Species Diversity of Myrmecofauna and Araneofauna Associated with Agroecosystem and Forest Fragments and their Interaction with Carabidae and Staphylinidae (Coleoptera)

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SPECIES DIVERSITY OF MYRMECOFAUNA AND ARANEOFAUNA ASSOCIATED WITH AGROECOSYSTEM AND FOREST FRAGMENTS AND THEIR INTERACTION WITH CARABIDAE AND STAPHYLINIDAE (COLEOPTERA)

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ABSTRACT

Faunistic and statistical analyses of species diversity of the mimercofauna and araneofauna associated with variously managed agricultural fields and adjacent forest fragments and their interactions with Carabidae and Staphylinidae (Coleoptera) are needed to identify the key species affecting the dynamics within the arthropod population affecting the agroecosystem. This knowledge is needed to devise more effective integrated pest management programs. In this study, a population survey of ants (Hymenoptera: Formicidae) and spiders (Araneae) was performed. The aims of this work were to determine the dominant species, to examine the fauna through several indexes and to evaluate the occurrence of adverse interaction between these arthropods and Carabidae and Staphylinidae (Coleoptera). The experimental areas were located in Guaíra City, São Paulo, Brazil, which consists of forest fragments and soybean/corn crops under no-tillage and conventional systems. The arthropods were sampled by pitfall traps from Nov 2004 to Apr 2007. The traps were distributed along 2 transects of 200 m long with 100 m each in 2 fields in corn/soybean rotations and 100 m in the forest fragments adjacent to these agricultural fields. The fauna were characterized by diversity indices, evenness, similarity, abundance, dominance, frequency and consistency and interspecific interactions by Pearson's correlation. The ants, *Pheidole* spp. and *Camponotus blandus,* and the spider, *Trochosa* sp. were dominant in the no-till and conventionally tilled corn/soybean fields. The diversities of spider and ant species were high in the forest fragments, and at the forest-crop interface. Indeed ant species were highly and similarly diverse in all of the habitats, whereas the diversity of ant species was substantially less in no-till than in conventionally tilled corn/soybean fields. The density of the ant, *Pheidole* sp.1, correlated negatively with that of spiders, carabids, and staphylinids in the no-till soybean/corn fields.

Key Words: biological control, diversity, faunistic analysis, interaction, predators

RESUMO

Diversidade de espécies da mimercofauna e araneofauna associadas a agroecossistemas e fragmento florestal e sua interação com Carabidae e Staphylinidae (Coleoptera). Neste estudo foi realizado um levantamento populacional de formigas (Hymenoptera) e aranhas (Araneae) visando-se determinar as espécies dominantes, analisar a fauna por meio de vários índices e avaliar a ocorrência de interações interespecíficas adversas entre esses artrópodes e Carabidae e Staphylinidae (Coleoptera). As áreas experimentais localizaram-se no município paulista de Guaíra, sendo constituídas de fragmento florestal e cultura da soja/milho sob sistema de plantio direto e convencional. As amostragens foram realizadas no período de novembro/2004 a abril/2007, sendo quinzenal durante o período de safra e mensal nas entressafras. Para a obtenção das amostras utilizou-se armadilhas de solo distribuídas em dois transectos de 200 m de comprimento, sendo 100 m na cultura e 100 m no fragmento. A fauna foi caracterizada pelos índices de diversidade, equitabilidade, similaridade, abundância, dominância, freqüência e constância e a interação interespecífica por correlação de Pearson. As espécies de formigas do gênero *Pheidole* e *C. blandus* são dominantes em áreas com sistemas de plantio direto e convencional, o mesmo ocorrendo com o aracnídeo *Trochosa* sp. A diversidade de espécies de aranhas e formigas é elevada no fragmento florestal, na interface e na cultura soja/milho sob sistema de plantio convencional. A maior similaridade de espécies de formigas e aranhas ocorre entre fragmento florestal e cultura soja/milho sob sistema de plantio direto que sob plantio convencional. O formicídeo *Pheidole* sp.1 correlaciona-se negativamente com aranhas, carabídeos e estafilinídeo em campo de soja/milho com sistema de plantio direto.

Palavras Chave: Controle biológico, diversidade, análise de fauna, interação, predadores

Forest fragments are considered natural habitats of insect predators, which may contribute to the occurrence of natural enemies in crops. Such components have economic value and their presence should be maintained or built into agroecosystems (Bedford & Usher 1994; Dennis & Fry 1992; Asteraki et al. 1995). It is noteworthy that in forest fragments there is a great variety of species of insects, usually with a relatively small number of individuals per species. In these environments, the population of each species is controlled by several interspecific relationships (Lara 1992). On the other hand, in monocultures a different scenario usually exists, i.e., a small number of species, each with a large population (Lara 1992).

Agricultural crops often have reduced insect diversity due to physical changes in the environment caused by the vegetation and cultural practices (Giller et al. 1997). The diversity and abundance of insect predators in these habitats are related to vegetation in the vicinity of the cultivated field, which may favor the occurrence of these natural enemies; and thereby increase the sustainability of the agroecosystem (Dyer & Landis 1997; Thomas et al. 2002; Lewinsohn et al. 2005). Studies on the composition of insect pests in crops and adjacent forest fragments have proved fundamental to understanding the role organisms play in agroecosystems (Clark et al. 1997). Most of the arthropod predators found in or on the soils of cultivated crops are species of spiders (Araneae), ants (Formicidae), ground beetles (Carabidae) and rove beetles (Staphylinidae) (Stinner & House 1990); and with respect to enhancing pest control, it is necessary to know how their populations respond to different crop management practices. Such knowledge is needed to help to determine options for increasing the density of these predators in agricultural systems (Andow 1992; Booij & Noorlander, 1992; Clark et al. 1997).

The study of insect fauna in conservation areas is of great importance for their use as benchmark areas with respect to elucidating species diversity and interactions in highly or partially modified ecosystems (Scatolini & Penteado-Dias 2003). In agriculture, these studies have been useful in developing programs of integrated pest management (Silveira Neto et al. 1977); and to characterize the community structure, and to assess the impact of environment on the insect fauna (Silveita Neto et al. 1995).

Ants are present in most terrestrial ecosystems. There are approximately 11,832 known species of ants, and there may be more than 21,000 ant species. Ants can constitute up to 80% of the animal biomass in a given ecosystem (Hölldobler & Wilson 1990); thus the paucity of taxonomic studies on such insects is deplorable (Silva 1998). Concern over environmental issues has led the search for bioindicators able to provide information on the ecosystem services that may be expected of the environment. Ants can be used as bioindicators of environmental quality, because they are to be sensitive to changes in environmental conditions, they have high species richness, wide geographical distribution, can be sampled easily and separated into morphospecies (Silva & Brandao 1999). Due to the various trophic levels that ants occupy in the food chain, their influence on the ecosystem can vary. Some ants are important predators of insects and other arthropods; thus ants have an important role in natural biological control (Hölldobler & Wilson 1990).

There are more than 39,000 described species of spiders, divided into 110 families (Platnick 2005). Spiders are ubiquitous except in the polar regions, and they are especially likely to be found in the presence of vegetation (Foelix 1996). These arthropods are known predators of a wide variety of organisms, especially insects (Nentwig 1989; Nyffeler et al. 1994). Spiders may be the most abundant natural enemies of economically important insects and mites, reaching high average densities both in natural environments and those modified by man (Rinaldi & Strong 1997). Spiders have great ecological importance (Coddington et al. 1991; Churchill 1997) because they occupy the top of the food chain of invertebrates (Coddington et al. 1991; Nyffeler et al. 1994), and they display the greatest diversity and abundance. Further spiders can be used as bioindicators because they are sensitive to biotic and abiotic changes in the environment (Foelix 1996).

Early works on spider diversity in Brazil were related to species surveys in the Atlantic region, especially in areas of Serra do Mar and on islands (Mello-Leitão 1923; Luederwaldt 1929; Bücherl 1949) such as the Isle of Cardoso, SP. These studies were restricted to ground spiders (Fowler & Venticinque 1995). Local arachnological surveys in Brazil have been conducted mainly during the 1990s in the Atlantic and Amazon regions (Hofer et al. 1994; Borges & Brescovit 1996; Martins & Lise 1997; Lise 1998; Höfer & Brescovit 2001), but such studies are largely lacking in other Brazilian ecosystems.

The objectives of this study were to survey populations of ants and spiders at the interface of forest fragments and cropped fields in order to identify dominant species, to analyze and characterize the ant and spider fauna through various indices, and to evaluate the occurrence of adverse interspecific interactions between ants, spider and staphylinid ground beetles.

Material and Methods

The study was conducted at 2 experimental areas located near Guaira City, SP, and at the Laboratório de Ecologia de Insetos—Faculdades de Ciências Agrárias e Veterinárias (FCAV), Universidade Estadual Paulista (UNESP), Jaboticabal Campus, SP.

Experimental Area 1 was located in the Farm Shed at latitude 20°21'10" South and longitude 48°14'47" West and soil type Hapludox. The experimental area consisted of a 48-ha fragment of semideciduous forest, and an 88.6-ha field that for the past 10 yr had been devoted to a no-till system of producing a summer crop of soybean *Glycine max* (L.) Merrill and a winter crop of corn *Zea mays* (L.).

Experimental Area 2 was located in the Wetlands Site at latitude 20°19'29" South and longitude 48°15'06" West, and soil type Hapludox. This area was about 2 km distant from Experimental Area 1, and consisted of a 6-ha fragment of semideciduous forest, and a 12-ha field in which conventional tillage was used to produce a summer crop of soybean and winter crop of corn.

During 2004/05, 2005/06 and 2006/07 in both experimental areas, soybean, *Glycine max*, was grown in the rainy summers with 0.50 m spacing between rows, and corn, *Zea mays*, was grown in the dry season with 0.80 m spacing between rows.

Insects were sampled with pitfall traps, each consisting of a plastic cup, 8 cm diam and 14 cm high, filled 1/3 with a solution of water and 1% formaldehyde and detergent. The trap was placed into another similar plastic cup that had been installed in the soil so that its rim was about 1 cm below the soil surface; thus the upper rim of trap was level with the soil surface.The bottom of the lower cup had been perforated to allow the drainage of rainwater. A 15 cm diam plastic cover affixed to three legs maintained at 7.6 cm (3 in) above each trap to prevent rain from filling the trap.

Two parallel 200-m transects separated 10 m apart were installed in each experimental area. Each transect spanned the habitat interface with 100 m in the forest fragment and 100 m in the field devoted to the production of soybean and corn. The interface consisted of barren 4-5 m wide strip largely devoid of vegetation. Arthropods were sampled by pitfall traps set along these transects. Thus 48 traps spaced 10 m apart were set in each area with 24 in the forest fragment and 24 in the cultured area. However at the interface traps were spaced 1 m apart with 4 traps per transect; because the interface was a transitional habitat between the forest fragment and the agricultural field.

The samples were taken every 14 days during the rainy season and monthly in the dry season, corresponding to the period from 9 Apr 2005 to 26 Apr 2007, totaling 44 sampling dates. The traps remained installed in the field for 1 wk. Then they were removed and sent to the laboratory for sorting, servicing and subsequent identification of arthropods. Dominance, abundance, frequency and constancy of species were obtained by means of the Anafau software (Moraes & Haddad 2003) developed at the Department of Entomology, Plant Pathology and Zoology, Escola Superior de Agricultura "Luiz Queiroz", The University of Sao Paulo (Esalq/Usp). In the program, discrepant data are analyzed by graphical residual analysis (Atkinson 1985) and are classified into exclusive categories known as super dominant, super abundant, and super frequent.

Constancy represents the percentage of species present in the survey. It was calculated based on the confidence interval (CI) of the arithmetic mean at 5% probability. The species were categorized into 3 classes, i.e., (i) Constant (W) - when the percentage of collections containing the species was above the upper CI limit, (ii) Accessory (Y) - when the percentage of collections containing the species fell within the CI, and (iii) Accidental (Z) - when the percentage of collections containing the species was below the lower CI limit.

Frequency is the percentage of each species relative to the total number of individuals collected (Silveira Neto et al. 1976); and the species were placed into 3 classes, i.e., (i) Little frequent (PF) - when the percentage of individuals captured was below the lower CI limit, (ii) Frequent (F) - when the percentage of individuals captured fell within the CI, and (iii) Very frequent (MF) - when the percentage of individuals captured was above the upper CI limit.

Abundance refers to the number of individuals per surface unit and varies in space and time (Silveira Neto et al. 1976). Abundance was determined by the total number of individuals of each species by use of a dispersion measure calculated from the CI of the arithmetic mean at 1 and 5% probability. Species were placed into 5 classes of abundance, i.e., (i) Rare (r) - number of individuals captured below the lower CI limit at 1% probability, (ii) Dispersed (d) - number of individuals captured between the lower CI limits at 5% and 1% probability, (iii) Common (c) - number of individuals captured within the CI at 5% probability, (iv) Abundant (a) - number of individuals captured between the upper CI limits at 5% and 1% probability, and (v) Very abundant (va) - number of individuals captured above the upper CI limit at 1% probability.

Dominance is the action exercised by the dominant organisms of a community. Dominance of beetle communities were assessed by the Shannon-Wiener and Morisita indices (Brower et al. 1998). Species with the largest abundance, dominance, frequency and constancy faunistic indices (Moraes et al. 2003) were designated as dominant.

Diversity was calculated by the Shannon – Wiener Index (H'), since it is the most commonly used index in ecology of communities (Ludwig & Reynolds 1988) and because it allows comparisons between communities.

The Equitability Index (E) represents the uniformity with which individuals are distributed in the sample. This index is obtained by the equation: E = H'/Hmax', where H' is the Shanon-Wiener Index and Hmax' is given by the following expression: Hmax' = log s, and where s is the number of species sampled.

The occurrence of interspecific interactions was assessed by determining the Pearson correlation coefficient (*r*) between the number of spiders, ground beetles, rove beetles and ants (Bussab & Morettin 1986). The species of Carabidae and Staphylinidae were those captured during the sampling described above. For data processing and analysis, we considered only the arthropod species represented by 10 or more individuals captured during the sampling period.

Species of Carabidae and Staphylinidae were identified by Dr. Sergio Ide of the Biological Institute, Center for Research and Development Plant Health - SP. The species of Araneae and Formicidae were identified, respectively, by Dr. Antonio D. Brescovit of the Butantan Institute, and by Dr. Ana Eugenia C. Flour of the Biological Institute of Sao Paulo.

Results and Discussion

In the no-tillage system 11,541 ants were captured belonging to 34 species (Table 1), while in conventional tillage area 16,585 ants were captured belonging to 39 species (Table 2). In the

Table 1. Total numbers of various species of ants captured at Guaira, SP during 2005 to 2007 in an area consisting of a forest fragment and an adjacent no-tillage field with a soybean - corn rotation; and analyzed for dominance (D), abundance (A), frequency (F) and constancy (C).

Species	N° individuals	%	D	A	F	C
Pheidole sp.3	8,412	50.72	SD	sa	SF	W
Pheidole sp.1	3,428	20.66	SD	sa	SF	W
Camponotus blandus	1,018	6.13	D	va	MF	W
Pheidole sp.9	714	4.30	D	va	MF	W
Dorymyrmex sp.2	561	3.38	D	va	MF	Y
Pheidole sp.2	487	2.93	D	va	MF	W
Pachycondyla sp.1	440	2.65	D	c	MF	W
Solenopsis	189	1.13	D	c	F	Y
Odontonanchus bauri	187	1.12	D	c	F	Y
Crematogaster sp.1	173	1.04	D	c	F	Y
Ectatoma	156	0.94	D	c	F	Y
Gnaptogenys	143	0.86	ND	c	F	Y
Camponotus sp.2	109	0.65	ND	c	F	Y
Pseudomyrmex	99	0.59	ND	c	F	Y
Megalomyrmex	69	0.41	ND	c	F	Z
Pagomomyrmex	67	0.40	ND	c	F	Z
Brachymyrmex sp.3	56	0.33	ND	d	PF	Z
Odontonanchus chelifer	41	0.24	ND	d	PF	Z
Pheidole sp.4	40	0.24	ND	d	PF	Z
Ectatoma edentatum	31	0.18	ND	r	PF	Z
Crematogaster sp.2	26	0.15	ND	r	PF	Z
Odontonanchus meinerti	24	0.14	ND	r	PF	Z
Hypoponera sp.2	21	0.12	ND	r	PF	Z
Pseudomyrmex sp.2	19	0.11	ND	r	PF	Z
Pachycondyla striata	12	0.07	ND	r	PF	Z
Ectatoma tuberculatum	11	0.06	ND	r	PF	Z
Pheidole sp.8	8	0.04	ND	r	PF	Z
Ectatoma pormagnum	6	0.03	ND	r	PF	Z
Camponotus cf. *lespesi*	6	0.03	ND	r	PF	Z
Trachymyrmex sp.2	5	0.03	ND	r	PF	Z
Sericomirmex	3	0.01	ND	r	PF	Z
Cephalotes pusillus	3	0.01	ND	r	PF	Z
Lachynomyrmex	3	0.01	ND	r	PF	Z
Total individuals	16,585					

SD = superdominant, D = dominant, ND = not dominant; sa = super abundant, very abundant = va, a = abundant, c = common, d = dispersed, r = rare; MF = very frequent, F = frequent, PF = infrequent; W = constant, Y = accessory, Z = accidental

TABLE 2. TOTAL NUMBERS OF VARIOUS SPECIES OF ANTS CAPTURED AT GUAIRA, SP DURING 2005 TO 2007 IN AN AREA CONSISTING OF A FOREST FRAGMENT AND AN ADJACENT CONVENTIONALLY TILLED FIELD WITH A SOYBEAN - CORN ROTATION; AND ANALYZED FOR DOMINANCE (D), ABUNDANCE (A), FREQUENCY (F) AND CONSTANCY (C).

Species	N° individuals	%	D	A	F	C
Pheidole sp.3	5,550	48.08	SD	sa	SF	W
Pheidole sp.1	2,394	20.74	SD	sa	SF	W
Pachycondyla sp.1	795	6.88	D	va	MF	W
Ectatoma tuberculatum	463	4.01	D	va	MF	W
Camponotus blandus	357	3.09	D	va	MF	W
Pheidole sp.2	356	3.08	D	va	MF	W
Dorymyrmex sp.2	269	2.33	D	va	MF	Y
Pheidole sp.9	210	1.81	D	va	MF	Y
Odontonanchus bauri	209	1.81	D	va	MF	W
Solenopsis	150	1.29	D	c	F	Y
Pagomomyrmex	123	1.06	D	c	F	Y
Gnaptogenys	89	0.77	ND	c	F	Y
Ectatoma edentatum	86	0.74	ND	c	F	Y
Pheidole sp.4	69	0.59	ND	c	F	Y
Crematogaster sp.1	65	0.56	ND	c	F	Y
Camponotus sp.2	50	0.43	ND	c	F	Y
Pachycondyla striata	40	0.34	ND	d	PF	Z
Ectatoma pormagnum	39	0.33	ND	d	PF	Z
Odontonanchus chelifer	27	0.23	ND	r	PF	Z
Camponotus sp.4	22	0.19	ND	r	PF	Z
Hypoponera sp.2	21	0.18	ND	r	PF	Z
Pseudomyrmex sp.2	21	0.18	ND	r	PF	Z
Pseudomyrmex	19	0.16	ND	r	PF	Z
Pheidole sp.8	16	0.13	ND	r	PF	Z
Brachymyrmex sp.3	16	0.13	ND	r	PF	Z
Camponotus cf. *lespesi*	13	0.11	ND	r	PF	Z
Camponotus cf. *dispérsi*	13	0.11	ND	r	PF	Z
Megalomyrmex	12	0.10	ND	r	PF	Z
Odontonanchus blandus	11	0.09	ND	r	PF	Z
Sericomirmex	10	0.08	ND	r	PF	Z
Paratrechina sp.1	5	0.04	ND	r	PF	Z
Trachymyrmex sp.2	4	0.03	ND	r	PF	Z
Odontonanchus meinerti	4	0.03	ND	r	PF	Z
Pheidole sp.5	3	0.02	ND	r	PF	Z
Cephalotes pusillus	2	0.01	ND	r	PF	Z
Labidus praedator	2	0.01	ND	r	PF	Z
Crematogaster sp.2	1	0.00	ND	r	PF	Z
Lachynomyrmex	1	0.00	ND	r	PF	Z
Total individuals	11,541					

D = dominant, ND = not dominant, SD = superdominant; sa = super abundant, very abundant = va, a = abundant, c = common, d = dispersed, r = rare; MF = very common, F = frequent, PF = infrequent; W = constant, Y = accessory, Z = accidental

area under the conventional tillage the ant species *Pheidole* sp.3, *Pheidole* sp.1, *Ectamoma tuberculatum* (Olivier), *Camponotus blandus* (Fr. Smith 1858), *Pheidole* sp.2, *Odontomachus bauri* (Emery 1892) and *Pachycondyla* sp. 1 were found to be dominant (Table 1). Further, in the no-tillage area *Pheidole* sp.1, *Pheidole* sp.2, *Pheidole* sp.3, *Pheidole* sp.9 and *Camponotus blandus* (Fr. Smith 1858) were found to be dominant (Table 2).

In the no-tillage area 1,154 individual spiders were sampled, while 1,148 individual spiders were sampled in the conventional tillage area. In the no-tillage area *Trochosa* sp. and *Mesabolivar* sp. were classified as dominant (Table 3), and those classified as dominant in the conventional tillage area were *Trochosa* spp. and *Freya* sp. (Table 4).

Spiders of the genus *Trochosa* sp. are extremely common in agroecosystems, where they prey on a wide variety of pests (Reichert & Lockley 1984). It is emphasized that the determination of the dominant species of arthropod preda-

TABLE 3. TOTAL NUMBERS OF VARIOUS SPECIES OF SPIDERS CAPTURED AT GUAIRA, SP DURING 2005 TO 2007 IN AN AREA CONSISTING OF A FOREST FRAGMENT AND AN ADJACENT NO-TILLAGE FIELD WITH A SOYBEAN -CORN ROTATION; AND ANALYZED FOR DOMINANCE (D), ABUNDANCE (A), FREQUENCY (F) AND CONSTANCY (C).

Species	No. of individuals	%	D	A	F	C
Troshosa sp.	309	26.77	D	va	MF	W
Mesabolivar sp.	168	14.55	D	va	MF	W
Freya sp.	85	7.36	D	c	F	W
Apopyllus sp.	82	7.10	D	c	F	Y
Falconina sp.	78	6.75	D	c	F	Y
Hisukatus sp.	62	5.37	ND	c	F	Y
Castianeira sp.	53	4.59	ND	c	F	Y
Magula sp.	50	4.33	ND	c	F	Y
Abapeba sp.	49	4.24	ND	c	F	Y
Hogna sp.	46	3.98	ND	c	F	Y
Dipoena sp.	35	3.03	ND	c	F	Z
Goeldia sp.	31	2.68	ND	c	F	Y
Scytodes sp.	30	2.59	ND	d	PF	Z
Neocteniza sp.	25	2.16	ND	d	PF	Z
Hypognatha sp.	20	1.73	ND	r	PF	Z
Nops sp.	13	1.12	ND	r	PF	Z
Trachelas sp.	10	0.86	ND	r	PF	Z
Oxyopes sp.	8	0.69	ND	r	PF	Z
Total of individuals	1,154					

D = dominant, ND = not dominant; sa = super abundant, very abundant = va, a = abundant, c = common, d = dispersed, r = rare; VC= very common, F = frequent, PF = infrequent; W = constant, Y = accessory, Z = accidental.

TABLE 4. TOTAL NUMBERS OF VARIOUS SPECIES OF SPIDERS CAPTURED AT GUAIRA, SP DURING 2005 TO 2007 IN AN AREA CONSISTING OF A FOREST FRAGMENT AND AN ADJACENT CONVENTIONALLY TILLED FIELD WITH A SOYBEAN - CORN ROTATION; AND ANALYZED FOR DOMINANCE (D), ABUNDANCE (A), FREQUENCY (F) AND CONSTANCY (C).

Species	No. of individuals	%	D	A	F	C
Troshosa sp	242	21.08	D	va	VF	W
Mesabolivar sp	133	11.58	D	va	VF	Z
Freya sp	124	10.80	D	va	VF	W
Apopyllus sp.	75	6.53	D	c	F	Y
Falconina sp.	60	5.22	N D	c	F	Y
Hisukatus sp.	59	5.13	N D	c	F	Y
Castianeira sp.	56	4.87	N D	c	F	Y
Magula sp.	48	4.18	N D	c	F	Y
Abapeba sp.	47	4.09	N D	c	F	Y
Hogna sp.	46	4.00	N D	c	F	Y
Dipoena sp.	45	3.91	N D	c	F	Y
Goeldia sp.	45	3.91	N D	c	F	Y
Scytodes sp.	44	3.83	N D	c	F	Y
Neocteniza sp.	41	3.57	N D	c	F	Y
Hypognatha sp.	37	3.22	N D	d	IN	Z
Nops sp.	26	2.26	N D	r	IN	Z
Trachelas sp.	14	1.21	N D	r	IN	Z
Oxyopes sp.	6	0.52	N D	r	IN	Z
Total of individuals	1,148					

D = dominant, ND = not dominant; sa = super abundant, very abundant = va, a = abundant, c = common, d = dispersed, r = rare; VF = very frequent, F = frequent, PF = infrequent; W = constant, Y = accessory, Z = accidental.

tors in agroecosystems is considered fundamental to the management of natural biological control agents because they have the potential to be used in biological control of pests (Ellsbury et al. 1998).

The coefficients of species diversity and evenness obtained for spiders were somewhat similar among forest fragments, crop/forest interfaces, and soybean/corn fields in both experimental areas (Table 5). The results of this study indicated that the diversity of spider species in all of the habitats studied was high; and this showed that the occurrence of various spider species was little affected by the environmental conditions. Spiders make up one of the most abundant groups of predators in most terrestrial habitats, including farmland. Despite the microclimatic conditions, chemical treatments and agricultural practices, the spider fauna in agroecosystems is surprisingly diverse (Rinaldi 1995; Rinaldi & Forti 1997).

The diversity of ant species was highest in the conventionally tilled/forest fragment interface, and moderately high in the adjacent forest and in the conventionally tilled soybean/corn field. In contrast in the no-tillage area the diversity of ants was fairly high in the forest fragments, 70% as high as that in the no-till/forest interfaces, and 68% as high in the no-till crop area (Table 5). The coefficient of species diversity of ants was higher in the forest fragment adjacent to the no-tillage field (0.849) than in forest fragment adjacent to the conventional tillage field (0.727). This discrepancy may have occurred because the fragment size of the no-tillage field (48 ha) was about 6 times larger than the conventionally tilled field (6 ha). According to Thomazini & Thomazini (2000) and Pichancourt et al. (2006), fragment size can interfere with insect diversity.

With respect to the effect of the tillage system, there was less diversity of ants in the no-tillage field than in the conventional tillage field. These results differ from those of some authors (Sloderbech & Yeargen 1983; Marasas et al. 2001) who reported that the conventional tillage decreased the diversity of arthropod predators compared to no-tillage. The opposite result has also been reported (Barney & Pass 1986), as has the non-existence of a differential effect of the two tillage programs on arthropod diversity (Cárcamo et al. 1995).

We highlight the high diversity of species observed at the interfaces between forest fragments and agricultural fields (Table 5). These results are consistent with those of Alderweireld (1989) who reported the occurrence of high species richness of spiders in the interfaces of different habitats.

In the area under no-till, the species compositions of communities of spiders and ants were highly similar between the various habitats in the 2 areas (Table 6). This may have occurred because the no-tillage system was more favorable as a refuge and feeding of these arthropods. In the conventionally tilled area the species compositions of spiders and ants were very similar between the forest fragments and the interfaces, but less similar between the cultivated areas and the interfaces, and even less similar between the forest fragments and the cultivated areas.

According to Kajak & Lukasiewicz (1994), the greater the similarity of arthropod communities in adjacent habitats, the greater the likelihood of dispersal of individuals between these habitats. Thus, higher levels of similarity obtained for ants and spiders throughout the no-till system and in the interface between the forest fragment and conventional tillage field implies the existence of substantial dispersion of these arthropods between these habitats (Table 6). On the other hand, the irregularities in similarity of arthropod species composition in the conventional tillage agroecosystem must have occurred due to some unfavorable environmental factors (Foelix 1996,

TABLE 5. COEFFICIENTS OF DIVERSITY (H) AND EQUITABILITY (E) FOR ARANEAE AND FORMICIDAE IN GUAIRA, SP. 2005/2007.

	Forest Fragment		Cultivated		Interface	
Location/Taxon	H	E	H	E	H	E
Area #1-no tillage						
Araneae	1.126	0.816	1.233	0.894	1.250	0.918
Formicidae	0.849	0.554	0.577	0.387	0.860	0.594
Area #2-coventional tillage						
Araneae	1.205	0.884	1.205	0.873	1.135	0.845
Formicidae	0.727	0.467	0.723	0.490	0.905	0.601

Note: Area #1 consisted of a 48 ha forest fragment and an 88.6 ha no-till field used to produce a summer crop of soybean and a winter crop of corn.

Area #2 consisted of 6 ha forest fragment and a 12 ha conventional tillage field used to produce a summer crop of soybean and a winter crop of corn.

TABLE 6. MORISITA SIMILARITY COEFFICIENTS FOR ARANEAE AND FORMICIDAE CAPTURED IN DIFFERENT HABITATS IN GUAIRA, SP, 2005-2007.

	Compared Habitats		
Location/Taxon	Fragment × Cultivated	Fragment × Interface	Cultivated × Interface
Area #1-no tillage			
Araneae	0.817	0.835	0.930
Formicidae	0.930	0.977	0.895
Area #2-coventional tillage			
Araneae	0.548	0.975	0.581
Formicidae	0.461	0.951	0.599

Silva & Brandao 1999), which restricted the occurrence of certain species in the conventionally tilled farm land.

Among the arthropods studied, just certain ants in the experimental area with no-till system showed negative correlation with other arthropods (Table 7), these results indicated an adverse interaction between certain species. In the forest fragments negative correlations occurred between the ant, *Pheidole* sp.1, and the spider, Freya sp.1, and between *Pheidole* sp.1 and the carabid, *Odontocheila nodicornis* (Dejean); as well as between the ant, Crematogater sp.1 and the staphylinid bettle, *Eulissus chalybaeus* Mannerheim. In the cropped fields negative interactions occurred between *Pheidole* sp.1 and the following spiders: *Falconina* sp., *Hogna* sp. and *Trochosa* sp.1; and between *Pheidole* sp.1 and the following beetles: the carabids, *Selenophorus seriatoporus* and *Scarites* sp. 4, and the staphylinid, *Xantholinini* sp.2. According to Rosenheim et al. (1995), negative interactions occur frequently between different predatory insect species. Since *Pheidole* sp.1 interacted adversely with various species of arthropods in the forest fragment, and especially in the no-till soybean / corn rotation, it is clear that this species has a high potential to interact negatively with diverse arthropod species. These data are consistent with those of Cividanes et al. (2009), who found adverse interactions between *Pheidole* sp.1 and the carabid, *Calosoma granulatum* Perty, in a corn crop. It is noteworthy that the genus *Pheidole* is composed of cosmopolitan species that are distinguished by their predatory ability (Cuezzo 1998).

TABLE 7. PEARSON CORRELATION COEFFICIENTS BETWEEN THE NUMBER OF ANTS AND THE NUMBER OF SPIDERS, GROUND BEETLES AND ROVE BEETLES CAPTURED IN A FOREST FRAGMENT AND SOYBEAN/CORN IN NO-TILLAGE SYSTEM. GUAIRA, BRAZIL, 2005-2007.

	Formicidae		
	Forest Fragment		Cropped Field
Taxon	*Pheidole* sp.1	*Crematogaster* sp.1	*Pheidole* sp.1
Araneae		—	—
Freya sp.1	-0.47*	—	—
Falconina sp.	—	—	-0.43*
Hogna sp.	—	—	-0.39*
Trochosa sp.1	—	—	-0.41*
Carabidae			
Odontocheila nodicornis	-0.40*	—	—
Selenophorus seriatoporus		—	-0.37*
Scarites sp.4	—	—	-0.47*
Staphylinidae			
Eulissus chalybaeus	—	-0.40*	—
Xantholinini sp.2	—	—	-0.49*

*Significant at 5% probability.

Pheidole is also the largest genus with species diversity, abundance and geographical distribution and, therefore, is considered the predominant genus on a global scale. Some authors (Vasconcelos 1999; Leal 2002; Bieber et al. 2006) reported the genus *Pheidole* as best represented in collections of ants in forests. Ants in the genera, *Pheidole* and *Crematogaster*, and the spider, *Trochosa* sp. are dominant in no-till and conventionally tilled fields.

In conclusion, the similarity of species of ant communities and the similarity of species of spider communities are each greater between the forest fragment and the no-till soybean/corn field than between the forest fragment and the conventionally tilled soybean/corn field. The predatory ant, *Pheidole* sp.1, correlates negatively with spiders, carabid ground beetles and staphylinid rove beetles in the no-till soybean/corn field.

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