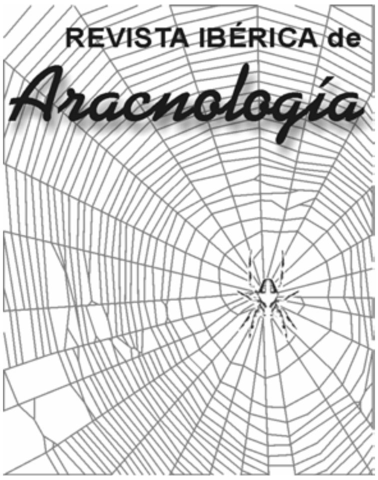

ARTÍCULO:

Composition of the spider assemblage in an urban forest reserve in southeastern Brazil and evaluation of a two sampling method protocols of species richness estimates

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Revista Ibérica de Aracnología
ISSN: 1576 - 9518.
Dep. Legal: Z-2656-2000.
Vol. **10**, 31-XII-2004
Sección: Artículos y Notas.
Pp: 185−194.

Edita:
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ARTÍCULO:

COMPOSITION OF THE SPIDER ASSEMBLAGE IN AN URBAN FOREST RESERVE IN SOUTHEASTERN BRAZIL AND EVALUATION OF A TWO SAMPLING METHOD PROTOCOLS OF SPECIES RICHNESS ESTIMATES

E. S. S. Álvares, E. O. Machado,
C. S. Azevedo & M. De-Maria

Abstract:
The composition and species richness of the spider assemblage, sampled with pitfall traps and beating-trays, in an urban forest reserve located in the metropolitan region of Belo Horizonte, state of Minas Gerais, Brazil, was evaluated. A total of 10,823 spiders (2,310 adults and 8,513 juveniles) were collected. The adults were represented by 223 species and morphospecies distributed in 30 families. Of these, 94 were collected with pitfall traps, and 153 with beating-trays. A higher percentage of adults (61.3%) and males (43.2% of all individuals) were found in pitfall traps, when compared to the beating-trays (13.2% adults; 5.1% males, respectively). Only 24 species were collected by both methods. The complementarity of these methods was 89.2%. The individuals based species accumulation curves did not asymptote. The use of pitfall traps and beating-trays combined proves to be a good choice for short-time low cost surveys.
Key words: spider, sampling method, pitfall traps, beating-trays, richness estimation, composition, Neotropical, "Estação Ecológica da UFMG"

Composición de la assemblea de arañas en una reserva florestal urbana en Sureste de Brasil y evaluación de un protocolo de colecta con dos metodos para la estimación de riqueza de especies.

Resumen:
Fue evaluado la composición y riqueza de las especies de la assemblea de arañas colectados por trampa de caída y batedor en una reserva localizada en la región metropolitana de Belo Horizonte, Minas Gerais, Brasil. Fueran colectados 10.823 arañas (2.310 adultos y 8.513 inmaturos). Los adultos constituyen 223 especies distribuidas en 30 familias. Fueran colectadas 94 especies con trampa de caída y 153 especies con batedor. Una mayor porcentaje de adultos (61,3%) y machos (43,2% de todos los individuos) fue encontrada en las trampas de caída cuando comparado con batedor (13,2% de adultos y 5,1% de machos, respectivamente). Solamente 24 especies fueran colectadas con ambos los métodos. La complementariedad de estes métodos fuera 89,2%. Las curvas de acumulación de especies basada en individuos no alcanzaran la asíntota. La trampa de caída combinada con batedor és una buena opción para inventarios breves y con bajo custo.
Palabras clave: Arañas; métodos de colecta; trampa de caída; batedor; Estimación de Riqueza; Composición; Neotropical; "Estação Ecológica da UFMG"

Introduction

In recent years, the importance of the planet's biodiversity has been exhaustively discussed in diverse academic and public areas. However, only recently has data on invertebrate richness been incorporated to conservation efforts, that used to privilege vertebrate groups (New, 1995). Nevertheless, a major challenge to the definitive inclusion of invertebrates in conservation politics is to determine and understand their diversity, the patterns of their taxonomic richness, and the parameters affecting their distribution and abundance (New, 1999).

Among the invertebrates, spiders represent an interesting study group because they are a very diverse taxa and extremely sensitive to habitat changes, including vegetation complexity and microclimatic characteristics (Turnbull, 1973; Hatley & Macmahon, 1980; Uetz, 1991; New, 1999). Furthermore, spiders play an important role in many terrestrial ecosystems due to their predatory nature, abundance and ubiquity (Wise, 1993). For the purpose of understanding their patterns of diversity, it is indispensable to evaluate and standardize sampling methods to collect them (New, 1995; Churchill, 1997).

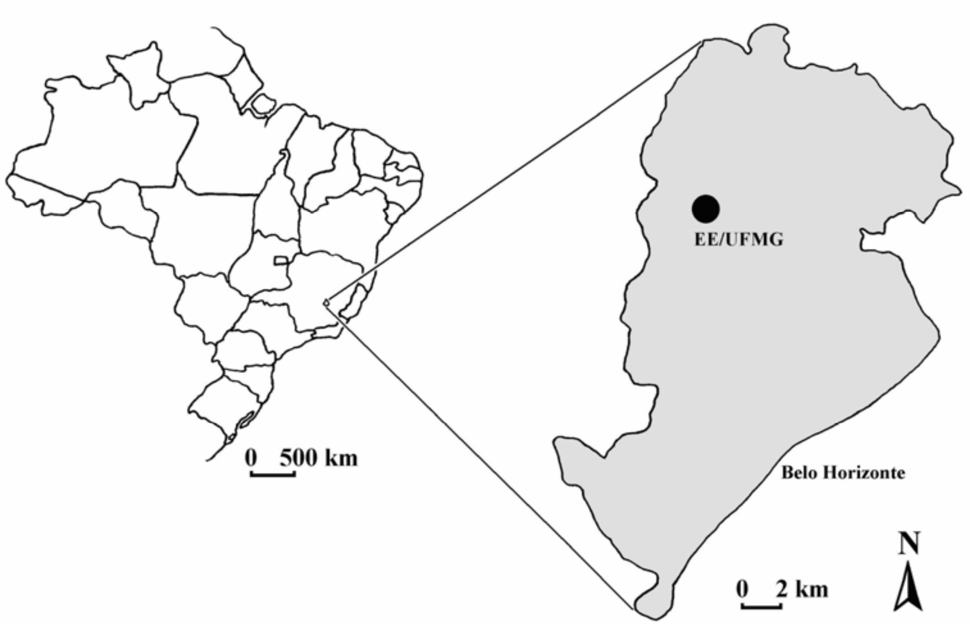

Fig. 1. Map showing the location of the sampling site in the Belo Horizonte municipality, in Minas Gerais State, Brazil.

Different sampling methods can misrepresent certain species in spider assemblages (Merrett & Snazell, 1983; Churchill, 1993). Commonly used sampling methods to collect spiders include: pitfall traps (Uetz & Unzicker, 1976), sweep net (Horvath *et al*., 2000), Berlese funnels (Szathmary, 1999), suction sampling (Greenstone, 2001), beating-trays (McCaffrey *et al.*, 1984), visual search (Coddington *et al*., 1991; Borges & Brescovit, 1996; Sørensen, 2004) and canopy fogging (Höfer *et al*., 1994). To obtain statistically and ecologically meaningful data and to maximize the number of species sampled in biodiversity assessments, several authors have used a wide range of combined methods. Coddington *et al*. (1991) and Silva & Coddington (1996), for example, standardized a collecting protocol in the Neotropical rainforest that includes mainly visual search and beating-trays, and Silva (1996) added to these methods the fogging technique; Rinaldi *et al*. (2002) and Rinaldi & Ruiz (2002) used beating-trays and visual search to sample spiders in sugar cane cultures and rubber tree plantations; Flórez (1998, 1999) used visual search, sweep net, beating-trays, Berlese funnels and pitfall traps; Churchill (1993) and Sørensen *et al*. (2002) used and compared pitfall traps, sweep net, and visual search. Other researchers tested different combinations of sampling protocols, but none of them tested pitfall traps and beating-trays as complementary methods in the Neotropical region.

Despite some disadvantages of the pitfall traps in producing biases in the catches (Luff, 1975; Adis, 1979), these traps are the most effective method for capturing ground-dwelling spiders. However, this method underestimates the diversity and abundance of the foliage-dwelling fauna, sampled more efficiently by beating-trays (Churchill, 1993; Green, 1999). In this paper, the composition of the spider assemblage collected using pitfall traps and beating-trays and the efficiency of these two sampling methods in capturing dominant spider taxa was compared at the "Estação Ecológica da Universidade Federal de Minas Gerais", illustrating how the choice of a method can influence the final interpretation of community composition and species richness.

Material and methods

Study area

The "Estação Ecológica da Universidade Federal de Minas Gerais" (EE/UFMG) is a 102 ha urban reserve located in the northwestern area of the metropolitan region of Belo Horizonte, state of Minas Gerais, southeastern Brazil (19°52' S, 43°58' W; 800-880 m) (Fig. 1). A warm and rainy season from October to March and a dry winter from April to September characterize the climate. Mean annual temperature is 21°C, and annual rainfall typically ranges from 1500 to1750 mm.

The vegetation consists predominantly of herbs, shrubs, and small sized trees. There are areas of secondary forest with Atlantic forest influence and patches of "cerrado" (savannah-like vegetation), and areas of "capoeira" (disturbed second-growth vegetation), marshlands and abandoned monocultures of introduced species (*Pennisetum purpureum* Schumach, *Bambusa* sp. and *Eucalyptus* spp.). Collections were conducted in two sampling sites: a secondary forest area, called "Bosque do Sossego", and a shrub dominant area of "capoeira". "Bosque do Sossego" predominant trees are *Copaifera langsdorfii* Desfonataines and *Chorisia speciosa* Saint Hillaire. "Capoeira" predominant vegetal species are *Baccharis* spp., *Panicum sp* and *Melinis minutiflora* Beauv.

Sampling methods

Forty-five pitfall traps were placed in each sampling site. These traps were arranged in three parallel lines, five meters apart, with 15 traps each separated by a distance of two meters, totalling approximately 450 m^2.

The trap consisted of a 500-ml plastic cup, with an opening diameter of 9.5 cm, filled with 200 ml of preservative solution (alcohol 70%, formaldehyde 4%, and a few drops of detergent). The containers were buried at ground level and protected from rain by a plastic plate (20 cm diameter) placed approximately 10 cm above the cup mouth. The pitfall traps were left open for seven days and were placed always in the same place throughout the collecting period.

Beating-trays were used for sampling lower vegetation strata (varying from 0.5 to 2.0 m height). These devices comprised a wood cross (85 cm length, each section) that supported a 0.5 m^2 white cotton sheet. In each sampling site, ten samples were collected using this method. Each sample corresponded to twenty explored shrubs or tree branches. The shrubs were arbitrarily chosen, and the beating-trays was positioned below a branch that was struck twenty times with a wooden stick. The spiders that fell onto the sheet were collected mannualy and placed in 70% alcohol. The entire areas (except the pitfall traps sites) were sampled by beating-trays.

This sampling protocol was carried out during one week at monthly intervals, from September 2000 to February 2001, and encompassed the end of the dry season and most of the wet season. After this sixth-month collecting period a total of 120 beating-trays samples and 540 pitfall traps samples were been obtained.

Identification of spiders

Immature and adult spiders were identified to family level. Only adult spiders were sorted into morpho-species, and were identified at genus and/or species level whenever possible. Some morpho-species however, were not assigned either to species or genus, due to the scarcity of recent taxonomic reviews, because many species are still undescribed, or because they were described without using modern taxonomic criteria, becoming unrecognizable today. For simplicity, we will use the term "species" to refer to both determined and undetermined morphospecies. Voucher specimens were deposited in the collections of the "Laboratório de Artrópodes do Instituto Butantan", IBSP, São Paulo (A.D. Brescovit), and of the "Laboratório de Aracnologia da Universidade Federal de Minas Gerais", LAMG, Belo Horizonte, (M. De Maria), and duplicates were deposited in the collections of the "Museu de Ciências Naturais da Fundação Zoobotânica do Rio Grande do Sul", MCN, Porto Alegre, (E.H. Buckup) and "Museu de Ciências e Tecnologia da Pontifícia Universidade Católica do Rio Grande do Sul" MCTP, Porto Alegre, (A.A. Lise).

Data analysis

Number, species composition, relative abundance of species, males, females and immatures, and the total and relative composition of families collected with both methods were compared. Complementarity of both methods was calculated using the formula proposed by Colwell & Coddington (1994: 112). An individual-based species accumulation curve was computed performing 100 randomizations. The individual-based curve was used instead of the sample-based curve because the number of samples for each method was very different, and because the sample-based curve could introduce errors in the analysis, as discussed in Gotelli & Colwell (2001) and Sørensen *et al.* (2002). To estimate spider richness for each method, the non-parametric estimators Bootstrap, Chao1, Chao2, and Jacknife1 were used.

Bootstrap estimator does not take into account only rare species but uses all sampled species to estimate the total richness. It is calculated by adding the observed richness to the sum of the inverse proportion of samples in which every species occur (Smith & van Belle, 1984) (Equation 1).

$$S_{boot} = S_{obs} + \sum_{k=1}^{S_{obs}} (1 - \rho_k)^m \qquad [1]$$

S_{boot} = bootstrap; S_{obs} = observed richness; ρ_k = proportion of samples in which the species k occur

Chao (1984; 1987) developed Chao 1 and Chao 2 estimators. The estimated richness by Chao 1 corresponds to the sum of the observed richness to the number of species,represented by only one individual (singletons), squared , divided by twice the number of species represented by only two individuals (doubletons) (Equation 2).

$$S_{chao1} = S_{obs} + \frac{F_1^2}{2F_2} \qquad [2]$$

$S_{chao\,1}$ = Chao 1; S_{obs} = observed richness; F_1 = number of singletons; F_2 = number of doubletons

The same equation was adapted to use the number of species that occur only in one or two samples respectively (uniques and duplicates – Chao 2) (Equation 3).

$$S_{chao2} = S_{obs} + \frac{Q_1^2}{2Q_2} \qquad [3]$$

$S_{chao\,2}$ = Chao 2; S_{obs} = observed richness; Q_1 = number of uniques; Q_2 = number of duplicates

Jacknife 1 estimator adds the observed richness to a parameter calculated from the number of rare species and the number of samples, particularly the number of uniques, to calculate the total species richness (Burham & Overton, 1979) (Equation 4).

$$S_{jack1} = S_{obs} + Q_1 \frac{m-1}{m} \qquad [4]$$

$S_{jack\,1}$ = Jacknife 1; S_{obs} = observed richness; Q_1 = number of uniques; m = number of samples

The formulas for the confidence intervals and detailed informations of such richness estimators are described and discussed in Colwell & Coddington (1994), Coddington *et al.* (1996) and Colwell (1997). The species accumulation curves and the richness estimators were obtained using the software EstimateS, version 6.0b1 (Colwell, 1997).

Table I. Number of individuals and species richness by family according to the collecting method in the EE/UFMG (N, total number of spiders; N', number of adults; %N', percentage of adults; S, number of species based only on adult specimens collected). The families marked with "*" are represented only by juveniles.

Families	Pitfall traps				Beating-trays				Pitfall + Beating-trays			
	N	N'	%N'	S	N	N'	%N'	S	N	N'	%N'	S
Actinopodidae	35	24	68.6	3	11	0	0	0	46	24	52.2	3
Amaurobiidae	1	1	100.0	1	2	2	100.0	1	3	3	100.0	1
Anyphaenidae	3	0	0	0	1852	87	4.7	11	1855	87	4.7	11
Araneidae	8	2	25.0	1	598	32	5.4	15	606	34	5.6	15
Corinnidae	228	177	77.6	10	22	0	0	0	250	177	70.8	9
Ctenidae	28	5	17.9	2	0	0	0	0	28	5	17.9	2
Deinopidae	2	0	0	0	43	6	14.0	1	45	6	13.3	1
Dictynidae	0	0	0	0	195	66	33.8	2	195	66	33.8	2
Dipluridae*	2	0	0	0	0	0	0	0	2	0	0	*
Gnaphosidae	11	2	18.2	2	8	0	0	0	19	2	10.5	2
Hahniidae	74	65	87.8	2	0	0	0	0	74	65	87.8	2
Idiopidae	1	1	100.0	1	0	0	0	0	1	1	100.0	1
Linyphiidae	241	182	75.6	8	3	2	66.7	2	244	179	73.4	9
Lycosidae	204	18	8.8	6	2	0	0.0	0	206	18	8.7	6
Mimetidae	0	0	0	0	136	15	11.0	1	136	15	11.0	1
Miturgidae	0	0	0	0	342	1	0.3	1	342	1	0.3	1
Mysmenidae	0	0	0	0	4	2	50.0	1	4	2	50.0	1
Nemesiidae	28	13	46.4	3	0	0	0	0	28	13	46.4	3
Oonopidae	31	28	90.3	4	64	25	39.1	4	95	53	55.8	6
Oxyopidae	40	16	40.0	4	235	24	10.2	4	275	40	14.5	5
Palpimanidae	6	5	83.3	1	0	0	0	0	6	5	83.3	1
Philodromidae	28	14	50.0	2	17	6	35.3	3	45	20	44.4	3
Pholcidae	73	38	52.1	3	127	93	73.2	3	200	131	65.5	3
Salticidae	215	148	68.8	23	1691	250	14.8	37	1906	398	20.9	52
Scytodidae	13	7	53.8	1	240	86	35.8	2	253	93	36.8	2
Segestriidae*	1	0	0	0	2	0	0	0	3	0	0	*
Selenopidae*	0	0	0	0	5	0	0	0	5	0	0	*
Senoculidae*	0	0	0	0	6	0	0	0	6	0	0	*
Sparassidae*	1	0	0	0	67	0	0	0	68	0	0	*
Tetragnathidae	12	0	0	0	217	14	6.5	5	229	19	8.3	5
Theraphosidae	1	1	100.0	1	2	0	0	0	3	1	33.3	1
Theridiidae	192	120	62.5	13	1721	404	23.5	38	1913	524	27.4	50
Theridiosomatidae*	0	0	0	0	2	0	0	0	2	0	0	*
Thomisidae	13	2	15.4	2	1370	71	5.2	22	1383	73	5.3	23
Titanoecidae	16	16	100.0	1	0	0	0	0	16	16	100.0	1
Trechaleidae*	0	0	0	0	4	0	0	0	4	0	0	*
Zodariidae	327	239	73.1	1	0	0	0	0	327	239	73.1	1
Total	**1835**	**1119**	**61.3**	**95**	**8988**	**1186**	**13.2**	**153**	**10823**	**2310**	**21.3**	**224**

Results

Total species richness and composition sampled by both methods

A total of 10,823 spiders (8,513 immatures and 2,310 adults belonging to 37 families were collected. Seven families were represented only by juveniles (Dipluridae, Segestriidae, Selenopidae, Senoculidae, Sparassidae, Theridiosomatidae and Trechaleidae). Adults comprised 223 species distributed in 30 families (Table I). The richest families were Salticidae (52 species) and Theridiidae (50 species), followed by Thomisidae (23 species), Araneidae (15 species) and Anyphaenidae (11 species). In relation to the number of adult individuals, the most representative families were Theridiidae (22.7%), Salticidae (17.2%), Zodariidae (10.3%), Linyphiidae (7.7%) and Corinnidae (7.6%). The five most abundant species were *Tenedos* sp. (10.3%), *Falconina gracilis* (Keyserling, 1891) (6.3%), *Meioneta* sp. (5.6%), *Tupigea* sp. (3.7%) and *Achaearanea hirta* (Taczanowski, 1873) (3.3%).

Sampling method, family composition and relative abundance

The results obtained by the two methods employed in this study are not statisticaly comparable due to statistical premisses and methodological differences. Thus, only qualitative descriptions of the composition of species and families collected by both methods can be made.

Table II. Summary of the values of number of species and families sampled with the two methods separated and combined, and the species richness estimated with these data. The decimal places in values obtained in the richness estimation were omitted. The families marked with "*" are represented only by juveniles.

	Pitfall traps	Beating-trays	Pitfall traps + Beating-trays
Number of samples	540	120	660
Number of individuals	1,835	8,988	10,823
Number of families (considering adults and immatures)	29	29	37
Number of adults	1124	1186	2310
Number of families (adults only)	25	18	30
Number of species	94	153	223
Exclusive species	70	129	-
Exclusive families (adults only)	12	6	-
Number of singletons	35	60	78
Number of doubletons	12	16	22
Richness estimators			
Chao1	140 ± 24	257 ± 42	333 ± 37
Chao2	131 ± 18	230 ± 29	312 ± 29
Jacknife1	129 ± 6	212 ± 9	299 ± 10
Bootstrap	109	179	257

With pitfall traps, 1,835 individuals (adults and juveniles) distributed in 29 families were collected. The most abundant spider families, collected in pitfall traps, were Zodariidae (18.4%), Linyphiidae (13.1%), Salticidae (11.7%), Lycosidae (11.1%) and Theridiidae (10.5%) (Table I). Adults comprised 1,124 spiders, belonging to 24 families and 94 species. This method collected a higher percentage of adults (61.3%) and more adult males (43.2%) than females (18.0%), than the other sampling method.

A total of 8,988 individuals (adults and juveniles) of 29 families were collected with beating-trays. The most abundant families were Anyphaenidae (20.6%), Theridiidae (19.2%), Salticidae (%18.8), Thomisidae (15.2%), Araneidae (6.6%) and Miturgidae (3.8%). The adults (1,186 spiders) were distributed in 18 families and 153 species. A low percentage of adults (13.2%) was obtained by this method, and adult females were more abundant than adult males (8.1% and 5.1%, respectively). Some families (Anyphaenidae, Thomisidae, Miturgidae, and Araneidae) were represented by a great number of individuals, but with a low proportion of adults (Table I).

Considering only the adult spiders, 12 families and 70 species (31.4% of total species) were collected exclusively by pitfall traps. Six families and 129 species (57.9%) were represented exclusively in beating-tray samples (Table II). Only 24 species (10.7%) were collected by both methods (Table II). These methods, thus, showed a very low overlapping, with a high complementarity (89.2%).

The composition of the most diverse and abundant families differed considerably between the methods (Table I). In terms of number of species, for both methods, Salticidae was also the most diverse family, with 52 species, followed by Theridiidae, with 50 species and Thomisidae with 23 species (Table I, Appendage I).

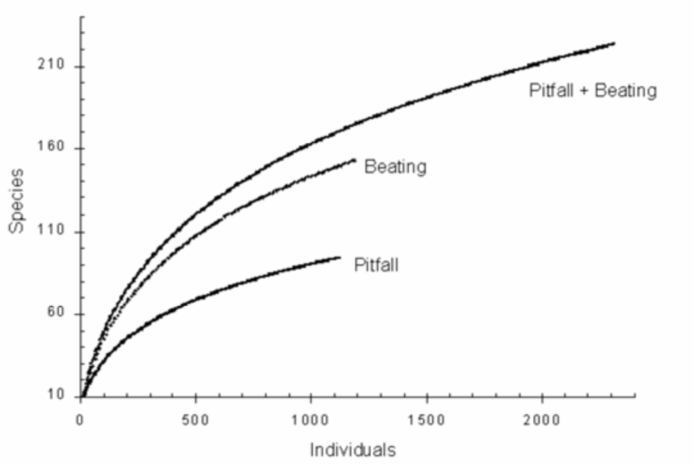

Fig. 2. Individual-based species accumulation curves with 100 randomizations for the beating-trays, pitfall traps and beating-trays + pitfall traps data set.

Sampling method and spider estimated richness

Figure 2 presents the species accumulation curves generated with pitfall traps, beating-trays and both methods combined. None of the curves reached an asymptote, but the one generated by the pitfall traps was less inclined. The results of estimated species richness for the combined methods and for each one are presented in table II. Estimators ranged from 179 (Bootstrap) to 257 ± 42 SD (Chao1) for beating-trays, 109 (Bootstrap) to 138 ± 22 SD (Chao1) for pitfall traps, and 257 (Bootstrap) to 333 ± 37 SD (Chao1) for combined methods. The percentage of singletons was lowest with the combined data (35.0%), when compared with each method alone (39.2 % for beating-trays and 37.2% for pitfall traps).

Discussion

Considering that the EE/UFMG is a disturbed urban reserve, the spider richness that resulted from this survey is considerable. However, direct comparisons of these results with other surveys carried out in the Neotropical region are very difficult to be made, since the sampling effort is not the same, allowing only qualitative comparisions. Indeed, these comparisons must be taken with care, since sampling effort, season, size, number of sampled sub-areas and part of community accessed in different studies were quite different from those employed in the EE/UFMG.

Analysing each method separately, the results of richness of ground spiders of EE/UFMG were greater than that obtained by pitfall traps in the three urban areas in the city of São Paulo (Candiani *et al*., in press), where 46 species (1569 adults) were found in 600 samples during four sampling periods, and in two sampling sites (continental area and Parque dos Eucaliptos Island) in the Guarapiranga Reservoir, in the city of São Paulo (Indicati *et al*., in press), where 86 species and 2171 adults were collected in 400 traps in four sampling expeditions. Analysing the results of the estimators, the expected richness for the EE/UFMG was also greater than that obtained in these two studies, except by the Chao2 in the continental area sampled by Indicatti *et al*. (in press), where an estimated richness of 135 species was obtained. In the Parque Estadual da Ilha do Cardoso, city of Cananéia, state of São Paulo, Fowler & Venticinque (1995) , using pitfall traps (number of samples not indicated), found 31 species and 477 spiders (number of adults not indicated). However authors did not provide further analysis with estimators and species acumulation curves. Concerning richness of spiders sampled by beating-trays, there are no studies for comparision in the Neotropics that specify the spiders species collected with this method. The same is true for studies from some other areas in Brazil (Borges & Brescovit, 1996; Martins & Lise, 1997; Lise, 1998; Brescovit *et al*., 2004), in which the authors did not separated the spiders collected by each method, thus, only the observed richness can be compared. In such case, the results of the spider richness of the EE/UFMG were similar to some areas surveyed in the Brazilian Amazonia and in other areas in the Atlantic Forest. For example, Lise (1998) found in the Ilha de Maracá, in the State of Roraima, 270 species (number of adults not indicated) using beating-trays, sweep-net and pitfall traps (number of samples not indicated), in 21 days of collecting. In Caxiuanã, city of Melgaço, State of Pará, Martins & Lise (1997) found 135 species (354 adults), using beating-trays, sweep net, pitfall traps and visual search (number of samples not indicated) during a ten day period. In the Mamirauá reserve, in the state of Amazonas, Borges & Brescovit (1996) found 102 species in 20 days using visual search (number of samples not indicated). In the Estação Ecológica Juréia-Itatins, in the state of São Paulo, in the Atlantic Forest dominium, Brescovit *et al*. (2004) found, after four expeditions, 274 species (about 3800 adults) using visual search (diurnal and nocturnal), beating-trays, litter sampling and pitfall traps (number of samples not indicated). Despite the urban location and the disturbed and fragmented nature of EE/UFMG reserve, these results give a good expectative of a very high richness in Cerrado and non-coastal Atlantic Forests.

None of the species accumulation curves reached an asymptote, as expected for most tropical communities of arthropods (Gotelli & Colwell, 2001). This suggests that there are more species to be discovered in both assemblages and an increase of sampling effort is needed to saturate the curves. The percentage of rare species (singletons) found (35%) is also similar to that found in the literature for tropical regions, which range from 30 to 70% (Silva, 1996; Silva & Coddington, 1996; Sørensen, 2004). The bootstrap estimate was the lowest in all analyses, as expected (Colwell & Coddington, 1994; Coddington *et al*., 1996; Sørensen *et al*., 2002). The percentage of observed richness in relation to the mean of the expected richness obtained by these estimators ranged from 67.1% to 86.2% for pitfall traps, 59.5% to 85.5% for beating-tray and 70.0% to 86.8% for combined data. These results of richness estimators corroborate that both soil and vegetation spider assemblages of the EE/UFMG were underestimated.

The low species overlapping observed in this study emphasizes the differences between the two methods. The coincident species can be interpreted as a stochastic event, as a behaviour of some individuals or sex class, or as habits of these species that include the zone between the lower parts of vegetation and the surface of soil. Sørensen *et al* (2002) found very similar results when testing diverse combination of methods in the Afrotropical region. They found that pitfall and beating-tray are a very complementar combination (92%), similar to the result found in this study (89.2%). These two methods have very different characteristics regarding to sample size, influence of the spider activity, sampling way, vegetal stratum sampled etc. Owing to this, quantitative comparisons between both methods are not recommended. However, a qualitative analysis might provide a better way to evaluate the composition of the spider assemblages sampled.

Studies on the natural history of most Neotropical species are lacking, and considerations about family habits are generalizations, sometimes inferred from a few species or from species of other zoogeographical regions. Although not definitive, our data suggest habitat preferences for some species. In the EE/UFMG, Linyphiidae species were very abundant in the soil, as found by Indicati *et al*. (in press), Candiani *et al*. (in press), Fowler & Venticinque (1995) and Azevedo *et al*. (2002). Spiders of the families Lycosidae and Corinnidae were also abundant in soil. Candiani *et al*. (in press) and Indicati *et al*. (in press) found that Zoridae spiders were abundant in soil, but species of this family was not found in the EE/UFMG in this survey. On the other hand, in the EE/UFMG, spiders fo the families Anyphaenidae and Thomisidae were more abundant in the vegetation, the main habitat of most of their species. Pitfall traps also collected individuals of Oxyopidae (four of the five species were represented), a family common in vegetation, showing that these spiders probably also use the soil for foraging. The Pholcids were very abundant in both habitats, but with different species dominating in each of these. Theridiids and Salticids were abundant and species rich in both soil and vegetation, as shown by most of the works in the tropical region (Silva, 1992; Silva, 1996; Flórez-D, 1998; Lise, 1998; Höfer & Brescovit, 2001; Azevedo *et al*., 2002; Rinaldi *et al*., 2002).

Pitfall traps were more efficient in capturing adult spiders. This result had already been observed in previous studies (Uetz & Unzicker, 1976; Churchill, 1993; Azevedo *et al*., 2002) and is related to the higher activity of mature spiders compared to immatures. Considering only adult spiders, males are also more active than females, and this fact also explains the high rate of males observed in pitfall samples (Costa, 1998). Therefore the proportion of spiders collected with pitfall traps does not reflect the real abundance in the assemblage but a higher activity rate (Luff, 1975; Uetz & Unzicker, 1976; Topping & Luff, 1995).

As suggested by some authors (Coddington *et al*., 1991, 1996; Churchill, 1993; Topping & Luff, 1995; Green, 1999), proper assessment of spider fauna requires the use of a combination of sampling methods. Pitfall traps and beating-trays are two important methods that, together, can catch a higher number of species from two of the most important microhabitats. Besides, these methods are simple, cheap and easily replicable. Another relevant aspect affecting the sampling is seasonal differences. Although poorly studied in Neotropical araneofauna, it has a very important role in the spider fauna composition sampled in a survey, and have been observed in a number of spider species taken by different sampling methods (Merret, 1983; Silva & Coddington, 1996). This emphasizes the need to choose not only the methods that can sample different microhabitats, but also to plan the survey to include different seasons.

Acknowledgments

We are grateful to the following researchers for their assistance in spider identification: Adalberto J. Santos (Oxyopidae), Antonio D. Brescovit (Anyphaenidae), Arno A. Lise (Thomisidae), Erika H. Buckup and Maria L. A. Marques (Theridiidae), Augusto Braul Jr. and Gustavo R. S. Ruiz (Salticidae), Alexandre B. Bonaldo (Corinnidae), Gustavo Hormiga (Linyphiidae and Tetragnathidae), Sylvia Lucas (Theraphosidae), Rafael P. Indicatti (Nemesiidae), Celina Y. Fukami (Idiopidae) and Laura T. Miglio (Actinopodidae). We thank Robert Young and Cristina A. Rheims for revising the English version. We also thank Antonio D. Brescovit, Adalberto J. Santos, Pedro Cardoso and Marcos Méndez for their invaluable suggestions on this paper, and to Gabriel S. Ramos and Frederico Miranda for help with the field collect. The finantial support was partly provided by FAPESP (grants 02/11275-6 and 99/05446-8) and CNPQ-Brasil (grant 133488/2004-7). This work was developed in the Laboratório de Aracnologia, Departamento de Zoologia, Instituto de Ciências Biológicas of the Universidade Federal de Minas Gerais, as part of obtention of Academic Degree in Zoology of Éder S. S. Álvares and Cristiano S. Azevedo.

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Appendage I.

Number of individuals by species according to the collecting method in the EE/UFMG
(B, beating-trays; P, Pitfall traps).

Species by family	P	B	Total
Actinopodidae			
Actinopus sp1	15	0	15
Actinopus sp2	9	0	9
Amaurobiidae			
Amaurobiidae sp1	1	2	3
Anyphaenidae			
Aysha marinonii Brescovit, 1992	0	4	4
Jessica osoriana (Mello-Leitão, 1922)	0	1	1
Osoriella tahela Brescovit, 1998	0	26	26
Pippuhana sp1	0	20	20
Teudis angusticeps (Keyserling, 1891)	0	3	3
Teudis sp1	0	7	7
Teudis sp2	0	4	4
Teudis sp3	0	10	10
Umuara sp1	0	10	10
Anyphaenidae sp1	0	1	1
Anyphaenidae sp2	0	1	1
Araneidae			
Alpaida bicornuta (Taczanowski, 1878)	0	1	1
Alpaida trispinosa (Keyserling, 1892)	0	1	1
Alpaida sp1	0	4	4
Araneus guttatus (Keyserling, 1865)	0	1	1
Araneus horizonte Levi, 1991	0	1	1
Cyclosa tapetifaciens Hingston, 1932	0	1	1
Dubiepeira dubitata (Soares & Camargo, 1948)	0	1	1
Gasteracantha cancriformis (Linnaeus, 1758)	0	2	2
Kapogea alayoi (Archer, 1958)	0	1	1
Mecynogea lemniscata (Walckenaer, 1842)	0	6	6
Micrathena plana (C. L. Koch, 1836)	2	5	7
Micrathena spitzi Mello-Leitão, 1932	0	1	1
Parawixia velutina (Taczanowski, 1878)	0	1	1
Testudinaria sp1	0	3	3
Wagneriana neglecta (Mello-Leitão, 1939)	0	1	1
Corinnidae			
Attacobius luederwaldti (Mello-Leitão, 1923)	2	0	2
Castianeira sp1	12	0	12
Castianeira sp2	1	0	1
Castianeira sp3	1	0	1
Corinna capito (Lucas, 1856)	1	0	1
Falconina gracilis (Keyserling, 1891)	146	0	146
Ianduba varia (Keyserling, 1891)	6	0	6
Mazax sp1	3	0	3
Orthobula sp1	4	0	4
Corinnidae sp1	1	0	1
Ctenidae			
Isoctenus sp1	4	0	4
Oligoctenus ornatus (Keyserling, 1876)	1	0	1
Deinopidae			
Deinopis sp1	0	6	6
Dictynidae			
Dictyna sp1	0	21	21
Dictynidae sp1	0	45	45
Gnaphosidae			
Apopyllus iheringi (Mello-Leitão, 1943)	1	0	1
Apopyllus sp1	1	0	1
Hahniidae			
Hahniidae sp1	40	0	40
Hahniidae sp2	25	0	25
Idiopidae			
Idiops sp1	1	0	1
Linyphiidae			
Antronetes sp1	9	0	9
Erigone sp1	2	0	2
Erigone sp2	7	0	7
Exocora sp1	5	0	5
Meioneta sp1	129	0	129
Meioneta sp2	27	1	28
Meioneta sp3	0	1	1
Sphecozone rubescens O. P.-Cambridge, 1870	2	0	2
Erigoninae sp1	1	0	1
Lycosidae			
Hogna sp1	4	0	4
Lycosa erythrognatha Lucas, 1836	1	0	1
Molitorosa molitor (Bertkau, 1880)	1	0	1
Lycosidae sp1	2	0	2
Lycosidae sp2	4	0	4
Lycosinae sp3	6	0	6
Mimetidae			
Gelanor sp1	0	15	15
Miturgidae			
Cheiracanthium inclusum (Hentz, 1847)	0	1	1
Mysmenidae			
Mysmenidae sp1	0	2	2
Nemesiidae			
Acanthognatus sp1	5	0	5
Prorachias bristowei Mello-Leitão, 1924	3	0	3
Rachias sp1	5	0	5
Oonopidae			
Opopaea sp1	18	0	18
Opopaea sp2	0	1	1
Orchestina sp1	6	1	7
Orchestina sp2	1	22	23
Oonopidae sp1	3	0	3
Oonopidae sp2	0	1	1
Oxyopidae			
Peucetia flava Keyserling, 1877	3	5	8
Oxyopes bolivianus Tullgren, 1905	1	0	1
Oxyopes pugilator Mello-Leitão, 1929	0	14	14
Oxyopes salticus Hentz, 1845	11	2	13
Oxyopes stephanurus Mello-Leitão, 1929	1	3	4
Palpimanidae			
Fernandezina pelta Platnick, 1975	5	0	5
Philodromidae			
Berlandiella sp1	12	3	15
Berlandiella sp2	2	1	3
Berlandiella sp3	0	2	2
Pholcidae			
Mesabolivar difficilis (Mello-Leitão, 1918)	29	7	36
Mesabolivar sp1	4	6	10
Tupigea sp1	5	80	85
Salticidae			
Amphidraus sp1	3	0	3
Aphirape uncifera (Tullgren, 1905)	1	0	1
Atelurius sp1	0	4	4
Bryantella sp1	0	1	1
Chira sp1	1	27	28
Chira sp2	0	1	1
Chira sp3	0	1	1
Cotinusa vittata Simon, 1900	0	28	28
Cotinusa sp1	0	1	1
Cylistella sp1	0	14	14
Descanso sp1	0	2	2
Descanso sp2	0	1	1
Frigga sp1	0	3	3

Species by family	P	B	Total
Gastromicans sp1	0	5	5
Gypogyna forceps Simon, 1900	0	1	1
Helvetia sp1	0	1	1
Hyetussa sp1	0	1	1
Lyssomanes bitaeniatus Peckham & Wheeler, 1889	0	40	40
Lyssomanes sp1	0	1	1
Maeota dichrura Simon, 1901	1	15	16
Myrmarachne sp1	1	1	2
Neonella sp1	5	0	5
Noegus sp1	1	25	26
Nycerella aprica (Peckham & Peckham, 1896)	0	1	1
Phiale gratiosa C.L. Koch, 1846	0	4	4
Phiale sp1	1	0	1
Phiale tristis Mello-Leitão, 1945	1	2	3
Saitidops sp1	0	5	5
Semiopyla sp1	2	0	2
Semiopyla sp2	3	0	3
Simprulla sp1	0	1	1
Sitticus sp1	5	0	5
Sitticus sp2	8	0	8
Tariona sp1	0	2	2
Thiodina germaini Simon, 1900	0	4	4
Thiodina vaccula Simon, 1900	0	3	3
Tullgrenella sp1	2	0	2
Tullgrenella yungae Galiano, 1970	1	0	1
Uspachus sp1	1	2	3
Vinnius subfasciatus (C. L. Koch, 1846)	2	1	3
Yepoella crassistylis Galiano, 1970	0	4	4
Dendriphantinae sp1	0	9	9
Dendriphantinae sp2	0	1	1
Dendriphantinae sp3	0	1	1
Freinae sp1	0	1	1
Sitticinae sp1	1	0	1
Salticidae sp1	1	33	34
Salticidae sp2	45	0	45
Salticidae sp3	7	0	7
Salticidae sp4	9	0	9
Salticidae sp5	46	0	46
Salticidae sp6	0	3	3
Scytodidae			
Scytodes itapevi Brescovit & Rheims, 2000	7	66	73
Scytodes sp1	0	20	20
Tetragnathidae			
Chrysometa guttata (Keyserling, 1881)	0	2	2
Nephila clavipes (Linnaeus, 1767)	0	11	11
Leucauge sp1	0	1	1
Leucauge sp2	0	1	1
Tetragnatha sp1	0	1	1
Theraphosidae			
Vitalius sp1	1	0	1
Theridiidae			
Achaearanea hirta (Taczanowski, 1873)	0	77	77
Achaearanea jequirituba Levi, 1963	0	1	1
Achaearanea nigrovittata (Keyserling, 1884)	0	1	1
Achaearanea sp1	0	2	2
Achaearanea sp2	1	0	1
Achaearanea sp3	0	1	1
Achaearanea sp4	1	0	1
Achaearanea trapezoidalis (Taczanowski, 1873)	0	11	11
Anelosimus ethicus (Keyserling, 1884)	0	1	1
Anelosimus rupununi Levi, 1956	0	28	28
Anelosimus studiosus (Hentz, 1850)	0	7	7
Argyrodes acuminatus Keyserling, 1891	0	3	3
Argyrodes alticeps Keyserling, 1891	0	3	3
Argyrodes elevatus Taczanowski, 1873	0	1	1

Species by family	P	B	Total
Chrysso pulcherrima (Mello-Leitão, 1917)	0	11	11
Coleosoma floridanum Banks, 1900	0	1	1
Coleosoma sp1	46	13	59
Coleosoma sp2	0	1	1
Craspedisia cornuta (Keyserling, 1891)	0	2	2
Dipoena alta Keyserling, 1886	0	1	1
Dipoena atlantica Chickering, 1943	0	5	5
Dipoena bryantae Chickering, 1943	0	6	6
Dipoena granulata (Keyserling, 1886)	27	0	27
Dipoena pusilla (Keyserling, 1886)	0	1	1
Dipoena sp1	0	76	76
Dipoena sp2	2	0	2
Dipoena sp3	0	10	10
Dipoena sp4	1	0	1
Dipoena sp5	0	6	6
Dipoena sp6	0	1	1
Emertonella taczanowskii (Keyserling, 1886)	0	23	23
Episinus cognatus O. P.-Cambridge, 1893	0	2	2
Episinus nebulosus (Simon, 1895)	0	28	28
Euryopis sp1	25	0	25
Euryopis sp2	4	0	4
Guaraniella bracata Baert, 1984	2	0	2
Latrodectus geometricus C. L. Koch, 1841	0	1	1
Steatoda ancorata (Holmberg, 1876)	8	0	8
Stemmops carius Marques & Buckup, 1996	1	0	1
Theridion fungosum Keyserling, 1886	0	24	24
Theridion oswaldocruzi Levi, 1963	0	6	6
Theridion pernambucum Levi, 1963	1	0	1
Theridion positivum Chamberlin, 1924	0	10	10
Theridion sp1	0	1	1
Theridion sp2	0	1	1
Theridula nigerrima (Petrunkevitch, 1911)	0	1	1
Thwaitesia affinis O. P.-Cambridge, 1882	0	33	33
Tidarren haemorrhoidale (Bertkau, 1880)	0	3	3
Wirada sp1	1	0	1
Theridiidae sp1	0	1	1
Thomisidae			
Aphantochilus rogersi O. P.-Cambridge, 1870	0	4	4
Bucranium taurifrons O. P.-Cambridge, 1881	0	1	1
Deltoclita sp1	0	1	1
Epicadinus sp1	0	3	3
Misumenops pallens (Keyserling, 1880)	0	1	1
Misumenops pallidus (Keyserling, 1880)	0	1	1
Misumenops sp1	0	3	3
Misumenops sp2	0	3	3
Misumenops sp3	0	5	5
Misumenops sp4	0	3	3
Onoculus echinicaudus Mello-Leitão, 1929	0	6	6
Onoculus garruchus Lise, 1979	0	10	10
Runcinioides sp1	0	3	3
Titidius galbanatus (Keyserling, 1880)	1	0	1
Tmarus sp1	1	1	2
Tmarus sp2	0	4	4
Tmarus sp3	0	5	5
Tmarus sp4	0	2	2
Tmarus sp5	0	7	7
Tmarus sp6	0	2	2
Tmarus sp7	0	3	3
Tmarus sp8	0	1	1
Thomisidae sp1	0	2	2
Titanoecidae			
Goeldia sp1	16	0	16
Zodariidae			
Tenedos sp1	239	0	239
Total	**1124**	**1186**	**2310**