

Epigeal ant communities in Atlantic Forest remnants of São Paulo: a comparative study using the guild concept

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ABSTRACT. Epigeal ant communities in Atlantic Forest remnants of São Paulo: a comparative study using the guild concept. The guilds constitute a valuable ecological tool, because they allow conducting comparisons among environments under different conditions. The ants can be used as ecological indicators, mainly for the monitoring of degraded forest areas. The aim of this research was to study guild organization among the epigeal Formicidae living in Atlantic forest remnants of the State of São Paulo, Brazil. Ant collections were performed in three distinct Atlantic forest biome areas: arboreal littoral vegetation (“restinga”) (Cananéia), semideciduous seasonal forest (Piracicaba) and dense ombrophylous forest (Pariquera-Açu). After identification, the ants were grouped into guilds, based on the ecological attributes of behavior and habit, according to the literature. Nine guilds were found; the semideciduous seasonal forest ecosystem presented eight of them, followed by the arboreal sandbank (7) and dense ombrophylous forest (6). The guilds found were: litter omnivorous and scavengers, granivorous species, specialist predators living in litter and soil, litter generalist predators, subterranean mealybug-dependent species, army ants, dominant or subdominants arboreal, that occasionally forage on the ground, soil or litter dominant and fungus-growers, using feces and insect body fragments. The guilds found can be used in the monitoring of the mirmecofauna in the Atlantic Forest biome, supplying insights for further ecological studies.

KEYWORDS. Ecological bioindicators; ecosystems; environmental monitoring; Formicidae; Hymenoptera.

RESUMO. Comunidades de formigas epígeas em remanescentes da Mata Atlântica do Estado de São Paulo: um estudo comparativo utilizando o conceito de guildas. As guildas constituem-se em uma valiosa ferramenta ecológica, pois permitem realizar comparações entre ambientes em diferentes condições. As formigas podem ser utilizadas como indicadores ecológicos, principalmente para o monitoramento de áreas florestais degradadas. O objetivo deste estudo foi agrupar em guildas os Formicidae epígeas, coletados em remanescentes da Mata Atlântica do Estado de São Paulo. As coletas ocorreram em três áreas distintas do bioma Mata Atlântica: restinga arbórea (Cananéia), floresta estacional semidecídua (Piracicaba) e floresta ombrófila densa (Pariquera-Açu). As formigas foram identificadas e agrupadas em guildas, com base nos atributos ecológicos de comportamento e hábito, de acordo com a literatura. As formigas foram agrupadas em nove guildas, sendo que o ecossistema floresta estacional semidecídua apresentou oito destas, seguido da restinga arbórea (7) e da floresta ombrófila densa (6). As guildas encontradas foram: espécies onívoras, espécies granívoras, espécies predadoras especialistas de serapilheira e do solo, espécies predadoras generalistas de serapilheira, formigas subterrâneas dependentes de *honeydew*, formigas que fazem corrediças, formigas arbóricolas dominantes ou subdominantes, que ocasionalmente forrageiam no chão, formigas dominantes de solo ou serapilheira e formigas cultivadoras de fungo, utilizando fezes e cadáveres de insetos. As guildas encontradas poderão ser utilizadas em monitoramento da mirmecofauna no bioma Mata Atlântica, fornecendo subsídios para futuros estudos ecológicos.

PALAVRAS-CHAVE. Bioindicadores ecológicos; ecossistemas; Formicidae; Hymenoptera; monitoramento ambiental.

The idea that some species can be used as an environmental quality indicator is older than ecology as a science (Beeby 1993). According to Louzada *et al.* (2000), bioindicators are live organisms or biological processes used to evaluate the responses of the ecosystem to environmental disturbances, and they are frequently associated with the use of the earth by man. For instance, several groups of invertebrate animals have been used as bioindicators of the success of mine rehabilitation, because they occupy specialized niches, supplying information on the area according to their presence or absence (Majer 1981). The ant group, one of the most successful of all the invertebrate animals (Wilson 1987), has been evaluated for many years as a potential tool as an

ecological indicator, especially in Australia, with the objective of evaluating the impact of forest practices under the effect of the fire (York 1994). One of the main reasons for that is that those insects are locally abundant and species rich, they possess several specialized taxa, are relatively predictable, easily sampled and identified, and are sensitive to changes in the environmental conditions (Majer 1983).

In Brazil, several studies have been conducted using ants as bioindicators (Majer 1992, 1996; Vasconcelos 1999; Vasconcelos *et al.* 2001; Ramos *et al.* 2003; Delabie *et al.* 2006). The first studies were carried out in areas disturbed by bauxite extraction in Poços de Caldas, MG (Majer 1992) and in Trombetas, PA (Majer 1996). The ants were also used

to determine the effects of the fragmentation and isolation of the Amazonian forest (Vasconcelos 1999; Vasconcelos *et al.* 2001), to evaluate the impact of silviculture practices in eucalyptus reforestations and as agrarian and natural environmental use bioindicators (Ramos *et al.* 2003).

The use of ants as biological indicators, as well as of any other organism, requires previous knowledge of the ecological factors determining the structure and composition of their communities (Andersen 1997). According to that author, seeking to facilitate the studies on ants, the environmentalists can join the species in functional groups or guilds (those concepts are usually confused, being considered synonyms by some authors). The pioneers of this kind of study in ants are mainly Andersen (1991, 1992, 1997), in Australia, while in Brazil, the first studies making references to the guild or functional group of Formicidae was Delabie *et al.* (2000) in the Atlantic Forest and Silvestre *et al.* (2003) in the "cerrado" biome. More recent publications referred to ant guilds in Brazil are those of Brandão *et al.* (2009) and Silva & Brandão (2010).

The term guild, adopted by the environmentalists, makes an analogy to the medieval crafts organizations, that gathered individuals with the same ability or who depended on the same form of sustenance, as for instance, artisans, goldsmiths, carpenters or millers (Elton 1927). For Root (1967), extending this to ecology, the term guild defines a group of species that explore the same class of environmental resources, showing similar exploration patterns of those resources. The description of functional groups or guilds has shown to be a valuable tool allowing making comparisons among environments under different conditions. That type of model has been used with success in different areas of the world in forest area monitoring programs (Lawton *et al.* 1998) and in relation to different types of soil use (Bestelmeyer & Wiens 1996).

The present study aimed to compare Atlantic Forest remnants in the State of São Paulo using the guild concept to epigeous Formicidae.

MATERIAL AND METHODS

The study of the myrmecofauna was conducted in three fragments of the Atlantic Forest of the State of São Paulo, located in the counties of Cananéia (24°53'S, 47°50'W), Pariquera-Açu (24°36'S, 47°53'W) and Piracicaba (22°46'S, 47°49'W). In all the localities, the Cwa climate type prevails, according to the Köppen classification, characterized by moderate temperatures with hot summer (Prado 1997).

In spite of belonging to the same biome, the three forest fragments are different structurally: arboreal littoral vegetation ("restinga") (Cananéia) where predatory and clandestine exploitation of wood and palm heart opportunely occurs, semideciduous seasonal forest (Piracicaba), and dense ombrophylous forest (Pariquera-Açu), an area of environmental protection belonging to the Agronomic Institute of Campinas (IAC). The sampling follows the methodology described in Macedo *et al.* (2006).

Formicidae were identified in the Myrmecologia Laboratory of the Cacau Research Center (CEPEC/CEPLAC), Ilhéus, BA, where a reference collection was deposited under the registration number #5395. The nomenclature follows Bolton (2003).

The ants were grouped into guilds, based on ecological attributes of behavior and habit available on each species, and follow Delabie *et al.* (2000) and Silvestre *et al.* (2003).

RESULTS AND DISCUSSION

The ant species were grouped into nine guilds based on ant morphology and of the nest type and following Delabie *et al.* (2000) and Silvestre *et al.* (2003), except the new guild: "granivorous species" (Table I).

The guilds found in the forest fragments of Piracicaba, Pariquera-Açu and Cananéia were: litter omnivorous and scavengers, granivorous species, specialist predators living in litter and soil, litter generalist predators, subterranean mealybug-dependent species, army ants, dominant or subdominant arboreal, that occasionally forage on the ground, soil or litter dominant and fungus-growers, using feces and insect body fragments (Table I).

Some genera observed in this study (Table I), but not mentioned in Delabie *et al.* (2000) and Silvestre *et al.* (2003), were included in the guilds based on their biology and behavior. Some species of the genera *Adelomyrmex*, *Basiceros*, *Lachnomyrmex*, *Pheidole*, *Rogeria*, *Solenopsis*, as well as the genus *Hylomyrma* were framed in the litter omnivorous and scavengers guild; some species of *Pheidole* and *Solenopsis* in that of the granivorous species since large individuals ("soldiers") showed strong mandibles generally reliable to seed collect and processing; *Amblyopone*, *Carebara*, *Discothyrea*, *Eurhopalothrix*, *Octostruma*, *Oxyepoecus*, *Proceratum* and *Typhlomyrmex* in that of the specialist predators living in litter and soil; *Acanthostichus* is included in the guild of army ants and army-ant like species due to its cryptic mode of hunting; *Camponotus* was also included in the soil or litter dominant category. *Acropyga* was framed in that of subterranean mealybug-dependent species; *Heteroponera* as litter generalist predators ants.

The arboreal "restinga" (Cananéia) and seasonal semideciduous forest (Piracicaba) ecosystems presented eight guilds each, except for, respectively, the army ant and army-ant like species guild and the subterranean mealybug-dependent species. The dense ombrophylous forest ecosystem (Pariquera-Açu) presented six guilds, army ants and army-ant like species, subterranean mealybug-dependent species and dominant or subdominant arboreal ants, which occasionally forage on the ground not being found (Fig. 1). The number of guilds followed the same tendency as the richness of species in each ecosystem, which was higher in semideciduous seasonal forest (n = 45), followed by arboreal "restinga" and dense ombrophylous forest (n = 37 and 36 respectively).

The specialist predators living in litter and soil guild was found in all of the ecosystems, comprising 36.7% of the

Table I. Classification of ant species by guild, collected in fragments of Atlantic Forest of São Paulo, between March 2002 and March 2003. The classification follows Delabie *et al.* 2000 and Silvestre *et al.* 2003.

Guilds	Species
1. Litter omnivorous and scavengers	– <i>Adelomyrmex longinodus</i> Fernandez & Brandão, 2003, <i>Adelomyrmex</i> sp. 1, <i>Basiceros disciger</i> Mayr, 1887, <i>Hylomyrma reitteri</i> (Mayr, 1887), <i>Lachnomyrmex plaumanni</i> Borgmeier, 1957, <i>Megalomyrmex silvestrii</i> Wheeler, 1909, <i>Pheidole</i> spp. (some species), <i>Rogeria pellecta</i> Kempf, 1963 and <i>Solenopsis</i> spp. (some species)
2. Granivorous species	– <i>Pheidole</i> spp. (alguns) and <i>Solenopsis</i> spp. (some species)
3. Specialist predators living in litter and soil	– <i>Amblyopone armigera</i> Mayr, 1887, <i>Amblyopone lurilabes</i> Lattke, 1991, <i>Carebara panamensis</i> (Wheeler, 1925), <i>Discothyrea sexarticulata</i> (Borgmeier, 1954), <i>Discothyrea</i> spp., <i>Eurhopalothrix</i> sp. prox. <i>bruchi</i> , <i>Basiceros iheringi</i> (Emery, 1888), <i>Basiceros petiolata</i> (Mayr, 1887), <i>Basiceros</i> sp. 1, <i>Oxyepoecus</i> sp. 1, <i>Proceratium brasiliense</i> Borgmeier, 1959, <i>Strumigenys denticulata</i> (Mayr, 1887), <i>Strumigenys tanyastax</i> (Brown, 1964), <i>Strumigenys</i> sp. 1, <i>Strumigenys dyseides</i> Bolton, 2000, <i>Strumigenys silvestrii</i> Emery, 1906, <i>Strumigenys sphaetula</i> Lattke & Goitia, 1997 and <i>Typhlomyrmex major</i> (Santschi, 1923)
4. Litter generalist predators	– <i>Anochetus</i> sp. 1, <i>Gnamptogenys striatula</i> (Mayr, 1883), <i>Heteroponera microps</i> Borgmeier, 1957, <i>Hypoponera foreli</i> Mayr, 1887, <i>Hypoponera</i> spp. and <i>Pachycondyla striata</i> Smith, F. 1858
5. Subterranean mealybug-dependent species	– <i>Acropyga</i> sp. 1
6. Army ants	– <i>Acanthostichus quadratus</i> (Emery, 1895)
7. Dominant or subdominants arboreal, that occasionally forage on the ground	– <i>Crematogaster</i> sp. 1
8. Soil or litter dominant	
8.1. Predators	– <i>Odontomachus</i> spp.
8.2. Omnivorous	– <i>Brachymyrmex</i> , <i>Camponotus (Myrmaphaenus)</i> sp. 1, <i>Linepithema</i> sp. 1, <i>Paratrechina fulva</i> (Mayr, 1862), <i>Paratrechina</i> spp., <i>Wasmannia auropunctata</i> (Roger, 1863) and <i>Wasmannia sigmoidea</i> (Mayr, 1883)
9. Fungus-growers, using feces and insect body fragments	– <i>Apterostigma</i> sp. comp. <i>pilosum</i> , <i>Cyphomyrmex bigibbosus</i> (Emery, 1894), <i>Cyphomyrmex peltatus</i> Kempf, 1966, <i>Cyphomyrmex salvini</i> Forel, 1899, <i>Cyphomyrmex transversus</i> Emery, 1894 and <i>Sericomyrmex</i> sp. 1

species found in the arboreal “restinga”, 18.9% in the seasonal semideciduous forest and 22.7% in the dense ombrophylous forest. Those were followed by the soil or litter dominant guild, with 13.3, 27.0 and 18.2% of the species found in the same habitats, respectively. The subterranean mealybug-dependent species guild was only observed in the arboreal “restinga”, corresponding to only 3.3% of the ants found in this ecosystem. The guilds of army ant and army-ant like species and the dominant or subdominant arboreal ants, which occasionally forage on the ground, were evidenced only in the seasonal semideciduous forest, both making up 2.7% of the ants found in this ecosystem (Fig. 1).

The fact of the semideciduous seasonal forest ecosystem presenting the highest guild numbers and higher richness of species suggests that it would be due to the higher complexity of the vegetative structure, since that ecosystem maintains well developed and relatively closed vegetation, there existing, therefore, higher microhabitat availability for the ants. In the closed arboreal “restinga”, as predatory and clandestine exploitation of wood and palm heart occurs, the trees were in their initial ecological succession stage, not presenting a defined canopy. Besides, the “restinga” vegetation characteristically increases in sandy soils, which do not allow the development of a particularly diverse plant biota (Fernandes 1998). A discontinuous canopy associated with

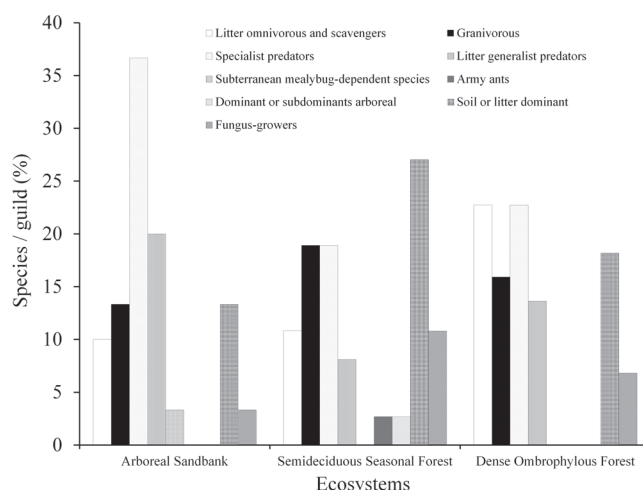


Fig. 1. Percent (%) of guilds in relation to the number of species in arboreal sandbank, semideciduous seasonal forest and dense ombrophylous forest ecosystems, between March 2002 and March 2003.

the vegetation in the ecological succession stage was also observed in the dense ombrophylous forest remnant. As a consequence, the last two fragments can have suffered stronger environmental disturbances than the semideciduous seasonal forest ecosystem, which is visible particularly in

the contribution of each ant guild (Fig. 1). According to Majer *et al.* (1984), there is a correlation between ant and plant richness, and the occurrence of certain plants facilitate area recolonization processes by ants. That is particularly important because many forest species found in the studied ecosystems possess an extremely developed root system growing in the superficial horizon of the soil. According to Delabie & Fowler (1995) and Delabie *et al.* (2000), the function of the ants in the plant root system, as well as in the litter, is still poorly known, but there are no doubt that some species have a fundamental role in the forest soil regeneration process (*i.e.*, mechanical action on soil nutrients and mineral incorporation, rotten vegetal material fractionation, water circulation, etc), as well as those under cultivation.

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