



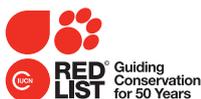
ISSN 0974-7907 (Online)
ISSN 0974-7893 (Print)

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 August 2015 | 7(10): 7612–7624

COMMUNITY STRUCTURE AND COMPOSITION OF LITTER SPIDERS (ARACHNIDA: ARANEAE) AND INFLUENCE OF MACRO-CLIMATIC FACTORS ON PARQUE ECOLÓGICO JATOBÁ CENTENÁRIO, MORRINHOS, Goiás, BRAZIL

OPEN ACCESS

Renan Castro Santana



Queensland Museum, Grey St, PO Box 3300, South Brisbane, 4101, Q. Australia
University of Queensland, Venom Evolution Lab, Gehrmann Building, Level 8, room 809, St Lucia, 4072, Q. Australia
renan.santana@qm.qld.gov.au

Abstract: Spiders are a diverse group and are considered to be good bioindicators due to their sensitivity to variation in biotic and abiotic factors. Despite this the taxonomy of the Araneae is poorly known, particularly in the tropical and subtropical regions. The use of spider guilds can improve our understanding of the dynamics of spider communities, and in this paper we analyse the influence of climatic factors on guilds and species dominance of spiders within the leaf litter layer of a semi-deciduous forest in the tropical savanna Cerrado, Brazil. The study site was Parque Ecológico Jatobá Centenário, a fragment of 90ha, in Morrinhos, Goiás, Brazil. Spiders were sampled from November 2006 to August 2007 using pitfall traps that remained open for seven days on each of four occasions. Overall 4139 spiders from 35 families and 118 species were collected. The main families were Salticidae (28%), Linyphiidae (27%), Lycosidae (12%) and Theridiidae (11%). In terms of richness the main families were: Theridiidae, Salticidae, Corinnidae and Araneidae, with 18, 16, 15 and 13 species respectively. The overall Shannon-Wiener (H') diversity was 3.6. The rainy season showed higher values than the dry season for abundance (2,868 and 1,271 respectively), richness (100 and 71) and diversity (3,296 and 3,237). The families Theridiidae, Corinnidae and Salticidae presented more species in both dry and wet seasons. Observed climatic variation (rainfall, humidity and temperature) between seasons influenced the community structure of ground-dwelling spiders.

Keywords: Abiotic factors, araneofauna, seasonality, soil.

DOI: <http://dx.doi.org/10.11609/JoTT.o4030.7612-24> | **ZooBank:** urn:lsid:zoobank.org:pub:AE933517-F535-43BA-845C-5549D165AF42

Editor: Manju Siliwal, WILD, Coimbatore, India.

Date of publication: 26 August 2015 (online & print)

Manuscript details: Ms # o4030 | Received 15 May 2014 | Final received 30 June 2015 | Finally accepted 21 July 2015

Citation: Santana, R.C. (2015). Community structure and composition of litter spiders (Arachnida: Araneae) and influence of macro-climatic factors on Parque Ecológico Jatobá Centenário, Morrinhos, Goiás, Brazil. *Journal of Threatened Taxa* 7(10): 7612–7624; <http://dx.doi.org/10.11609/JoTT.o4030.7612-24>

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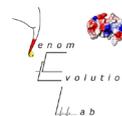
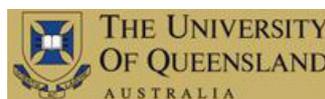
Funding: None.

Competing interests: The author declares no competing interests.

Author Details: Studied ecology of spider during graduation and masters degree in Brazil. Moving to Australia, start work on taxonomy of tarantulas at Queensland Museum. Nowadays, as a PhD student researching tarantulas venom and systematics at Venom Evolution Lab at University of Queensland.

For Portuguese abstract see end of this article

Acknowledgements: I am grateful to my graduation supervisor, Professor Marcos Antonio Pesquero, Universidade Estadual de Goiás, and my colleagues, Adagmar Vaz Ferreira and Digggenes de Souza Oliveira, for help in the collection and sorting of the samples. Professor Kleber Del Claro, Universidade Federal de Uberlândia, also provided valued comments on the project design and report. Dr Antonio Brescovit, Instituto Butantan, is very gratefully acknowledged for identifying over 100 morphospecies sample to family, genus and species levels, where possible. I am also most grateful to Drs. Tracey Churchill and Robert Raven, Queensland Museum, for reading the manuscript and providing valued criticisms of content.



INTRODUCTION

Spiders, Order Araneae, are a group of megadiverse arthropods with 3,960 genera and 45,674 species currently described worldwide (Platnick 2015). As in most invertebrate groups the taxonomy of the Araneae is poorly known, mainly due to the limited number of specialists (Lewinsohn & Prado 2002). Coddington & Levi (1991) estimate that the true diversity of spiders is over 100,000 species, with most occurring in the tropical and subtropical regions. Studies on spiders are of ecological interest because they are abundant generalist predators in terrestrial ecosystems, effecting population control of other arthropods, notably of phytophagous insects (Roth 1993). Sensitive to environmental heterogeneity (Hatley & MacMahon 1980; Gunnarsson 1990; Baur et al. 1996; Raizer 2004), spider communities are utilised as bio-indicators in studies assessing the condition of terrestrial biomes (Baert et al. 1991).

Patterns of species richness in spiders can vary spatially and temporally (Uetz 1977). Temporal changes in the composition of spider communities can be influenced by changes in soil moisture, temperature, rainfall, flooding regime, prey availability, competitors and predators (Uetz 1977; Schaefer 1987; Battirolo et al. 2004). The spatial stratification (horizontal or vertical) of spider fauna is strongly influenced by the physical structure of the environment (Uetz 1991; Raizer & Amaral 2001).

The Cerrado (Brazilian Savannah) is one of 25 global hotspots for biota with high conservation priority

(Myers et al. 2000). The richness of this biome can represent up to 33% of the Brazilian biota (Aguiar et al. 2004). Strategies for the conservation and sustainable use of remnant vegetation are urgently required due to the rapid rate of destruction of these tropical forests and the associated species extinctions (Espírito-Santo et al. 2002).

This study aimed to characterize the spider community of the leaf litter in a semi-deciduous tropical forest remnant inside the Brazilian Cerrado, and identify the correlated climatic factors.

MATERIAL AND METHODS

Study Area

The study was undertaken at the Parque Ecológico Jatobá Centenário, hereafter referred to as PEJC (Fig. 1). With an area of 90ha, PEJC is located north of the city of Morrinhos in the microregion of the Meia-Ponte basin, which lies in the southern part of the state of Goiás, Brazil (17°43'36"S & 49°07'55"W), at an altitude of 790m. The study area lies within the Plateau Demoted of Goiânia that includes convex landforms dominated by tabular quartzite and the mica group Araxá, and situated between 600 and 850 metres elevation (Nascimento 1992).

The climate is defined as AW according to the classification of Köppen (Lohmann et al. 1993), characterized by two well defined seasons, one dry and



Figure 1. Satellite image - Ecological Park Centennial Jatoba (PEJC) Morrinhos-GO, Brazil showing quadrant pattern. Source: Google Earth 5.0.

cold and the other hot and rainy.

Originally, various categories of vegetation called "cerrado" sensu lato covered the entire region (Eiten 1993). The PEJC aims to preserve the native vegetation as well as the spring and the Açude stream. The vegetation is a semi-deciduous stationary forest (Veloso et al. 1991) and is represented by trees up to 25m high. In the southern region of the park, several water holes join forming the Açude stream, where characteristics of the soil support ferns, palms and trees with tabular and air roots.

Collection procedure

Pitfall traps were used for the collection of spiders in the leaf litter in PEJC. This method is widely employed in the study of dwelling active arthropods (Barreiros et al. 2003; Candiani et al. 2005; Rocha-Dias et al. 2005; Lopes et al. 2006; Brito et al. 2007; Oliveira et al. 2007; Podgaiski et al. 2007).

Sampling was restricted in 12 quadrats, number of traps and distance between the trap is as follows (Figs. 1, 2):

Three quadrats 8x8m (64m²) with the following characteristics:

81 traps equidistant, 1m between each trap (grid 1x1m)

25 traps equidistant, 2m between each trap (grid 2x2m)

9 traps equidistant, 4m between each trap (grid 4x4m)

Three quadrats of 12x12m (144m²) with the following characteristics:

169 traps equidistant, 1m between each trap (grid 1x1m)

49 traps equidistant, 2m between each trap (grid 2x2m)

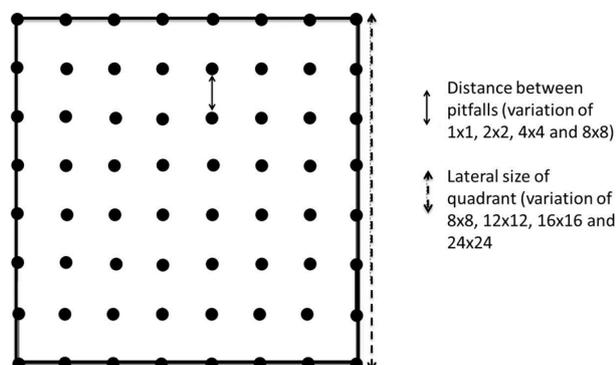


Figure 2. Layout of quadrats.

16 traps equidistant, 4m between each trap (grid 4x4m)

Three quadrats of 16x16m (256m²) with the following characteristics:

81 traps equidistant, 2m between each trap (grid 2x2m)

25 traps equidistant, 4m between each trap (grid 4x4m)

9 traps equidistant, 8m between each trap (grid 8x8m)

Three quadrats of 24x24m (576m²) with the following characteristics:

169 traps equidistant, 2m between each trap (grid 2x2m)

49 traps equidistant, 4m between each trap (grid 4x4m)

16 traps equidistant, 8m between each trap (grid 8x8m)

The use of different size quadrants and different distance between pitfall into the quadrants provide a most diverse sampling, collecting spiders with different foraging strategies.

Pitfall traps were made of plastic cups (500ml, 13cm tall and 8.5cm in diameter) buried with the lip close to the soil surface and containing 200ml of preservative solution (4% formalin with 4 drops of detergent liquid). The study was conducted from November 2006 to August 2007: with two collections during the rainy season and two during the dry season. The pitfall traps were left open for seven days on each occasion.

Identification of spiders collected

Spiders were collected and preserved in 70% ethanol and then transported to the Laboratory of Ecology, State University of Goiás, for identification to family and morphospecies level using the identification keys of Pikelin & Schiapelli (1963) and Brescovit et al. (2002). Upon completion of this study, the specimens were deposited in the collection of the Laboratory of Arthropods of the Butantan Institute in São Paulo, SP, Brazil.

Climate Data

The abiotic data relating to mean temperature, mean rainfall and relative humidity were obtained from the Meteorological station of the Department of Geography, State University of Goiás - Unit University of Morrinhos, GO, Brazil.

Data Analysis

The Shannon-Wiener (H') diversity was calculated for the entire sample and for each season was sampled (wet and dry) by using the PAST version 1.36 (Hammer et al. 2001).

The normality analysis of data on “abiotic” variables (relative humidity, mean temperature and average monthly rainfall) and “biotic” spider variables (species richness, abundance and diversity) was performed using the Lilliefors test.

The difference between the relative humidity, mean temperature, mean rainfall, abundance, richness, adults and juveniles in the dry and rainy seasons and the difference between male and female of each family were analyzed using the Mann-Whitney U test, because of the non-parametric distribution of the sampled data. All data were processed using the programs BioEstat 5.0 (Ayres et al. 2007) and Microsoft® Office Excel 2007

Species accumulation curve was estimated using EstimateS 9.1.0 (Colwell 2013).

To analyze the interference of climatic factors on community structure permutation MANOVA on R package Vegan 2.3-0 (Oksanen et al. 2015) was used.

RESULTS

Diversity of spider fauna

A total of 4,139 spiders were captured belonging to 118 morphospecies and 35 families (Table 1). Adults represented 52% of all spiders: 1,275 males and 877 females. All families sampled had mature individuals. Only adults were subjected to data analysis, as the reliable identification of spiders to family level relies on mature reproductive structures. The species

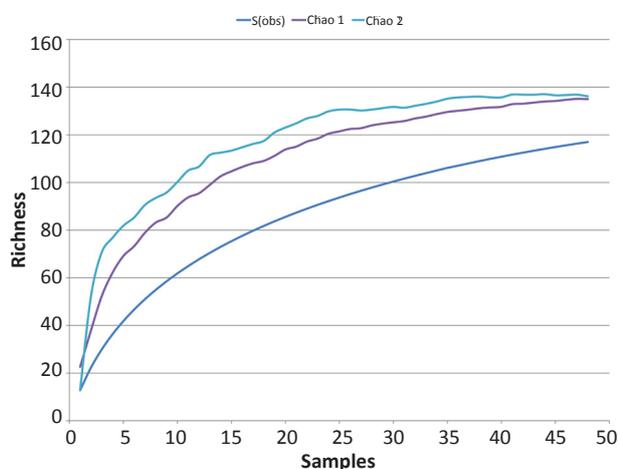


Figure 3. Species accumulation curve for one year of sampling at PEJC.

accumulation curve reached 135 and 137 species with Chao1 and Chao2 respectively (Fig. 3).

The families Theridiidae, Salticidae, Corinnidae and Araneidae had the highest levels of richness (18, 16, 15 and 13 species, respectively). And these accounted for 51% of total richness (Fig. 4). Families that represented the highest levels of abundance were the Salticidae (1145 individuals), the Linyphiidae (522), the Lycosidae (491) and the Theridiidae (460), which together accounted for 63% of all spiders and 58% of adults collected (Fig. 5).

Among the families with highest numbers of adults, only Lycosidae had more females than males (152 females and 138 males), while Linyphiidae, Theridiidae, Ochyroceratidae, Hahniidae and Salticidae had more males than females (294, 193, 114, 91 and 73 males and 184, 155, 68, 53, and 54 females, respectively) (Fig. 6).

Of the 118 morphospecies sampled only six were assignable to known species, 68 to known genera and 44 to families. The most abundant morphospecies were Linyphiidae sp.4 with 358 individuals; *Ochyrocera* sp. (*Ochyroceratidae*) with 182; Lycosidae sp.2 with 176; Hahniidae sp. with 144.

The Shannon-Wiener diversity index H' was 3.519.

Seasonality of the spider fauna

In the rainy season (April to September) a total of 2,868 spiders were captured, including 1,419 adults and 100 morphospecies. The number of adult males and females was even (50%), whereas in the dry season 1271 spiders were sampled, with 733 adults grouped into 71 morphospecies. About 58% of all spiders collected were adults representing 77% male and 23% female only (Fig. 7).

The Theridiidae was the most species rich family followed by Salticidae and then Corinnidae in both wet season (16, 14 and 13 morphospecies, respectively) and dry season (12, 12 and 08 morphospecies, respectively). Araneidae was the fourth richest in the rainy season with 12 morphospecies, while in the dry season the fourth was Lycosidae with four morphospecies (Fig. 8).

The families that represented the greatest numbers of spiders collected in the rainy season were the Salticidae, with 987 individuals; Lycosidae, with 309; Linyphiidae with 276 and Theridiidae with 242 (Fig. 9). These families represented 63% of total spiders collected during this period, and 54% of adults collected. Members of the family Mysmenidae were not encountered during this season. The Deinopidae, Titanoecidae and Zodariidae were represented by two specimens each, while only one individual of the Oxyopidae and Uloboridae were

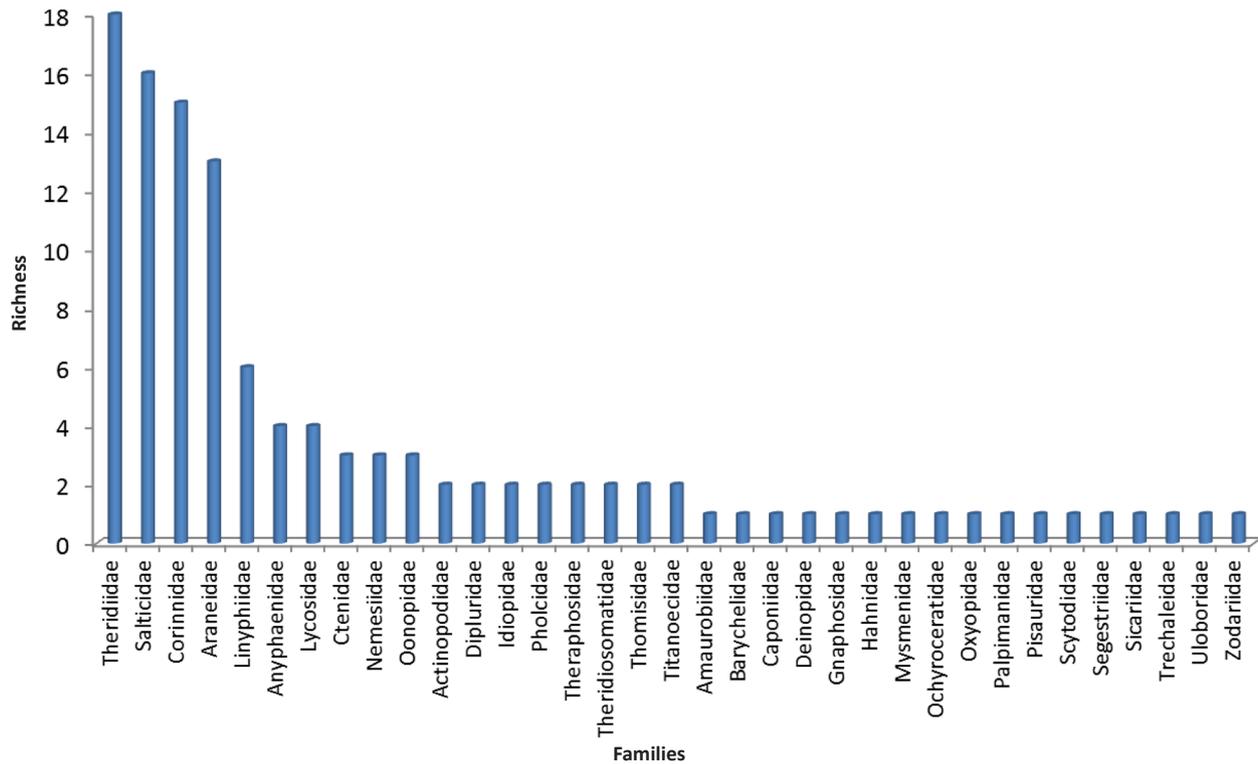


Figure 4. Total richness of spider families sampled by pitfall traps between November 2006 and August 2007 in PEJC.

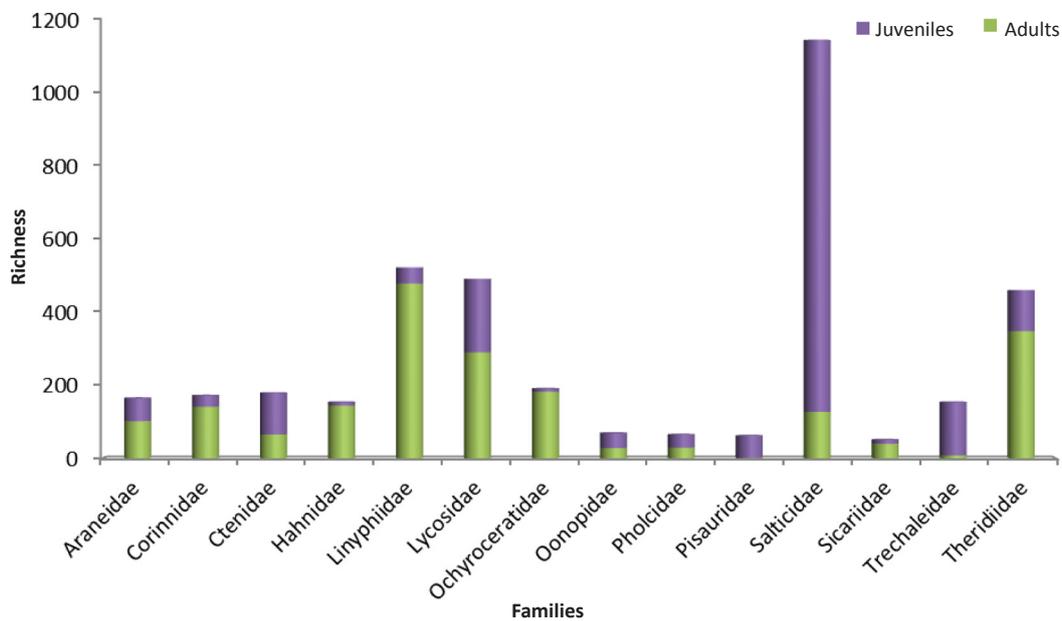


Figure 5. Abundance of adult and juvenile spiders from 14 families sampled that have more than 50 individuals collected on soil of Ecological Park Centennial Jatoba between November 2006 and August 2007.

collected in the rainy season. The most common families collected in the dry season were Linyphiidae with 246 individuals; Theridiidae with 218; Lycosidae with 182 and Salticidae with 158 representing 63% of all samples

and 65% of adults. Barychelidae, Deinopidae and Palpimanidae each were represented by two individuals while Idiopidae, Segestriidae and Uloboridae were represented only by one individual. Actinopodidae,

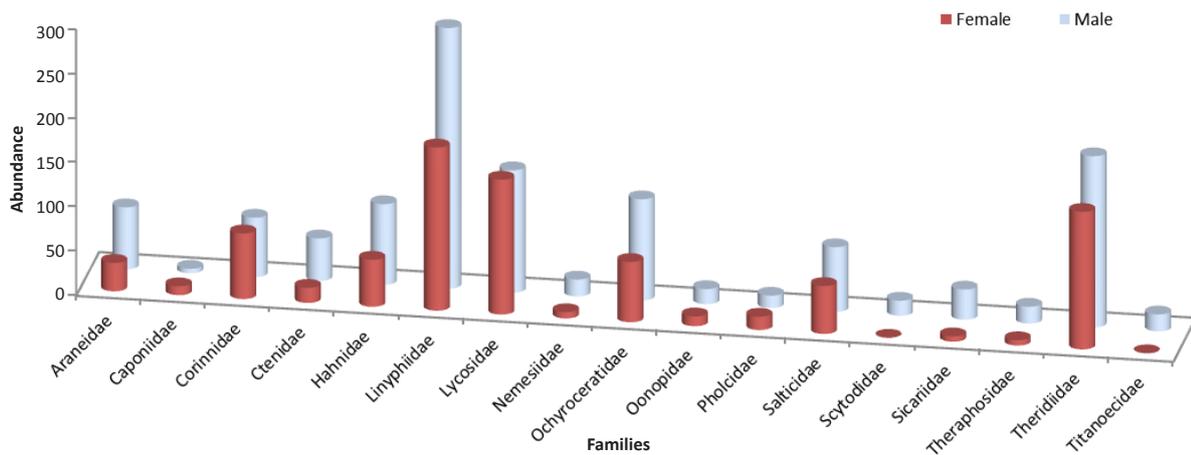


Figure 6. Spider abundance of males and females from 17 families with the highest number of adults collected in the Ecological Park Centennial Jatoba. (U=102; P=0.07)

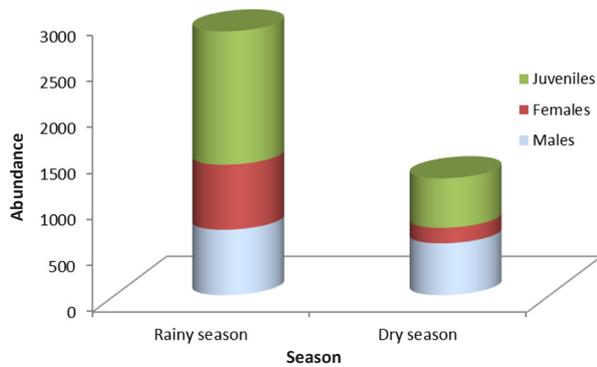


Figure 7. Seasonal difference between adult spiders (males and females) and juveniles abundance in the Ecological Park Centennial Jatoba. (Male: U=9213, P=0.32; Female: U=6654, P<0.0001; Juveniles: U=9285, P=0.36)

Oxyopidae, Scytodidae, Trechaleidae and Zodariidae were not found in the dry season.

The species collected in greater abundance in the rainy season were Linyphiidae sp. 4 with 204 individuals; Lycosidae sp. 2 with 246; *Ochyrocer* sp. with 172 and Hahnidae sp. with 128. These four morphospecies represented 53% of the adults sampled, with the remaining 47% distributed among the 95 other taxa. The most abundant species in the dry season were Linyphiidae sp. 4 with 154 individuals; *Isoctenus* sp. 1, with 56; Linyphiidae sp. 1 with 48; Lycosidae sp. 3 with 46 and *Chryssa* sp. 3 with 40. The most abundant morphospecies accounted for 47% of the adults collected, the remaining 53% are distributed among 64 other taxa.

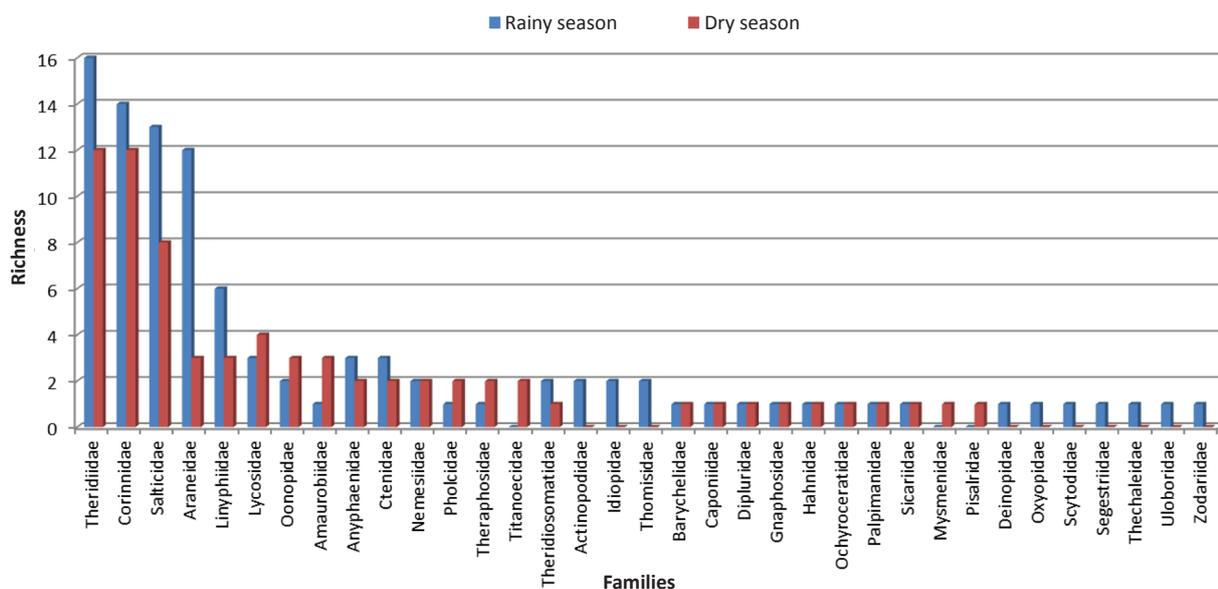


Figure 8. Species richness of spider families sampled in dry and rainy seasons in the Ecological Park Centennial Jatoba. (U=529; P=0.16)

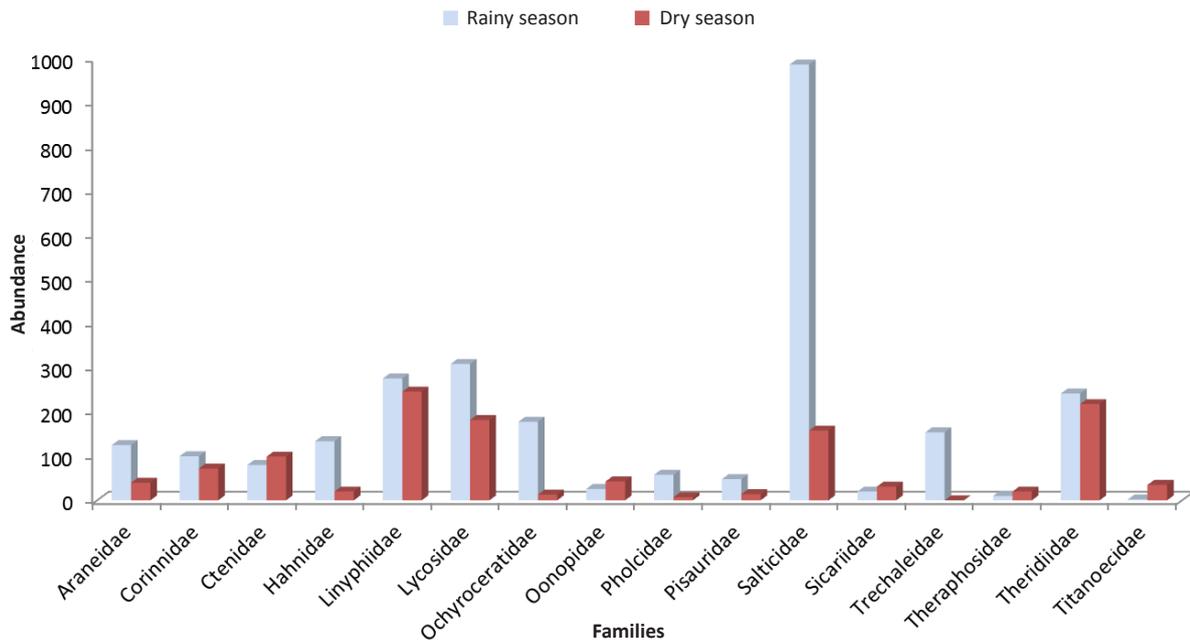


Figure 9. Total abundance of major spider families according to the season of collection in the Ecological Park Centennial Jatoba. (U=87; P=0.06)

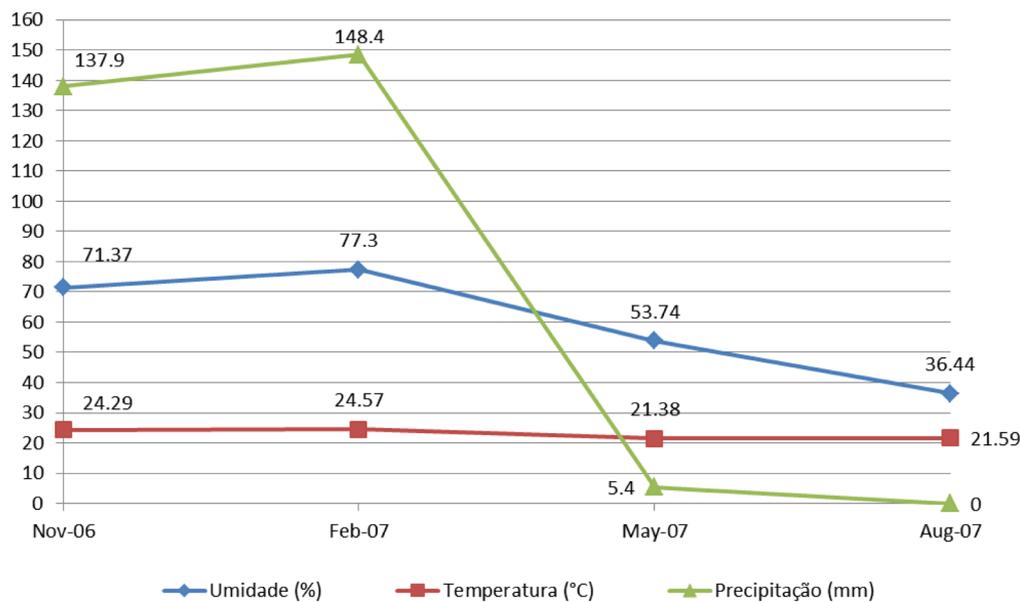


Figure 10. Accumulative month precipitation rate of each collection; average of temperature and humidity in each collection held at Centennial Park Ecological Jatoba. (Standard Deviation of temperature is 1.71, 0.76, 2.03 and 1.67, respectively, as it is not showed on graph, Standard deviation of humidity as showed on graph)

The diversity of the dry period was $H' = 3.237$, while the rainy season was $H' = 3.296$.

Comparison between wet and dry season related araneofauna

The relative humidity averaged $71.1\% \pm 13.26$ in the first wet season collection (November 2006), with a

minimum of 41% and a maximum of 98%. In the month of the second wet season collection (February 2007) the average relative humidity was $77\% \pm 7.69$, with minimum 51% and maximum of 93%.

In one of the dry months (May 2007) relative humidity varied for 26–90 % with mean of $53.48 \pm 8.43\%$, in another (August/2007) this indices varied for 19–65 % with

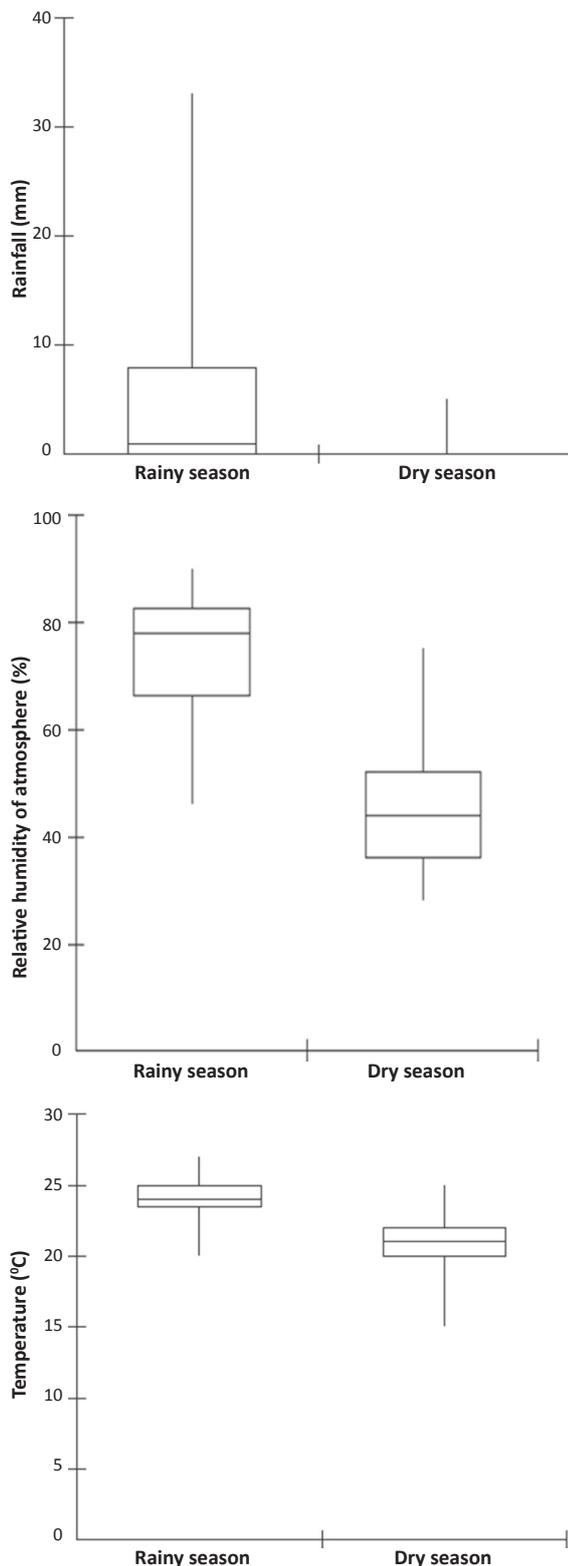


Figure 11. Comparison of humidity, temperature and rainfall between stations dry and rainy in the Parque Ecológico Jatobá Centenário

mean of $36.19 \pm 4.91\%$ (Fig. 10).

The temperature in the month of first sample showed a mean of $23.93^\circ\text{C} \pm 1.76$, with a minimum of 14.3°C and maximum of 34.3°C ; in the following sampled month the mean was $24.07^\circ\text{C} \pm 0.81$, with a minimum of 16.5°C and maximum of 32.1°C ; in the third month of sampling the mean was $20.93^\circ\text{C} \pm 2.03$, with minimum of 6.8°C and maximum of 31.7°C , and the last sampling the average was $21.09^\circ\text{C} \pm 1.78$, with a minimum of 9.6°C and maximum of 34.8°C (Fig. 11).

The accumulated rainfall in the months of collections was 137.9mm in the first, the second 148.4mm, 5.4mm in the third and fourth 0mm. Significant differences were observed between the relative humidity ($U = 161$, $P < 0.0001$), the temperature ($U = 354$, $P < 0.0001$) and precipitation ($U = 831$, $P < 0.0001$) between the two seasons. However, a high correlation between the climatic factors was found (Table 2).

The mean annual temperature of approximately 22°C and relative humidity and high rainfall during the warm months and very low in the cold months is typical feature of tropical savanna climate (Lohmann et al. 1993).

Permutation MANOVA show that there were significant effects of all climatic factors on community structure. Humidity ($F_{1,91} = 10.85$, $P < 0.001$) was responsible for almost 10% of all community variations, followed by precipitation ($F_{1,91} = 9.29$, $P < 0.001$) responsible for slight over 8% and temperature ($F_{1,91} = 8.88$, $P < 0.001$) responsible for 7.8%.

DISCUSSION

Diversity of spiders

Of spider inventories in Brazil, few have surpassed the total abundance, abundance of adults and number of families observed in this study. Of those few, Rocha-Dias et al. (2005), sampled 2090 spiders included in 30 families, with 1450 adults distributed in 98 morphospecies in the Atlantic Forest of southern Bahia; Candiani et al. (2005) collected 2339 spiders, that were 1569 adults and 770 juveniles, distributed in 25 families and 46 morphospecies in urban forests of São Paulo; Mineo (2009) sampled 3477 spiders, with 1605 adults belonging to 31 families, arranged in 112 morphospecies in the Cerrado of Minas Gerais. All these studies used pitfall traps for sampling.

Inventories that exceed the numbers recorded in Morrinhos used different collection methods, sampling both the spider fauna of litter and trees and shrubs. This can be observed in Podgaiski et al. (2007) that collected

Table 1. List of morphospecies/species collected in semi-deciduous forest in the municipality of Morrinhos - GO.

Family / Species	Total abundance		Number of adults	Richness
	Rainy season	Dry season		
Actinopodidae	7	0	7	2
<i>Actinopus</i> sp.1	6	0		
<i>Actinopus</i> sp.2	1	0		
Amaurobiidae	9	3	8	1
<i>Amaurobiidae</i> sp.	6	2		
Anyphaenidae	8	8	8	4
<i>Anyphaenidae</i> sp.	0	1		
<i>Aysha</i> sp.	2	1		
<i>Isigonia</i> sp.	1	0		
<i>Teudis</i> sp.	3	0		
Araneidae	125	40	102	13
<i>Acacesia</i> sp.	1	0		
<i>Alpaida</i> sp.	79	0		
<i>Araneidae</i> sp.1	1	0		
<i>Araneidae</i> sp.2	1	0		
<i>Araneidae</i> sp.3	1	1		
<i>Araneidae</i> sp.4	1	0		
<i>Araneidae</i> sp.5	0	2		
<i>Araneus</i> sp.1	3	2		
<i>Araneus</i> sp.2	2	0		
<i>Hipognatha</i> sp.	1	0		
<i>Mangora</i> sp.	2	0		
<i>Ocrepeira</i> sp.	1	0		
<i>Pronous</i> sp.	4	0		
Barychelidae	12	2	3	1
<i>Barychelidae</i> sp.	1	2		
Caponiidae	13	8	15	1
<i>Nops</i> sp.	12	3		
Corinnidae	100	72	141	15
<i>Attacobius</i> sp.1	7	1		
<i>Attacobius</i> sp.2	3	0		
<i>Attacobius</i> sp.3	1	2		
<i>Castianeira</i> sp.	16	21		
<i>Corinna</i> sp.1	21	1		
<i>Corinna</i> sp.2	16	1		
<i>Corinna</i> sp.3	3	9		
<i>Corinna</i> sp.4	4	1		
<i>Corinna</i> sp.5	1	0		
<i>Corinnidae</i> sp.1	3	5		
<i>Corinnidae</i> sp.2	5	1		
<i>Corinnidae</i> sp.3	0	3		
<i>Falconina</i> sp.	2	1		
<i>Myrmecium</i> sp.	6	0		
<i>Parachemmis</i> sp.	4	3		
Ctenidae	80	99	65	3
<i>Ctenus ornatus</i>	1	0		

Family / Species	Total abundance		Number of adults	Richness
	Rainy season	Dry season		
<i>Ctenus</i> sp.1	1	1		
<i>Isoctenus</i> sp.1	6	56		
Deinopidae	2	2	2	1
<i>Deinopidae</i> sp.1	2	0		
Dipluridae	3	6	7	2
<i>Dipluridae</i> sp.	1	0		
<i>Diplura</i> sp.	0	6		
Gnaphosidae	3	4	3	1
<i>Vectiusniger</i>	1	2		
Hahnidae	134	20	144	1
<i>Hahnidae</i> sp.	128	16		
Idiopidae	9	1	3	2
<i>Neocteniza</i> sp.1	1	0		
<i>Neocteniza</i> sp.2	2	0		
Linyphiidae	276	246	478	6
<i>Linyphiidae</i> sp.1	3	48		
<i>Linyphiidae</i> sp.2	1	0		
<i>Linyphiidae</i> sp.3	48	0		
<i>Linyphiidae</i> sp.4	204	154		
<i>Linyphiidae</i> sp.5	5	13		
<i>Linyphiidae</i> sp.6	2	0		
Lycosidae	309	182	290	4
<i>Aglaoctenus</i> sp.	0	1		
<i>Lycosidae</i> sp.1	30	26		
<i>Lycosidae</i> sp.2	146	30		
<i>Lycosidae</i> sp.3	11	46		
Mysmenidae	0	3	3	1
<i>Mysmenidae</i> sp.	0	3		
Nemesiidae	6	20	26	3
<i>Nemesiidae</i> sp.	1	1		
<i>Stenoterommata</i> sp.1	5	0		
<i>Stenoterommata</i> sp.2	0	19		
Ochyroceratidae	178	13	182	1
<i>Ochyrocera</i> sp.	172	10		
Oonopidae	26	43	28	3
<i>Neoxyphinus</i> sp.	13	12		
<i>Oonopidae</i> sp.	0	1		
<i>Triaerisstenaspis</i>	1	1		
Oxyopidae	1	0	1	1
<i>Hamataliwa</i> sp.	1	0		
Palpimanidae	8	2	7	1
<i>Otiothops</i> sp.	5	2		
Pholcidae	58	7	29	2
<i>Mesabolivar</i> sp.	0	1		
<i>Pholcidae</i> sp.	25	3		
Pisauridae	48	14	1	1

Family / Species	Total abundance		Number of adults	Richness
	Rainy season	Dry season		
Pisauridae sp.	0	1		
Salticidae	987	158	127	16
<i>Breda</i> sp.	1	0		
<i>Chira</i> sp.	2	0		
<i>Corythalia</i> sp.	3	1		
<i>Cotinusa</i> sp.	2	0		
<i>Cyllostela</i> sp.	0	1		
<i>Noegus</i> sp.1	4	4		
<i>Noegus</i> sp.2	3	2		
Salticidae sp.1	2	0		
Salticidae sp.2	1	17		
Salticidae sp.3	2	0		
Salticidae sp.4	4	0		
Salticidae sp.5	65	0		
Salticidae sp.6	5	0		
Salticidae sp.7	2	2		
Salticidae sp.8	0	2		
Salticidae sp.9	0	2		
Scytodidae	17	0	17	1
<i>Scytodes eleonora</i>	17	0		
Segestriidae	5	1	3	1
<i>Ariadna</i> sp.	3	0		
Sicariidae	20	31	40	1
<i>Loxosceles</i> sp.	17	23		
Thechaleidae	154	0	8	1
<i>Rhoicinus</i> sp.	8	0		
Theraphosidae	10	20	25	2
<i>Oligoxystrebolivianum</i>	9	15		
Theraphosidae sp.	0	1		
Theridiidae	242	218	348	18
<i>Chrosiothes</i> sp.	1	0		

Family / Species	Total abundance		Number of adults	Richness
	Rainy season	Dry season		
<i>Chryso</i> sp.1	1	1		
<i>Chryso</i> sp.2	7	0		
<i>Chryso</i> sp.3	1	40		
<i>Coleosoma floridanum</i>	10	13		
<i>Dipoena</i> sp.	31	29		
<i>Episinus</i> sp.1	1	0		
<i>Episinus</i> sp.2	57	6		
<i>Helvibis</i> sp.1	10	0		
<i>Helvibis</i> sp.2	0	2		
<i>Helvibis</i> sp.3	8	1		
<i>Styposis</i> sp.	8	2		
Theridiidae sp.1	68	25		
Theridiidae sp.2	16	4		
Theridiidae sp.3	1	0		
Theridiidae sp.4	1	2		
Theridiidae sp.5	0	1		
<i>Thwaitesia</i> sp.	1	0		
Theridiosomatidae	4	6	5	2
<i>Plato</i> sp.1	1	2		
<i>Plato</i> sp.2	2	0		
Thomisidae	9	6	4	2
<i>Tmarus</i> sp.	3	0		
Thomisidae sp.	1	0		
Titanoecidae	2	35	19	2
<i>Goeldia</i> sp.1	0	14		
<i>Goeldia</i> sp.2	0	5		
Uloboridae	1	1	1	1
<i>Uloborus</i> sp.	1	0		
Zodariidae	2	0	2	1
<i>Tenedos</i> sp.	2	0		
TOTAL			2152	118

8724 individuals from 37 families, being 2946 adults distributed in 447 morphospecies in Rio Grande do Sul; Höfer (1990) found 208 morphospecies representing 37 families in the Amazon region; and Höfer & Brescovit (2001) sample 506 morphospecies and 56 families on a period of approximately 10 years in the Amazon region. Brescovit et al. (2004) registered 48 families and 274 morphospecies in São Paulo. The relatively small size of the area sampled in this study and the low number of samples during the survey period make the high numbers achieved even more impressive, even with the use of only pitfall traps.

Based on the most abundant and rich families, similar

results were found in several studies with soil spiders except family Araneidae which usually is only sampled with high richness in studies using tree and shrub collections (Candiani et al. 2005; Rocha-Dias et al. 2005; Rodrigues 2005; Podgaiski et al. 2007). This phenomenon can be explained by males seeking females, dispersal of newly matured females and/or juveniles, noting that the vast majority of individuals collected were adults and 64% of individuals belonging to this family were obtained in the first collection in rainy season, a period where most species starts mating (Lopes et al. 2006). The *Alpaida* sp. represented the majority of individuals of this family, being a genus typically represented by

Table 2. Correlation of climatic factors.

Abiotic variable	Humidity	Temperature	Precipitation
Humidity	1.0000000	0.9028215	0.9317037
Temperature	0.9028215	1.0000000	0.9969316
Precipitation	0.9317037	0.9969316	1.0000000

tree species, found in abundance in the inventories of the Amazon and the African Savanna (Hofer & Brescovit 1991; Whitmore et al. 2002). The high capture rate of this spider may be related with the precipitation, when arboreal species could drop from the trees because of heavy rain.

Salticidae had the largest number of individuals, with the predominance of juveniles in the rainy season. Gasnier et al. (1995), Green (1999) and Toti et al. (2000) reported high abundance of this family on bushes and trees, which may be an indication that the rainy season is the period of dispersal of immature individuals. Agreeing with Jocqué (1984), jumping spiders are common in tropical soil, since the high temperatures benefit wandering spiders. A more detailed study would show which hypothesis is true about the immature specimens found in this study, dispersion of bush and tree jumping spiders or high levels of juveniles of soil salticids.

The abundance of the family Lycosidae reflects anthropic action in the sampled area, because they are more frequent in open environments and are considered good biological indicators (Costa et al. 1991), besides having a strategy of predation active hunting, moving through wide area. Linyphiidae is a family abundant in several studies, as noted by Indicatti et al. (2005) wherein 60% of their specimens belonged to this family. These spiders are typically present in litter. They are also species that nest in the upper strata of vegetation (Lopes et al. 2006). The family Theridiidae features a high phenotypic plasticity, being found in many environments and strata, also urban areas (Lopes et al. 2006). Another factor that would justify its abundance is the fact that they show a negative correlation between the number of specimens and size of the fragment, i.e., they are less sensitive to the size of the fragment (Miyashita et al. 1998).

Species of Linyphiidae and Hahnidae are more abundant in forest fragments, while *Ochyrocera* spp. are also abundant in the forest environment (Rock-Dias 2005). Mineo (2009) noted that one species of *Tenedos* (Zodariidae) was the most abundant in samples in the savannah, but in this study a species of the same

genus was found only in the first collection of the rainy season, being represented only by two males, this may indicate the preference of the species of this genus for open vegetation environments, but more extensive research is needed to prove this hypothesis.

Zodariidae and Linyphiidae species are the most common in open vegetation of Cerrado, while species of the family Zodariidae and the genus *Lycosinae* (Lycosidae) are the most abundant in cerrado sensu stricto. Mineo (2009) showed that one species of *Tenedos*, one of *Lycosinae* and a *Euryopis* (Theridiidae) are the most represented in dense woodland environment. The genus *Tenedos* and the most abundant families present in previous studies were sample in this research, with the exception of family Zodariidae.

The family Actinopodidae, despite having several species in Brazil is rarely present on inventories (Mineo 2009; Platnick 2015; Podgaiski et al. 2007; Raizer et al. 2005), probably present species that use the "Stakeout on soil" as foraging strategy (Souza 2007). Despite being a family Amaurobiidae quite common in studies of spiders in a recent survey conducted on different vegetation of the cerrado biome that family was not recorded (Mineo 2009).

Mysmenidae and Nemesiidae families are poorly sampled, Rock-Dias et al. (2005) found specimens related to these two families in forest fragments of Atlantic Forest in southern Bahia, while Barreiros (2004) sampled only family Mysmenidae in an ecological station in Amazon. As both mentioned above and this study collected in dense forest, it can be an indication that these families have a preference to dense forest habitats.

The genus *Ariadna* (Segestriidae) is distributed on all continents except Antarctica, being found by Barreiros (2004) in the Amazon. The records of these taxa in this study may be the first for Brazilian savannah.

Frequency of spiders

In this study was observed marginally greater amount of spiders ($U=87$; $P=0.06$) in the rainy season compared to the dry season, as well as greater amount of females ($U=6654$, $P<0.0001$). Candiani et al. (2005), Lopes et al. (2006) and Podgaiski et al. (2007) found similar pattern, observing greater richness in spring and lowest richness in autumn. Spring and autumn coincide with the onset of the rainy season and dry season respectively in the study region. Rodrigues (2005) in a study of the sandbank vegetation of southern Brazil found a different pattern in the distribution of young, males and females. Their samples resulted in 70% of young, while

in adults sex ratio was 36% males and 64% females. The difference in diversity between seasons may be related to the high richness and abundance observed in the rainy season, unlike the study reported by Podgaiski et al. (2007) that found greater diversity in the autumn, which was justified by the lack of uniformity presented by the spring, which presented many singletons.

Comparison between wet and dry season related with fauna of spiders

The interference of relative humidity, rainfall and temperature with the structure of the spider community in the study area is expected, because spiders are sensitive to environmental changes. However, the abiotic variables tested in this study explain just 20% of all variation together. The remaining 80% are influenced by other various factors, including microclimatic changes. An example is the residual soil moisture, which negatively influenced litter spider community, i.e., the higher the soil humidity, the lower is the abundance and richness of spiders (Rodrigues 2004). Miglio (2004) did not observe differences in abundances between the dry and rainy season in the Amazon region, with the exception of wetland area. Mineo (2009) showed that in cerrado soil spiders are influenced by climatic factors, the relative humidity influences the total abundance, richness is influenced by several factors depending on the physiognomy, the number of males is influenced by the minimum temperature, relative humidity and the maximum rainfall in 24 hours, number of females is influenced mainly by the high rainfall in 24 hours, and the representation of young are changed by various climatic factors such as among the main maximum temperature and relative humidity.

Uetz (1991) states that the structure of the vegetation being together with the heterogeneity of habitats is one of the factors that mostly influence of spider fauna because they are extremely sensitive to small changes in habitat, including the complexity, depth of litter and microclimate (Uetz 1991; Hurd & Fagon 1992). These factors may be responsible for 80% seasonal variation of litter spider community not explained by this study.

REFERENCES

- Aguiar, L.M.S., R.B. Machado & J. Marinho-Filho (2004). A diversidade biológica do Cerrado, pp. 17–40. In: Aguiar, L.M.S. & A.J.A. Camargo (eds.). *Cerrado: Ecologia e Caracterização*. Embrapa, Brasília.
- Ayres, M., M.A. Júnior, D.L. Ayres & A.A. Santos (2007). *BioEstat 5.0 – Aplicações Estatísticas nas áreas das Ciências Biomédicas*. Ong Mamiraua. Belém, Pará.
- Baert, L., K. Desender & J.P. Maelfait (1991). Spider communities of isla Santa Cruz (Galapagos, Equador). *Journal of Biogeography* 18: 333–340.
- Barreiros, J.A.P. (2004). *Inventário da araneofauna (Arachnida, Araneae) de serapilheira na Estação Científica Ferreira Penna, Pará, Brasil*. Masters thesis of Zoology posgraduation at Museu Paraense Emílio Goeldi and Universidade Federal do Pará, 1–87pp.
- Barreiros, J.A.P., J. Ricetti, D.R. Santos-Souza & A.B. Bonaldo (2003). Diversidade de aranhas (Arachnida: Araneae) da macrofauna de serapilheira na Estação Científica Ferreira Penna (ECFPn), Melgaço, Pará, pp. 012–012. In: *Estação Científica Ferreira Penna - Dez Anos de Pesquisa na Amazônia: Contribuições e Novos Desafios. Ideias e Debates - Livro de Resumos Seminário*. Museu Paraense Emílio Goeldi, Belém, VI.
- Battilola, L.D., M.I. Marques, J. Adis & A.D. Brescovit (2004). Aspectos ecológicos da comunidade de Araneae (Arthropoda: Arachnida) em copas da palmeira *Attalea phalerata* Mart. (Arecaceae), durante o período de cheia no Pantanal de Mato Grosso, Brasil. *Revista Brasileira de Entomologia* 48(3): 421–430.
- Baur, B., J. Joshi, B. Schmid, A. Hänggi, D. Borcard, J. Starý, A. Pedrolin-Christen, G.H. Thommen, H. Luka, H. Rusterholz, P. Oggier, S. Ledergerber & A. Erhardt (1996). Variation in species richness of plants and diverse groups of invertebrates in three calcareous grasslands of the Swiss Jura mountains. *Revue Suisse de Zoologie* 103: 801–833.
- Brescovit, A.D., R. Bertani, R. Pinto-da-Rocha & C.A. Rheims (2004). Aracnídeos da Estação Ecológica Juréia-Itatins: inventário preliminar e história natural, pp. 198–221. In: Marques, O.A.V. & W. Duleba (eds.). *Estação Ecológica Juréia-Itatins: Ambiente físico, flora e fauna*. Holos, Ribeirão Preto.
- Brescovit, A.D., C.A. Rheims & A.B. Bonaldo (2002). Araneae, pp. 303–343. In: Adis, J. (eds.). *Amazonian Arachnida and Myriapoda - Keys for the Identification to Classes, Orders, Families, Some Genera, and Lists of Know Species*. Pensoft, Moscou.
- Brito, I.V., E.B.O. Marques, J.Q. Sousa, I.G. Sucupira, R.A. Luz, L.S. Fontes, S.R.S. Cardoso & P.R.R. Silva (2007). Composição das famílias de aranhas de solo em dois fragmentos da cidade de Teresina, Piauí, Brasil. In: *VIII Congresso de Ecologia do Brasil - Anais do VIII Congresso de Ecologia do Brasil*. Caxambú.
- Candiani, D.F., R.P. Indicatti & A.D. Brescovit (2005). Composição e diversidade da araneofauna (Araneae) de serapilheira em três florestas urbanas na cidade de São Paulo, São Paulo, Brasil. *Biota Neotropica* 5: 1–13.
- Coddington, J.A. & H.W. Levi (1991). Systematics and evolution of spiders (Araneae). *Annual Review of Ecology and Systematics* 22: 565–592.
- Colwell, R.K. (2013). EstimateS: Statistical estimation of species richness and shared species from samples. Version 9.1.0. User's Guide and application published at: <http://purl.oclc.org/estimates>.
- Costa, F.G., F. Pérez-Miles, E. Gudynas, L. Prandi & R.M. Capocasale (1991). Ecologia de los aracnidos criptozoicos, excepto acaros, de Sierra de las Animas (Uruguay). *Aracnologia* 13/15: 1–41.
- Eiten, G. (1993). Vegetação do cerrado, pp. 17–73. In: Pinto M.N. (eds.). *Cerrado: Caracterização, Ocupação e Perspectivas*. Universidade de Brasília, Brasília.
- Espírito-Santo, F.D.B., A.T. Oliveira-Filho, E.L.M. Machado, J.S. Souza, M.A.M.L. Fontes & J.J.G. Marques (2002). Variáveis ambientais e a distribuição de espécies arbóreas em um remanescente de floresta estacional semidecídua Montana no Campo da Universidade Federal de Lavras, MG. *Acta botânica brasileira* 16(3): 331–356.
- Gasnier, T.R., H. Höfer & A.D. Brescovit (1995). Factors affecting the “activity density” of spiders on tree trunks in an Amazonian rainforest. *Ecotropica* 1: 269–277.
- Green, J. (1999). Sampling method and time determines composition of spider collection. *The Journal of Arachnology* 27: 176–182.
- Gunnarsson, B. (1990). Vegetation structure and the abundance and size distribution of spruce-living spiders. *Journal of Animal Ecology* 59: 743–752.
- Hammer, Ø., D.A.T. Harper & P.D. Ryan (2001). PAST: paleontological statistics software package for education and data analysis.

- Palaeontologia Electronica* 4(1): 1–9.
- Hatley, C.L. & J.A. Macmahon (1980). Spider community organization: Seasonal variation and the role of vegetation architecture. *Environmental Entomology* 9: 632–639.
- Höfer, H. (1990). The spider community (Araneae) of a central Amazonian blackwater inundation forest (igapó). *Acta Zoológica Fennica* 190: 173–179.
- Hoefler, H. & A.D. Brescovit (2001). Species and guild structure of a Neotropical spider assemblage (Araneae, Reserva Ducke, Amazonas, Brazil). *Andrias* 15: 99–120.
- Hurd, L.E. & W.F. Fagon (1992). Cursorial spiders and succession: age or habitat structure? *Oecologia* 92: 215–221.
- Indicatti, R.P., D.F. Candiani, A.D. Brescovit & H.F. Japyassú (2005). Diversidade de aranhas (Arachnida, Araneae) de solo na bacia do reservatório do Guarapiranga, São Paulo, Brasil. *Biota Neotropica* 5(1a): 151–162.
- Jocqué, R. (1984). Considérations concernant l'abondance relative des araignées errantes et des araignées à toile vivant au niveau du sol. *Revue Arachnologique* 5(4): 193–204.
- Lewinsohn, T.M. & P.I. Prado (2002). *Biodiversidade brasileira: síntese do estado atual do conhecimento*. São Paulo, Contexto.
- Lohmann, U., R. Sausen, L. Bengtsson, U. Cubasch, J. Perlwitz & E. Roeckner (1993). The Köppen climate classification as a diagnostic tool for general circulation models. *Climate Research* 3: 177–193.
- Lopes, J., F.P. Santos & I.M. Medri (2006). Araneofauna capturada no interior da mata e área de pastagem adjacente, no norte do Paraná, Brasil. *Seminário Ciências Biológicas e da Saúde* 27: 133–138.
- Miglio, L.T. (2004). Composição, Abundância e Riqueza de Migalomorfos (Arachnida, Araneae, Opistothele) na Estação Científica Ferreira Penna, Melgaço, Pará. *Thesis*. Biology Department, Federal University of Para, Brazil, i+70pp.
- Mineo, M.F. (2009). Ecologia da comunidade de aranhas de solo de uma área de cerrado no sudeste do Brasil. PhD Thesis. Laboratory of Behavior Ecology and Interactions, Federal University of Uberlândia, IV+70pp.
- Miyashita, T., A. Shinkai & T. Chida (1998). The effects of forest fragmentation on web spider communities in urban areas. *Biological Conservation* 86: 357–364.
- Myers, N., R.A. Mittermeier, C.G. Mittermeier, G.A.B. Fonseca & J. Kent (2000). Biodiversity hotspots for conservation priorities. *Nature* 403: 853–859.
- Nascimento, M.A.S. (1992). Geomorfologia do Estado de Goiás. *Boletim de Geografia* 12: 1–22.
- Oksanen, J., F.G. Blanchet, R. Kindt, P. Legendre, P.R. Minchin, R.B. O'Hara, G.L. Simpson, P. Solymos, M.H.H. Stevens & H. Wagner (2015). *Vegan: Community Ecology Package*. R package version 2.3-0. <http://CRAN.R-project.org/package=vegan>
- Oliveira, L.P., L. Boccardo, P.M. Brito, R. Jucá-Chagas & A.D. Brescovit (2007). Araneofauna em trechos de mata ciliar no reservatório da Barragem da Pedra, Bahia, Brasil, PP. 1–2. In: *VIII Congresso de Ecologia do Brasil*. Anais do VIII Congresso de Ecologia do Brasil, Caxambú.
- Peixoto, K.S., M. Sanchez, F. Pedroni & M.N. Ribeiro (2007). Estrutura da comunidade arbórea da floresta estacional semidecidual no Parque Estadual da Serra Azul (PESA), no município de Barra do Garças - MT, Brasil. In: *VIII Congresso de Ecologia do Brasil*. Anais do VIII Congresso de Ecologia do Brasil, Caxambú.
- Pikelin, B.S.G. & R.D. Schiapelli (1963). Llave para la determinación de familias de arañas argentinas. *Physis* 24(67): 43–72.
- Platnick, N.I. (2015). World Spider Catalog. Natural History Museum Bern, online at <http://wsc.nmbe.ch>, version 16.5, accessed on 16 of August of 2015.
- Podgaiski, L.R., R. Ott, E.N.L. Rodrigues, E.H. Backup & M.A.L. Marques (2007). Araneofauna do Parque Estadual do Turvo, RS, Brasil. *Biota Neotropica* 7: 1–15.
- Raizer, J. (2004). Comunidade de aranhas em capões de mata das sub-regiões Miranda e Abobral no Pantanal sul-mato-grossense. PhD Thesis. Biology Institute, University of Campinas.
- Raizer, J. & M.E.C. Amaral (2001). Does the structural complexity of aquatic macrophytes explain the diversity of associated spider assemblages? *Journal of Arachnology* 29: 227–237.
- Raizer, J., H.F. Japyassú, R.P. Indicatti & A.D. Brescovit (2005). Comunidade de aranhas (Arachnida, Araneae) do pantanal norte (Mato Grosso, Brasil) e sua similaridade com a araneofauna amazônica. *Biota Neotropica* 5(1).
- Rocha-Dias, M.F., A.D. Brescovit & M. Menezes (2005). Aranhas de solo (Arachnida: Araneae) em diferentes fragmentos florestais no sul da Bahia, Brasil. *Biota Neotropica* 5(1).
- Rodrigues, E.M.L. (2005). Araneofauna de serapilheira de duas áreas de uma mata de restinga no município de Capão do Leão, Rio Grande do Sul, Brasil. *Biotemas* 18(1): 73–92.
- Roth, M. (1993). Investigations on lead in the soil invertebrates of a forest ecosystem. *Pedobiologia* 37: 270–279.
- Schaefer, M. (1987). Life cycles and diapause, pp. 331–347. In: Nentwig W. (eds.). *Ecophysiology of spiders*, Springer-Verlag, Berlin.
- Souza, A.L.T. (2007). Influência da estrutura do habitat na abundância e diversidade de aranhas, pp. 25–43. In: Gonzaga, M.O., A.J. Santos & H.F. Japyassú (eds.). *Ecologia e Comportamento de Aranhas*, Interciência, Rio de Janeiro.
- Toti, D.S., F.A. Coyle & J.A. Miller (2000). A structure inventory of Appalachian grass bald and heath bald spider assemblages and a test of species richness estimator performance. *The Journal of Arachnology* 28: 329–345.
- Uetz, G.W. (1977). Coexistence in a guild of wandering spiders. *Journal of Animal Ecology* 46: 531–541.
- Uetz, G.W. (1991). Habitat structure and spider foraging, pp. 325–348. In: Bell, S.S., E.D. McCoy & H.R. Mushinsky (eds.). *Habitat Structure: The Physical Arrangement of Objects in Space*. Chapman and hall, London.
- Veloso, H.P., A.L.R. Rangel-Filho & J.C.A. Lima (1991). *Classificação da Vegetação Brasileira, Adaptada a um Sistema Universal*. Instituto Brasileiro de Geografia e Estatística, Rio de Janeiro.
- Whitmore C., R. Slotow, T.E. Crouch & A.S. Dippenaar-Schoeman (2002). Diversity of spiders (Araneae) in a Savanna Reserve, Northern province, South Africa. *The Journal of Arachnology* 30: 344–356.

Portuguese abstract: As aranhas constituem um grupo megadiverso. Sensíveis a variações abióticas e bióticas do ambiente são consideradas potenciais bioindicadoras. Mesmo apresentando tamanha importância, a ordem Araneae está longe de ser totalmente amostrada. As regiões tropicais e subtropicais estão subamostradas, carecendo de pesquisadores na área. Neste estudo foi caracterizada a comunidade de aranhas de solo, verificando a influência de fatores climáticos sobre a araneofauna em uma floresta estacional semidecidual no centro da distribuição do Cerrado. A área de coleta foi o Parque Ecológico Jatobá Centenário, um fragmento de 90 hectares, localizado no município de Morrinhos no estado de Goiás. As aranhas de solo foram amostradas quatro vezes durante um ano através da utilização de armadilhas de queda do tipo pitfall, que permaneceram em campo por sete dias completos em cada amostragem. Foram coletadas 4139 aranhas distribuídas em 35 famílias e 118 morfoespécies. As famílias mais representadas foram Salticidae com 28%, seguida por Linyphiidae com 13%, Lycosidae com 12% e Theridiidae com 11%. Enquanto as famílias com maior riqueza foram Theridiidae, Salticidae, Coriniidae e Araneidae com 18, 16, 15 e 13 espécies, respectivamente. A diversidade total de acordo com o índice de Shannon-Wiener (H') foi de 3,6. Na estação chuvosa observou-se maior abundância (2868 e 1271), riqueza (100 e 71) e diversidade (3,296 e 3,237). Theridiidae, Coriniidae e Salticidae foram as famílias com maior número de espécies em ambas as estações. As temperaturas, umidades relativas do ar e precipitações amostradas durante o período de coleta apresentaram diferenças entre as estações e influencia a estrutura da comunidade de aranhas de solo.

