Distribution and importance of spiders inhabiting a Brazilian sugar cane plantation

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ABSTRACT. The spider fauna (Araneae) of a sugar cane plantation was surveyed monthly by hand collection and beating vegetation in sugar cane fields across Botucatu, State of São Paulo, Brazil. Composition and richness (family and species where identification to species was possible) microhabitat preferences were recorded, and diversity and evenness indices were calculated. A total of 1291 spiders belonging to 73 species and 20 families were collected. The most diverse families were Theridiidae, Salticidae, and Araneidae, and the most abundant ones were Theridiidae, Salticidae, Anyphaenidae, and Araneidae. Seven species represented 58.6% of the total fauna, with *Crysso pulcherrima* (Mello-Leitão, 1917) (Theridiidae) composing 28.2%. About 65% of the spiders occupied the upper part of the plants (above 20 cm). Five spider species were present in the sugar cane throughout crop development. Evidence of spiders feeding on sugar cane pest species was observed.
KEY WORDS. Araneae, Sugar cane plantation, spider fauna, spider diversity, natural enemies

Sugar cane has great economical and social importance to the State of São Paulo, Brazil. Unfortunately, the burning of cane foliage preceding harvest degrades the soil and pollutes water supplies and the air of urban centers. Harvesting without such burning seems to be a solution (SPAVOREK *et al.* 1997), and it will soon become international policy. A benefit from no burning is to increases the possibilities of survival and settlement of endemic predatory arthropod populations in the soil and foliage. Many of these arthropods are generalist predators, and may serve as agents of biological control in sugar cane plantations.

Spiders are the 6th most diverse group of animal species and occupy practically all terrestrial ecosystems. These generalists attack insects non-specifically, and may stabilize arthropod populations (RIECHERT & LOCKLEY 1984; NATURAL RESOURCES INSTITUTE 1991; WISE 1995). Analysis of the arachnological communities regarding their different trophic strategies, phenologies, and habitat preferences allows the definition of several functional groups (UETZ *et al.* 1999), some of which have an effect on certain prey groups (MARC & CANARD 1997).

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Spiders have been observed in sugar cane plantations attacking leafhoppers (GUAGLIUMI 1972/73), and 32 species of hunting spiders were collected in sugar cane plantations in the State of São Paulo (RINALDI & FORTI 1997). The main reason spiders are not part of integrated pest management programs in most agroecosystems is lack of basic life cycle and ecological data. The aim of this study was to evaluate the richness and diversity of spider species present in sugar cane plantations over time, and to define their microhabitat preferences.

MATERIALS AND METHODS

Study site

The survey was conducted in Botucatu, State of São Paulo, Brazil, located close to the tropic of Capricorn (22° S, 48° W), in a field of sugar cane (*Saccharum officinarum* Linnaeus) on the Nossa Senhora da Conceição Farm owned by São Manoel Ltda. Mill. The field received the standard agricultural treatments: fertilization fifteen days after cutting, a broad-spectrum herbicide, and an organophosphate insecticide to control leaf-cutting ants.

Sampling

About 640 m^2 of 704 total m^2 of the sugar cane field were sampled by foliage beating. In 64 m^2 (8 distinct plots of 8 m^2) the spiders simultaneously were caught manually. All collections occurred diurnally. Eight samples were gathered during eight months in a plantation 3,5 to 10,5 months old, the plants being 0,60 to 3,5 meters high. Beat sampling was done by sharply striking the foliage with a stick and collecting the spiders dislodged on a 68 X 58 cm white plastic tray with a 11 cm tall rim that was impregnated with unrefined talc, hindering their escape.

Hand-sampling was done in specific microhabitats: A) Upper-Plant: the upper part of the plants above 20 cm, B) Low-Plant: the surface of the soil up to 20 cm on the stalk, C) Substrate: straw and stem remains on the soil (residues from the previous crop), D) Soil: all loose lumps of soil. All arthropods were killed with ethyl acetate and fixed in 70% ethanol. Because immature spiders are active predators and important indicators of population age structure, they were included in the analyses.

Data analyses

Most spiders were identified using LEVI (1978), KASTON (1980), ROTH (1985) and M. Ramirez (pers. comm.). The guild associations are according to UETZ *et al.* (1999). Species accumulation curve, Shannon-Wiener diversity (H') and evenness (J) indices were calculated according to LUDWIG & REYNOLDS (1988). How well manual captures represented the spider fauna was estimated according to SILVEIRA NETO *et al.* (1976): $s^2 = [\Sigma x^2 - (\Sigma x)^2 /N]/N-1]$, where: N = number of samples; N-1 = number of degrees of freedom; and $(\Sigma x)^2/N$ = correction.

RESULTS AND DISCUSSION

The combined samples (beating and hand-capture) yielded 1,291 specimens representing 73 species across 20 families (Tab. I). The species diversity and evenness indices suggest a varied spider fauna (Tab. I).

Table. I. Total numbers of spiders captured from the sugar cane Botucatu, São Paulo, Brazil, with species diversity and evenness.

Methods of capture	Spider families	Number of spiders	Spider species	Shannon-Wiener (H')	Evennes (J)
Handling	8	156	13		
Beating	16	1135	62	3,200	0.70
Total	20	1291	73		

The diversity index values obtained here were higher while the evenness values (J) were smaller compared to a similar sugar cane crop where the hunting spider fauna was sampled during two years by beating and pitfall trapping (RINALDI & FORTI 1997). As the number of manual samples accumulated over time, sample variances rose (Tab. II) while the species accumulation curve reached a plateau after eight samples (Fig. 1). Since results from beating and hand sampling were different (Tab. I), and the 73 spider species sampled covered a wide variety of trophic strategies and microhabitats (Tab. III), a combination of data from the two techniques were used for analyses to more completely represent the spiders living in sugar cane agroecosystems.

Table. II. Variance of spider samples over time obtained by manual capture in Brazilian sugar cane.

Acumulated number of samples	4	8	12	16	20	24	28	32
Variance (S^2)	4,1	5,2	4,9	4,6	4,4	5,6	6,1	5,8

Table. III. Frequencies, microhabitat selection, foraging behavior, and stage of the spider species captured in a sugar cane Botucatu, São Paulo, Brazil. Microhabitats: (A) upper-plant, (B) low-plant, (C) substrate, (D) soil, (a) adult, (y) young.

Families and species	Number of individuals	Microhabitat	Foraging behavior	Stage
Anyphaenidae			Foliage runners	
Arachosia bergi (Simon, 1880)	86	A		a/y
Sanogasta sp.	67	A		a/y
Xiruana sp.	21	A		a/y
Araneidae			Orb web	
Alpaida sp.	10	A		Y
Argiope argentata (Fabricius, 1775)	8	A, B		a/y
Gea (?) sp.	2	A		Y
Parawixia bistriata (Rengger, 1836)	1	A		Y
Parawixia audax (Blackwall, 1863)	1	A		a
Cyclosa sp.	30	A		a/y
Araneidae sp. 1	4	B		y
Araneidae sp. 2	12	A		y
Araneidae sp. 3	1	A		y
Araneidae indeterminated	11	–		y
Clubionidae			Foliage runners	
Clubionidae sp. 1	5	C		y
Clubionidae sp. 2	3	A		y
Corinnidae			Foliage runners	
Castianeira sp. 1	21	A, C		a/y
Castianeira sp. 2	18	A		a/y
Falconina gracilis (Keyserling, 1891)	18	C		a/y
Gnaphosidae			Ground runners	
Gnaphosidae sp.	2	C		y
Apopyllus iheringi (Mello-Leitão, 1943)	3	C		a/y
Camillina pulcher Keyserling, 1891	7	C		a/y
Gnaphosidae indeterminated	1			y

Continued

Table. III. Continued.

Families and species	Number of individuals	Microhabitat	Foraging behavior	Stage
Hahniidae			Sheet web	
Hahniidae sp.	4	D		a/y
Heteropodidae			Foliage runners	
Heteropodidae sp.	1	A		y
Linyphiidae			Wandering sheet	
Dubiaranea sp.	8	B		
Meioneta sp.	12	B, D		a/y
Meioneta cf *straminicola*	12	B		a/y
Neriene redacta (Chamb.,1925)	1	B		a
Sphecozone rubescens (O. P. Cambridge, 1870)	12	B, D		a/y
Lycosidae			Ground runners	
Lycosidae sp. 1	18	C, D		a/y
Lycosidae sp. 2	1	D		y
Lycosidae indeterminated	1			y
Mimetidae			Stalkers	
Mimetus brasilianus? Keyserling, 1886	9	A		a/y
Miturgidae			Foliage runners	
Cheiracanthium inclusum (Hentz, 1847)	10	A		a/y
Teminius insularis Keyserling, 1887	5	A		a/y
Radulphius sp.	1	A		y
Oxyopidae			Stalkers	
Oxyopidae sp.	4	A		y
Philodromidae			Ambushers	
Paracleocnemis sp.?	1	A		y
Pholcidae			Space web	
Physocyclus sp.?	1	A		y
Salticidae			Stalkers	
Agelista andina Simon, 1900	37	B		a/y
Aphirape boliviensis Galiano, 1981	1	A		a
Aphirape missionensis Galiano, 1981	1	A		a
Dendryphantes sexgutattus (Mello-Leitão, 1929)	2	A		y
Euophrys sp.	66	A		a/y
Freya sp.	19	A		a/y
Freya aff. *regia*	1	A		y
Freynae sp.	1	A		y
Parafluda banksi Chickering, 1946	1	A		a
Pensacola sp.	1	A		y
Phiale sp.	2	A		y
Psecas cf. *chapoda*	75	A		a/y
Psecas cf. *zonatus*	7	A		a/y
Sassacus sp.	1	A		y
Synemosyna sp.	1	A		y
Salticidae indeterminated	5			y
Scytodidae			Space web?	
Scytodes fusca (Walckenaer, 1837)	17	A, B		a/y
Theridiidae			Space web	
Achaearanea sp.	2	A, B	Space web	a/y
Achaearanea hirta (Taczanowski, 1873)	5	A		a
Coleosoma floridanum (Banks, 1900)	7	B		a
Crysso pulcherrima (Mello-Leitão, 1917)	358	A	Space web	a/y
Crysso sp.	1	A		a
Dipoena sp.	1	B		a
Euryopis sp. 1	1	B		a
Euryopis sp. 2	6	D	Vagrant weaver	a
Euryopis sp. 3	20	A, B	Vagrant weaver	a/y
Latrodectus geometricus (C.L. Koch, 1841)	21	A, B	Vagrant weaver	a/y
Theridion adamsoni (Berland, 1934)	10	A	Space web	a/y
Theridion pernanbucum (Levi, 1963)	22	A, B		a
Theridion volubile (Keyserling, 1884)	9	A		a/y
Steatoda sp.	3	B		y
Theridiidae indeterminated	7			y
Tetragnathidae			Orb web	
Leucauge sp.	30	A, B		a, y
Thomisidae			Ambushers	
Misumenops sp.	1	B		y
Titidius sp.	13	B		y
Tmarus sp.	44	A		y
Titanoecidae			Vagrant weaver	
Goeldia sp.	59	C, D		a/y

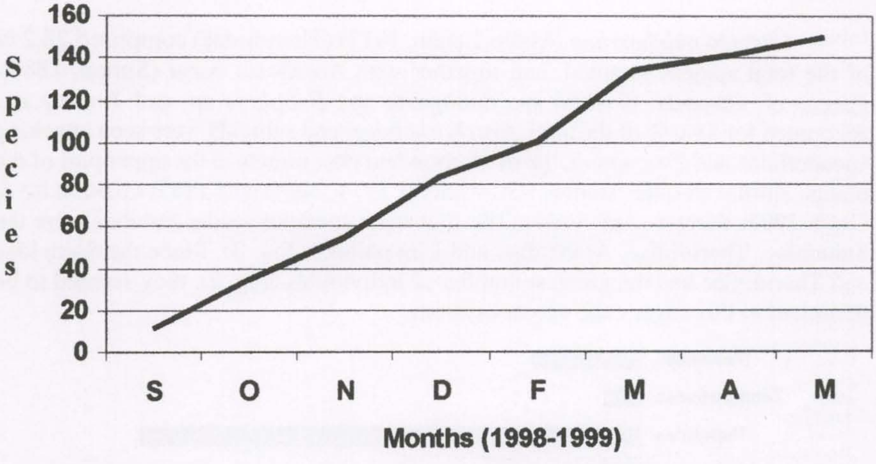

Fig. 1. Species accumulation curve for collections of spider fauna from the sugar cane Botucatu, São Paulo, Brazil.

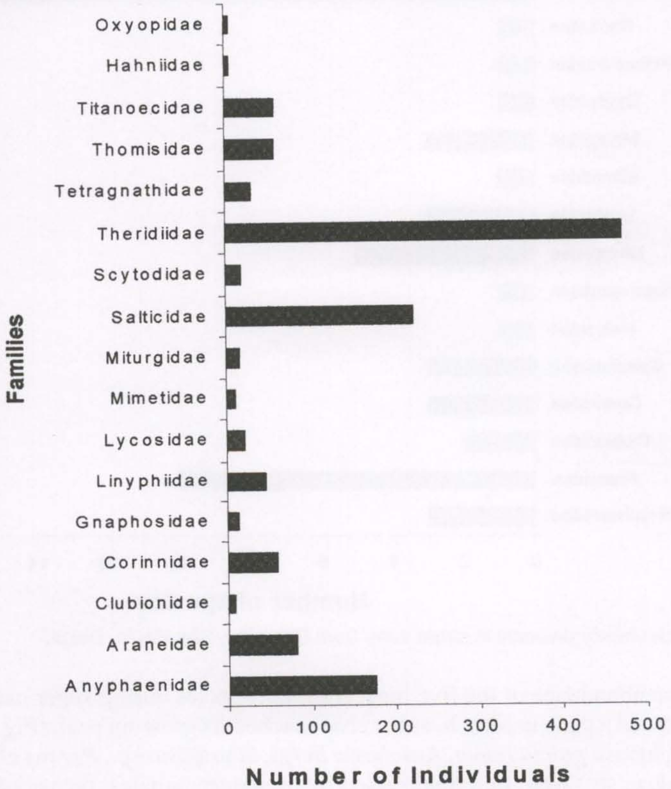

Fig. 2. Spider family abundances in sugar cane from Botucatu, São Paulo, Brazil. (N > 1 individual).

Chrysso pulcherrima (Mello-Leitão, 1917) (Theridiidae) comprised 28.2 % of the total spiders sampled, and together with *Arachosia bergi* (Simon, 1880), *Psecas* cf. *chapoda*, *Goeldia* sp., *Sanogasta* sp., *Euophrys* sp. and *Tmarus* sp., accounted for 58.6 % of the total. *Arachosia bergi* and salticids were seen attacking Cicadellidae and Psocoptera, the most abundant pest insects in the upper part of the plants, similar to other studies (GUAGLIUMI 1973; NENTWIG 1987; GONZÁLEZ & CAVE 1997; REYNA *et al.* 1994). The four most specious spider families were the Salticidae, Theridiidae, Araneidae, and Linyphiidae (Fig. 3). Since the Salticidae and Theridiidae had the greatest number of individuals (Fig. 2), they seemed to be dominant in this sugar cane agroecosystem.

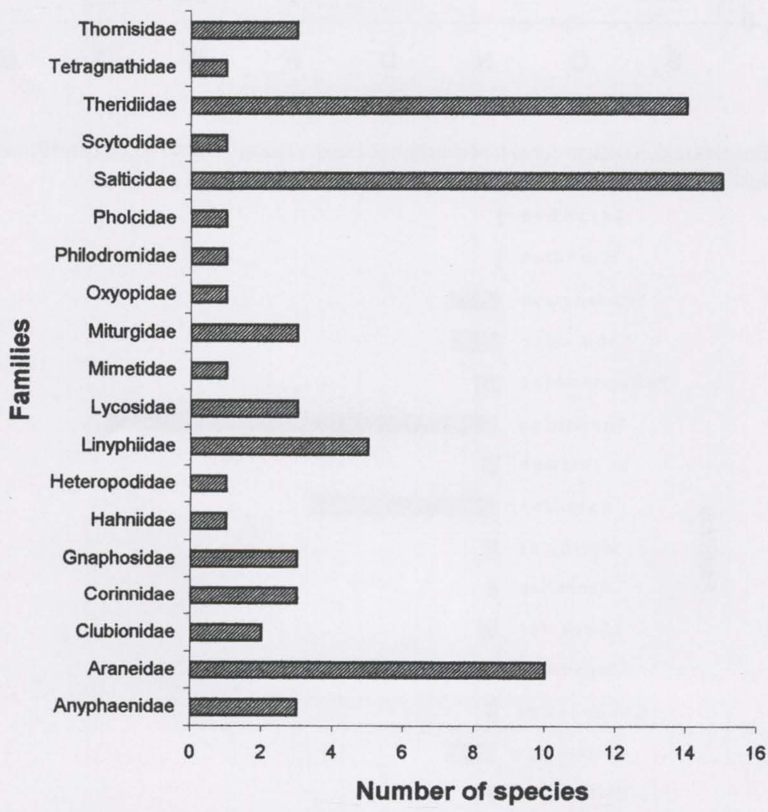

Fig. 3. Spider family diversity in sugar cane from Botucatu, São Paulo, Brazil.

The abundance of the five most common species during sugar cane development showed a peak in March, as the crop reached its growing peak (Fig. 4). These species (*Chrysso pulcherrima*, *Arachosia bergi*, *Sanogasta* sp., *Psecas* cf. *chapoda* and *Euophrys* sp.) were first represented by immature females, then adult females, followed by the young males. After March, crop growth was stable but the number of spiders decreased as the temperature dropped.

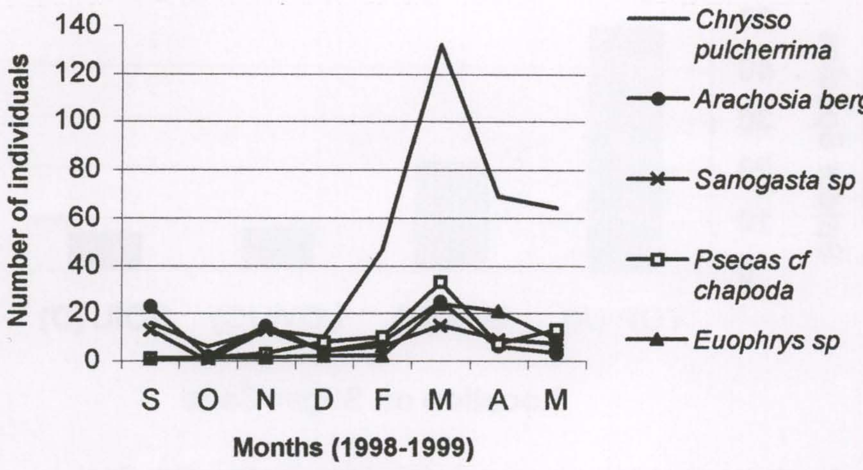

Fig. 4. Distribution of most abundant spiders throughout sugar cane development in Botucatu, São Paulo, Brazil.

Irregular weavers (38.5 %), nocturnal running spiders (20.8 %), and jumping spiders (17.34 %), were the most represented guilds (Tab. III). Remnants of eaten insects were observed in the webs of *Cyclosa* sp. at 0,50 m from the soil and consisted of a variety of beetle elytra, including the Scolytidae and *Xyleborus affinis* (Eichoff, 1867), a well known sugar cane pest. Hunting spiders are generally more tolerant to harvesting methods applied in the agroecosystems, making them common in USA crops (YOUNG & EDWARDS 1990; UETZ *et al.* 1999). However, since 55.2% of the spiders found on this Brazilian sugar cane crops were weavers, predatory activities of web building spiders up on sugar cane stalks must be investigated.

Spiders preferably selected the tops of sugar cane plants (Fig. 5). This area sheltered 48 species of spiders probably because rain water collected at the leaf-stem junctions, creating favored microhabitat (higher humidity and a small crevice) and offering them shelter from the wind, heat, and predators. In this microhabitat were found salticids and *Arachosia bergi*, a species more typical of pastures and swamps. They build nests in the grass and plunge into water stored in the grass when in danger (M. Ramirez, personal communication). *Arachosia bergi* and *Psecas* cf. *chapoda* have longitudinal stripes on their body and are elongated, making them cryptic within the dry leaves and color patterns on sugar cane and grass stems.

Despite the severe microclimatic conditions, chemical treatments, agricultural disturbances, bare soil, and especially periodic burning, the sugar cane agroecosystems surveyed here had a surprisingly diverse spider fauna. This is promising concerning efforts to employ endemic generalist predatory arthropods as agents of biological control in sugar cane plantations. The suppression of pre-harvest burning will allow the litter layer to accumulate, probably promoting a greater diversity of these natural enemies. Future studies should compare spider community compositions pre-and post- burning.

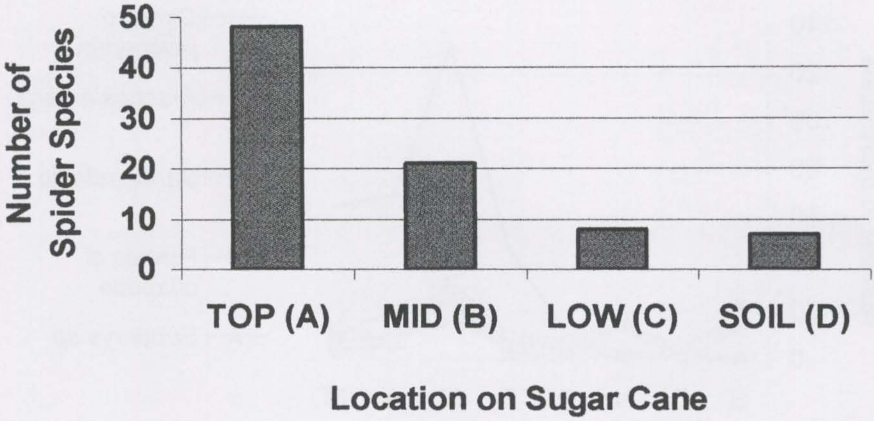

Fig. 5. Vertical stratification of spiders on sugar cane plants in São Paulo State, Brazil.

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