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Baseline study of the leaf-litter ant fauna in a French Guianese forest

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Abstract. 1. Leaf-litter ants represent a major component of biodiversity and are excellent bioindicators reflecting the health of terrestrial ecosystems. This study, conducted in an unspoiled forest near the Nouragues Research Station, represents the first inventory of leaf-litter ant diversity conducted in French Guiana, and so can be considered as the baseline dataset for ants in this country.

2. Ants were extracted from the leaf-litter using the Ants of the Leaf Litter Protocol, along an altitudinal gradient at four forest sites, including an inselberg.

3. A total of 196 ant species representing 46 genera distributed over eight subfamilies were collected. Four distinct communities spread over a gradient of diversity were thus identified: the liana forest was the most species-rich (140 species) followed by the forested plateau (102 species), the transition forest (87 species) and the forest at the top of the inselberg (71 species).

4. The discovery of species new to science plus several species recorded for the first time in French Guiana, coupled with the particular context of this area, suggests that the Nouragues Research Station might represent a centre of endemism. Once completed, this leaf-litter ant dataset will contribute greatly to the knowledge of ant biodiversity in French Guiana, and has the potential to progressively become an indispensable tool for country-wide conservation planning programmes.

Key words. Ants of the Leaf Litter Protocol, baseline study, leaf-litter ants, Nouragues, Winkler method

Introduction

It is commonly acknowledged that invertebrates are essential to the processes shaping ecosystems because they are major components of biodiversity and good biological indicators of biota diversity and environmental quality. Consequently, they have more and more often been the focus of environmental studies (Hites *et al*., 2005; Rohr *et al*., 2006; Grimbacher *et al*., 2008). Among terrestrial invertebrates, ants have many attributes making them indispensable tools for conservation projects. Indeed, by their ecological dominance in most terrestrial ecosystems – especially in the tropics, their diversity, the relative ease of sampling them, and their sensitivity to environmental changes, they are relevant bioindicators reflecting the health of ecosystems (Kaspari & Majer, 2000; Andersen *et al*., 2002; Lapolla *et al*., 2006; Rohr *et al*., 2006). Ground- and litter-dwelling ants, for example, have commonly been used as bioindicators in numerous biodiversity studies conducted in tropical regions (Brühl *et al*., 1999; Delabie *et al*., 2000b, 2006; Fisher, 2000; Longino *et al*., 2002; Leponce *et al*., 2004). These ants form a particularly promising group because a standard protocol to sample them was developed: the Ants of the Leaf Litter Protocol (ALL Protocol; Agosti & Alonso, 2000; Fisher *et al*., 2000). This protocol provides a quantitative methodology for comparing species richness between sites. This is of major importance because there are only a few standardised methods for

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sampling invertebrates despite a growing call for their use in conservation biology (New, 1995; Samways, 2005).

The Neotropics undoubtedly possess one of the richest ant faunas in the world, with about 3100 known species (Fernández & Sendoya, 2004). For example, La Selva Biological Reserve (1500 ha in Costa Rica) has at least 437 ant species (Longino *et al*., 2002), and at Ilheus (1750 km^2 in Bahia, Brazil) 442 species have been identified (Delabie *et al*., 1998). Since the late 1990s, ant fauna inventories have multiplied in projects promoting a greater understanding of biodiversity in South and Central America: Argentina (Leponce *et al*., 2004), Brazil (Delabie *et al*., 2000a; Marinho *et al*., 2002; Vasconcelos *et al*., 2003; Hites *et al*., 2005), Colombia (Jiménez *et al*., 2007), Costa Rica (Longino & Colwell, 1997), and Guyana (Lapolla *et al*., 2006). In comparison, the French Guianese ant fauna is still poorly known, largely unexplored, and taxonomic literature on it scarce.

In addition to the absence of studies on the ground-dwelling ant fauna of French Guiana justifying the choice of and interest in creating just such an inventory, it also has relevance for clarifying the role of vegetal cover in the diversity of leaf-litter ants. Because of its preservation from relatively recent anthropisation, the biodiversity at the 'inselberg site' of the Nouragues Research Station, a totally preserved area situated in the Nouragues Nature Reserve, French Guiana, is commonly used as a reference point for monitoring programmes (for plants see Bongers *et al*., 2001). With the aim of expanding knowledge of the ground- and litter-dwelling ant communities of this area and establishing a reference collection, we conducted an analysis of the litter-dwelling ant diversity.

Material and methods

Study sites

The Nouragues Research Station is located in the Balenfois Mountains, southeast of Regina. Mainly dominated by hills, it is covered by an expanse of dense forest that has remained uninhabited for over two centuries. This site is particularly interesting for its granitic inselberg, a tabular rocky outcropping rising abruptly from the surrounding rainforest to 430 m above sea level (Bremer & Sander, 2000). The geology of this area is dominated by two types of substrates: Caribbean granite, and metavolcanic rocks from the Paramaca series (Grimaldi & Riéra, 2001). Consequently, the soil is acidic, and the vegetation is particularly heterogeneous.

In March 2006, four different forested environments were sampled along an altitudinal gradient: a liana forest (4°04′58″N, 52°40′28″O; 120 m altitude); a wide, forested plateau (4°05′20″N, 52°40′28″O; 140 m altitude); a low transition forest (4°05′30″N, 52°40′38″O; 200 m altitude) and the inselberg's summit (4°05′47″N, 52°40′51″O; 430 m altitude). The liana forest is separated from the wide, forested plateau by 700 m; the same is true for the distance between the transition forest and the summit of the inselberg, while only 400 m separate the transition forest and the plateau.

The liana and the plateau forests, although different, have high tree species richness where Leguminosae and Lecythidaceae dominate (Larpin, 2001). The transition forest, a patch of shrubby forest characterised by the absence of large trees, is much less diverse than the previous two. Finally, the inselberg summit, characterised by a specific type of rock savannah vegetation adapted to drought, is dominated by evergreen shrubs belonging to the Clusiaceae, Myrtaceae and Bombacaceae families (Sarthou *et al*., 2003).

The litter layer, varying from one environment to another, depending on the altitude, soil type and vegetation, was thick in the liana forest, on the plateau (classical primary rainforest) and at the summit of the inselberg, whereas it was minimal in the transition forest.

Experimental protocol

Because it is highly recommended for invertebrate inventories in forested habitats where litter abounds (Fisher, 1999; Delabie *et al*., 2000b), the Winkler method was used (see Bestelmeyer *et al*., 2000). We collected ant workers from a series of 1 m^2 leaf-litter samples that were weighed, and their weight considered as a proxy of the leaf-litter thickness.

The ALL Protocol (Agosti & Alonso, 2000; Fisher *et al*., 2000) suggests using a minimum of 20 sampling points separated by 10 m intervals to collect at least 70% of the ant fauna at a given site. We thus selected 50 sampling points separated by 10 m in the forested plateau (one 500 m-long transect), liana forest (two 250 m-long transects), and the transition forest (five 100 m-long transects). Given the relatively small size of the inselberg forest, only 20 sampling points, separated by 10 m, were set up.

All ant samples were preserved in 70% ethanol; for each sample at least one individual per morphospecies was kept in order to constitute a reference collection. The ants were identified to species (whenever possible), according to the key developed by Bolton (1994, 1995) and Bolton *et al*. (2006). Voucher specimens were deposited in the *Laboratório de Mirmecologia*, Cocoa Research Centre CEPEC/CEPLAC (Ilhéus, Bahia, Brazil).

Data analysis

For each sample, the number of worker morphospecies was recorded. Thus, the specific richness (number of species captured) and species occurrences (number of times that a given species was collected in a sampled site) were compared between the four forests.

To estimate and compare the efficiency of the sampling of the ant fauna, species accumulation curves (cumulated numbers of species according to the number of samples) were plotted for each environment, and the Chao 2 non-parametric estimator of total species richness was used (Chao, 1987). Because the number of individuals is not a reliable parameter in ant studies (data can be distorted when ants are collected close to a nest, an ant trail or a site where ants recruit nestmates), only species occurrences were taken into account. EstimateS 7.5 software was employed to build these curves with a confidence interval of 95%; because the order in which each sample is added influences the shape of these curves, the matrices of species occurrences (presence/absence) were treated with 500 randomisations of the sampling order without replacement (see Colwell *et al.*, 2004; Colwell, 2005).

We aimed to compare the number of species in each sampled site, taking into account the effect of leaf-litter thickness (through its weight), using a Generalised Linear Model (GLM, McCullagh & Nelder, 1989). We used the canonical link function, so that the model is:

$$\ln(E(Y_{ij})) = \mu + \alpha_i + \beta x_{ij} + \gamma_i x_{ij}$$

where Y_{ij} is the number of species (assumed to be independent and distributed according to a Poisson distribution for parameter λ_{ij}; see Vincent & Haworth, 1983), i stands for the site, α_i the effect of site i for sample j, β the effect of leaf-litter weight, and γ_i the difference in slopes between sites (i.e. the interaction between the site and leaf-litter weight). The formula corresponds to an ANCOVA in a linear model context. We performed a pairwise comparison between environments using the Bonferroni correction (Shaffer, 1995). These analyses were conducted using the R statistical software (R Development Core Team, 2003).

The similarity among the ant assemblages at the different sites was assessed using a cluster analysis (Jaccard coefficient of similarity). The resulting similarity matrix was analysed through a sequential, agglomerative, hierarchical and nested clustering algorithm described by Sneath and Sokal (1973). The option used was the Unweighted Pair-Group Method, arithmetic average (UPGMA). This analysis was conducted using the MVSP programme (Kovach, 2001).

Results

Taxonomic structure of the entire litter-dwelling ant fauna

A total of 196 species representing 46 genera and eight subfamilies were collected from 170 m^2 of leaf-litter from all sites (Appendix 1).

The species accumulation curve for all environments combined as well as those for the different sites sampled tended to slow down, but they did not reach a horizontal asymptote corresponding to the total estimated number of species for the environment considered (Fig. 1). Yet, the Chao 2 estimator, providing a theoretical species number, showed that a reasonable part of the community of litter-dwelling ants was inventoried: more than 74% of the species were recorded for all environments combined, and 81%, 67%, 66% and 73% for the liana, plateau, transition and inselberg forests respectively (Table 1).

The GLM analysis resulted in a significant difference ($P < 0.001$) showing the combined effect of leaf-litter weight and sites on species number with a significant difference between the liana forest and both the plateau and the inselberg forests, but non-significant differences between the three other forest types (Table 2).

The most diverse subfamilies were the Myrmicinae with 27 genera and 129 species, followed by the Ponerinae, the Formicinae, the Ectatomminae and the less speciose ones (Amblyoponinae, Dolichoderinae, Proceratiinae and Pseudomyrmicinae) (Table 3). The most speciose genera were *Pheidole* (42 sp.),

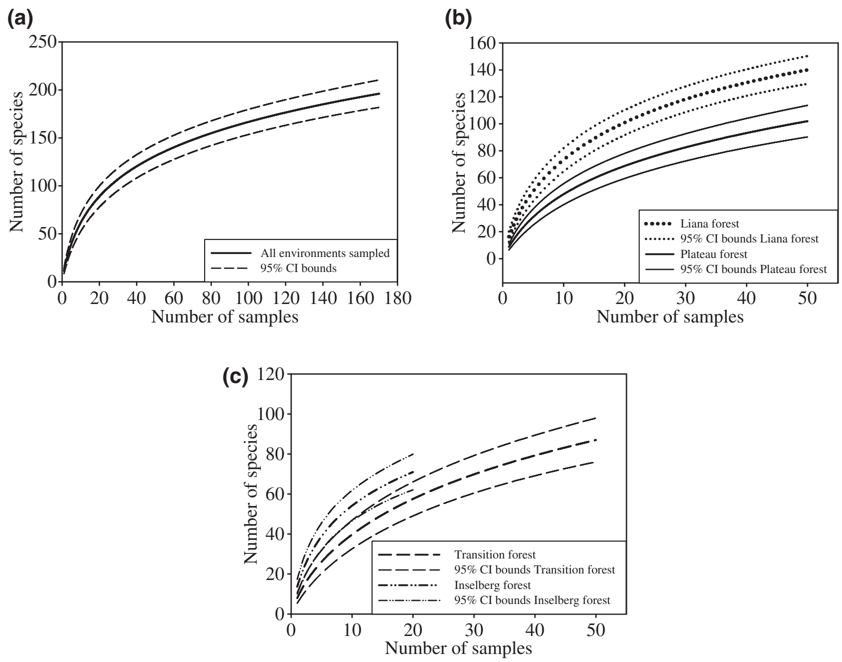

Fig. 1. Species accumulation curves representing the total cumulated number of species depending on the number of samples (with 95% confidence intervals) for (a) all studied environments pooled ($N = 170$ samples), and (b, c) for each environment studied ($N = 50$ samples for the liana, plateau and transition forests; $N = 20$ samples from the inselberg forest).

Table 1. Number and percentage of species collected, and number of estimated species for all environments and each site sampled (Chao 2) with its standard deviation.

	Number of species collected	% of species collected	Chao 2	Chao 2 SD
All environments	196	74.1	264.47	24.18
Liana forest	140	81.2	172.45	13.20
Plateau forest	102	67	152.23	21.22
Transition forest	87	66.4	131.1	19.88
Inselberg forest	71	73.4	96.73	13.50

Table 2. *P*-values associated with the pairwise comparison of the ANCOVA coefficient slopes.

	Liana forest	Forested plateau	Transition forest	Inselberg forest
Liana forest	×	0.441	0.004	0.008
Forested plateau	×	×	0.071	0.093
Transition forest	×	×	×	0.881
Inselberg forest	×	×	×	×

The multi-comparison test resulted in *P*-values, which based on the Bonferroni correction, had to be inferior to 0.0083 to be considered as significant in our analysis.

Table 3. Number and proportion of genera and species for each subfamily of ants collected.

Subfamilies	Number of genera	%	Number of species	%
Myrmicinae	27	58.7	129	65.8
Ponerinae	6	13	31	15.8
Formicinae	4	8.8	13	6.6
Ectatomminae	3	6.5	13	6.6
Amblyoponinae	2	4.3	3	1.5
Dolichoderinae	2	4.3	3	1.5
Proceratiinae	1	2.2	2	1.1
Pseudomyrmecinae	1	2.2	2	1.1

Solenopsis (13 sp.), *Pyramica* (12 sp.), *Hypoponera* and, unexpectedly, *Gnamptogenys* (10 sp.) (Appendix 1).

Of the 196 species collected, 108 (55%) were identified to species level. The remaining 45% were (1) species new to science (at least 11 species), (2) species awaiting description, (3) species belonging to genera awaiting revision (e.g. *Hypoponera*, *Paratrechina*), and (4) species belonging to the most speciose genera and thus difficult to identify (*Pheidole* and *Solenopsis*). Indeed, the current state of taxonomy may imply that we have overlooked cryptic species in these problematic genera. Furthermore, 37 species (nearly 20%) were recorded for the first time in French Guiana, most of them Myrmicinae (including the genera *Cryptomyrmex* and *Stegomyrmex*) plus one species of Amblyoponinae, Ectatomminae and Proceratiinae (Appendix 1).

Ant communities in the forests studied

The most species-rich site was the liana forest (140 species; 71.4% of all species); the poorest, the inselberg forest (71 species; 36.2%), and the diversity of the two other sites somewhere in-between (plateau forest 102 species, 52%; transition forest 87 species, 44.4%). In addition to the ubiquitous presence of Myrmicinae, Formicinae and Ectatomminae, the transition and inselberg forests are distinct from the other sites due to the lower species number of Ponerinae, more occurrences of Dolichoderinae and the presence of Pseudomyrmecinae. Therefore, each forest has its own ant fauna resulting largely from different geological conditions influencing the type of dominant vegetal formation, itself influencing the microclimatic conditions, something illustrated by the low similarity coefficients (Fig. 2).

The proportion of subfamilies, in terms of number of species, remained broadly constant for the most frequently represented subfamilies (Myrmicinae, Formicinae and Ectatomminae; Table 3). The Amblyoponinae and Proceratiinae were found on occasion in three out of the four sampled forests. It is noteworthy that the Ponerinae, predators of litter-dwelling arthropods, were better represented in the liana and plateau forests. Because they are mostly represented by arboreal species, the Dolichoderinae and Pseudomyrmecinae are not very diverse in this study and present almost only in the transition and inselberg forests, both with low vegetation (Appendix 1).

The ant fauna at a given site consists of generalist (i.e. found in all sampled environments) and specific species (only found at one site, they are 'indicator species' characterising each environment), the whole forming a species assemblage. The frequency of the 34 ubiquitous species varied between sites, three species being the most frequent at all sites: *Pyramica denticulata*, *Solenopsis* (*Diplorhoptrum*) sp.4 and *Solenopsis* (*Diplorhoptrum*) sp.5 (Appendix 1). Indicator species represent 29% of all species in the liana forest compared to 24%, 17% and 11% for the plateau, transition and inselberg forests respectively.

The number of species new to science and species still being described followed a gradient from the liana to the inselberg forests (Appendix 1). Moreover, among the 37 species recorded for the first time in French Guiana, 21 (57%) are specific to one forest: ten, seven, three and one for the liana, plateau, transition and inselberg forests, respectively (Appendix 1).

Discussion

Sampling the leaf-litter ant fauna

Although conducted over a limited period of time and through only one extraction method, our inventory indicates a great diversity in the litter-dwelling ant fauna at the Nouragues Research Station, demonstrating that there is still much to learn about the Guianese ant fauna, particularly if we keep in mind the very small surface of the areas sampled.

Even though it is probably impossible to reach a horizontal asymptote in a very diverse Neotropical site in a single survey and with one sampling method, we captured a reasonable part of the community of leaf-litter ants, creating an acceptable first

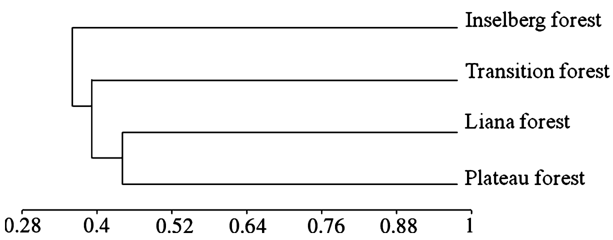

Fig. 2. Dendrogram of the similarities (Jaccard coefficient, UPGMA cluster analysis) of the leaf-litter ant fauna among the four sites sampled. The scale illustrates the low similarity coefficients (< 0.5 in all cases).

inventory. Numerous studies have shown that a 50 m^2 litter sample enables reliable estimations to be made with the first-order Jackknife and Chao 2 estimators (Delabie *et al*., 2000b; Fisher, 2000; but see Leponce *et al*., 2004). However, it is essential to combine several sampling methods to obtain an exhaustive inventory of the litter-dwelling ant fauna (Bestelmeyer *et al*., 2000; Delabie *et al*., 2000b; Fisher *et al*., 2000). Indeed, this would increase the number of Guianese ant species recorded.

Because the litter is dependent on the nature of vegetal cover at each sampling site, we showed a positive relationship between leaf-litter thickness (weight) and ant species diversity, as noted by Kaspari (1996), Soares and Shoereder (2001), Theunis *et al*. (2005). Litter quantity is related to a structural complexity due to a vertical layering (Vasconcelos, 1990); however, the leaf-litter quantity did not influence ant species abundance, density or composition in two other studies (Delabie & Fowler, 1995; Soares & Shoereder, 2001).

The litter-dwelling ant diversity in the sites studied

The liana forest, by far the most species-rich site and with the largest number of indicator species, is very likely anthropized, developing from forests that Amerindians felled and burned for shifting cultivation at least once in the past. After the fields were abandoned, a succession of trees developing and then decaying all at once favoured the formation of the liana forest, stopping the development of new trees (see Balee & Campbell, 1990). Liana forests are formed after numerous large trees of about the same age fall, providing an abundant vegetal biomass for litter- and wood-degrading arthropods, their predators and parasites, resulting in the development of a very diverse fauna. Ants, which are present in a wide range of trophic levels, are particularly diverse in this context.

Among the 37 newly recorded species, at least five were until now considered to be endemic to one country or region: *Carebara elongata* in Colombia; *Crematogaster wardi*, *Mycocepurus tardus* and *Pheidole carinata* in Central America; and *Rogeria alzatei* in Central America and the Caribbean islands. On the contrary, *Wasmannia scrobifera*, *Carebara urichi* and *Strumigenys elongata* have already been reported in Suriname and in much of tropical South America (Bolton *et al*., 2006).

Because we found at least 11 species new to science, all awaiting description, the litter-dwelling ant fauna at the Nouragues Research Station might have a certain rate of endemism. Finally, among the 34 ubiquitous species, four were recorded for the first time in French Guiana: *Crematogaster wardi* Longino, *Pheidole scolioceps* Wilson, *Rogeria lirata* Kugler and *Strumigenys elongata* Roger (Bolton *et al*., 2006). Consequently, our results underscore the need to augment research efforts to better understand the uniqueness of this site in terms of its ant fauna and very probably other faunas.

Taxonomic structure of the litter-dwelling ant fauna

The taxonomic structure of the ant fauna at Nouragues is a perfect example of the characteristic Neotropical litter-dwelling ant fauna highlighted by Ward (2000): (1) the presence of some common litter-dwelling genera (like *Brachymyrmex*, *Octostruma*, *Pyramica*, *Rogeria* and *Wasmannia*), and all fungus-growing genera (particularly *Cyphomyrmex* in our study), (2) the virtual absence of the *Monomorium* and *Tetramorium* genera, and (3) a high diversity of *Pheidole* (higher species richness per sample in our study) and *Solenopsis*, mainly represented by small to minute, morphologically similar species (e.g. *Diplorhoptrum* subgenus). Also, the relative importance of the Ponerinae and Formicinae in our study corroborates data from the Brazilian Atlantic and Amazonian forests (Delabie *et al*., 2000a; Vasconcelos *et al*., 2000, 2003; Hites *et al*., 2005).

As expected the extremely diverse genus *Pheidole* was the most speciose genus in our study with 42 species (21% of all species collected; see Wilson, 2003). In comparison, the second most speciose genus, *Solenopsis*, represented by only 13 species, was probably undervalued (1.97 species per Winkler sample *versus* 3.14 noted by Ward, 2000). The same is true for the genera *Pheidole*, which although recently revised, needs still further revision (Wilson, 2003), and *Hypoponera* due to the need for a modern taxonomic revision (see Bolton *et al*., 2006). Moreover, it is likely that some species of collected genera belong to cryptic species complexes (leaf-cutting ants, *Hypoponera*, *Pachycondyla*, *Pheidole*, *Pyramica*, *Solenopsis* and *Strumigenys*), which increases the risk of underestimating the true species number.

To conclude, the high specific richness at the Nouragues Research Station confirms that this area can be used as a reference point for comparative studies. An exhaustive inventory of this diversity would imperatively require further surveys combining several extraction methods in other Guianese areas. Such an inventory would imply collecting ant species regardless of their ecology: subterranean, litter- and ground-dwelling; living in dead wood, semi-arboreal or canopy-dwelling, etc. Unfortunately, there is no standardised sampling protocol for collecting species that do not live in the ground, which greatly complicates their capture and represents a substantial time and monetary investment.

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Appendix 1. Species collected at each site, according to their classification: liana forest (LF), forested plateau (FP), transition forest (TF) and inselberg forest (IN). The first column indicates species new to science (NS) including among them, those being described (BD), and the species recorded for the first time in French Guiana (nsg).

	Species according to their classification	LF	FP	TF	IN
Subfamily AMBLYOPONINAE Bolton					
	Amblyoponini Forel				
nsg	*Amblyopone lurilabes* Lattke			3	
	Prionopelta sp.1		1		7
	Prionopelta sp.2			1	2
Subfamily DOLICHODERINAE Forel					
	Dolichoderini Forel				
	Azteca instabilis (Smith)			4	1
	Dolichoderus attelaboides (Fabricius)			3	
	Dolichoderus imitator Emery	2			2
Subfamily ECTATOMMINAE Lepeletier					
	Ectatommini Emery				
	Ectatomma lugens Emery	2	1	1	3
	Ectatomma edentatum Roger	4	3		
	Gnamptogenys acuminata (Emery)	1		2	
nsg	*Gnamptogenys enodis* Lattke, Fernandez & Palacio	4			
	Gnamptogenys haenschi Emery	1			
	Gnamptogenys horni (Santschi)	7	1	3	2
	Gnamptogenys mina (Brown)	1			
	Gnamptogenys minuta (Emery)	1			1
	Gnamptogenys mordax (Smith)		1		
	Gnamptogenys relicta (Mann)		2	2	1
	Gnamptogenys striatula Mayr	1	1		
	Gnamptogenys sulcata (Smith)			2	
	Typhlomyrmecini Emery				
BD	*Typhlomyrmex* sp. (sp. nov.4 *sensu* Lacau, 2005)	3	3	3	
Subfamily FORMICINAE Latreille					
	Brachymyrmecini Emery				
	Brachymyrmex sp.1		1	3	5
	Brachymyrmex sp.2			1	
	Camponotini Forel				
	Camponotus fastigatus Roger			1	
	Camponotus femoratus (Fabricius)	2	1		
	Camponotus rapax (Fabricius)			1	
	Lasiini Ashmead				
	Paratrechina fulva (Mayr)	10	12	8	14
	Paratrechina sp.1	1	4		16
	Paratrechina sp.2	4			
	Paratrechina sp.3	4	6		
	Paratrechina sp.4	1			
	Paratrechina sp.5	2			
	Plagiolepidini Forel				
	Acropyga fuhrmanni (Forel)				1
	Acropyga smithii Forel				2
Subfamily MYRMICINAE Lepeletier					
	Adelomyrmecini Fernández				
nsg	*Cryptomyrmex longinodus* (Fernández & Brandão)	2			
	Attini Smith				
	Acromyrmex octospinosus (Reich)	1			
	Apterostigma sp. group *pilosum*	16	15	1	1
	Cyphomyrmex bigibbosus Emery		1		
	Cyphomyrmex laevigatus Weber	2	2	1	
	Cyphomyrmex peltatus Kempf	15	9	1	6
	Cyphomyrmex salvini Forel	4			2
	Mycocepurus smithii Forel	1			

Appendix 1. *Continued*

	Species according to their classification	LF	FP	TF	IN
nsg	*Mycocepurus tardus* Weber		2		
	Myrmicocrypta sp.	5			1
	Sericomyrmex sp.1	1			
	Sericomyrmex sp.2		1		
	Trachymyrmex ixyodus Mayhé-Nunes & Brandão		1		
	Trachymyrmex sp.1		1		
	Trachymyrmex sp.2	3	1	2	1
	Basicerotini Brown				
	Octostruma balzani Emery	27	4		
	Octostruma betschi Perrault	16	8	7	
	Octostruma iheringi Emery				1
BD	*Octostruma* sp. near *iheringi*	1	1		
NS	*Rhopalothrix* sp.	3			
	Blepharidattini Wheeler & Wheeler				
	Wasmannia auropunctata (Roger)	3	6	5	3
nsg	*Wasmannia scrobifera* Kempf		4		
	Cephalotini Smith				
nsg	*Procryptocerus hylaeus* Kempf	1			
	Crematogastrini Forel				
nsg	*Crematogaster flavosensitiva* Longino	1			
	Crematogaster limata Smith	41	23	11	4
	Crematogaster longispina Emery	6		17	1
	Crematogaster nigropilosa Mayr	3		4	
nsg	*Crematogaster sotobosque* Longino	7	3		
	Crematogaster tenuicula Forel	3			
nsg	*Crematogaster wardi* Longino	13	3	22	1
	Dacetonini Forel				
nsg	*Pyramica appretiata* (Borgmeier)		1		
	Pyramica auctidens Bolton	23	1		
nsg	*Pyramica beebei* (Wheeler)	2		1	
nsg	*Pyramica deinomastax* Bolton	2		1	
	Pyramica denticulata (Mayr)	47	28	40	19
nsg	*Pyramica hadrodens* Bolton	1			
nsg	*Pyramica hyphata* (Brown)			2	
nsg	*Pyramica metopia* (Brown)				5
	Pyramica subedentata (Mayr)	4	2	2	
	Pyramica sp.1 near *longinoi*		1		
NS	*Pyramica* sp.2 group *thaxteri*		1		
	Pyramica sp.3 proche groupe *substricta*			1	
nsg	*Strumigenys cosmotela* Kempf	2			
nsg	*Strumigenys diabola* Bolton		5		
nsg	*Strumigenys dyseides* Bolton	16			4
nsg	*Strumigenys elongata* Roger	18	11	2	1
nsg	*Strumigenys lanuginosa* Wheeler		1		
nsg	*Strumigenys trudifera* Kempf & Brown	10			
	Formicoxenini Forel				
	Nesomyrmex tristani Emery				1
	Myrmicini Lepeletier				
	Hylomyrma balzani Emery	18	10	6	
	Hylomyrma immanis Kempf	2		1	
	Hylomyrma reginae Kutter	1			
	Hylomyrma sagax Kempf	1			
NS	*Hylomyrma* sp.		1		
	Ochetomyrmecini Emery				
	Ochetomyrmex neopolitus Fernández	1	2	2	
	Ochetomyrmex semipolitus Mayr	3	1	2	1
	Pheidolini Emery				
nsg	*Pheidole alienata* Borgmeier	7		3	
nsg	*Pheidole carinata* Wilson	4			

Appendix 1. *Continued*

	Species according to their classification	LF	FP	TF	IN
nsg	*Pheidole dolon* Wilson	2		1	
nsg	*Pheidole midas* Wilson	7			4
nsg	*Pheidole pedana* Wilson	32	13		3
nsg	*Pheidole scolioceps* Wilson	2	1	22	8
nsg	*Pheidole walacei* Mann		1		
	Pheidole sp.1 group *fallax*		1	3	
	Pheidole sp.2 group *fallax*		1		
	Pheidole sp.3 group *fallax* near *tijucana*	2			
	Pheidole sp.4 group *fallax*			1	1
	Pheidole sp.5 group *diligens* near *spilota*	2			1
	Pheidole sp.6 group *flavens*	8	3	9	
	Pheidole sp.7 group *diligens*	2		4	
	Pheidole sp.8 group *flavens*		4		
	Pheidole sp.9 group *diligens* near *medialis*	6	2		
	Pheidole sp.10 group *fallax*	3		14	1
	Pheidole sp.11 group *flavens*	11	5	4	1
	Pheidole sp.12 group *flavens*	1			3
	Pheidole sp.13		1		
	Pheidole sp.14 group *flavens*	1	1		4
	Pheidole sp.15 group *flavens*			1	1
	Pheidole sp.16 group *flavens*	4	10	2	
	Pheidole sp.17 group *flavens*		2		
	Pheidole sp.18	1			
	Pheidole sp.19 group *diligens*	5		5	
	Pheidole sp.20 group *fallax*	6	2		
	Pheidole sp.21 group *fallax*	1			
	Pheidole sp.22	1	2		
	Pheidole sp.23 group *fallax*	11	6		
	Pheidole sp.24	1			1
	Pheidole sp.25 group *fallax*			1	
	Pheidole sp.26 group *flavens*	8	1	1	1
	Pheidole sp.27 group *tristis* near *pepo*	1			
	Pheidole sp.28 group *fallax*	1			
	Pheidole sp.29 group *flavens*	3	1	1	
	Pheidole sp.30	2			
	Pheidole sp.31	2	1	1	
	Pheidole sp.32	4	3	3	8
	Pheidole sp.33	17	7		2
NS	*Pheidole* sp.34 group *tristis* near *securiger*	1	4		2
	Pheidole sp.35 group *flavens*	1			
	Pheidologetonini Emery				
nsg	*Carebara elongata* Fernández	2			
nsg	*Carebara urichi* Wheeler	5	6	2	
NS	*Carebara* sp.1			1	
NS	*Carebara* sp.2	1			
NS	*Carebara* sp.3	1			
	Solenopsidini Forel				
	Allomerus decemarticulatus Mayr	1			
	Carebarella sp.1	1			
	Carebarella sp.2	2			
	Megalomyrmex silvestrii Wheeler	1	2		
	Megalomyrmex sp.	2			
	Solenopsis (*Diplorhoptrum*) *pollux* Forel			5	
	Solenopsis virulens Smith	6	9		
	Solenopsis (*Diplorhoptrum*) sp.1	16			
	Solenopsis (*Diplorhoptrum*) sp.2	3			
	Solenopsis (*Diplorhoptrum*) sp.3	1			
	Solenopsis (*Diplorhoptrum*) sp.4	35	25	25	15
	Solenopsis (*Diplorhoptrum*) sp.5	32	20	12	10

Appendix 1. *Continued*

	Species according to their classification	LF	FP	TF	IN
NS	*Solenopsis* (*Diplorhoptrum*) sp.6	2		1	
	Solenopsis (*Diplorhoptrum*) sp.7	6	6		3
	Solenopsis (*Diplorhoptrum*) sp.8	13	7	22	9
	Solenopsis (*Diplorhoptrum*) sp.9	16	10	10	2
	Solenopsis (*Diplorhoptrum*) sp.10	10	3	1	
	Solenopsis (*Diplorhoptrum*) sp.11			1	
	Stegomyrmecini Wheeler				
nsg	*Stegomyrmex manni* Smith		1		
	Stenammini Ashmead				
nsg	*Lachnomyrmex pilosus* Weber	1			
BD	*Lachnomyrmex* sp.	1	1		
nsg	*Rogeria alzatei* Kugler	7		1	3
nsg	*Rogeria lirata* Kugler	1	1	1	1
	Rogeria micromma Kempf	4	2	1	6
nsg	*Rogeria scobinata* Kugler	11	6	4	11
nsg	*Rogeria subarmata* Kempf			1	
Subfamily PONERINAE Lepeletier					
	Ponerini Lepeletier				
	Anochetus diegensis Forel	6	2	2	1
	Anochetus horridus Kempf	3	2	1	2
	Anochetus inermis André	2	5		
	Anochetus mayri Emery			1	
	Anochetus simoni Emery		1		
	Hypoponera foreli Mayr	2	4	3	2
	Hypoponera sp.1	8	7	9	9
	Hypoponera sp.2	2	3	7	5
	Hypoponera sp.3		1		
	Hypoponera sp.4	1			
	Hypoponera sp.5	4	3	3	6
	Hypoponera sp.6	10	5	14	7
	Hypoponera sp.7	12	6	1	4
	Hypoponera sp.8	5	11	5	6
	Hypoponera sp.9	3		1	
	Hypoponera sp.10	1	1		2
	Leptogenys dasygyna Wheeler	1			3
	Odontomachus biumbonatus Brown	7	6		
	Odontomachus caelatus Brown		1		
	Odontomachus haematodus (Linnaeus)				1
	Odontomachus hastatus (Fabricius)		1		
	Odontomachus scalptus Brown	1	5	4	
	Pachycondyla arhuaca (Forel)	1			1
	Pachycondyla constricta (Mayr)	4	1	5	3
	Pachycondyla harpax (Fabricius)	5	2	2	5
	Pachycondyla stigma Fabricius	3	2	1	
	Pachycondyla striata Santschi	1			
	Pachycondyla sp.1 group *harpax*			1	1
	Pachycondyla sp.2 group *harpax*		1		
	Pachycondyla sp.3				1
	Thaumatomyrmecini Emery				
NS	*Thaumatomyrmex* sp.	2			
Subfamily PROCERATIINAE Bolton					
	Proceratiini Emery				
	Discothyrea denticulata Weber	5	1	1	
nsg	*Discothyrea sexarticulata* Borgmeier	7	1	1	
Subfamily PSEUDOMYRMECINAE Smith					
	Pseudomyrmecini Emery				3
	Pseudomyrmex tenuis Fabricius				
	Pseudomyrmex sp. group *pallidus*			1	