differed between habitats. To estimate the total richness of each habitat, including the approximate number of species we missed on our survey, we used the non-parametric incidence based coverage estimator (ICE). This estimator uses species found on  $\leq 10$  samples to build an asymptotic model to extrapolate the real richness of each habitat (Chao & Lee 1992). We used the Chao-Jaccard similarity index to calculate the percentage of species common to both habitats (Chao et al. 2004). This index uses abundance data to calculate the chance that two random species found on one habitat are collected on both. To measure the community evenness we calculated Pielou’s index ( $J' = H'/H'\text{max}$ , where  $H'$  is the number derived from Shannon diversity index and  $H'\text{max}$  is the maximum value of  $H'$ ) (Begon 2006). These analyses were performed on EstimateS 8.0 (Colwell 2006).

Heterogeneity hypothesis requires species to specialize to different parts of the resources (Hutchinson 1959, Tilman & Pacala 1993). We used Indicator Values (IndVals) (Dufrene & Legendre 1997), as a proxy for species specialization to both substrates. A high IndVal value indicates a high specificity and fidelity of a given species for a habitat. Statistical probability of finding a given IndVal for every species was calculated using 1000 iterations.

We determined differences on community composition between habitats with a non-metric multidimensional scaling (NMDS) on abundance data. This technique represents samples on a bidimensional space such that the relative distances on the space represent differences on composition (Van der Gucht et al. 2005). To establish dissimilarities between samples we used the Bray-Curtis index (Clarke 1993). Goodness of fit was estimated as a stress function ( $E$ ) that varies from 0 (total fit) to 1 (no

fit). In this analysis we excluded rare ( $n < 10$ ) species because they could have distorted the dissimilarity matrix (Pielou 1984). Then, we performed an analysis of similarities (ANOSIM) using abundance data. This analysis tests composition differences on community composition between two or more groups of samples. It works over a dissimilarity matrix and, as on NMDS, we used the Bray-Curtis index to build it. If two groups have different species composition then compositional dissimilarities between the groups ought to be greater than those within the groups (Chapman & Underwood 1999). ANOSIM generates a number "R" that indicates the separation degree between groups, the closer to 1 this number is, the more similar the groups are (Van der Gucht *et al.* 2005). Statistical signification of observed "R" was assessed by permuting the grouping vector to obtain the empirical distribution of "R" under a null model (Clarke 1993). A logarithmic ( $\log X+1$ ) transformation was performed for all analysis. These analyses were performed on R (R Development Core Team 2008).

Because preliminary results suggested that leaf litter ant communities were more diverse, we wondered if bank ant communities were composed by a sub-set of leaf litter ant community. To approximate an answer we used a nestedness analysis over an incidence matrix, on which every row represented a species and every column a habitat. We arranged the matrix in descending order with respect to the marginal totals, so common species appeared on upper rows and the more diverse habitat was set at the left column (Ulrich *et al.* 2009). To evaluate nestedness we used the metric based on overlap and decreasing fill (NODF), this varies from 0 (no nestedness) to 1 (total nestedness). Statistical significance was assessed by comparing the ordered matrix with the predetermined "CE" null model implemented on the software ANINHADO (Guimaraes &

Guimaraes 2006) (CE: the probability of a cell AIJ showing a presence is equal to  $(PI/C+PJ/R)/2$ , on which PI is the number of presences on the row I, PJ is the number of presences on the column J, C is the number of columns and R the number of rows). A thousand iterations were generated with this model; we chose it because it is less prone to produce type-I errors (Rodríguez-Gironés & Santamaría 2006). This analysis was performed with the software ANINHADO (Guimaraes & Guimaraes 2006).

## RESULTS

A total of 1,666 individuals belonging to 74 species (Table 2), 38 genera and 11 subfamilies were collected (Table 2). *Pheidole* ( $n = 8$ ), *Solenopsis*, ( $n = 6$ ), *Hypoponera*, ( $n = 5$ ) and *Gnamptogenys* and *Megalomyrmex* ( $n= 4$ ) were the most diverse genera (37% of all species). *Solenopsis* contributed with most individuals (52% of the total) and this was due mainly to *Solenopsis* sp. 1 which contributed with 25% of the sampled individuals.

Species accumulation curves showed a tendency to reach an asymptote (Figure 1), although more sampling effort is needed for leaf litter. Leaf litter samples had more species ( $t_{(2)}31.3 = 10.5$ ,  $P < 0.001$ , Figure 2A) and individuals ( $t_{(2)}38 = 5.1$ ;  $P < 0.001$ ; mean abundance at litter=70.2 and banks=23.6, Fig.2B) than banks. The leaf litter ant community was slightly more even ( $J=0.74$ ) than the ant community of banks ( $J=0.67$ ). A total of 39 species were collected on banks and 73 on leaf litter, of these approximately 58% of all the species found, were present on both habitats (Chao-Jaccard Index = 0,58). ICE predicted 39 species for banks and 87 for leaf litter, our survey failed to collect 16 species from leaf litter.

We found four indicator species for leaf litter *Ocotostruma* sp. 1 ( $IndVal = 0,4$ ;  $P= 0,002$ ,

*Octostruma* sp. 3 (IndVal = 0,6; P = 0,006), *Cyphomyrmex* sp. 3 (IndVal = 0,25; P = 0,04) and *Crematogaster* sp. 1 (IndVal = 0,078; P = 0,001). These species have a high fidelity and specificity for leaf litter. No indicator species were found for banks.

NMDS revealed, with relatively low stress ( $E = 0,24$ ), that similarity on species composition was tighter among leaf litter samples, while banks samples were dispersed (Fig. 3). ANOSIM found differences on community composition between habitats, for species richness ( $R = 0,158$ ;  $P = 0,001$ ) and abundance ( $R = 0,126$ ;  $P = 0,004$ ). Nestedness analysis showed that banks ants were not a subset of leaf litter ants ( $NODF = 49,9$ ;  $P = 0,96$ ).

## DISCUSSION

Clay banks are known to host a specialized ant fauna, different from that of the leaf litter. Our study adds to this framework showing that clay bank and leaf litter ant communities on a tropical montane forest are composed of different sets of species, and that neither substrate represents a subset of the other. These results demonstrate that banks act as ant habitat and therefore contribute to forest heterogeneity. Clay banks increase the diversity of nesting spaces, and give rise to ant species specialized at nesting or foraging on them. We expect leaf litter to support more species than clay banks, because leaf litter is structurally and chemically more heterogeneous (composed of leafs, twigs, fruits, acorns, etc., Hansen 2000, Kaspari 2000). Our findings showing that ant richness was lower on clay banks than on leaf litter supports this observation.

Our specificity analysis indicates that the leaf litter is the substrate to which more ant species specialize. Indicator species for leaf litter belonged to the ant genera *Octostruma*, *Cyphomyrmex* and *Crematogaster*. *Octostruma*

is a genus of cryptic ants typically found on leaf litter. Specialized pilosity helps them to trap soil particles as camouflage; they also use thanatosis to avoid predation (Hölldobler & Wilson 1986). Little is known about their nesting habits, except that they form small colonies and prey on small arthropods (Palacio 1997). *Cyphomyrmex* is a neotropical genus of fungus-growing ants, with some species among the most commonly collected ants from leaf litter strata. *Cyphomyrmex* are small slow-moving ants that nest on decayed wood, tree trunks, etc. but most commonly on the ground or leaf litter where they form small colonies (Snelling & Longino 1992). *Crematogaster* is a diverse ant genus at the neotropical region (Blaimer 2012). They are found most frequently on the forest canopy, although sometimes they descend to forage at leaf litter, especially during dry season (Delabie et al. 2000). Some of the species in this genus nest on the leaf litter (Longino 2003).

Most clay bank species were collected from few samples, while the number of ant collections for species leaf litter had a more normal distribution. This suggests that leaf litter ants are evenly dispersed on the forest. This may be due to low competition between ant colonies at tropical forest litter, as it was observed on Panamanian forests (Yanoviak & Kaspari 2000). In New Guinea, however, despite an apparently uniform forest structure, ant species were patchily distributed both at a microgeographic and a local scale (Wilson 1958). Similar results are reported in many litter ant communities on the neotropics (e.g. Panama, Olson 1994; Colombia, Armbrecht et al 2004; New Guinea, Sagata et al. 2010; Brazil, Silva et al. 2011).

Vertical banks present many characteristics that make them different from leaf litter and that determine the ant community they host. While on flat surfaces ants nest on leaf litter (Ryder et al. 2007, Kaspari 1996), at banks ants generally

nest on clay rich surfaces similar —because of its texture— to that of those of ants that nest on soil and subsoil (Johnson 1992). Clay and sand content are important on nest building as they contribute to nest texture and stability, and they have indirect effects over plant cover and water drainage (Greenslade & Greenslade 1977). We suggest that a more detailed analysis, partitioning the forest floor ant community into different subsets (e.g. those of soil, litter, and clay banks), may provide further insight on the nature and characteristics of the specialized clay bank fauna.

Another important characteristic of banks is their inclination. Inclination prevents the accumulation of a litter layer and, because nutrients are continuously washed away by water and wind, lush vegetation growth is not possible. In the absence of a litter layer the existence of an environmental “buffer” is not possible (Arpin *et al.* 1995). Furthermore, the microclimate at banks is likely drier than on inner forest habitats because banks tend to form at forest borders and gaps, where they are exposed to high vapour pressure deficits that desiccate the surface (Foggo *et al.* 2001). As ants have a large surface area relative to volume they easily loss their moisture, thus humidity regulates their activity by regulating desiccation risk and access to nutrients (Kaspari 2000). While ants on this habitat could present some physiological and behavioural adaptations to avoid desiccation (see Hölldobler & Wilson 1990); evidence suggests that the main way by which ants avoid desiccation at banks is by nesting at shaded sites with low light incidence (Longino 2005) or near water courses (i.e. *Cyphomyrmex*, Mueller & Wcislo 1998), where evapotranspiration is lower.

Our study adds to a growing body of literature describing association between habitats and the ants that nest on them (Longino & Nadkarni 1990, Delabie & Fowler 1995, Kaspari 2000,

Ryder *et al.* 2007, Vasconcelos 2008, Ryder *et al.* 2010). Our results suggest that clay banks provide a unique substrate that shape the structure of ant communities. Banks contribute to the high species richness typical of neotropical mid-elevation forests in general (Ward, 2000), and of Ecuadorian andean forests in particular (Donoso *et al.* 2006, Donoso & Ramón 2009, Delsinne & Fernández, 2011, Delsinne *et al.* 2012).

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Table 1. Ant species that nest exclusively or preferentially on vertical surfaces or clay banks. All species but *Harpegnathos venator* are in the subfamily Myrmicinae.

Forest type	Species	Nest location	Substrate	Reference
Montane	<i>Cyphomyrmex longiscapus</i>	Banks near permanent streams	Clay	Mueller & Wcislo (1998), Schultz <i>et al.</i> (2002)
Montane	<i>C. muelleri</i>	Banks near permanent streams	Clay	Schultz <i>et al.</i> (2002)
Rain forest	<i>Trachymyrmex cf. zeteki</i>	Vertical embankments	Clay	Mueller & Wcislo (1998)
Rain forest	<i>Pheidole bigote</i>	Low on vertical embankments	Clay	Longino (2009)
Rain forest	<i>P. eowilsoni</i>	Banks near streams	Clay	Longino (2009)
Montane	<i>Stenamma alas</i>	Banks in mature forest	Clay	Longino (2005)
Montane	<i>S. expolitum</i>	Banks on mature forest	Clay	Longino (2005)
Rain forest	<i>S. diversum</i>	-	-	Branstetter (pers. comm.)
Pre-montane	<i>Lenomyrmex foveolatus</i>	Banks on mature forest	Clay	This study
Rain forest	<i>Stegomyrmex vizottoi</i>	Vertical surfaces at primary and secondary forests	Soil	Diniz & Brandão (1993)
Mature Rain forest	<i>Harpegnathos venator</i>	Banks on mature forest	Clay	Crosland (1995)

Table 2. List of ant species collected during the surveys. For every species the total number of individuals and the total percentage of incidence on every habitat are given. One asterisk (\*) represents a singleton and two (\*\*) a doubleton.

Species	Individuals		Incidence (%)	
	Banks	Litter	Banks	Litter
<b>AGROECOMYRMECINAE</b>				
<i>Tatuidris tatusia</i> Brown & Kempf	4	2	10	10
<b>AMBLYOPONINAE</b>				
<i>Prionopelta amabilis</i> Borgmeier	21	0	5	0
<i>Prionopelta modesta</i> Forel	0	18	0	15
<i>Stigmatomma lurilabes</i> Lattke	3	2	5	5
<b>CERAPACHYINAE</b>				
<i>Cerapachys</i> sp. 1*	1	0	5	0
<b>DOLICHODERINAE</b>				
<i>Tapinoma</i> sp.1 *	0	1	0	5
<b>ECTATOMMINAE</b>				
<i>Gnamptogenys bisulca</i> Kempf & Brown *	1	0	5	0
<i>Gnamptogenys continua</i> Mayr	0	10	0	20
<i>Gnamptogenys</i> sp. 1	14	33	25	40
<i>Gnamptogenys</i> sp. 2	1	2	5	5
<b>FORMICINAE</b>				
<i>Acropyga</i> sp. 1	2	4	5	10
<i>Brachymyrmex</i> sp. 1	4	44	10	20
<i>Brachymyrmex</i> sp. 2	0	8	0	15
<i>Nylanderia</i> sp. 1	2	6	5	10
<i>Paratrechina longicornis</i> Latreille	0	101	0	20
<b>HETEROPONERINAE</b>				
<i>Acanthoponera mucronata</i> (Roger) **	0	2	0	10
<b>LEPTANILLOIDINAE</b>				
<i>Leptanilloides nubecula</i> Donoso, Vieira & Wild	3	0	5	0
<b>MYRMICINAE</b>				
<i>Acanthognathus telelectus</i> Brown & Kempf	2	16	5	25
<i>Acromyrmex</i> sp. 1	0	3	0	5
<i>Apterostigma</i> sp. 1	7	25	15	25
<i>Apterostigma</i> sp. 2	0	7	0	10

Cont. Table 2.

<i>Apterostigma</i> sp. 3	0	6	0	10
<i>Atta cephalotes</i> (Linnaeus)	5	0	5	0
<i>Carebara</i> sp. 1	5	9	15	10
<i>Crematogaster</i> sp. 1	0	44	0	50
<i>Crematogaster</i> sp. 2 *	0	1	0	5
<i>Cyphomyrmex</i> sp. 1	0	3	0	15
<i>Cyphomyrmex</i> sp. 2	22	64	35	45
<i>Cyphomyrmex</i> sp. 3	0	55	0	25
<i>Hylomyrma</i> sp. 1	3	11	10	30
<i>Hylomyrma</i> sp. 2 **	1	1	5	5
<i>Lachnomyrmex</i> sp. 1 *	1	0	5	0
<i>Lenomyrmex foveolatus</i> Fernández & Palacio **	0	2	0	10
<i>Lenomyrmex</i> sp. 1 *	1	0	5	0
<i>Megalomyrmex bidentatus</i> Fernández & Baena *	0	1	0	5
<i>Megalomyrmex incisus</i> Smith R.**	0	2	0	5
<i>Megalomyrmex</i> sp. 1	0	4	0	20
<i>Megalomyrmex</i> sp. 2	0	19	0	10
<i>Octostruma</i> sp. 1	0	37	0	40
<i>Octostruma</i> sp. 2	3	0	10	0
<i>Octostruma</i> sp. 3	37	99	30	85
<i>Pheidole</i> sp. 1	22	25	40	35
<i>Pheidole</i> sp. 2	3	5	10	10
<i>Pheidole</i> sp. 3	9	0	10	0
<i>Pheidole</i> sp. 4	2	1	5	5
<i>Pheidole</i> sp. 5	0	25	0	20
<i>Pheidole</i> sp. 6	4	16	20	60
<i>Pheidole</i> sp. 7 **	1	1	5	5
<i>Pheidole</i> sp. 8 *	0	1	0	5
<i>Protalaridris armata</i> Brown	2	3	5	5
<i>Pyramica</i> sp. 1 **	0	2	0	10
<i>Pyramica</i> sp. 2 *	0	1	0	5
<i>Pyramica</i> sp. 3 *	0	1	0	5
<i>Rogeria belti</i> Mann **	0	2	0	5
<i>Solenopsis</i> sp. 1	47	27	30	40
<i>Solenopsis</i> sp. 2	0	7	0	5
<i>Solenopsis</i> sp. 3	9	0	5	0
<i>Solenopsis</i> sp. 4	0	31	0	15
<i>Solenopsis</i> sp. 5	161	261	50	75
<i>Solenopsis</i> sp. 6	36	23	30	10
<i>Strumigenys</i> sp. 1	12	39	35	55
<i>Strumigenys</i> sp. 2	1	7	5	10
<i>Wasmannia auropunctata</i> (Roger)	0	13	0	5
PONERINAE				
<i>Anochetus</i> sp. 1	0	5	0	5
<i>Hypoponera cf. trigona</i> (Mayr) *	1	0	5	0

Cont. Table 2.

<i>Hypoponera distinguenda</i> (Emery)	0	30	0	15
<i>Hypoponera</i> sp. 1	14	19	30	25
<i>Hypoponera</i> sp. 2 *	0	1	0	5
<i>Hypoponera</i> sp. 3 **	0	2	0	5
<i>Odontomachus bauri</i> Emery	3	0	5	0
<i>Pachychondyla harpax</i> (Fabricius)	2	1	10	5
<i>Thaumatomyrmex atrox</i> Weber *	0	1	0	5
PROCRATIINAE				
<i>Proceratium</i> sp. 1 *	0	1	0	5

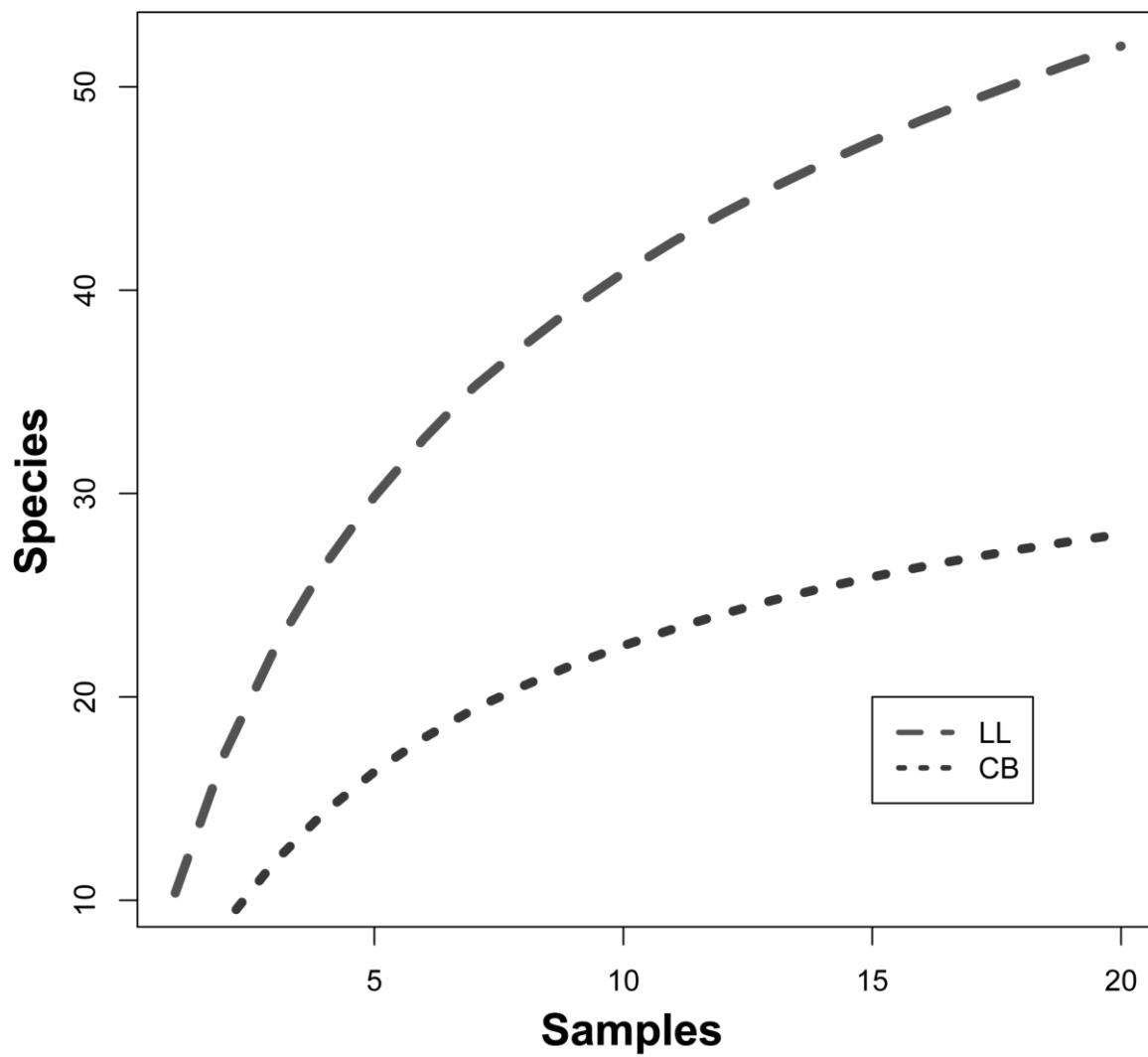


Figure 1. Sample-based species accumulation curves (Mao Tau) for leaf litter (LL) and clay banks (CB) ants. Species accumulation curves show a tendency to reach an asymptote, although more sampling effort is needed at leaf litter.

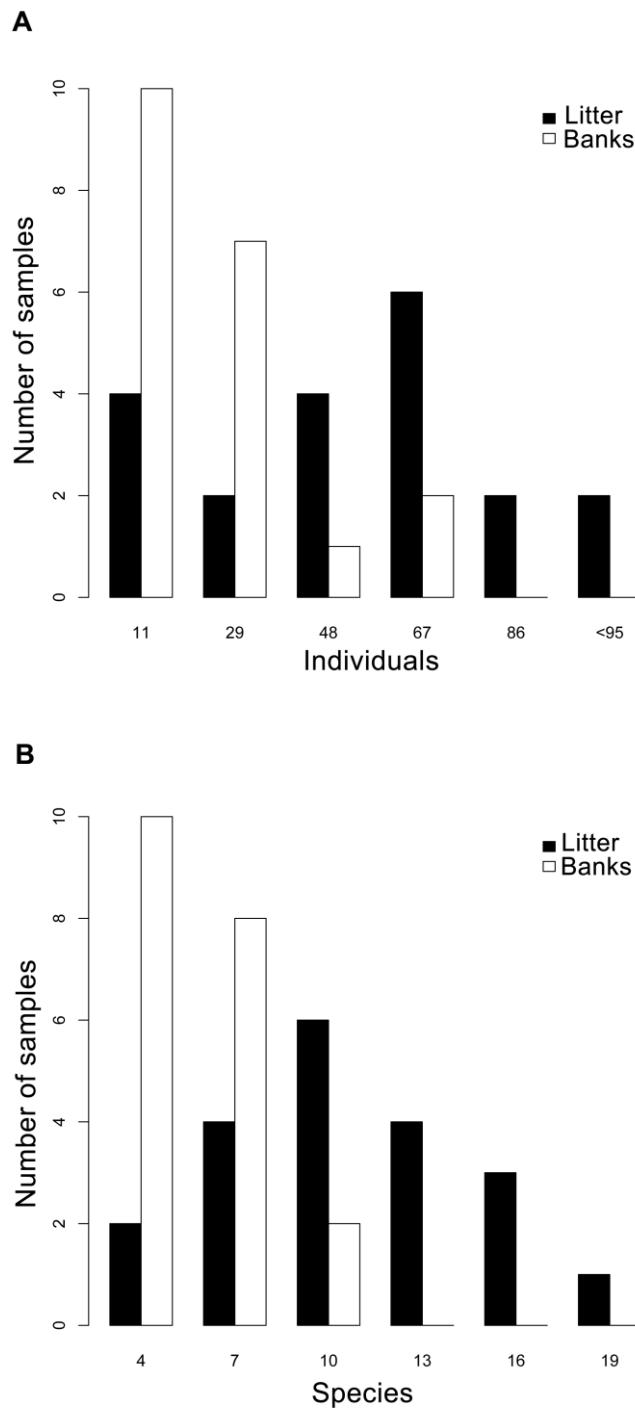


Figure 2. (A) Richness and (B) abundance frequency histograms. Leaf litter had more species ( $t_{(2)31,3} = 10.5$ ,  $P < 0,001$ ) and individuals ( $t_{(2)38} = 5.1$ ;  $P < 0.001$ ; mean abundance at litter=70.2 and banks=23.6) than banks.

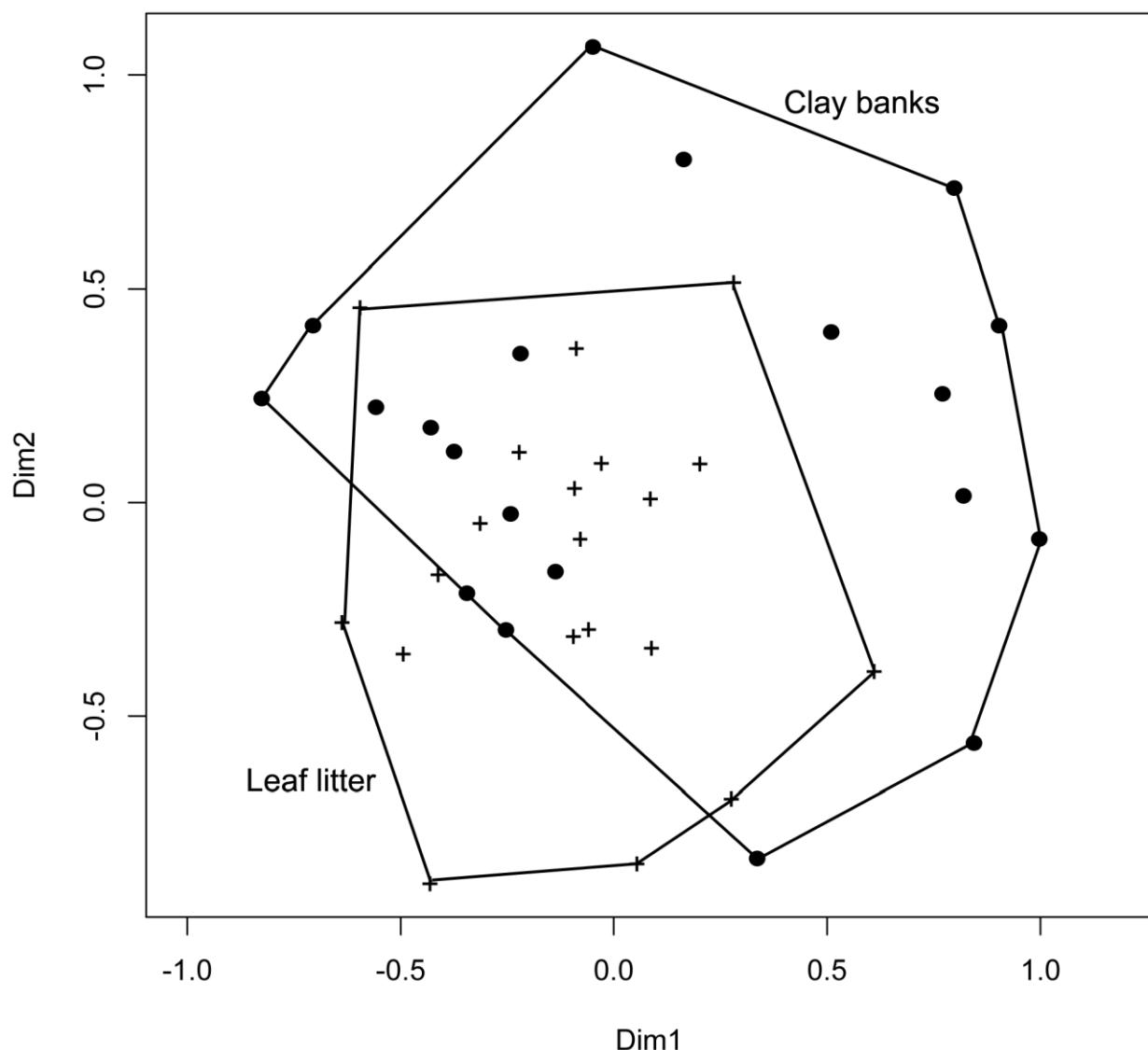


Figure 3. Non-metric multidimensional scaling (NMDS), with convex hulls of both habitats (Circles = Clay banks, crosses = Leaf litter;  $E = 0,24$ ). While litter samples form a compact cluster, bank samples are scattered.