Distribution of leaf litter spider (Araneae) in treefall gaps and on adjacent forest in an atlantic rainforest remnant in Bahia State, Brazil

Distribuição de aranhas cursoriais (Araneae) em clareiras naturais e floresta adjacente num remanescente de Floresta Atlântica da Bahia, Brasil

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ABSTRACT
We compared the species distribution of leaf litter spider between adjacent forests and treefall gaps in an Atlantic Forest urban remnant in the Brazilian State of Bahia. The spiders were extracted from the leaf litter using a Berlese funnel from January to December, 2004. Each site was evaluated throughout the sampling period by measuring or estimating the microhabitat and microclimate variables of the treefall gaps and adjacent forest. The variables measured obtained a statistical difference (T= -2.4742605; P= 0.020855). A total of 550 spiders were collected, distributed among 15 families. A hundred and twenty one adult specimens were collected, 60 being in adjacent forest and 61 in treefall gaps. According to analysis, significant differences cannot be observed among sites with regard to abundance and number of spider species. However, there was a large number of exclusive species in both environments, 31.67% of all the species collected in adjacent forest and 26.53% of all species collected in treefall gaps, suggesting that the gaps created environmental differentiated structures that increase the diversity of spiders in Neotropical forest.
Key words: *natural disturbance, Metropolitan Park of Pituaçu, habitat selection.*

RESUMO
Comparou-se a distribuição das espécies de aranhas que habitam a serrapilheira entre clareira natural e floresta adjacente em um remanescente de Mata Atlântica urbano no Estado da Bahia (Brasil). As aranhas foram extraídas da serrapilheira, utilizando-se o funil de Berlese, de janeiro a dezembro de 2004. Concomitantemente, durante todo o período de amostragem, todos os pontos de coleta foram avaliados, mensalmente, por mensuração ou estimativa das variáveis de micro-hábitat e microclima das clareiras naturais e trechos de florestas adjacentes. Houve diferença significativa das variáveis de micro-hábitat e microclima entre os pontos de clareira e floresta adjacente (T = -2,4742605, p = 0,020855). Foram coletadas 550 aranhas, distribuídas em 15 famílias, sendo 121 indivíduos adultos, 60 na floresta adjacente e 61 em clareiras. Não foram encontradas diferenças significativas em relação à abundância e, à riqueza em espécies de aranhas. Entretanto, houve um grande número de espécies exclusivas em ambos os ambientes, 31,67% espécies exclusivas coletadas na floresta adjacente e 26,53%, nas clareiras naturais, sugerindo que clareiras naturais promovem estruturas ambientais diferenciadas que aumentam a diversidade de aranhas em florestais neotropicais.
Palavras-chave: *distúrbios naturais, Parque Metropolitano de Pituaçu, seleção de habitat.*

I. Introduction

The most common form of disturbance in forest environments is the formation of treefall gaps (Green 1996; Richard 1996). These treefall gaps cause a shifting mosaic of habitat patches, which form a continuum from "mature phase" sites with intact canopy to "gap phase" sites with little or no canopy (Brokaw 1985). Because the physical environment differs dramatically between gaps and the adjacent forest (Chazdon & Fetcher 1984), many types of organisms may distinguish between these two habitats (Stiles 1975; Thompson 1980). However, studies comparing species assemblages found in treefall gaps with those of adjacent forest sites have focused on trees (Vandermeer *et al.* 1974; Denslow 1980), bamboo species (Tabarelli & Mantovani 2000), birds (Blake & Hoppes 1986; Wunderle *et al.* 1987; Levey 1988) and only one paper relating to spiders (Peres *et al.* 2007). In all of these groups of organisms, important differences were observed between species assemblages inhabiting treefall gaps and adjacent forest, indicating that treefall gaps may be more important in structuring tropical assemblages than is generally appreciated (Gilbert 1980; Levey 1988).

Spiders are one of the most diverse groups among animals. In the total, 40.719 species have been described and grouped in 3,802 genera and 109 families (Platnick 2010). Spiders are generalist predators in terrestrial ecosystems (Riechert & Bishop 1990; Breene *et al.* 1993; Wise 1993) that feed mostly on insects (Riechert & Bishop 1990; Wise 1993; Foelix 1996). Spider distribution and population density vary in response to several environmental factors, such as temperature, air relative humidity, wind, and light (Dondale & Binns 1977; Rypstra 1986; Foelix 1996). However, it has been argued that other environmental factors, such as vegetation structure, food availability, competitors and enemies influence spider assemblages more than climatic factors (Uetz 1991; Gibson *et al.* 1992; Wise 1993; Foelix 1996). Because of their high species diversity as well as their sensitivity to several environmental factors, spiders are an appropriate taxonomic group to use in assessing if the environmental differences between adjacent forests and treefall gaps may influence the structure and composition of assemblages of tropical forest invertebrates. This paper quantifies distribution of leaf litter spider species in treefall gaps and adjacent forest in an Atlantic Forest urban remnant in the Brazilian state of Bahia.

II. Methods

Study area. - The study was conducted year round in 2004 in the Parque Metropolitano de Pituaçu (12° 56'S, 38° 24'W), a reserve with 425 ha of secondary stage Atlantic Forest, surrounded by a predominantly urban matrix within the city of Salvador, Brasil (Benati *et al.* 2005). Rainfall averages 1840 mm annually (Batista 1998) with dominant vegetation being tropical evergreen forest that predominates the Brazilian Atlantic coast.

Sampling - We used the 12 sites (7 X 3 m each, totalizing 252 m^2) to sample spider (six in treefall gaps and six in adjacent forest). The sites were selected based on Tabarelli & Mantovani (1999) and Armelin & Mantovani (2001). Each leaf litter site sampling (50 x 50 cm) was used to collected spiders, totaling 3 m^2 (12 plots) monthly and 36 m^2 during the year. The spiders were extracted from the leaf litter using a Berlese funnel. Each site was evaluated throughout the sampling period by measuring or estimating the microhabitat and microclimate variables of the treefall gaps and adjacent forest. The variables were sampled in same sites where the spiders were collected. The thermal variation during a 24 hour period, leaf litter depth, frequency, and decomposition degree (initial, intermediate and advanced) of the fallen trunk diameter at breast height (DBH) ≥ 10 cm were quantified with many ordinals. The leaf litter and herbaceous coverage was measured using the adapted Fournier Intensity Percent (Fournier 1974).

Only adult specimens were identified to genera, species, or morphospecies level. The specimens were deposited in Instituto Butantan of São Paulo (IBSP, curator: I. Knysak). The collected (authorized by IBAMA 02006.002568/02-21 Case of 17/07/2002)

Statistical. - We used the Mann Whitney test to compare spider abundance and richness collected in adjacent forest and treefall gaps between these two habitat types. We used Graphpad Instat 2.0 software. To compare microhabitat and microclimate variables between adjacent forest and treefall gaps, Multi-Response Permutation Procedures (Euclidean distance) were used by PC-Ord 4.25 software (McCune & Mefford 1999).

III. Results and Discussion

The variables measured showed differences between adjacent forest areas and treefall gaps (T= -2.4742605; p= 0.020855; Table 1), corroborating with the hypothesis that the treefall gaps promote an environment different from the structure of forest adjacent environments (Chazdon & Fetcher 1984; Brokaw 1985; Richard 1996).

Table 1: Average values of the microhabitat and microclimate variables in treefall gaps and adjacent forest in the Parque Metropolitano de Pituaçu (Salvador – Bahia - Brazil).

Microhabitat and microclimate variables	Treefall gaps	Adjacent Forest
Thermal largeness (°C)	5.6	5.0
Deep leaf litter (cm)	4.5	5.3
Diameter at breast height (cm)	20.5	31.1
Coverage herbaceous (*)	2.5	3.6
Coverage leaf litter (*)	2.2	1.8
Frequency of fallen trunk (absolute frequency)	10.5	5.9

* Measured using the adapted Fournier Intensity Percent (Fournier 1974).

A total of 550 spiders were collected, distributed among 14 families. Among these, 121 were adult, 60 were collected in adjacent forests and 61 in tree fall gaps (Table 2). This difference is not significant (U'= 685.50, p= 0.6752). A total of 36 species was collected. More species were collected in adjacent forest than in treefall gaps, but this difference is not significant (26 versus 22, respectively; U'= 21.500, p= 0.5887). The three most common species in adjacent forest include Salticidae sp. 1 (Salticidae) with 13.33% of all specimens, *Coleosoma floridanus* Banks 1900 (Theridiidae) with 10% and *Tenedos* sp. (Zodariidae) with 8.33%. Altogether, they represent 31.6% of all specimens collected. The three most common species in treefall gaps are Salticidade sp. 1 (Salticidae) with 18.03% of all specimens, *Tanybelus aeneiceps* Simon 1902 (Salticidae) with 14.75%, and *Tenedos* sp. (Zodariidae) with 11.47%. Altogether, these species represent 44.25% of all collected specimens.

Table 2: Number of individuals by species collected by litter sifting in treefall gaps and adjacent forest in the Parque Metropolitano de Pituaçu (Salvador – Bahia - Brazil).

Family	Species	Treefall gaps n	Treefall gaps %	Adjacent forest n	Adjacent forest %	Total n	Total %
Anyphaenidae							
	Anyphaeninae sp.1	1	1.67	0	0.00	1	0.83
Araneidae							
	Alpaida negro (Levi 1988)	1	1.67	0	0.00	1	0.83
	Alpaida sp.1	0	0.00	1	1.64	1	0.83
	Araneus tijuca (Levi 1988)	1	1.67	0	0.00	1	0.83
	Eustala sp.1	0	0.00	1	1.64	1	0.83
	Mangora sp.1	0	0.00	1	1.64	1	0.83
Caponiidae							
	Nops sp.1	1	1.67	1	1.64	2	1.65
Clubionidae							
	Elaver sp.1	0	0.00	1	1.64	1	0.83
Coriniiidae							
	Castianeira sp.1	1	1.67	0	0.00	1	0.83
	Creugas sp.1	3	5.00	2	3.28	5	4.13
	Parachemmis sp.1	3	5.00	0	0.00	3	2.48
Ctenidae							
	Isoctenus sp.1	1	1.67	3	4.92	4	3.31
Gnaphosidae							
	Zimiromus sp.1	0	0.00	5	8.20	5	4.13
Oonopidae							
	Oonopidae sp.1	1	1.67	0	0.00	1	0.83
Palpimanidae							
	Otiothops atlanticus (Platnick,	2	3.33	0	0.00	2	1.65

	Grismado & Ramírez 1999)						
Pholcidae							
	Carapoia sp.1	3	5.00	2	3.28	5	4.13
Salticidae							
	Akela sp.1	0	0.00	1	1.64	1	0.83
	Breda sp.1	0	0.00	1	1.64	1	0.83
	Corythalia sp.1	0	0.00	2	3.28	2	1.65
	Euophryinae sp.1	1	1.67	0	0.00	1	0.83
	Freya sp.1	4	6.67	3	4.92	7	5.79
	Pachomius sp.1	1	1.67	0	0.00	1	0.83
	Tanybelus aeneiceps (Simon 1902)	5	8.33	9	14.75	14	11.57
	Salticidae sp.1	8	13.33	11	18.03	19	15.70
	Salticidae sp.2	4	6.67	0	0.00	4	3.31
	Scopocira sp.1	1	1.67	0	0.00	1	0.83
Scytodidae							
	Scytodes fusca (Walckenaer 1837)	2	3.33	1	1.64	3	2.48
Sparassidae							
	Thomasettia sp.1	1	1.67	0	0.00	1	0.83
Theridiidae							
	Chysso sp.1	0	0.00	1	1.64	1	0.83
	Coleosoma floridanus (Banks 1900)	6	10.00	2	3.28	8	6.61
	Dipoena granulata (Keyserling 1886)	1	1.67	1	1.64	2	1.65
	Episinus sp.1	1	1.67	2	3.28	3	2.48
	Steatoda diamantina (Levi 1963)	1	1.67	1	1.64	2	1.65
	Thymoites sp.1	0	0.00	2	3.28	2	1.65
	Wamba crispulum (Simon 1895)	1	1.67	0	0.00	1	0.83
Zodariidae							
	Tenedos sp.1	5	8.33	7	11.48	12	9.92
	Frequency	**60**	**100**	**61**	**100**	**121**	**100**
	Richness	**26**		**23**		**36**	**100**

The high frequency of Salticidae sp.1 may be related to the adaptability of this family, having the ability to migrate to more favorable environments (Turnbull 1966; Huhta 1971; Almqvist 1973; Coyle 1981). Therefore, with the corroborating proposal by Peres *et al.* (2007), we suggest that these spiders can leave treefall gaps and adjacent forests in search of more favorable environmental conditions. In environments such as adjacent forests, spiders may find a microclimate more stable due to greater structural complexity of leaf litter (Uetz 1975, 1976, 1979). In treefall gaps where there is a wider variety of substrates, such as fallen trunks, more common in this environment, these spiders can use these resources as refuge. Additionally, these trunks can promote greater availability of prey for these spiders (Coyle 1981). Since these spiders have good vision (Wise 1993), the highest luminosity in treefall gaps can facilitate the capture of those prey.

The frequency of rare species found in the adjacent forest and the treefall gaps (singletons 16.67% and 11.48%; doubletons 3.33% and 6.56% respectively) was relatively low when compared with other studies (see Coddington 1991; Silva 1996; Silva & Coddington 1996; Sørensen 2003; Peres *et al.* 2007). Moreover, Peres *et al.* (2007) argue that the high frequency of species in rare neotropical forest is related not only to the effects of sub-sampling, but also represents a natural phenomenon in these forests, as has been proposed and studied in other taxonomic groups such as birds and mammals (Wiens 1989; Brown 1995; Gaston & Blackburn 2000).

Therefore, although the spider assemblages of adjacent forests and treefall gaps did not differ significantly in both number of individuals and number of species collected, there was a high number of species specific to both environments; 13 species were exclusive to adjacent forests and 10 species to treefall gaps. Exclusive species represent about 31.67% of all the species collected in adjacent forest and 26.53% of all species collected in tree fall gaps. Therefore, considering the fact that the spiders respond to the changes in the structure of habitats (Uetz 1976, 1979; Wise 1993; Downie *et al.* 1999; Whitmore *et al.* 2002; Peres *et al.* 2007) and that many species exhibit specificity of habitats (Mallis & Hurd 2005), we conclude that the high occurrence of exclusives species in both environments suggests that the treefall gaps increase the diversity of spiders in neotropical forests. The same result was verified by Peres *et al.* (2007) in an area of forest in the northeastern Brazilian Atlantic. Thus we corroborate the findings proposed by several authors (Connell 1978; Denslow 1980; Souza 1984; Pickett & White 1986), that the treefall gaps promote an increase in the diversity of habitats, allowing more species to coexist, avoiding competition.

IV. Literature Cited

ALMQVIST, S. Habitat selection by spiders on coastal sand dunes in Scania, Sweden. *Entomologica Scandinavica*, v. 4, p.134–154, 1973.

ARMELIN, R.S.; MANTOVANI, W. Definições de clareira natural e suas implicações no estudo da dinâmica sucessional em floresta. *Rodriguésia,* v. 52, p.5-15, 2001.

BENATI, K.R. et al. Aspectos comparativos das comunidades de aranhas (Araneae) em dois remanescentes de Mata Atlântica do Estado da Bahia, Brasil. Biota Neotropica, v 5, n.1a. Disponível em: http://www.biotaneotropica.org.br/v5n1a/pt/abstract?article+BN005051a2005. ACESSO EM: 15, JULHO DE 2009.

BLAKE, J.B.; HOPPES, W.G. Resource abundance and microhabitat use by bird in an isolated east-Central Illinois woodlot. *Auk*, v. 103, p.328-340, 1986.

BREENE, R.G.; MEAGHER, R.L.; DEAN, D.A. Spiders (Araneae) and ants (Hymenoptera: Formicidae) in Texas sugarcane fields. *Florida Entomologica* , v.76, p.645-650, 1993.

BROKAW, N.V.L. Gap-phase regeneration in a tropical forest. *Ecology*, v. 66, p.682-687, 1985.

BROWN J.H. *Macroecology*. Chicago: Chicago University Press, 1995.

CHAZDON, R.L.; FETCHER, N. Photosynthetic light environments in a lowland tropical rainforest in Costa Rica. *Journal of Ecology*, v. 72, p.553–564, 1984.

CODDINGTON, J.A. et al. Designing and testing sampling protocols to estimate biodiversity in tropical ecosystems. In: INTERNATIONAL CONGRESS OF SYSTEMATIC AND EVOLUTIONARY BIOLOGY, 4, 1991, Portland. *The Unity Evolutionary Biology* .Portland: Dioscorides Press, 1991. p. 44-60.

CONNELL, J. H. Diversity in tropical rain forest and coral reefs. *Science*, v. 199, p.1302-1310, 1978

COYLE, F.A. Effects of clear-cutting on the spiders community of a Southern Appalachian forest. *Journal of Arachnology*, v. 9, p.285–298, 1981.

DENSLOW, J.S. Gap partitioning among tropical rain forest trees. *Biotropica,* v. 12, p.47-55, 1980.

DONDALE, C.D.; BINNS, M.R. Effect of weather factors on spiders (Araneida) in an Ontario meadow. *Canadian Journal of Zoology*, v. 55, p.1336-1341, 1977.

DOWNIE, I. S. et al. The impact of different agricultural land-use on epigeal spider diversity in Scotland. *Journal of Insect Conservation*, v. 3, p.273-286, 1999.

FOELIX, R.F. *Biology of Spiders*. New York :Oxford University Press, 1996.

FOURNIER, L. A. Un método cuantitativo para la medición de características frenológicas en árboles. *Turrialba*, v. 24, p.422-423, 1974.

GASTON, K.J.; BLACKBURN, T. M. *Patterns and Process in Macroecology*. Oxford: Blackwell Science,2000.

GIBSON, C.W.D.; HAMBLER, C. ; BROWN, V.K. Changes in spider (Araneae) assemblages in relation to succession and grazing management. *Journal of Applied Ecology*, v. 29, p.132-142, 1992.

GILBERT, L.E. Food web organization and the Conservation of Neotropical diversity. In: SOULE, M.; WILCOX , B. *Conservation Biology*. Sunderland: Sinauer.1980. p. 11-33

GREEN, P.T. Canopy gaps in rain forest on Christmas Island, Indian Ocean: size distribution and methods of measurement. *Journal of Tropical Ecology*, v.12, p.427-434, 1996.

HUHTA V. Succession in the spider communities of the forest floor after clear-cutting and prescribed burning. *Annales Zoologici Fennici*, v. 8, p.483–542, 1971.

LEVEY, D.J. Tropical wet forest treefall gaps and distributions of understory birds and plants. *Ecology,* v. 69, p.1076-1089, 1988.

MALLIS, R. E.; HURD, L.E. Diversity among ground-dwelling spider assemblages: habitat generalists and specialists. *Journal of Arachnology*, v. 33, p.101–109, 2005.

MCCUNE, B.; MEFFORD, M. J. *Multivariate Analysis of Ecological Data*: Version 4.25, MjM Software. Gleneden Beach: Oregon, 1999.

PERES, M. C. L.; SILVA, J. M.C.; BRESCOVIT, A. D. The influence of treefall gaps on the distribution of web building and ground hunter spiders in an Atlantic Forest remnant, Northeastern Brazil. *Studies on Neotropical Fauna and Environment*, v. 42, p.49-60, 2007.

PLATNICK, N. I. *The World Spider Catalog, version 11.0*. American Museum of Natural History. Disponível em: < http://research.amnh.org/entomology/spiders/catalog/index.html.>
Access: 17 de junho de. 2010.

PICKETT, S. T.; WHITE, P. S. *The Ecology of Natural Disturbances and Patch Dynamics*. New York: Academic Press, 1986.

RICHARD, P.W. *The tropical rain forest: an ecological study*. London: Cambridge University Press, 1996.

RIECHERT, S.E; BISHOP, L. Prey control by an assemblage of generalist predators: spiders in a garden test system. *Ecology*, v.71, p.1441-1450, 1990.

RYPSTRA, A.L. Web spiders in temperate and tropical forests: relative abundance and environmental correlates. *American Midland Naturalist*, v.115, p.42-51, 1986.

SILVA, D.; CODDINGTON, J.A.. Spiders of Pakitza (Madre de Dios, Perú): Species richness and notes on community structure. In: WILSON, D.E.; SANDOVAL, A. *Manual the Biodiversity of Southeastern Peru*. Washington: Smithsonian Institution, 1996. p. 253-311

SILVA D. Species composition and community structure of Peruvian rainforest spiders: a case study from a seasonally inundated forest along the Samiria river. *Revue Suisse de Zoologie*, v. 1, p.597– 610, 1996.

SOUZA, W. P. The role disturbance in natural communities. *Annual Review of Ecology and Systematic.*, v. 15, p.353-391,1984.

SØRENSEN, L.L. Stratification of spider fauna in a Tanzanian forest. Pp. 92-101. In: BASSET, Y. et al. *Arthropods of Tropical Forest: Spatiotemporal Dynamics and Resource Use in the Canopy*. Cambridge: Cambridge University Press,2003.

STILES, F.G. Ecology, flowering phonology, and hummingbird pollination of some Costa Rica Heliconia species. *Ecology,* v.56, p.285-301, 1975

TABARELLI, M.; MANTOVANI; W.. Clareiras naturais e a riqueza de espécies pioneiras em Floresta Atlântica Montana. *Revista Brasileira de Biologia*, v.59, p.251-261, 1999.

____________. Gap-phase regeneration in a tropical montane forest: the effects of gap structure and bamboo species. *Plant Ecology,* v.148, p.149-155, 2000.

THOMPSON, J.N. Treefalls and colonization patterns of temperate forest herbs. *American Midland Naturalist*, v.104, p.176-184, 1980.

TURNBULL, A. L. A population of spider and their potential prey in an overgrazed pasture in eastern Ontario. *Canadian Journal of Zoology*, v.44, p. 557–583, 1966.

UETZ, G.W. Gradient analysis of spiders communities in a Streamside forest. *Oecologia*, v. 22, p.373-385, 1976.

____________ . The influence of variation in litter habitats on spider communities. *Oecologia,* v. 40, p.29-42, 1979.

UETZ, G.W. Habitat structure and spider foraging. In: BELL, S.A.; MCCOY, E.D.; MUSHINSKY, H.R. *Habitat Structure*: The Physical Arrangement of Objects in Space. London : Chapman & Hall Press,1991. p. 325-348

VANDERMEER, J.H.; STOUT, J.; MILLER, G. Growth rates of Welfia georgii, Socratea durissima, and Iriartea gigantea under various conditions in a natural rainforest in Costa Rica. PRINCIPES , v.18, p.148-154, 1974.

WHITMORE, C. et al. Diversity of spiders (Araneae) in a Savanna Reserve, Northern province, South Africa. *Journal of Arachnology*, v.30, p.344-356, 2002.

WIENS, J.A. *The Ecology of Bird Communities*: Foundations and Patterns. London: Cambridge University Press, 1989.

WISE, D.H. *Spiders in Ecological Webs*. Londres: Cambridge University Press, 1993.

WUNDERLE, J.M. et al. A.Forest openings and the distribution of understory birds in a Puerto Rican rainforest. *Wilson Bulletin***,** v. 99, p.22-37, 1987.