Ecología Austral 23:37-43. Abril 2013
Asociación Argentina de Ecología

Evaluation of an ant sampling protocol (Hymenoptera: Formicidae) in three modified environments located inside an austral Atlantic Forest area of Brazil

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Resumen. Evaluación de un protocolo de muestreo de hormigas (Hymenoptera: Formicidae) en tres ambientes modificados en la área austral del Bosque Atlántico de Brasil: Evaluamos el uso de seis técnicas de muestreo para hormigas en tres ambientes (pino, eucalipto y bosque nativo) en el Bosque Nacional de Chapecó y el efecto de estos ambientes sobre la complementariedad del muestreo. Las técnicas de muestreo fueron las trampas de caída, dos cebos (sardina y glucosa), la red entomológica, agitación de follaje y trampa Malaise. La eficacia del conjunto de técnicas para lograr un inventario de las hormigas de estos ambientes se evaluó empleando curvas de rarefacción, estimadores de riqueza y registros de ocurrencia. El conjunto de técnicas capturó la mayor riqueza en el bosque nativo (S = 95), seguida de la plantación de eucalipto (S = 81) y bosque de pino (S = 78). La trampa de caída, el cebo de sardina, la trampa Malaise y la red entomológica mostraron registros únicos en los tres ambientes, los cebos de glucosa mostraron registros únicos en los ambientes de eucalipto y bosque nativo, y la agitación de follaje sólo en el bosque de eucalipto. Los resultados mostraron que la utilización de técnicas complementarias para el inventario de la fauna de hormigas resultó más eficiente que las técnicas por separado en todos los ambientes. Contrariamente a lo esperado, la mayor complejidad del ambiente del bosque nativo con respecto a los otros ambientes no se asoció a una menor eficiencia de la utilización de una determinada técnica.

[Palabras clave: Cebos, composición, diversidad, riqueza, planes de conservación]

Abstract. This study evaluated the efficiency as a tool for ant survey of a sampling protocol composed of six methods, and examined the role of environmental features on the efficiency of methods complementarity . We applied them in three environments (pine, eucalyptus and native forest) in the National Forest of Chapecó and the effect of the characteristics of these environments on methods complementarity. The sampling methods were pitfall traps, two types of bait (sardines and glucose), sweep net, entomological umbrella and Malaise trap. The protocol efficiency of the protocol in the ant inventory was evaluated based on rarefaction curves, richness estimators and records of occurrence of ants. The protocol captured the greatest richness on native forest environment (S = 95), followed by the eucalyptus plantation (S = 81) and pine forest (S=78). Pitfall trap, sardine baits, Malaise trap and sweep net contributed with unique records in the three environments, while the glucose baits contributed with unique records in the eucalyptus plantation and native forest, and entomological umbrella only in eucalyptus environment. The results highlighted the importance of using complementary techniques for the ant fauna inventory irrespective of the environment complexity. Contrary to our prediction, the greater environmental complexity of the native forest with respect to the other environments was not associated to lower efficiency of using single technique.

[Keywords: Bait, composition, conservation planning, diversity, richness]

Introduction

The demand for systematic surveys of richness and abundance of species in certain environments created the need for structuring plans for conservation, monitoring environmental impacts and recovery of degraded areas. Among insects, ants stand out for richness and geographical distribution in terrestrial ecosystems (Longino et al. 2002; Arcila & Lozano-Zambrano 2003; Lutinski & Garcia 2005; Lutinski et al. 2008) and should be considered in diversity surveys in any environment (Osborn et al. 1999; Silva & Brandão 1999; Silvestre & Silva 2001; Arcila & Lozano-Zambrano 2003).

An important aspect to be considered in surveys is the establishment of a sampling protocol able to capture a representative and comparative portion of the community (Wang et al. 2001). Several sampling methods

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Editor asociado: Alejandro Farji-Brener

Recibido: 12 de agosto de 2012, Fin de arbitraje: 2 de octubre, Ultima versión: 23 de enero de 2013, Aceptado: 24 de enero

have been proposed to include the variety of niches occupied by ants (Romero & Jaffe 1989; Andersen 1991; Majer 1997; Agosti & Alonso 2000). Nevertheless, each method presents advantages and disadvantages considering the cost, sample quality, relative abundance and reproducibility (Bestelmeyer et al. 2000; Wang et al. 2001). Moreover, the richness and abundance of ants can change significantly from one environment to another and are influenced by land use and phytophysiognomy even within the same biome (Campos et al. 2008). Thus, it is necessary to adopt standardized sampling methods to achieve results minimally comparable with similar studies at a larger geographical scale (Agosti & Alonso 2000).

The intense human pressure on remnants of Atlantic Forest and the fragmentation process are among the main threats to biodiversity of this biome (Galindo-Leal & Câmara 2003; Caetano 2011). Thus knowing this biodiversity and techniques that make possible this knowledge is imperative for its conservation. The National Forest (FLONA) of Chapecó is one of the largest forest fragments of the Atlantic Forest remaining in Southern Brazil and has environments affected by different land use (Balen et al. 2011; Caetano 2011). These characteristics support the existence of different communities of ants associated with these environments (Lutinski et al. 2008; Lutinski et al. 2011). Moreover, the evaluation of a sampling protocol for ant fauna in these types of environments and the effect of the characteristics of these environments on the performance of these sampling techniques is needed.

Higher richness of ants is usually associated with structurally more complex environments (Ribas et al. 2003). Natural environments have greater structural complexity. If different ant assemblages inhabit these different habitat niches, it is expected a greater complementarity (i. e., the number of different species sampled by different methods) in these environments compared to those in disturbed ones, which are normally more homogeneous than natural environments. This study aimed to (1) examine the effectiveness of a protocol composed of six sampling methods for ants in three different environments of the FLONA of Chapecó, using measures of richness and occurrence records, and (2) explore whether in natural, more complex habitats sampling protocol complement better than in disturbed, more homogeneous habitats.

METHODS

The study was conducted in the glebe I of the National Forest of Chapecó (27° 05′ 50″S; 52° 46′ 40′′W) in the municipality of Guatambú, Santa Catarina state. This glebe has a total area of 1,290.68 hectares, at a distance of about 18 km west of Chapecó city. Three environments with approximately five hectares each were selected: 1) formed by a stand of pine (*Pinus taeda* and *P. elliptic*) aged about 35 years, with understory of well diversified native vegetation; 2) eucalyptus plantation (*Eucalyptus saligna* and *E. grandis*), aged about five years, with sparse understory exclusively formed by grasses; and 3) native vegetation formed by Mixed Ombrophilous Forest and Semideciduous Seasonal Forest, with no history of deforestation. The distance between the areas 1 and 2 is approximately 500 m and from these to the third is 1,500 m.

Sampling

Samplings were undertaken every month from December 2003 to November 2004. The sampling protocol that was tested was composed of pitfall traps, two types of baits, one with sardine and another with inverted glucose (Agosti & Alonso 2000; Bestelmeyer et al. 2000; Sarmiento 2003), sweep net, entomological umbrella, and Malaise trap (Sarmiento 2003).

The sampling effort employed was the same to each environment. Pitfall traps were 40 plastic vials, 10 cm diameter X 15 cm deep, buried in the ground to the top edge and containing a solution of 150 ml water and a drop of detergent, and remained in the soil for one week. Baits included 40 baits with sardines (~1g) and 40 with inverted glucose (~1 ml) which were prepared and stored in 10 x 10 cm aluminum foil that remained in the environment for one hour. In both cases, baits and pitfall traps were distributed in groups of 10 into four parallel transects and perpendicular from the edge to the center, obeying a 10 m-distance between each transect, pitfall trap and bait.

The use of sweep net was performed at random inside each environment, with four repetitions of 20 minutes per collection and was applied to the herbaceous vegetation to the maximum height of one meter and each event had about 120 hits. The entomological umbrella used was characterized by the use of a square of cloth (1m x 1m) and held by two cross battens and stuck in the corner of the cloth (Garcia 2008). Four repetitions of approximately 10 shrubs and 60 flips characterized each collection at each environment. Malaise traps 2m height X 2m length were set at a height between one and three meters, in the understory and at locations far from the movement of people. Each environment had four replications of Malaise traps exposed for a week.

The identification of ants was performed in laboratory, from taxonomic keys proposed by

Fernández (2003). Expert confirmation of taxa was undertaken by Dr. Benedito Cortês Lopes of the Federal University of Santa Catarina, based on the classification of Bolton (2003). Some species whose genera did not have key for species identification were morphotyped to genus level (Lutinski et al. 2008).

Data analysis

In order to compare the richness and occurrence records obtained by the protocol in each environment, rarefaction curves were constructed based on the number of records of species (Gotelli & Colwell 2001) and obtained through the software EcoSim 700 (Gotelli & Entsminger 2001). Rarefaction curves enable the comparison of the richness between communities and samples that differ markedly in the records of individuals (Melo et al. 2003).

The extent of capture of the protocol was examined through richness estimators (Jackknife 1 and Chao 2) compared with their respective observed richness. These two estimators are qualitative therefore are less influenced by abundant species (Melo 2004). These estimates were generated through the software EstimateS 8.0 (Colwell 2006).

To evaluate the effect of complementarity the percentage of the sampled species by each method relative to total richness of ants in each environment were calculated. The effect of each environment on each method set was evaluated through the frequency of unique species sampled in each method and through the relative percentage of those species occurring in each environment.

RESULTS

In total, 10,013 occurrences were recorded with the evaluated protocol in the three environments. These records were distributed into nine subfamilies, 18 tribes, 35 genera, and 114 ant species, representing 55% of the ant fauna known for the western region of Santa Catarina state (Ulysséa et al. 2011). Pitfall trap captured the highest richness (S=105) followed by sardine bait (S=55), glucose bait (S=54) and Malaise trap (S=47). The sweep net (S=34) and the entomological umbrella (S=29) presented the lowest richness (Supplementary Information, Table S1). Using the six methods in a complementary way, the obtained richness were 78, 81 and 95 for pine forest, eucalyptus plantation and native forest, respectively.

A total richness of 38 species was captured exclusively using the pitfall trap: *Acanthosthichus serratulus* Fr. Smith, 1858, *Eciton burchellii* (Westwood, 1842), *Nomamyrmex hartigii* (Westwood, 1842), *Gnamptogenys striatula* Mayr, 1884, *Camponotus* sp. 11, *Camponotus* sp. 14, *Camponotus* sp. 15, *Brachymyrmex* sp, *Myrmelachista* sp. 4, *Paratrechina* sp. 2, *Acanthoponera mucronata* (Roger, 1860), *Heteroponera microps* Borgmeier, 1957, *Basiceros convexiceps* Mayr, 1887, *Crematogaster crinosa* Mayr, 1862, *Crematogaster* sp. 4, *Acanthognathus ocellatus* Mayr, 1887, *Acanthognathus* sp, *Strumigenys cultriger* Mayr, 1887, *Strumigenys* sp, *Pogonomyrmex* sp, *Pheidole* sp. 2, *Pheidole* sp. 9, *Pheidole* sp. 13, *Pheidole* sp. 14, *Solenopsis* sp. 4, *Acromyrmex disciger* (Mayr, 1887), *Acromyrmex subterraneus* Forel, 1893, *Acromyrmex* sp., *Apterostigma* sp. 2, *Dinoponera australis* Emery, 1901, *Hypoponera foeda* (Forel, 1912), *Hypoponera* sp. 1, *Hypoponera* sp. 2, *Hypoponera* sp. 3, *Hypoponera* sp. 4, *Pachycondyla crenata* (Roger,1861) and *Pachycondyla* sp. 2. This richness represents approximately 32.5% of all species surveyed in the Chapecó National Forest.

Sardine baits registered three unique species for the eucalyptus plantation (*Camponotus* sp. 9, *Wasmannia* sp. and *Crematogaster acuta* (Fabricius, 1804), two for native forest (*Camponotus* sp. 12 and *Solenopsis* sp. 5) and one for pine forest (*Camponotus* sp.8). Glucose bait contributed with three unique species for the eucalyptus plantation (*Linepithema* sp. 2, *Camponotus* sp. 6 and *Myrmelachista* sp. 2) and one for the native forest (*Cephalotes pusillus* (Klug, 1824)).

The sweep net contributed with unique records of one ant species (*Paratrechina* sp. 1) for the pine forest, one (*Nylanderia fulva* (Mayr, 1862)) for the eucalyptus plantation, and two (*Crematogaster* sp. 3 and *Pseudomyrmex* sp. 4) for the native forest. The entomological umbrella contributed with only one unique record and it was *Pseudomyrmex* sp. 3 for the eucalyptus plantation. The Malaise traps contributed with the second largest exclusive richness with one species (*Crematogaster acuta* (Fabricius, 1804)) for the native forest, four (*Camponotus* sp. 12, *Paratrechina longicornis* Latreille, 1802, *Cephalotes* sp. 2 and *Pseudomyrmex* sp. 2) for the eucalyptus plantation, and five (*Camponotus sericeiventris* Guérin-Méneville, 1838, *Myrmelachista* sp. 1, *Myrmelachista* sp. 2, *Crematogaster acuta* (Fabricius, 1804) and *Crematogaster* sp. 2) for the pine forest.

The differences between the observed and estimated richness (Jackknife 1 and Chao 2) for the pine forest (20.5% and 17.9%), eucalyptus plantation (20.6% and 22.3%) and native forest (22.4% and 24.4) were relatively similar to each other demonstrating that, despite the environmental characteristics, the protocol

sampled 80.7%, 78.6% and 76.6% of the ant fauna, respectively (Table 1).

Rarefaction curves based on the number of records (Figure 1) showed that the protocol captured greater richness and the greatest abundance of ants in native forest compared to pine forest and eucalyptus plantation and that there were no differences between these two environments according to these criteria.

The pitfall trap sampled the highest percentages of richness of ants in the three environments: 92.6% in native forest, 83.3% in the pine forest and 81.5% in eucalyptus plantation. In the pine forest, the sardine bait sampled 42.3% of the ant fauna, followed by Malaise trap with 39.7% and glucose bait with 37.2%. In eucalyptus plantation, the glucose bait sampled 48.1%, followed by sardine bait with 42% and Malaise trap with 34.6% while, in the native forest environment, the sardine bait sampled 43.2%, followed by glucose bait with 42.1% and Malaise trap with only 25.3%. The sweep net and entomological umbrella sampled between 21% and 23.5% of the ant fauna of the three environments (Table 2).

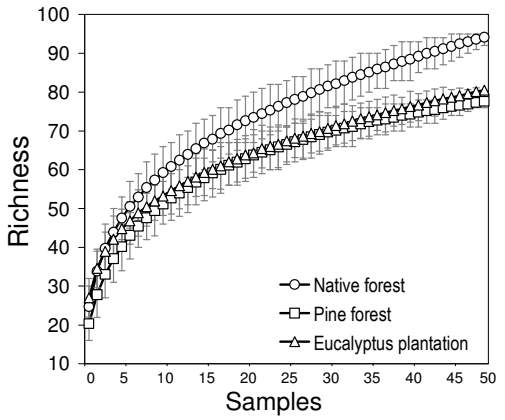

Figure 1. Rarefaction curves of species richness (Mao Tau) of ants based on occurrence records obtained by a protocol of six sampling methods in three environments of the National Forest of Chapecó, Santa Catarina State (December 2003 to November 2004).

Figura 1. Curvas de rarefacción de la riqueza de espécies (Mao Tau) de hormigas sobre los registros de la ocurrencia obtenido por un protocolo de seis métodos de muestreo en tres ambientes del Bosque Nacional de Chapecó, Santa Catarina (diciembre de 2003 hasta noviembre 2004).

Table 1. Richness of ants observed and estimated by a protocol of six sampling methods in three environments of the National Forest of Chapecó, Santa Catarina state (December 2003 to November 2004). Chao 2: estimator based on species abundance; Jackknife 1: estimator based on species incidence.

Tabla 1. Riqueza de hormigas observada y estimada por un protocolo de seis métodos de muestreo en tres ambientes del Bosque Nacional de Chapecó, Santa Catarina (diciembre de 2003 hasta noviembre 2004) (otros detalles en leyenda en inglés).

	Observed richness	Estimated ichness (Jackknife 1)	Estimated richness (Chao 2)
Pine forest	78	98.2 ± 3.61	95 ± 9.34
Eucalyptus plantation	81	102 ± 3.44	104.2 ± 13.02
Native forest	95	122.5 ± 5.82	125.7 ± 15.08

The pitfall trap sampled the highest percentages of unique species, 37.9%, 32.1% and 29.6% of the ant fauna of native forest, pine forest and eucalyptus plantation, respectively. In this way, Malaise trap stood out in the pine forest with 6.4% and in eucalyptus plantation, with 4.9%; the glucose bait in eucalyptus plantation stood out with 3.7%; and sardine bait with 2.5%. The sweep net and sardine bait, both with 2.1%, stood out in the native forest environment (Table 2).

Table 2. Richness, relative percentage of total richness of each environment, number of unique species and relative percentage of unique species in relation to the total richness of each environment sampled by six sampling methods in three environments of the National Forest of Chapecó, Santa Catarina state (December 2003 to November 2004).

Tabla 2. Riqueza, porcentaje relativo de la riqueza total de cada ambiente, número de especies únicas y porcentaje relativo de especies únicas en relación a la riqueza total de cada ambiente muestreados por seis métodos de muestreo en tres ambientes del Bosque Nacional de Chapecó, Santa Catarina (diciembre de 2003 hasta noviembre 2004).

	Pitfall trap	Sardine bait	Glucose bait	Sweep net	Entomological umbrella	Malaise trap
Pine forest						
Sampled richness	65 (83.3)	33 (42.3)	29 (37.2)	18 (23.1)	17 (21.8)	31 (39.7)
Unique species	25 (32.1)	1 (1.3)	1 (1.3)	1 (1.3)	0 (0)	5 (6.4)
Eucalyptus plantation						
Sampled richness	66 (81.5)	34 (42)	39 (48.1)	19 (23.5)	18 (22.2)	28 (34.6)
Unique species	24 (29.6)	2 (2.5)	3 (3.7)	1 (1.2)	1 (1.2)	4 (4.9)
Native Forest						
Sampled richness	88 (92.6)	41 (43.2)	40 (42.1)	20 (21.1)	20 (21.1)	24 (25.3)
Unique species	36 (37.9)	2 (2.1)	1 (1.1)	2 (2.1)	0 (0)	1 (1.1)

DISCUSSION

Heterogeneous environments normally support higher species richness because they offer more availability and diversity of food and shelter (Colli et al. 2003). Factors like availability of food and nesting sites enrich the soil and litter ant fauna in relation to arboreal ants (Campos et al. 2008). The greater complexity of the native forest may explain the greater richness and abundance of ants captured by the protocol of combined methods in this environment in relation to the others.

All protocol methods captured unique species. This result indicates the importance of using complementary methods for sampling ants that occupy different niches in the environment (Gotelli et al. 2012). Many studies have demonstrated that in species surveys, each method samples some unique species that are not collected by any other method (Longino & Colwell 1997). Thus the additional use of capture methods maximizes the estimation of the real richness of an environment (King & Porter 2005; Lopes & Vasconcelos 2008).

The closer proximity between observed and estimated richness for the protocol in the three environments corroborates the results of Albuquerque & Diehl (2009) and indicates its efficiency and application in inventories of ants in these types of environments. The lower efficiency (76.5%) of this ant sampling protocol in the inventory of native forest in relation to the eucalyptus plantation and pine forest (78.6% and 80.7%) can be explained by the increased complexity observed in native environments (Colli et al. 2003; Ribas et al. 2003). The occurrence of rare species in environments with this characteristic is more frequent and Jackknife 1 and Chao 2 richness estimators consider these records in their estimates (Melo 2004).

All the rarefaction curves presented a weak trend for stabilization, indicating that the protocol not fully inventoried any of the three ant communities studied. For Bestelmeyer et al. (2000), the social trait of ants, the uneven distribution of colonies in the landscape, and strata, should be considered when selecting the sampling protocol. Sarmiento (2003) highlights the need for standardization of capture method to more effectively enable the correlation of different studies in different locations.

Environmental characteristics exerted influence on protocol performance in all environments. The highest percentage of unique species was sampled by pitfall trap in the native forest environment compared to pine forest and eucalyptus plantation and can be explained by the presence and composition of leaf litter that provides niches for a greater number of ant species. Factors such as quality of organic matter, pH, temperature, moisture, texture of the substrate, ground cover affect the soil fauna (Socarrás 1998) and can also influence positively the ant species occurrence, especially in the environment of native forest.

Malaise traps are a recommended set in a relatively open area, capture insects that fly or climb on vegetation and should be installed along sides of infrequently traveled roads, trails and in opening forests (Johnson et al. 2012). The highest percentage of unique ant species sampled by Malaise trap in the pine forest and eucalyptus plantation corroborates the indication of this technique for open environments.

Both tested baits stood out in the sampling of unique species in the eucalyptus plantation environment while the sardine bait stood out in native forest. These environments have different characteristics and because of this it can be inferred that the environment conditions did not impose significant influence on the tested baits. The ants more frequently sampled through the baits are generalist or dominant species (Bestelmeyer 2000) and so the samples are more influenced by the composition of ant communities than by the environmental characteristics.

Formicidae is an abundant taxon in the soil and also widely distributed in all vegetation strata (Hölldobler & Wilson 1990) however, the ants species found in the understory can also be found in the soil or canopy (Campos et al. 2008). The sampling of unique ant species through the sweep net in native forest can be explained by the heterogeneity of understory present in this environment.

The convenience of handling, the relatively low cost, and the wide spectrum of ant species captured by pitfall trap qualify it as one of the most important sampling techniques for these insects (Olson 1991). However, it cannot be used during floods, steep or rocky areas, or with intense movement of people or animals (Sarmiento 2003). Whenever exposed they can also represent a threat to other animals, since

it can capture rodents, amphibians and even small reptiles. The preservative, especially formaldehyde, can also present a risk of environmental contamination if overflow or if the trap is flooded (Calixto et al. 2007), although these preservatives are being replaced by more harmless substances to the environment such as water and detergent solutions as used in this study.

The distance of 10 meters between pitfalls and between baits utilized in this study was in accordance with recommendations for epigean ants studies (Agosti & Alonso 2000; Bestelmeyer et al. 2000; Sarmiento 2003), however, the frequencies of the catches may be influenced by leaf-cutting ant species whose range can exceed 10 meters and workers of the same colony can be captured in more than a single trap (Franzel & Farji-Brener 2000; Anjos et al. 2008).

The cost of Malaise trap and the time required in the field for collecting with sweep net and entomological umbrella restricts the number of repetitions in each sample of this study. The use of the sweep net or entomological umbrella was conditioned to the availability of personnel in field. The richness and abundance of species collected are strongly influenced by attractiveness of the baits used and dominance played by some species (Tavares et al. 2008; Gotelli et al. 2012; Hahn & Wheeler 2002).

The selection of the sampling protocol should also consider microhabitats to be surveyed, for example, litter, tree layer, or subterranean environment. For each case, specific methods are recommended which are more effective or include a particular group (Gotelli et al. 2012). The contribution of these techniques and constancy in ant fauna inventory of these three types of environments qualify as suitable for inventories of ants inhabiting soil and litter in these environments and corroborates the results of Parr & Chown (2001) and Lopes & Vasconcelos (2008).

The distribution of ants may have similarly influenced the richness and the unique species occurrences recorded by each sample technique in the three environments. Ants are non-randomly distributed, individual ants are aggregated into colonies on small scales and colonies are often regularly dispersed owing to competition (Bestelmeyer et al. 2000). The results highlighted the importance of using complementary techniques for the ant fauna inventory irrespective of the environment complexity. Contrary to our prediction, the greater environmental complexity of the native forest with respect to the other environments was not associated to lower efficiency of using single technique.

ACKNOWLEDGEMENTS: B Cortês Lopes helped with species identification and provided suggestions for the manuscript. F Joner, AB Barros de Morais and DL Guadagnin, A Enimar Loeck, and T Gomes dos Santos and M Spies contributed with suggestions on the manuscript.

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SUPPLEMENTARY INFORMATION

Table S1. Ant species captured with six sampling methods (I: pitfall traps; II: sardine bait; III: glucose bait, IV: sweep net; V: entomological umbrella; VI: Malaise trap) in three environments (P: pine forest; E: eucalyptus plantation; N: native forest) of the National Forest of Chapecó, Santa Catarina state (December 2003 to November 2004).

Taxon	I	II	III	IV	V	VI
Subfamily Cerapachyinae						
Tribe Acanthostichini						
Acanthosthichus serratulus Fr. Smith, 1858	E	_	_	_	_	_
Subfamily Dolichoderinae						
Tribe Dolichoderini						
Dorymyrmex brunneus Forel, 1908	P,E,N	P,E,N	P,E,N	P,E	P,E,N	E
Dorymyrmex sp.	P,E,N	P,E,N	E,N	P,E	E	_
Linepithema humile Mayr, 1868	P,E,N	P,E,N	P,E,N	_	_	_
Linepithema sp. 1	P,E,N	N	P	_	_	_
Linepithema sp. 2	P,N	N	E,N	_	_	N
Linepithema sp. 3	P,E,N	E	P,N	E	P	_
Tapinoma atriceps Emery, 1888	P,E	P,E	E	_	_	_
Subfamily Ecitoninae						
Tribe Ecitonini						
Eciton burchelli (Westwood, 1842)	P,N	_	_	_	_	_
Labidus coecus (Latreille, 1802)	P,E,N	N	E	_	_	_
Labidus praedator (Fr. Smith, 1858)	P,E,N	_	_	N	N	_
Nomamyrmex hartigii (Westwood, 1842)	E	_	_	_	_	_
Subfamily Ectatomminae						
Tribe Ectatommini						
Ectatomma edentatum Roger, 1863	P,E,N	_	E	E	_	_
Gnamptogenys striatula Mayr, 1884	P,E,N	_	_	_	_	_
Subfamily Formicinae						
Tribe Camponotini						
Camponotus crassus Mayr, 1862	P,E,N	P,E,N	P,E,N	P,E,N	P,E,N	P,E,N
Camponotus diversipalpus Santschi, 1922	P,E,N	P,E,N	P,E,N	N	P,E,N	P,E,N
Camponotus rufipes (Fabricius, 1775)	P,E,N	P,E,N	P,E,N	P,E,N	P,E,N	P,E,N
Camponotus sericeiventris G.-Méneville, 1838	N	_	_	_	_	P,N
Camponotus sp. 1	E,N	E	E,N	P,E	E	P,E,N
Camponotus sp. 2	P,E,N	N	E,N	P,N	N	P,E
Camponotus sp. 3	P,E,N	P,E,N	P,E,N	P,E,N	P,E	P,E,N
Camponotus sp. 4	P,E,N	E,N	E	_	_	P,N
Camponotus sp. 5	P,E,N	E	P	_	P,E	P,E,N
Camponotus sp. 6	P,N	_	E	_	_	P
Camponotus sp. 7	P,E,N	P,E,N	E,N	P,E,N	P,E,N	P,E,N
Camponotus sp. 8	E,N	P,N	_	_	N	_
Camponotus sp. 9	P,N	E	_	_	_	_
Camponotus sp. 10	N	P	_	_	P,E	P,E
Camponotus sp. 11	N	_	_	_	_	_
Camponotus sp. 12	_	N	_	_	_	E
Camponotus sp. 13	E,N	N	E	_	_	E
Camponotus sp. 14	N	_	_	_	_	_
Camponotus sp. 15	N	_	_	_	_	_
Tribe Plagiolepidini						
Brachymyrmex sp.	P,E,N	_	_	_	_	_
Myrmelachista sp. 1	_	_	_	_	_	P
Myrmelachista sp. 2	_	_	E	_	_	P
Myrmelachista sp. 3	P,E,N	P,E,N	P,E,N	P,E,N	P,E,N	P,N
Myrmelachista sp. 4	N	_	_	_	_	_
Nylanderia fulva (Mayr, 1862)	P,N	_	_	E	_	N
Paratrechina longicornis Latreille, 1802	P,N	_	N	_	_	E
Paratrechina sp. 1	E,N	N	_	P	_	_
Paratrechina sp. 2	N	_	_	_	_	_
Subfamily Heteroponerinae						
Tribe Heteroponerini						
Acanthoponera mucronata (Roger, 1860)	N	_	_	_	_	_
Heteroponera microps Borgmeier, 1957	E	_	_	_	_	_
Subfamily Myrmicinae						
Tribe Basicerotini						
Basiceros convexiceps Mayr, 1887	P	_	_	_	_	_
Tribe Blepharidattini						
Wasmannia auropunctata Roger, 1863	P,E,N	P	P	_	_	P
Wasmannia sp.	N	E	N	_	_	_
Tribe Cephalotini						
Cephalotes pusillus (Klug,1824)	P	_	N	_	_	_
Cephalotes sp. 1	_	_	_	_	_	E
Cephalotes sp. 2	N	N	_	_	_	_
Procryptocerus sp.	E	_	N	N	_	_

Taxon	I	II	III	IV	V	VI
Tribe Crematogastrini						
Crematogaster acuta (Fabricius, 1804)	E	E	_	_	_	P,N
Crematogaster corticicola Mayr, 1887	E,N	P,N	N	N	N	P,E,N
Crematogaster crinosa Mayr, 1862	E	_	_	_	_	_
Crematogaster nigropilosa Mayr, 1870	P,E,N	P,E,N	P,E,N	_	_	P,E
Crematogaster sp. 1	N	P,N	E,N	_	_	P,E,N
Crematogaster sp. 2	E,N	E,N	E,N	_	_	P
Crematogaster sp. 3	_	_	_	N	_	_
Crematogaster sp. 4	E,N	_	_	_	_	_
Tribe Dacetini						
Acanthognathus ocellatus Mayr, 1887	P,N	_	_	_	_	_
Acanthognathus sp.	P	_	_	_	_	_
Strumigenys cultriger Mayr, 1887	P	_	_	_	_	_
Strumigenys sp.	E	_	_	_	_	_
Tribe Myrmicini						
Pogonomyrmex naegelli (Fabricius 1805)	P,E,N	E	E,N	_	_	_
Pogonomyrmex sp.	P,E,N	_	_	_	_	_
Tribe Pheidolini						
Pheidole sp. 1	P,E,N	P,E,N	P,E,N	P,E,N	P,N	P,E,N
Pheidole sp. 2	N	_	_	_	_	_
Pheidole sp. 3	P,E,N	P,E,N	P,E,N	E	_	P
Pheidole sp. 4	P,E,N	P,E,N	P,E,N	P,E,N	P,E,N	P,E,N
Pheidole sp. 5	P,E,N	P,E,N	P,E,N	P,N	N	N
Pheidole sp. 6	P,E,N	P,E,N	N	E	_	_
Pheidole sp. 8	P,E,N	P,E,N	P,E,N	P	_	P
Pheidole sp. 9	E	_	_	_	_	_
Pheidole sp. 10	P,E,N	P,E,N	P,E,N	N	N	P
Pheidole sp. 11	P,E,N	P,E,N	P,E,N	_	_	_
Pheidole sp. 13	E,N	_	_	_	_	_
Pheidole sp. 14	N	_	_	_	_	_
Pheidole sp. 15	P,E,N	P,N	P,N	_	_	_
Tribe Solenopsidini						
Solenopsis saevissima (Fr. Smith, 1855)	P,E,N	P,E,N	P,E,N	N	N	N
Solenopsis sp. 1	P,E,N	P,E,N	P,E,N	_	_	E,N
Solenopsis sp. 2	P,E,N	P,E,N	P,E,N	P,N	_	N
Solenopsis sp. 3	P,E,N	E,N	E,N	_	_	_
Solenopsis sp. 4	E,B	_	_	_	_	_
Solenopsis sp. 5	_	N	_	_	_	_
Solenopsis sp. 6	P,N	P	_	_	_	_
Tribe Attini						
Acromyrmex disciger (Mayr, 1887)	N	_	_	_	_	_
Acromyrmex niger (Fr. Smith, 1858)	P,E,N	E	_	E,N	P,E,N	_
Acromyrmex subterraneus Forel, 1893	P,E,N	_	_	_	_	_
Acromyrmex sp.	N	_	_	_	_	_
Apterostigma pilosum Mayr, 1865	P,E,N	_	_	_	_	E
Apterostigma sp. 1	P,N	_	_	_	_	_
Apterostigma sp. 2	E,N	_	P,E	_	_	_
Atta sexdens (Linnaeus, 1758)	P,E,N	N	P,E,N	E,N	E,N	P,E,N
Mycocepurus goeldii Forel, 1893	P,E,N	P	_	_	_	_
Subfamily Ponerinae						
Tribe Ponerini						
Dinoponera australis Emery, 1901	E	_	_	_	_	_
Hypoponera distinguenda Emery 1890	P,E,N	_	N	_	_	E
Hypoponera foeda (Forel, 1912)	N	_	_	_	_	_
Hypoponera opacior (Forel, 1893)	P,E,N	_	N	P	_	_
Hypoponera sp. 1	N	_	_	_	_	_
Hypoponera sp. 2	N	_	_	_	_	_
Hypoponera sp. 3	P	_	_	_	_	_
Hypoponera sp. 4	P	_	_	_	_	_
Odontomachus chelifer (Latreille, 1802)	P,E,N	P	P	_	_	_
Pachycondyla crenata (Roger,1861)	P	_	_	_	_	_
Pachycondyla harpax (Fabricius, 1804)	P,N	N	_	_	P,N	P
Pachycondyla striata Fr. Smith, 1858	P,E,N	P,E,N	P,E,N	P	E,N	E
Pachycondyla villosa (Fabricius, 1804)	P,N	_	P	_	P	P,N
Pachycondyla sp.	N	_	_	_	_	_
Subfamily Pseudomyrmecinae						
Tribe Pseudomyrmecini						
Pseudomyrmex avidulus (Fr. Smith, 1858)	N	_	E	_	_	E
Pseudomyrmex gracilis (Fabricius, 1804)	P,E,N	P,N	P,E,N	P,E,N	P,E,N	P,E,N
Pseudomyrmex sp. 1	N	_	_	E	P,E	P,E
Pseudomyrmex sp. 2	_	_	_	_	_	E
Pseudomyrmex sp. 3	_	_	_	_	E	_
Pseudomyrmex sp. 4	_	_	_	N	_	_