Composition and diversity of bees (Hymenoptera) attracted by Moericke traps in an agricultural area in Rio Claro, state of São Paulo, Brasil

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ABSTRACT. The composition and diversity of bees in an agricultural area in Rio Claro, state of São Paulo, Brazil, were studied from May 2003 to June 2004, using Moericke traps. The collection site, an area with 58.08 hectares, is characterized by grain production and direct planting, with 70% of the surrounding area planted with sugar cane. During the study, 456 bees were collected, distributed among 20 genera, pertaining to the families Andrenidae (4.8%), Apidae (40.8%) and Halictidae (54.4%). Specimens of genera *Dialictus* (38%) and *Diadasia* (30%) predominated in this area. The species diversity, assessed using the Shannon and Simpson indices, were H'=1.88 and 1/D= 4.15, respectively, and the Evenness index was 0.61.

KEYWORDS. Community ecology, apifauna, annual crops, direct planting, pantraps.

RESUMO. Composição e diversidade de abelhas (Hymenoptera) coletadas por armadilhas Moericke em uma área agrícola de Rio Claro, Estado de São Paulo, Brasil. Foram estudadas a composição e diversidade de abelhas em uma área agrícola no município de Rio Claro, Estado de São Paulo, de maio de 2003 a junho de 2004, utilizando armadilha de Moericke. O local de coleta, uma área com 58,08 hectares, caracteriza-se pela produção de grãos e a prática de plantio direto, sendo que 70% da área de entorno é utilizada para o plantio de cana-de-açúcar. Foram coletadas 456 abelhas distribuídas em 20 gêneros, pertencentes às famílias Andrenidae (4,8%), Apidae (40,8%) e Halictidae (54,4%). Espécimes dos gêneros *Dialictus* (38%) e *Diadasia* (30%) foram predominantes nesta área. A diversidade de espécies avaliadas pelos índices de Shannon e Simpson foram H'=1,88 e 1/D= 4.15, respectivamente, e o índice de Equitatibilidade de 0,61.

PALAVRAS-CHAVE. Ecologia de comunidade, apifauna, cultura anual, plantio direto, armadilha de água.

The Hymenoptera species are vital components of terrestrial land systems (LaSalle & Gauld, 1993), and bees in particular are the most important pollinators of natural vegetation. Many of the angiosperm species in habitats such as tropical forest and savannah are pollinated by bees, thus sustaining an entire guild of herbivores and frugivores (Neff & Simpson, 1993; Potts *et al*., 2006).

Bees are also dependent on the floral products of the angiosperms, collecting mainly nectar and pollen as carbohydrates and protein sources, respectively, to feed the adults and, especially, the young brood; some species collect oil that is added to the pollen mass to feed the larvae. A review of the various adaptations of plants and bees can be found in Michener (2000).

Many cultivated plants depend on ecological services offered by bees for their development (Richards, 2001; Maués, 2002) or to increase and improve the production of fruits and seeds (Santana *et al*., 2002; Westerkamp & Gottsberger, 2002; Malerbo-Souza *et al*., 2003; Witter & Blochtein, 2003; D'Avila & Marchini, 2005). The basis for a sustainable agriculture is the maintenance of a diversified pollinator fauna for a wide variety of cultivated species.

Some authors estimate that 85% of crops are pollinated by *Apis* Linnaeus, 1758 (Williams, 2002), and the remainder by native bees, which appears to be an overestimative (Michener, 2000); but the consensus is that *Apis* is one of the most abundant pollinators for many crops. In Brazil, 50% of the tropical fruit crops are pollinated by *Apis*, and the remainder by a diversity of native bees (Castro, 2002).

Urban growth and expansion of agricultural area for food production are directly related to the reduction in populations of native bees and the disappearance of species recorded throughout the world, and the destruction of habitats is cited as the most important factor contributing to this decline, with the disappearance of nesting and foraging sites (Corbet *et al*., 2001; Steffan-Dewenter *et al*., 2002).

In Brazil, many studies have been developed in agricultural areas, however they have focused either on a particular plant species of economic interest, or on one group of pollinating bees (MMA, 2006). Pinheiro-Machado *et al*. (2002), in a compilation of 46 surveys carried out in various regions of Brazil, found that only 10% had been conducted in agricultural environments. Silveira & Campos (1995) and Andena *et al*. (2005) studied the communities of bees associated to Cerrado vegetation in a fragment enclosed by agricultural matrix in Corumbataí (state of São Paulo), very close to Rio Claro.

Since knowledge regarding the bee fauna in agro-ecosystems is recommended in order to be able to sketch a profile of the locale and obtain information to monitoring the area (Pinheiro-Machado & Silveira, 2006), the objective of the present study was to examine the composition and diversity of the bee fauna in an agricultural area located within the municipality of Rio Claro, state of São Paulo, Brazil.

MATERIAL AND METHODS

The study area is located in the northeastern Paulista sector of the Paraná Sedimentary Basin, in central state of São Paulo, municipality of Rio Claro, 180km from the city of São Paulo. The altitude of the region varies from 500 to 700m, and its primitive vegetation, classified as cerrado, has been systematically substituted by the advance of the urban area, and in the rural areas, by coffee plantations, followed by orange groves, and is currently planted mainly with sugar cane. The climate is classified as Cwa according to the Köeppen classification, i.e. tropical with two well-defined seasons ("C" signifies that the mean temperature during the coldest month varies between 3ºC and 18ºC, "w" that the winter is dry, and "a" that the hottest month has temperatures exceeding 22ºC). The mean annual precipitation is 1600mm. During the period of drought, from April to September, the mean precipitation level is below 100mm (Troppmair, 1992). The soil is classified as red-yellow latosol with a sandy layer.

The study area is located in a rural area (22º20'262"S, 47º32'768"W) (Fig. 1). It encompasses 58.08 hectares which are used for the production of grains (beans, corn, sorghum, and wheat) in a direct planting system with irrigation and pesticide use to control plagues.

Sixteen yellow Moericke traps containing 1.5 liters of water and 10 drops of dishwashing liquid were used to collect the bees, placed directly on the ground around the planted fields at a distance of 100m from each other (Calabuig, 2000). Seven traps were placed along the trail that separates the planted fields from the preservation area along the banks of Cachoeirinha Creek, which passes through the property. In this area, the predominant vegetation is composed of grasses (*Brachiaria* and *Digitaria*) and some shrubs (*Vernonia polyanthes* – Asteraceae and *Solanun erianthus* – Solanaceae), and was used regularly as pasture for cattle and horses; the other bank of the creek is planted and surrounded by some fruiting plants that compose the orchards of the neighboring farms. The other traps were also placed along the trail that surrounds the field, at the end of the property. The area surrounding the planted field is bordered by a narrow strip of vegetation (1-3m) composed by small trees and shrubs, predominantly *Cuscuta racemosa* and *Ipomoea* spp. (Convolvulaceae), *Mikania cordifolia* (Asteraceae) and some *Eucalyptus* (Myrtaceae); this entire area is surrounded by the sugar cane fields of the neighboring property. The location of the traps in the field is shown in Fig. 1.

Two monthly collections were carried out from May 2003 through June 2004, with the exception of October 2003 and January 2004. The traps remained exposed in the field for 36 hours, and the bees were sorted and identified. Identification was based on the keys of Michener *et al*. (1994) and Silveira *et al.* (2002). Confirmation and identification of the Halicitidae taxa were done by Dr. Beatriz Coelho (Museu de Zoologia, USP - MZSP) and the others by Dr. Isabel Alves-dos-Santos (Laboratório de Abelhas – USP/SP). The vouchers were deposited in the Paulo Nogueira Neto collection at the Universidade de São Paulo (USP).

Following identification, the bees were grouped into body size classes according to the mean size presented by Michener (2000).

The diversity of bee species collected was measured using the Shannon index (Magurran, 1988), the

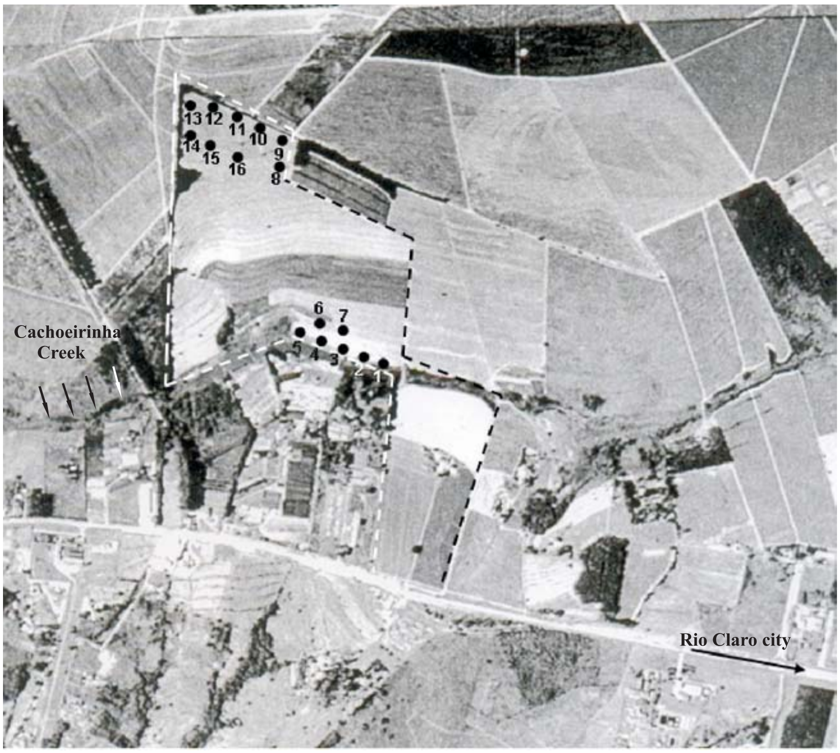

Fig. 1. Aerial photograph of the studied area in Rio Claro, state of São Paulo, showing the placement of the traps in the field (circles 1 to 16). (Source: Ceapla/UNESP)

Evenness index, which represents the relative participation in real diversity estimated as a function of maximum diversity expected theoretically ($E=H'/H_{max} \times 100$), as well as the Simpson index to verify species dominance. The program used for these calculations was BIO-DAP (THOMAS, 2000).

Relative frequency of the taxa (RF=n x 100/N; where n=number of bees collected/taxon and N=total number of bees collected) was calculated, as well as the relative frequency of the genus within the family (RFF=n x 100/NF; where n=number of bees and NF = total number of bees collected in the family).

During the study, it was registered the different kinds of crops and the use of pesticides in the area.

RESULTS

The collection yielded 456 bees of three families (Andrenidae, Apidae and Halictidae), ten tribes, twenty genera and twenty two species (Tab. I).

Halictidae (N=248) was the family that contributed most to the sampled bee fauna during the study period (54.4%), followed by Apidae (N=186; 40.8%) and Andrenidae (N=22; 4.8%) (Fig. 2).

Table I. Taxa collected in Rio Claro, state of São Paulo, from May 2003 to June 2004, using Moericke traps (RF, relative frequency of the taxon collected in the total; RFF, relative frequency of the genus in relation to the family to which it belongs).

Taxa	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total	RFF	RF
ANDRENIDAE																	
OXAEINAE																	
Oxaea flavences Klug, 1807	1			2											3	13.6	0.7
PANURGINAE; Calliopsini																	
Acamptopoeum sp.	2								2	2	1		1		8	36.4	1.8
Callonychium sp.				2			2	1	1		1		1	8	36.4	1.8	
PANURGINAE; Protandrenini																	
Psaenythia sp.	3														3	13.6	0.7
Total	6	0	0	2	2	0	0	2	3	3	1	1	1	1	22		
APIDAE																	
APINAE																	
Apini; Apina																	
Apis mellifera Linnaeus, 1758	6	2	4	7	4	3							1		27	14.5	5.9
Apini; Meliponina																	
Trigona spinipes (Fabricius, 1793)	2		1	1							1				5	2.69	1.1
Emphorini																	
Ancyloscelis sp.					1									1	0.54	0.2	
Diadasia sp.	5	1		1						2	5	3	115	3	135	72.6	30
Exomalopsini																	
Exomalopsis sp.	4		2	7	1	1				1					16	8.6	3.5
Tetrapediini																	
Tetrapedia sp.	1														1	0.54	0.5
XYLOCOPINAE; Ceratinini																	
Ceratina sp.	1														1	0.54	0.2
Total	19	3	7	16	5	5	0	0	0	3	6	3	116	3	186		
HALICTIDAE																	
HALICTINAE; Augochlorini																	
Augochlora sp.	3	2	3	6	2		1	2	2	1	1				23	9.27	5
Augochlorella acarinata Coelho, 2004	3				1	1	2								7	2.82	1.5
Augochlorella ephyra (Schrottky, 1910)												1		1	0.4	0.2	
Augochlorella tredecim (Vachal, 1911)				1									1	0.4	0.2		
Augochloropsis sp.	2		1	2	4				2						11	4.44	2.4
Pereirapis semiaurata (Espinola, 1853)	7	1			1		5	2		7	2			1	26	10.5	5.7
Pseudaugochlora sp.				1											1	0.4	0.2
Thectochlora alaris (Vachal, 1940)					1				2		1				4	1.61	0.9
HALICTINAE; Halictini																	
Dialictus sp.	23	3	7	17	29	7	6	3	17	9	26	8	11	6	172	69.4	38
Pseudagapostemon sp.	1														1	0.4	0.2
Sphecodes sp.	1														1	0.4	0.2
Total	40	6	11	26	38	9	14	7	23	17	30	8	12	7	248		100
Monthly total	65	9	18	44	45	14	14	9	26	23	37	12	129	11	456		

In Halictidae, the most frequent genus was *Dialictus* (69.4%) followed by *Pereirapis* (10.5%), *Augochlora* (9.3%) and *Augochoropsis* (4.4%). It was not possible to observe a pattern in temporal distribution of these genera along the studied period (Tab. I, Fig. 3).

There was a peak in the abundance of the family Apidae in May, 2004. This occurred due to the fact that 105 individuals of *Diadasia* were collected in a single day, and this value was removed when Fig. 4 was generated in order to better illustrate the fluctuation of the other genera. Thus, *Diadasia* represents 72.6% of the total of the family, followed by *Apis* (14.5%) and *Exomalopsis* (8.6%) (Tab. I, Fig. 4).

A small number of individuals of Andrenidae was collected (N=22) and as observed for Halictidae (Fig. 3) and Apidae (Fig. 4), it was not possible to observe a pattern in the temporal distribution of the different genera (Tab. I, Fig. 5).

On the total, the bee fauna collected in the Moericke traps in this agricultural area was composed mainly of *Dialictus* (38%) and *Diadasia* (30%), followed by *Apis* (5.9%), *Pereirapis* (5.7%), and *Exomalopsis* (3.5%). The values of the Shannon, Evenness, and Simpson indices to the area were H'=1.88; E=0.61 e 1/D=4.16, respectively.

Observing the pattern of body size of the fauna, a predominance of genera with body size between 5-10mm was found, classified as "small size" by MICHENER (2000) and FRANKIE *et al*. (2005) (Fig. 6).

Table II presents the agricultural management applied to the area during the period of study, including crop rotation and pesticides application.

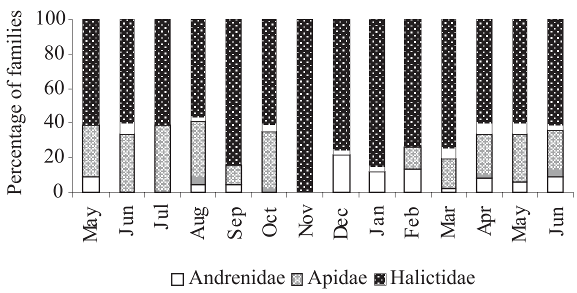

Fig. 2. Percentage of monthly contribution of each family to the total number of individuals collected in Rio Claro, state of São Paulo from May 2003 to June 2004, using Moericke traps.

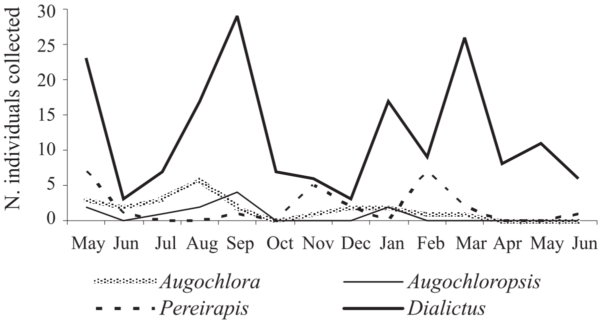

Fig. 3. Number of individuals of Halictidae collected with greater frequency throughout the study period in Rio Claro, state of São Paulo from May 2003 to June 2004, using Moericke traps.

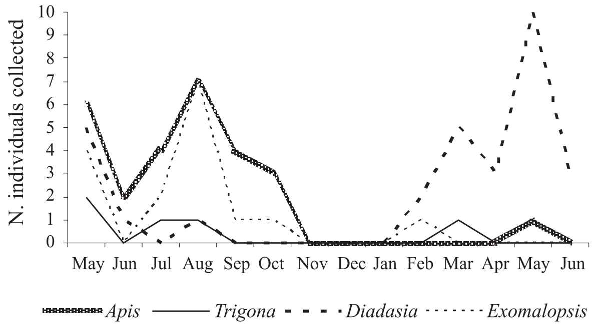

Fig. 4. Number of individuals of Apidae collected with greater frequency during the study period in Rio Claro, state of São Paulo from May 2003 to June 2004, using Moericke traps.

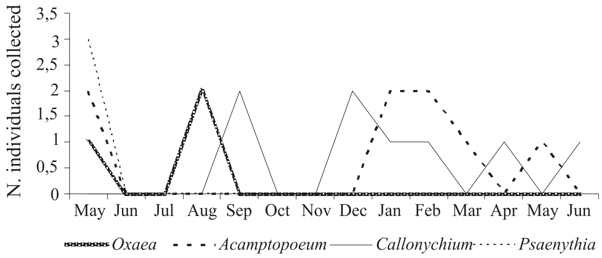

Fig. 5. Number of individuals collected with greater frequency of Andrenidae during the study period in Rio Claro, state of São Paulo from May 2003 to June 2004, using Moericke traps.

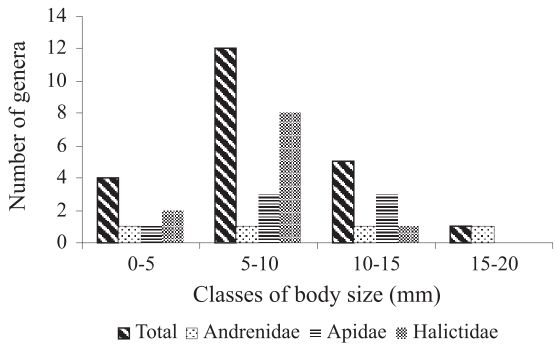

Fig. 6. Number of genera bees collected in Moericke traps in an agricultural area in Rio Claro, state of São Paulo from May 2003 to June 2004, using Moericke traps, grouped by body size classes.

Table II. Crop rotation and pesticides application in an agricultural area in Rio Claro, state of São Paulo, from May 2003 to June 2004.

Year	Month	Crop	Pesticide application	Active principle
2003	May	Sorghum and beans	Fungicide	Mancozeb
	June	Sorghum and beans	Fungicide	Chlorothalonil
	July	Sorghum and beans	No pesticide	
	August	No crop	No pesticide	
	September	No crop Insecticide	Herbicide Cypermethrin	Glyfosate
	October	Corn	Herbicide Insecticide	Alachlor + atrazine Chlorpyrifos
	November	Corn	No pesticide	
	December	Corn	No pesticide	
2004	January	Corn	No pesticide	
	February	Corn	Herbicide	Glyfosate
	March	No crop	No pesticide	
	April	Wheat	Herbicide	2,4-D
	May	Wheat	No pesticide	
	June	Wheat	Insecticide	Methamidophos

Following the harvest of beans at the end of June and beginning of July 2003, the area was used to plant corn from October 2003, to February 2004, and wheat from April 2004, until the end of the study period in June 2004.

DISCUSSION

In the agricultural area studied, the bee fauna was represented by three families out of the five that occur in Brazil (SILVEIRA *et al.*, 2002), distributed among ten tribes and 20 genera, corresponding to 23.81% of the tribes (42) and 9.13% of the genera (219) found in various ecosystems in Brazil (PINHEIRO-MACHADO *et al.,* 2002) and to 13.19% of the genera (145) recorded in the state of São Paulo (PEDRO & CAMARGO, 1999).

Analysis of the habits of the 20 genera found reveals one parasitic genus (*Sphecodes*), two eusocial genera (*Apis*, *Trigona*), and 17 genera of solitary bees with some tendency to communal (Xylocopinae) and sub social behavior (Augochlorini and Halictini), nesting in pre-existing cavities in tree trunks or decomposing wood, or nesting in the ground in banks or flat areas.

Sphecodes is cleptoparasitic, using the nests of other Halictidae bees (MICHENER, 2000; ENGEL, 2000). BORTOLI & LAROCA (1990) previously observed a reduction in parasitic species collected in the same area, from thirteen in 1962-63 to three in 1981-82, and associated the decline of these more specialized groups with modifications that had occurred in their habitat.

The low frequency of *Trigona*, observed in this study, may be due to the lack of nesting sites resulting from the intense agricultural activity; in the area the surrounding vegetation is cleaned regularly to prevent the propagation of weeds in the cultivated areas, and dead wood removed. Some small okra producers were observed burning the nests to prevent damage to their crops.

Except for some genera of solitary bees that nest in solid or decomposing wood (e.g. *Tetrapedia*), the majority of species dig holes in banks or flat ground (MICHENER, 2000; WCISLO *et al*., 2003) and prefer areas without vegetation, as observed experimentally by GATHMANN *et al*. (1994). These nesting sites are common in the area, around paths, field margin and roads.

The type of management employed in the area, i.e., the direct planting system, probably contributed to the presence of bees in the area, as this type of management helps maintain the humidity, temperature, and organic material in the soil, and benefits a diversified weed flora (SILVA *et al*., 2006), favoring the germination of the seed bank between two planting periods. Different plants occurring in the area, that grow and flower rapidly, mainly wild radish, *Raphanus raphanistrum* (Cruciferae); hairy beggarticks, *Bidens pilosa* (Asteraceae) and tropical soda apple, *Solanun viarum* (Solanaceae) may be sources of pollen and nectar for small bees such as those found in the area, which is mostly polyletic, exploiting various plants (BARBOLA *et al*., 2000).

The family Halictidae composed 54.4% of the sampled bee fauna and represents a group of bees whose species are often common in temperate regions (MICHENER, 2000) as well as various regions of Brazil (PINHEIRO-MACHADO *et al*., 2002); this predominance of Halictidae was also observed in different areas exposed to intense anthropic activity in the state of Paraná (BORTOLI & LAROCA, 1990; 1997; SCHWARTZ-FILHO & LAROCA, 1999; TAURA & LAROCA, 2001; JAMHOUR & LAROCA, 2004).

A large part of the Halictidae observed in those studies in Paraná corresponds to the genus *Dialictus*, as was also observed in this agricultural area (69% of the individuals collected).

The second family with the greatest occurrence in the area, 40.8%, was Apidae, as also observed in the altered areas in Paraná when individuals of Anthophoridae are considered, since these are also subordinated to Apidae (SILVEIRA *et al.*, 2002).

The highest number of *Apis* and *Exomalopsis* appeared in August 2003, coinciding with the flowering of the ruderal plants in the field, mainly wild radish, *Raphanus* (Cruciferae), and ironweed (*Vernonia*, Asteraceae) along the banks of the creek. This vegetation also may explain the occurrence of *Dialictus* (Halictidae) and *Diadasia* (Apidae) during the rainy period.

Diadasia is a genus of solitary bees, and the nests can, at times, form large aggregations (MICHENER, 2000). This behavior probably contributed for the collection of 105 individuals on a single day of May 2004 at the same collection point in this agricultural area. Regarding whether or not this increase in population was influenced by the availability of floral resources of the ruderal plants, the findings obtained in this study are not conclusive.

The family Andrenidae contributed with 4.8% of the local bee fauna, and is the group with the smallest contribution to the fauna in Paraná, being absent in Ilha das Cobras (SCHWARTZ-FILHO & LAROCA, 1999) and Passeio Público (TAURA & LAROCA, 2001). Specimens of the genus *Oxaea* is found only in Vila Velha State Park, Paraná, which is not considered an altered area (GONÇALVES & MELO, 2005). DUTRA & MACHADO (2001) collected visiting insects of *Stenolobium stans* (Bignoniaceae) in the city of Rio Claro, and recorded bees of *Oxaea* on the university campus, however the species was not found in an altered area in nearby Charqueada, state of São Paulo, probably due to the destruction of natural habitats, as discussed earlier. In preserved areas, like Corumbataí, state of São Paulo, this genus was collected in low frequency (SILVEIRA & CAMPOS, 1995; ANDENA *et al*., 2005).

Callonychium is a genus that had not yet been recorded as occurring in the state of São Paulo (SILVEIRA *et al.*, 2002; PEDRO & CAMARGO, 1999).

It can be observed that the families Halictidae, Apidae and Andrenidae, were well represented in May 2003, which may be due to the presence of cultivated beans in different phases of growth which were being irrigated, favoring the growth of many plants in the surroundings and in the rows between the crops.

The decrease in the number of individuals collected in October and November 2003 may have been influenced by the use of pesticides a few days prior to planting corn, which was being done on the day the traps were placed in the field (Tab. II). Cypermethrin, particularly, is reported to be toxic to bees (RISSATO *et al*., 2006).

The families Megachilidae and Colletidae did not form part of the sampled fauna, but did contribute significantly to the fauna in altered areas in Paraná, as well as preserved areas in other regions, as reported by Cure *et al*. (1992), Silveira & Campos (1995) and Andena *et al*. (2005). Cure *et al.* (1992) studied an area of secondary vegetation in the Zona da Mata (Forest Zone) in southeastern Minas Gerais, and the bee fauna sampled was composed by Apidae (65.6%), Halictidae (15.9%), Megachilidae (15%), Andrenidae (2.4%) and Colletidae (1.1%), out of a total of 712 individuals from 43 genera.

In the study conducted by Silveira & Campos (1995) in cerrado, the bee fauna was represented by Apidae (77%), Halictidae (12.3%), Megachilidae (3.8%), Andrenidae (3.6%) and Colletidae (3.3%), out of a total of 691 individuals collected from 47 genera. In the same area, after sixteen years, Andena *et al*. (2005) collected from June 2000 until May 2001, 923 bees of 40 genera. The proportion of Apidae (87%), Halictidae (4.9%), Colletidae (3.5%), Andrenidae (2.5%) and Megachilidae (2.1%) changed in this period of time between the first and the second study, probably due to changes in agricultural management around the area with increase of sugar cane plantation.

All these studies used entomological nets in order to collect bees directly from flowers and it could explain the differences in bee fauna sampled in those studies and in the present one.

Sampling with colored traps requires no specialized equipment, is relatively easy to carry out in the field, and can be a useful method for monitoring native and introduced bee populations in natural, agricultural, and restored areas. In addition, sampling is totally passive, with no potential effect of the collector (Leong & Thorp, 1999).

Cane *et al.* (2000) compared the use of Moericke traps to entomological nets and collected comparatively few bees in the traps – the opposite of the results obtained by Monsevièius (2004), even taking into consideration the different regions of collection. In another survey, Stephen & Rao (2005) used yellow and blue Moericke traps and collected 369 bees of 17 genera, the majority being *Bombus* (62.1%) and Halictidae (23.8%).

Although the trap is considered to be ecologically selective (Kirk, 1984), it has been used in various studies to capture large bees, such as *Bombus*, *Megachile* and *Osmia* (Calabuig, 2000; Bartholomew & Prowell, 2005). In the present study, large bees were not collected which suggests that they are probably absent in the area.

With respect to richness, even in altered areas of Paraná, various genera contributed to the composition of the families; this was not the case in the present study, and the reduction in composition of the three families occurring in this area was reflected in the Shannon diversity index of H'=1.88 and E=0.61. But here again it is necessary to consider the differences in sampling methods.

It has been widely discussed and studied that agricultural practices lead to a decline in diversity of plant species, rendering the landscape homogenous with the planting of monocultures, thus decreasing available resources and provoking the decline in bee populations observed around the world (Steffan-Dewenter & Tscharntke, 1999; Carvell, 2002). The same appears to be what was found in the present study, as the agricultural profile of Rio Claro has been changing since the 1980's, from coffee plantations and orange groves to the production of sugar cane. Currently the rural area is a mosaic of fragments of native areas with characteristics of cerrado surrounded by sugar cane fields.

Although no other studies have been conducted in this agricultural area, Bortoli & Laroca (1990) documented well the decrease in number, albeit not of species, in the samples collected in Paraná in 1962-63 compared to 1981-82, and associated this decline with anthropic modifications in the sample areas that decreased the density of wild plants. Andena *et al*. (2005) discussed that in Corumbataí cerrado, where their study was conducted, the apifauna was poor in species and number of individuals compared the bee communities from another cerrado areas probably because it is a small area inside cane sugar plantation.

In general, what one observes with respect to the composition of these bee fauna is that in areas of preserved vegetation, Apidae is the family with the greatest occurrence and diversity, mainly due to the presence of the social species, whereas in perturbed areas, the halictids are more predominant over the others (Knoll *et al*., 1993).

Since the adequate availability of pollen appears to be the greatest structuring force of bee communities (Gathmann *et al.*, 1994), the large species are more inclined to local extinction than the smaller species due to the quantity of pollen they require (Müller *et al*., 2006). Frankie *et al*. (2005) observed a decrease in the population of large bees (greater than 12mm) as a result of El Niño and La Niña, which altered the climate in Costa Rica, affecting the availability of pollen, nectar, and oil in the area studied.

The decrease in the availability of pollen in this agricultural area as a result of the types of crops and absence of preserved natural vegetation may be affecting bees larger than 12mm which, despite having a wider radius of flight, have greater energy demands, need pollen for bodily maintenance (Smeets & Duchateau, 2003), and prefer to forage perennial resources (Dramstad & Fry, 1995). In the present study, however, other factors may be affecting the populations of larger bees.

With the results of this study, it is possible to infer that this area favors the presence of small bees, given the predominance of individuals with body size of up to 10mm and small foraging radius (Michener, 2000; Taura & Laroca, 2001; Frankie *et al*., 2005). Steffan-Dewenter *et al.* (2002) observed a correlation between bees that have shorter foraging distances and the structure of the landscape on a small spatial scale, which could explain why a larger number of this group of bees was collected in this study, but again it is necessary to consider the differences in sampling methods.

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