Analysis of Ant Communities Comparing Two Methods for Sampling Ants in an Urban Park in the City of São Paulo, Brazil

by

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ABSTRACT

This study aimed to analyze the species composition and functional groups of the ant community and to assess the efficiency of two sampling methods, pitfall and leaf litter sampling, in an urban park. A total of 1,401 ants were collected, which belonged to six subfamilies and 36 species. The predominant species was *Wasmannia auropunctata* (present in 45.36% of the samples), while the functional group of opportunistic ants were the most frequent (present in 83.75% of the samples) and abundant (95.29% of the total collected specimens) functional group. The Jaccard Similarity Index showed a low similarity between the two sampling methods, as the difference of the number of individuals for each species between these two methods was not significant in only one case (*Linepithema* sp. 1, p = 0.4561). The fungus-growing and cryptic ants were more collected in leaf litter samples (p<0.0001; p = 0.0348 respectively). Although there was no significant difference (p = 0.6397) between the two sampling methods for the total individuals of opportunistic ants, more species of this group were collected in pitfall traps. This difference was not significant because of the high presence of *W. auropunctata*, an opportunistic ant, in samples of leaf litter. Due to the predominance of tramp ants in the studied area, this article illustrates the importance of green urban areas in ant control strategies, since these sites could be used as a source of new colonization for these ants. Furthermore, the combination of the two sampling methods seems to be complementary for obtaining a more complete picture of the ant community.

Key words: ant community, urban areas, tramp ants, functional group, urban areas, pitfall trap, leaf litter sample

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INTRODUCTION

Ants are one of the groups of animals with the greatest diversity in the planet. Different species can be found in all regions except the poles (Hölldobler & Wilson 1990). Among the 2,500 known species of ants in Brazil, around 50 species are known as tramp ants due to their ability to survive in urban environments (Bueno & Campos-Farinha 1999 Campos-Farinha 2002). This ability to survive in highly disturbed environments is related to certain characteristics that these ants present, such as unicolonialism, polygyny, sociotomy, small size of workers, and migration and fragmentation of colonies in response to changes in environment (Fowler *et al.* 1994, Passera 1994, Bueno & Campos-Farinha 1999, Vega 2001).

The damage that these ants cause in urban areas comes from their presence in residences, invasion and damage of electronic appliances and structures of buildings, like wood ceilings and door frames. They also cause public health problems due to their presence in food facilities, hospitals, health centers, as they can mechanically vector many pathogens that pose risks to human health. In addition, some species such as *Solenopsis invicta* show aggressive behavior and some of their victims, who are allergic to their stings, may go into anaphylactic shock, which can lead to death (Bueno & Campos-Farinha 1995, Zarzuela *et al.* 2002, Zarzuela *et al.* 2005).

Studies on ants in urban environments go beyond the simple understanding of their biology and control, focusing on how the whole ant community responds to the environment, especially in urban parks and squares (Silva & Loeck 1999, Yamaguchi 2004, Clarke *et al.* 2008, Iop *et al.* 2009). These green areas are important for the conservation of plants and animals that are more sensitive to anthropization due to milder environmental conditions (Rodrigues *et al.* 1993).

The development of research on ant communities in green areas can provide important information on the environmental quality, since ants are essential to ecological processes such as decomposition, pollination, seed dispersal, nutrient cycling, etc. (Hölldobler & Wilson 1990, Moutinho 1998, Lobry de Bruyn 1999). Moreover, ants are considered good bioindicators due to the diversity of the group, the facility of sampling individuals, for being susceptible to environmental changes and also for being a well-known taxa (Andersen 1997, Silva & Brandão 1999).

In order to evaluate ant species as bioindicators, species are grouped into functional groups based on characteristics such as diet, nest location and response to habitat disturbance (Andersen 1995, Delabie *et al.* 2000, Silvestre & Silva 2001). With this grouping we can go beyond simply assessing the environment for species richness, but one can analyze how these groups react differently to environmental disturbance (Philpott *et al.* 2010).

The two main methods of sampling ants in urban environments are active collection and attractive baits (Piva & Campos-Farinha 1999, Yamaguchi 2004, Zarzuela *et al.* 2005, Clark *et al.* 2008, Piva & Campos 2012). This methodology is efficient for collecting urban species, particularly within households (Alder & Silverman 2005, Vital 2007). In areas with greater vegetation covers where there is the presence of leaf litter, as some urban parks and squares, there is a possibility to use two other sample methods: pitfall traps and leaf litter samples.

These two methods are part of the protocol for collection of leaf litter ants (Agosti & Alonso 2000) created to standardize the collection methodology and enable better comparisons among studies. Although this protocol was widely used for sampling ants in forest physiognomies (Fisher *et al.* 2000) and it has been also validated for other environments with very different physiognomies as Brazilian savannah (Lopes & Vascocelos 2008), little is known about its efficiency in urban green areas.

The objective of this study was to evaluate the species composition and functional groups of the ant community in an urban park, and compare two methods of sampling ants in this locality: pitfall traps and leaf litter sampling. The results of this research were also compared with two other studies conducted in the same neighborhood, but in households.

MATERIAL AND METHODS

Study site

The studied area was the 3 ha park of Instituto Biológico, a research institution located in one of the oldest areas in the city of São Paulo, the Vila Mariana neighborhood, 5 km away from downtown. The site is next to a major avenue that crosses the city from north to south and separates the studied area from the Ibirapuera Park, the most visited park in the city, which covers an area of 1,584 km^2 and receives about 220,000 visitors each week.

Ant Sampling

Data collection was conducted in April, September and October 2005.

Two transects were designed to cover the largest area of the park. Along each transect 36 pitfall traps were placed, spaced 10 meters apart (N = 72). Each trap consisted of a 500 ml disposable plastic cup filled with 3% formalin and detergent. The traps were laid in the soil and collected 48 hours later.

Five transects of 40 m each were established in the main grassed areas, in order to collect leaf litter. In each transect one square meter of leaf litter was collected every10 meters (N = 25), later processed in a Winkler extractor.

Data Analysis

Frequency (number of traps where the species occurred relative to total number of traps) and relative abundance (total number of individuals collected of the species relative to total number of individuals of all species) were calculated for ant fauna sampled in pitfall traps and leaf litter.

Species richness was calculated through the Chao 2 richness estimator and species accumulation curve using the Mao Tao Estimator with EstimateS, version 8.2 (Colwell 2004). Chao 2 is an incidence-based estimator of species richness, which relies on the number of unique units and duplicates (species found in only one and two sample units) (Chao, 2004) and species accumulation curve illustrates the rate at which new species are found (Magurran 2004). Species richness was analyzed for each sample methodology separately and also for both methods together. Ant species were grouped into functional groups adapted from Delabie *et al.* (2000) and Silvestre & Silva (2001).

To compare the two sampling methodologies, the chi-square test was applied to the number of specimens (Zar 1996). In this analysis those species or functional groups where the sum of individuals between the two methods was less than 11 were discarded. The Jaccard Similarity Index was calculated to estimate the similarity between the species richness in both sampling methods.

The list of ant species of two other studies conducted in the same neighborhood (Piva & Campos-Farinha 1999, Piva & Campos 2012) was also grouped in order to compare data with the ant fauna collected at the Instituto Biológico park.

RESULTS

A total of 1,401 ant specimens were collected, distributed in 36 species and six subfamilies, Myrmicinae was the richest (19 species), followed by Formicinae (6 species), Ponerinae and Dolichoderinae (both with 4 species), Ectatomminae (2 species) and Pseudomyrmecinae (1 species) (Table 1).

The CHAO2 index estimated 43 species for both sampling methods, seven more species than the observed number. The species accumulation curve is represented in Fig. 1 for each method and for both when analyzed together.

Wasmannia auropunctata was the predominant species in the samples with a total frequency (45.36%) two times greater than the second most frequent species (*Pheidole* sp.1 - 22.68%) and accounting for over half of the collected specimens (abundance = 53.96%) (Table 1).

The genus *Pheidole* was the richest (9 species) followed by *Solenopsis* (3 species). These two genera after *W. auropunctata* represented the most frequent group of ants (*Pheidole* spp. = 37.11% and *Solenopsis* spp. = 34.02% from the 97 pitfall traps and leaf litter samples).

The predominant functional group in the community was the opportunistic ants, since most species fitted in this group (25 species - Table 1), which were the most frequent in the 97 samples (F = 83.75%) and the most abundant (95.29% of the total collected specimens) (Table 2).

Ants with aggressive behavior and omnivorous species were grouped as "opportunistic ants", regardless of taxonomic group or if they show features such as massive recruitment and dominance of baits, since we did not use baits.

The groups of cryptic species ($p < 0.0001$) and fungus-growing ($p = 0.0348$) were the only two that showed significant differences between the two sampling methodologies. The group of arboreal ants was discarded for not reaching the assumptions of the test (Table 2).

Comparing the two sample methodologies, pitfall traps and leaf litter collection, only *Linepithema* sp. did not show a significant difference between the two sampling methodologies according to the number of collected specimens ($p = 0.4561$). Twenty four ant species were discarded from analysis

Table1. Relative abundance (Ab) and frequency (F) of ant species collected with pitfall traps and leaf litter samples, the comparison between the two sample methodologies (Chi-square test) and the classification of species into functional groups (FG), where Op = opportunistic, Fu = fungus-growing, Cr = cryptic, Lp = Large predator and Ar = arboreal. Collections in the park of Instituto Biológico, São Paulo, Brazil.

		Pitfall		Leaf Litter			Total	
Species	FG	Ab (%)	F (%)	Ab (%)	F (%)	p	Ab (%)	F (%)
Dolichoderinae								
Dorymyrmex sp.1	Op	1.70	5.56				0.86	4.12
Dorymyrmex sp.2	Op	1.28	6.94			discarded	0.64	5.15
Linepithema sp.1	Op	2.84	16.67	3.59	40.00	0.4561	3.21	22.68
Tapinoma melanocephalum	Op	0.28	2.78	0.29	4.00	discarded	0.29	3.09
Formicinae								
Brachymyrmex sp.1	Op	0.57	4.17	0.14	4.00	discarded	0.36	4.12
Brachymyrmex sp.2	Op	1.28	9.72	0.14	4.00	discarded	0.71	8.25
Camponotus sp.1	Op	0.14	1.39			discarded	0.07	1.03
Nylanderia fulva	Op	12.07	13.89	0.29	8.00	>0.0001	6.21	12.37
Paratrechina longicornis	Op	8.10	6.94			>0.0001	4.07	5.15
Paratrechina sp.1	Op	9.80	8.33	3.01	24.00	>0.0001	6.42	12.37
Myrmicinae								
Cyphomyrmex sp.1	Fu	0.57	4.17	0.29	8.00	discarded	0.43	5.15
Monomorum floricola	Op			0.29	8.00	discarded	0.14	2.06
Monomorium pharaonis	Op			0.29	8.00	discarded	0.14	2.06
Mycocepurus goeldii	Fu	0.57	4.17			discarded	0.29	3.09
Pheidole sp.1	Op	9.23	30.56			>0.0001	4.64	22.68
Pheidole sp.2	Op	0.28	1.39			discarded	0.14	1.03
Pheidole sp.3	Op	0.28	1.39			discarded	0.14	1.03
Pheidole sp.4	Op	0.57	4.17			discarded	0.29	3.09
Pheidole sp.5	Op	1.99	9.72			0.0002	1.00	7.22
Pheidole sp.6	Op	0.14	1.39			discarded	0.07	1.03
Pheidole sp.7	Op			1.00	16.00	discarded	0.50	4.12
Pheidole sp.8	Op			1.15	8.00	discarded	0.57	2.06
Pheidole sp.9	Op			0.14	4.00	discarded	0.07	1.03
Solenopsis sp.1	Op	11.93	20.83	1.15	4.00	>0.0001	6.57	16.49
Solenopsis sp.2	Op	0.14	1.39	0.57	12.00	discarded	0.36	4.12
Solenopsis sp.3	Op	7.39	18.06	0.29	8.00	>0.0001	3.85	15.46
Strumigenys sp.1	Cr	0.28	2.78	3.01	40.00	>0.0001	1.64	12.37
Trachymyrmex sp.	Fu	0.14	1.39			discarded	0.07	1.03
Wasmannia auropunctata	Op	26.85	30.56	81.35	88.00	>0.0001	53.96	45.36

Table1 (continued). Relative abundance (Ab) and frequency (F) of ant species collected with pitfall traps and leaf litter samples, the comparison between the two sample methodologies (Chi-square test) and the classification of species into functional groups (FG), where Op = opportunistic, Fu = fungus-growing, Cr = cryptic, Lp = Large predator and Ar = arboreal. Collections in the park of Instituto Biológico, São Paulo, Brazil.

		Pitfall		Leaf Litter			Total	
Species	FG	Ab (%)	F (%)	Ab (%)	F (%)	p	Ab (%)	F (%)
Ponerinae								
Anochetus sp.1	Cr			0.14	4.00	discarded	0.07	1.03
Hypoponera sp.1	Cr			1.72	24.00	0.0005	0.86	6.19
Odontomachus sp.1	Lp			0.14	4.00	discarded	0.07	1.03
Pachycondyla sp.1	Lp	0.28	1.39			discarded	0.14	1.03
Ectatomminae								
Ectatomma sp.1	Lp	0.85	5.56	0.14	4.00	discarded	0.50	5.15
Ectatomma sp.2	Lp	0.14	1.39	0.86	4.00	discarded	0.50	2.06
Pseudomyrmecinae								
Pseudomyrmex sp.1	Ar	0.28	2.78			discarded	0.14	2.06

Table 2. Relative abundance of functional groups for each sampling methodology and their sum, the comparison between the sampling methods (Chi-square test).

Functional Group	Pitfall (%)	Leaf Litter (%)	p	Total (%)
Opportunistic	96.875	93.687	0.640	95.289
Arboreal	0.284	0.000	discarded	0.143
Cryptic	0.284	4.878	<0.0001*	2.498
Large Predator	1.278	1.148	0.808	1.285
Fungus-Growing	1.278	0.287	0.0348*	0.785

*significance at 5% level

as they represented less than 11 specimens in both sample methodologies (Table 1).

The CHAO2 index estimated 28 species for leaf litter sampling and 34 for pitfall traps, meaning that the difference between what was estimated and what was found in both methodologies was six species (Fig. 1) and the similarity between the species collected in the two sampling methods was 0.388 (Jaccard Similarility Index).

Table 3. Comparison of functional group species richness (number of species) among the two sampling methods to survey ants and data from Piva &Campos-Farinha (1999) and Piva & Campos (2012) in Vila Mariana neighborhood, São Paulo, Brazil.

Functional Group	Pitfall	Leaf Litter	Total	Piva & Campos-Farinha 1999	Piva & Campos 2012
Oportunistic	20.00	14.00	25.00	19.00	20.00
Arboreal	1.00	0.00	1.00	0.00	1.00
Cryptic	1.00	3.00	3.00	1.00	2.00
Large Predator	3.00	3.00	4.00	1.00	2.00
Fungus-Growing	3.00	1.00	3.00	0.00	0.00

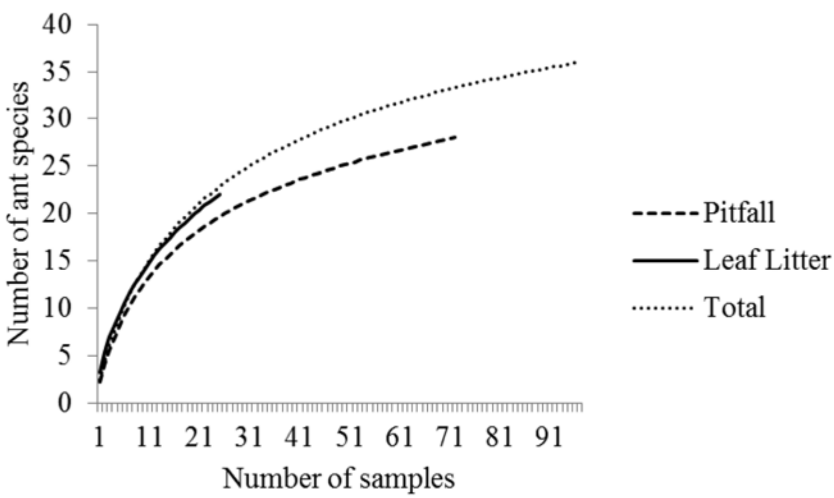

Fig.1. Species accumulation curve for ants collected with pitfall traps and leaf litter samples in the park of Instituto Biológico, São Paulo, Brazil.

DISCUSSION

Composition of the ant community

The high richness of ants found in the park contrasts with the results obtained in houses in the same neighborhood where 23 ant species were found in a 1999 study (Piva & Campos-Farinha 1999) and 25 species were found between 2009 and 2011 (Piva & Campos 2012). Certainly this difference is due to the less disturbed environment of the park in relation to the residences and also because the sampling methods were not the same. The latter authors used baits for ant collection.

Although the accumulation curve (Fig. 1) did not stabilize in the total sampling and also for each sampling methodology and the CHAO2 estimator showed a difference from what was expected and what was collected, this result is expected in tropical areas due to the large number of rare species in the samples (Longino *et al.* 2002, Leponce *et al.* 2004). Therefore, it is likely a greater sampling effort would reduce this difference.

W. auropunctata, the most frequent and abundant species in this study, is one of the most common tramp ants in southeastern Brazil (Campos-Farinha *et al.* 2002), and it is an outstanding invasive species (Orivel *et al.* 2009) - despite being native to South America, its distribution currently extends to Central America, tropical regions of North America and Oceanic Islands, and Galapagos (Robinson 2005).

In contrast to this result, in residences and in their surroundings this species showed low frequency (F = 3.8%) (Piva & Campos 2012) or it was absent (Piva & Campos-Farinha 1999), showing that despite being considered a tramp ant, the presence of *W. auropunctata* in urban areas is more common outside households, such as backyards and gardens (Bueno & Campos-Farinha 1999), where it can nest in the soil under substrates such as leaf litter and stones (Wetter & Porter 2003).

Ants of the genus *Pheidole* and *Solenopsis* along with *W. auropunctata* represented 72.16% of the total abundance in both samples. These two genera are cosmopolitan ants with a high richness of species in both tropical and temperate regions (Robinson 2005).

Functional groups

The species mentioned above formed the functional group of opportunistic ants along with *Paratrechina* spp., *Nylanderia fulva, Brachymyrmex* spp., *Monomorium* spp., *Linepithema* sp., and *Tapinoma melanocephalum* (Table 1). This group was the most frequent and abundant (Table 2), and all these genera or species are recognized as tramp ants.

Some characteristics used to classify ants in the group of opportunistic ants, such as omnivory, are among those that identify tramp ants, besides others such as polygyny, sociotomy, migration and colony budding in response to environmental disturbances (Passera 1994).

The analysis of community composition by functional groups in our data compared to households and their surroundings in two studies conducted in the same neighborhood (Piva & Campos-Farinha 1999; Piva & Campos 2012) suggests that, despite the similar dominance of opportunistic species, there is a greater number of species belonging to other functional groups in our research. The occurrence of such species in the studied area is related to the presence of leaf litter (Table 3) and of course due to the different collection methodologies used in the different studies.

Vital (2007) considered the use of baits in consortium with pitfall traps and active search, as an efficient methodology to assess the diversity of ants in urban squares, where leaf litter is not always present, something that must be considered when urban ant communities are being assessed. Therefore it is important to remember that generalist ants may be collected with more frequency and also if active search is performed, the results are more effective the higher the research efforts.

Thus, while in households and in certain urban areas such as squares, the use of baits, active search and pitfall traps combined may be a good approach, in green areas, in these same urban environments, the leaf litter must also be sampled, combined with pitfall traps, due to the great number of ant species present in this substrate as shown in this study.

Pitfall x Leaf Litter Samplings

The Jaccard Similarity Index (0.388) indicates a low similarity between the two sampling methodologies, which points to the importance of combining the two types of sampling for a better evaluation of the ant fauna.

The difference between these two methods was expressive mainly for the cryptic species *Hypoponera* sp. ($P = 0.0005$) and *Strumigenys* sp. ($P < 0.0001$), as well as for *W. auropunctata* ($p < 0.0001$), which were found more frequently in the samples of leaf litter, clearly because they use this substrate for nesting and foraging.

The results from the two methodologies are not significantly different for the group of opportunistic ants ($p = 0.6397$), however, for *Dorymyrmex* sp.1, *Pheidole* sp.1, *Solenopsis* sp.1, *Solenopsis* sp.4, the two species of *Paratrechina* and *Nylanderia fulva* the difference was significant, indicating that pitfall traps are more efficient than leaf litter samplings in collecting opportunistic ants.

Moreover, the difference between the two methods for the group of opportunistic ants was not significant only because of the large number of individuals collected of *W. auropunctata*, a species that, despite being classified as opportunistic, nests in substrates such as leaf litter. Excluding *W. auropunctata* from this group, the difference changes drastically to 493 specimens of opportunistic ants in pitfall traps against 130 in the leaf litter, a significant difference ($p < 0.0001$).

This finding is close to the results of Lopes & Vasconcelos (2008) who evaluated the effectiveness of these two methods and baits to assess the communities of ants in Brazilian savannah. They found that the collection of leaf litter was more effective where there was greater abundance of this substrate, while in areas where it was scarce the use of pitfall traps was the best methodology. According to these authors, although a single methodology is enough to compare very different environments, they suggest a combination of methods to produce a more complete inventory, particularly pitfall traps and leaf litter sampling.

The large number of opportunistic species present in the samples, particularly in pitfall traps (with the exception of *W. auropunctata*), suggests that baits, in urban environments with similar characteristics to the studied area, are not necessary, as they attract species that have omnivorous feeding habits, which also tend to be the species most collected in the pitfall traps.

Final considerations

Although at first glance the ant community of the studied area shows high species richness, approximately 90% were opportunistic ants, and some of them such as *W. auropunctata* and the genera *Solenopsis* and *Pheidole,* showed high frequency and abundance.

These results raise a question about the control of tramp ants in urban areas: Are squares and parks being used as a source for dispersion of tramp ant colonies instead of increasing the diversity of species? If this does happen the control of ants in urban areas, especially near parks and squares, should evaluate the potential of these sites as sources of new colonization of tramp ants.

The hypothesis of these areas serving as a source of dispersion for the opportunistic species is supported by the presence of other functional groups that apparently do not compete directly with the tramp ants. Thus, the mere presence of other functional groups, in addition to opportunistic ants, does not seem to be the most important factor to assess the condition of the local community of ants.

Moreover, it is important to determine if in the opportunistic group there are only tramp ants. The presence of opportunistic species that are not tramp ants could be a sign that the ant community has better quality, since it supports species that compete directly with these urban species.

This study also showed that the combination of pitfall traps to collect leaf litter is a valid methodology for sampling ants in urban areas with leaf litter. The large number of omnivorous species collected suggests that the use of baits may not be necessary in these areas, although more specific studies that focus on methodologies for sampling ants in green areas in urban environments are essential.

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