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Floral resources used by insects in a grassland community in Southern Brazil[1]

MARDIORE PINHEIRO[2,5], BIANCA ESPINDOLA DE ABRÃO[3], BIRGIT HARTER-MARQUES[4] and SILVIA TERESINHA SFOGGIA MIOTTO[3]

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ABSTRACT – (Floral resources used by insects in a grassland community in Southern Brazil). The goal of the present study was to identify plant species used as food source, the floral resources utilized, and the insects that visit flowers in a grassland community in southern Brazil. The study was carried out in an area of one hectare, located in a grassland formation in the Parque Estadual de Itapuã, State of Rio Grande do Sul, Brazil. The flowering pattern was seasonal, and richness and abundance of insects was higher during the period of high resource availability. Flowers of 106 species of angiosperms (73 genera and 34 families) were used as source of floral resources for 219 species (2,767 specimens) of insects. A total of 91.5% of plant species were visited by bees, 53.8% by flies, 34.9% by wasps, 22.6% by butterflies, and 12.3% by beetles. Nectar was the main resource consumed by the visitors (41.1%). Asteraceae was the richest (38 spp.) and most visited family, with 63.1% of the species and 49.5% of all specimens of recorded insects. Bees were the most representative insects (33.2% spp., 65% indiv.), followed by flies (26.9% spp., 16.5% indiv.), wasps, butterflies and beetles. 40 plant species were considered important resources for the floral visitors' community, due to high number of, both, species and individuals recorded in their flowers. The family Asteraceae as a species set was the main floral resource used by insect visitors through the year and has great importance for the maintenance of populations of many species of bees, flies, wasps and butterflies in the studied area.

Key words - anthophilous insects, Asteraceae, community ecology, floral resources, floral visitors

RESUMO – (Recursos florais utilizados por insetos em uma comunidade campestre no sul do Brasil). O objetivo deste trabalho foi identificar as espécies vegetais utilizadas como fontes de alimento, os recursos florais utilizados e os insetos visitantes das flores em uma comunidade campestre no sul do Brasil. O estudo foi realizado em uma parcela de um hectare, alocada em uma formação campestre no Parque Estadual de Itapuã, RS. O padrão de floração foi sazonal e a riqueza e abundância de insetos, maior no período de mais oferta de recursos. Flores de 106 espécies de angiospermas (73 gêneros e 34 famílias) foram utilizadas como fontes de recursos florais para 219 espécies e 2.767 espécimes de insetos. 91,5% das espécies vegetais foram visitadas por abelhas, 53,8% por moscas, 34,9% por vespas, 22,6% por borboletas e 12,3% por besouros. Néctar foi o principal recurso consumido pelos visitantes (41,1%). Asteraceae foi a família mais rica (38 spp.) e a mais visitada, com 63,1% das espécies e 49,5% de todos os espécimes de insetos registrados. Espécies com numerosas flores agrupadas em inflorescências e com recursos florais acessíveis foram as mais visitadas, por espécies e indivíduos de visitantes florais. Abelhas foram os insetos mais representativos (33,2% spp., 65% indiv.), seguidas de moscas (26,9% spp., 16,5% indiv.), vespas, borboletas e besouros. Quarenta espécies de plantas foram consideradas importantes fontes de recursos para a comunidade de visitantes florais, devido à alta abundância e elevado número de espécies de insetos registrados em suas flores. A família Asteraceae, como um conjunto de espécies, foi a principal fonte de recursos florais utilizada durante o ano, com grande importância para a manutenção das populações de muitas espécies de abelhas, moscas, vespas e borboletas ocorrentes na área de estudo.

Palavras-chave - Asteraceae, ecologia de comunidade, insetos antófilos, recursos florais, visitantes florais

Introduction

The great variety of floral types found in the Neotropical Region, demonstrates the high diversity of angiosperms in this region, and consequently a high diversity of floral visitors using resources of these plants (Endress 1994). Once the majority of angiosperms depends on pollinators for reproduction, the flower-animal interactions have a considerable influence on the biodiversity, and on the structure of plant community (Heithaus 1974, Bawa 1990), that could be characterized by the food preferences of different groups of floral visitors, the more attractive plants, and the existence of competition for resources (Barbola *et al*. 2000). Another important point is the necessity of understanding the plant-pollinator interactions to effective conservation and management of communities (Prance 1990).

In Brazil, there are several studies about bee-plant interactions at community level (*e.g*. Camargo &

1. Part of the first author's Ph D thesis developed at the Programa de Pós-Graduação em Botânica, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil.
2. Universidade Estadual de Campinas, Departamento de Botânica, Caixa Postal 6109, 13083-970 Campinas, SP, Brazil.
3. Universidade Federal do Rio Grande do Sul, Departamento de Botânica, Av. Bento Gonçalves 9500, 91501-970 Porto Alegre, RS, Brazil.
4. Universidade do Extremo Sul Catarinense, Programa de Pós-Graduação em Ciências Ambientais, Av. Universitário 1105, 88806-000 Criciúma, SC, Brazil.
5. Corresponding author: mardiore.pinheiro@gmail.com

Mazucato 1984, Martins 1995, Schlindwein 1995, Carvalho & Bego 1997, Schlindwein 1998, Alves-dos-Santos 1999, Barbola *et al.* 2000, Aguiar 2003, Antonini & Martins 2003, Faria-Mucci *et al*. 2003, Lorenzon *et al.* 2003, Viana *et al*. 2006). However, information about floral sources for other insect groups, at community level, are less common (*e.g*. Silberbauer-Gottsberger & Gottsberger 1988, Arruda & Sazima 1996, Wilms *et al*. 1997, Oliveira & Gibbs 2000, Corrêa *et al*. 2001, Souza-Silva *et al*. 2001, Darrault & Schlindwein 2002, Machado & Lopes 2004, Oliveira *et al*. 2004, Freitas & Sazima 2006, Hermes & Köhler 2006). Moreover, the majority of studies with anthophilous insects only indicate which plants are visited, with few works mentioning floral resources utilized in each plant species by the visitors.

The goals of the present study were to identify plant species used as food source, the floral resources utilized, and the insect visitors of the flowers in a grassland community in southern Brazil. In addition, the plant species which play a key role in the community, as resources for a high number of species and individuals of floral visitors, were also identified.

Material and methods

Study site – The present work was carried out in an area of rocky grasslands in the Parque Estadual de Itapuã (PEI) located in the South of Itapuã district (30°20' and 30°27' S; 50°50' and 51°05' W), Viamão Municipality, metropolitan region of Porto Alegre, Rio Grande do Sul State, Brazil. The total area of the PEI is about 5,566 ha (Secretaria Estadual do Meio Ambiente 1997). Data survey was performed in a plot of one hectare located in Morro do Araçá, on the west side of PEI. The vegetation in the PEI is very diverse with forests that appear mainly to the south of the mountains, rocky grasslands restricted to the top and northern slopes of hills, and with the plateau region comprising dry and wet fields, and restinga vegetation (Secretaria Estadual do Meio Ambiente 1997). These rocky grasslands are composed by scattered bushes and occasional trees, and its occurrence is related to the presence of shallow soils with low water retention capacity. According to the Köppen system (Köppen 1948), the climate in this region is classified as subtropical humid (Cfa), with well distributed rain throughout the year. Summers are usually warmer with mean temperatures in the warmest month higher than 22 °C (Universidade Federal do Rio Grande do Sul 1982). Annual precipitation falls between 1,100 and 1,300 mm (Secretaria Estadual do Meio Ambiente 1997). Data recorded during the study period were obtained from the Applied Meteorology and Observation Section (Seoma) of the Eighth District of the National Institute of Meteorology (INMET), located 55 km from the study area.

Flowering phenologies of the species in the community were established by biweekly observations over a period of two consecutive years, between December 2002 and November 2004. Plants were grouped according flowering patterns described by Newstron *et al.* (1994). Floral resources utilized by visitors were verified by direct observation, and five classes of resources were defined: (1) nectar, (2) pollen, (3) nectar and/or pollen, (4) pollen and/or oil, and (5) floral tissues (petals and stamens). In classes one and two only the main used resource was considered (primary attractants, see Faegri & van der Pijl 1979). In classes 3 and 4, due to preferences for a determined resource by different groups of floral visitors, one or more resources were used in the same plant species simultaneously. In order to attribute a degree of importance as food source, each plant species was classified based on the number of species and individuals of floral visitors recorded as follow: (1) frequency of insect species: rare (1-5), frequent (5-15), very frequent (15-30); (2) frequency of insect individuals: rare (1-10), frequent (10-50), very frequent (> 50). Plant species were grouped into families according to Angiosperm Phylogeny Group II (2003). Voucher specimens were deposited in herbarium of Instituto de Ciências Naturais/Universidade Federal do Rio Grande do Sul.

Insects visiting the flowers were collected with entomological nets. Sampling was performed every fifteen days between December 2002 and November 2003. On each day, nine hours of sampling were divided in three periods of three hours: 8:00 to 11:00 h; 11:00 to 14:00 h, and from 14:00 to 17:00 h. During each period the plant species under observation were sampled individually, and had all floral visitors collected for 10 minutes. In each period was possible to observe four species per hour, with a total of 12 plant species in three hours. In the next two periods, the same plant species were observed again. Consequently, for each day, the same sampling effort was applied for all species observed (30 minutes each day). Thus, total sampling time for each plant species varied only with the flowering period (longer flowering periods resulted in more sampling hours), and was independent of the abundance of each species in the study area. With this method, it was possible to estimate exactly the sampling time used for each plant species through the study period. Sampling was performed by two researchers, each observing a different plant species. A total of 404 sampling hours were performed, distributed over 47 sampling days. Insect visitors were categorized into five functional groups: (1) bees, (2) wasps, (3) flies, (4) beetles, and (5) butterflies. Insect specimens were identified by specialists with identification keys and compared with specimens placed in the entomological collections from Museu de Ciências e Tecnologia/Pontifícia Universidade Católica do Rio Grande do Sul (bees), Universidade Federal de Santa Maria (wasps and flies), Museu de Ciências Naturais/Fundação Zoobotânica do Rio Grande do Sul (beetles) and Universidade Federal do Rio Grande do Sul (butterflies). Bees, social wasps (Vespidae), flies (Syrphidae) and butterflies were classified following Silveira *et al.* (2002), Carpenter & Marques (2001), Marinoni *et al.* (2007) and Lamas (2004), respectively. Morpho-species of wasps and flies (other than social wasps and syrphids), and beetles were identified at

family level using the keys of Triplehorn & Johnson (2005). Collected insects were placed in the entomological collection at Museu de Ciências e Tecnologia/Pontifícia Universidade Católica do Rio Grande do Sul.

Results

In the Morro do Araçá grassland, ca. 180 plant species visited by anthopilous insects were recorded (M. Pinheiro, unpublished data), and insect visitors were collected in 106 species, representing ca. 59.0% of plant species recorded in the community. In addition, of the 64 species registered in the Asteraceae family, from rocky grasslands in Parque Estadual de Itapuã (M. E. Beretta, unpublished data), 38 species (ca. 59%) were recorded in the present study, indicating that this sample was fairly representative of this grassland community.

Flowering pattern in the studied community was seasonal. There was a pronounced decrease in the number of flowering species during the dry season in the winter when lowest temperatures were recorded. On the other hand, an increase in the number of flowering species was observed in the beginning of the wet season, in September, increasing in October and November (figure 1-2). Among the 106 species, 67.0% presented an annual flowering pattern, 25.5% a sub annual pattern, and 7.5% a continuous flowering pattern (table 1).

During the study period, 106 species of plants belonging to 73 genera and 34 families of angiosperms were visited by 2,767 floral visitors belonging to 219 insect species representing the orders Hymenoptera, Diptera, Lepidoptera and Coleoptera. The majority of plant species

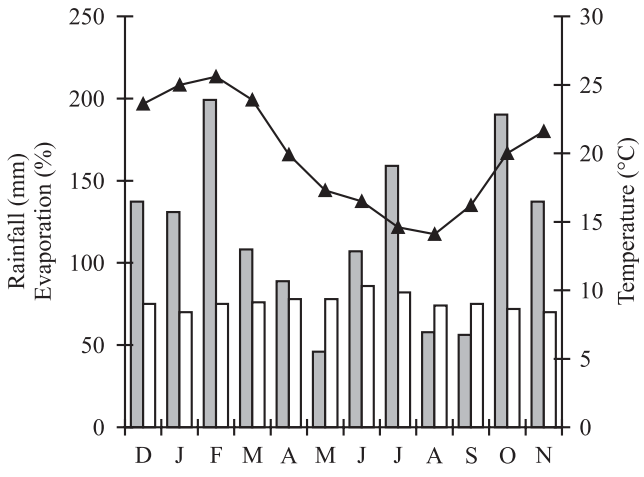

Figure 1. Diagram of climate conditions in a grassland community in southern Brazil from December 2002 to November 2003. (▲ = temperature; ▩ = mean rainfall; □ = evaporation).

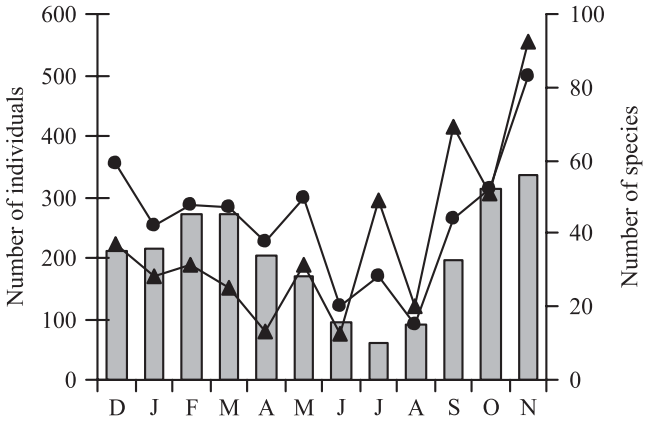

Figure 2. Number of flowering plant species and number of species and individuals of floral visitors recorded monthly from December 2002 to November 2003 in a grassland community in southern Brazil (▩ = plant species; ▲ = insect species; ● = insect individuals).

belonged to the family Asteraceae (38 spp., 35.8%), followed by Iridaceae (8 spp.), Rubiaceae (6 spp.), Apiaceae, Myrtaceae and Verbenaceae (5 spp. each one), Oxalidaceae (4 spp.), Fabaceae and Plantaginaceae (3 spp. each one). On the other hand, 21 families were represented by only one species, and four families by two.

A total of 91.5% of plant species were visited by bees , while 53.8% were visited by flies, 34.9% by wasps, 21.7% by butterflies, and 12.3% by beetles (table 1). Four plant families received 75.5% of 2,767 individuals of floral visitors recorded: the family Asteraceae was the most visited with 49.5% of individuals, followed by Arecaceae (13.0%), Apiaceae (8.0%), and Euphorbiaceae (5.0%) (table 1). In relation to the number of species of floral visitors, the family Asteraceae was the richest with 63.1% of 219 species of floral visitors recorded, followed by Apiaceae (23.0%), Rubiaceae (15.2%), Euphorbiaceae and Verbenaceae (14.3% each one), and Arecaceae (12.4%) (table 1). The family Asteraceae also presented the highest number of species and individuals of floral visitors from each insect group, except beetles: bees (52.7% spp., 50.3% indiv.), wasps (80.5% spp., 59.5% indiv.), flies (62.7% spp., 48.5% indiv.), butterflies (33.8% spp., 59.1% indiv.), and beetle (53.8% spp., 16.8% indv.) (table 1). At generic level *Baccharis* was the most visited genus, both in terms of species (37.4%) and individuals (31.6%) of floral visitors, followed by *Butia* (12.3% spp., 13.0% indiv.), *Eryngium* (22.8% spp., 8.0% indiv.), and *Croton* (13.6% spp., 5.0% indiv.) (table 1). These four genera together received 57.6% of all individuals, and 54.0% of all species of floral visitors recorded.

Table 1. Number of species and individuals of floral visitors recorded for each plant species, genera, and family in a grassy community in Southern Brazil, between December 2002 and November 2003. Collection number follows the plant species name in parentheses (*M. Pinheiro*), and the next numbers indicate the flower visitors listed in table 2. (spp/ind = number of species and individuals for group of floral visitors, and for plant species, genera, and family; F.p. = Flowering pattern (during a period of two consecutive years) = (c) continuous, (a) annual, (sb) sub-annual; F.r. = Floral resources = (n) nectar, (p) pollen, (n/p) nectar and/or pollen, (p/o) pollen and/or oil, (ft) floral tissue, (wr) without resource; V.f. = Visitor frequency = Frequency of insect species: (r) rare (1-5), (f) frequent (5-15), (vf) very frequent (16-30); Frequency of insect individuals: (r) rare (1-10), (f) frequent (11-50), (vf) very frequent (> 50)).

Family/Specie	Visitors					spp/ind per Plant sp	spp/ind per Plant gen	spp/ind per Plant fam	obs Time (h)	F.p.	F.r.	V.f. spp/ind	
	Bees spp/ind	Wasps spp/ind	Flies spp/ind	Beetles spp/ind	Butterflies spp/ind								
ALLIACEAE	5/8		2/2					7/10					
Nothoscordum inodorum (Aiton) Asch. & Graebn. (*443*) 26, 37, 86, 115, 125, 126	4/7		2/2			6/9	7/10		3	a	p	f	r
Nothoscordum montevidensis Beauv. (*444*) 130	1/1					1/1			1	a	p	r	r
AMARANTHACEAE	3/5	1/1	1/1					5/7					
Pfaffia tuberosa (Spreng.) Hicken (*370*) 32, 86, 126, 127, 172	3/5	1/1	1/1			5/7	5/7		12	c	n/p	r	r
AMARYLLIDACEAE	1/1							1/1					
Zephyranthes sp. (*445*) 125	1/1					1/1	1/1		1	a	p	r	r
ANACARDIACEAE	10/45	2/2	4/5		1/1			17/53					
Lithraea brasiliensis Marchand (*371*) 16, 29, 32, 72, 79, 91, 93, 100,101, 103, 120, 177	7/39	1/1	4/5			12/45	12/45		2	a	n/p	vf	f
Schinus weinmannifolius Engl. (*372*) 121, 122,126, 170, 219	3/6	1/1			1/1	5/8	5/8		3	a	n/p	r	r
APIACEAE	12/83	10/32	18/98	5/10	5/7			50/230					
Eryngium eriophorum Cham. & Schltdl. (*373*) 26, 32, 34, 40, 44, 57, 58, 79, 86, 104, 113, 121, 124, 125, 126, 129, 134, 156, 169, 172, 173, 189, 198, 201, 203	10/46	4/17	7/24		4/6	25/93	50/230		6	sb	n/p	vf	vf
Eryngium horridum Malme (*374*) 1, 2, 7, 12, 17, 25, 26, 28, 29, 32, 37, 57, 61, 62, 79, 104, 125, 126, 129, 155, 168, 169, 173, 176, 177, 178, 179	5/13	8/14	10/31	4/10		27/68			1	a	n/p	vf	vf

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Family/Specie	Visitors					spp/ind per Plant sp	spp/ind per Plant gen	spp/ind per Plant fam	obs Time (h)	F.p.	F.r.	V.f. spp/ind	
	Bees spp/ind	Wasps spp/ind	Flies spp/ind	Beetles spp/ind	Butterflies spp/ind								
Eryngium megapotamicum Malme (*375*) 57, 125, 126, 129, 212	3/110		1/2		1/1	5/13			1	a	n/p	r	f
Eryngium pristis Cham. & Schltdl. (*376*) 173		1/1				1/1			1	a	n/p	r	r
Eryngium sanguisorba Cham. & Schltdl. (*377*) 17, 21, 26, 29, 30, 31, 32, 40, 58, 91, 93, 125, 126, 129	5/14		9/41			14/55			4	a	n/p	vf	vf
APOCYNACEAE		1/1						1/1					
Blepharodon lineare (Decne.) Decne. (*380*) 159		1/1				1/1	1/1		4	sb	n	r	r
AQUIFOLIACEAE	1/22	2/2	11/24	1/1				15/49					
Ilex dumosa Reissek (*378*) 12, 22, 24, 26, 28, 29, 32, 38, 39, 46, 53, 70, 79, 174, 177	1/22	2/2	11/24	1/1		15/49	15/49		1	a	n/p	vf	f
ARECACEAE	14/230	5/20	7/26	1/81				27/357					
Butia capitata (Mart.) Becc. (*379*) 12, 17, 19,27, 28, 29, 44, 63, 79, 86, 91, 93, 104, 112, 117, 121, 123, 124, 125, 126, 129, 134, 168, 169, 175, 176, 177	14/230	5/20	7/26	1/81		27/357	27/357		9	c	n/p	vf	vf
ASTERACEAE	39/913	29/177	37/223	7/21	24/42			136/1376					
Achyrocline satureioides (Lam.) DC. (*381*) 32, 91, 126, 129, 168, 170, 172, 174, 180, 216	3/19	5/6	1/1		1/1	10/27	10/27		4	a	n	f	f
Acmella bellidioides (Sm.) R.K. Jansen (382) 32, 86	1/3		1/1			2/4	15/45		5	sb	n	r	r
Acmella decumbens (Sm.) R.K. Jansen (*383*) 32, 44, 50, 53, 86, 113, 125, 126, 127, 129, 130, 189, 195, 206, 218	7/20		4/14		4/7	15/41			7	sb	n	vf	f

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Family/Specie	Visitors					spp/ind per Plant sp	spp/ind per Plant gen	spp/ind per Plant fam	obs Time (h)	F.p.	F.r.	V.f. spp/ind	
	Bees spp/ind	Wasps spp/ind	Flies spp/ind	Beetles spp/ind	Butterflies spp/ind								
Baccharis articulata (Lam.) Pers. (*384*) 4, 6, 11, 26, 28, 29, 37, 38, 39, 79, 91, 93, 104, 106, 133, 168, 173, 174, 177	6/99	4/8	6/6	3/3		19/116	82/876		1	a	n/p	vf	vf
Baccharis cultrata Baker (*385*) 3, 20, 23, 26, 28, 29, 32, 37, 39, 40, 50, 53, 56, 58, 60, 65, 68, 79, 93, 129, 163 168, 169, 173, 175, 176, 177, 180	3/76	8/48	16/46	1/1		28/171			6	a	n/p	vf	vf
Baccharis ochracea Spreng. (*386*) 28, 32, 53, 129, 206	1/1		3/5		1/1	5/7			2	a	n/p	r	r
Baccharis patens Baker (*387*) 28, 29, 37, 38, 40, 41, 42, 47, 50, 79, 91, 93, 168, 175, 176, 177	3/125	4/14	9/27			16/166			3	a	n/p	vf	vf
Baccharis pseudomyriocephala I.L. Teodoro (*388*) 17, 37, 79, 126, 152, 168, 169, 176, 177	2/17	5/7	2/2			9/26			4	a	n/p	f	f
Baccharis rufescens Spreng. (*389*) 20, 28, 36, 37, 49, 50, 51, 53, 66, 67, 93, 105, 111, 117, 150, 151, 154, 165, 168, 175, 177	4/169	7/21	10/26			21/216			3	a	n/p	vf	vf
Baccharis sessiliflora Vahl (*390*) 32, 38, 39, 44, 66, 67, 91, 129, 168, 169, 173, 174, 177, 178	2/4	6/15	6/10			14/29			1	a	n/p	vf	f
Baccharis tridentata Vahl (*391*) 8, 9, 32, 41, 53, 55, 91, 118, 126, 127, 129, 168, 173, 177, 182	5/23	4/8	4/6	2/2		15/39			5	sb	n/p	vf	f
Baccharis trimera (Less.) DC. (*392*) 28, 37, 61, 64, 79, 85, 86, 113, 124, 125, 126, 129, 173, 177, 183, 199, 203	8/41	2/5	4/4		3/3	17/53			3	a	n/p	vf	vf
Baccharis af. *tridentata* (*393*) 57, 126, 149, 161, 165	1/4	3/3	1/1			5/8			3	a	n/p	r	r
Baccharis sp. (*394*) 28, 29, 101, 104, 105, 125, 127, 133, 158, 166, 169, 174, 176, 177, 179, 213	6/13	7/26	2/5		1/1	16/45			3	a	n/p	vf	f

continue

continuation

Family/Specie	Visitors					spp/ind per Plant sp	spp/ind per Plant gen	spp/ind per Plant fam	obs Time (h)	F.p.	F.r.	V.f. spp/ind	
	Bees spp/ind	Wasps spp/ind	Flies spp/ind	Beetles spp/ind	Butterflies spp/ind								
Calea uniflora Less. (*395*) 32, 79, 84, 86, 134, 204	4/7		1/1		1/1	6/9	6/9		4	sb	n	f	r
Eupatorium candolleanum Hook. & Arn. (*396*) 181, 182		2/2				2/2	23/79		3	sb	n	r	r
Eupatorium laete-virens Hook. & Arn. (*397*) 32, 37, 39, 71, 79, 197, 215, 219	1/15		4/6		3/3	8/24			4	a	n	f	f
Eupatorium ligulaefolium Hook. & Arn. (*398*) 44, 85, 86, 87, 89, 194	4/5		1/1		1/1	6/7			3	a	n	f	r
Eupatorium serratum Spreng. (*399*) 3, 37, 39, 41, 53, 61, 79, 139, 145, 156, 215	3/31	1/1	5/10	1/1	1/2	11/45			1	a	n	vf	f
Eupatorium subhastatum Hook. & Arn. (*400*) 113	1/1					1/1			3	a	n	r	r
Heterothalamus psiadioides Less. (*401*) 32, 79, 91	2/10		1/6			3/16	3/16		1	a	n	r	f
Hieracium commersonii Monnier (*402*) 53, 86, 121, 125	3/4		1/1			4/5	4/5		5	sb	n	r	r
Holocheilus brasiliensis (L.) Cabrera (*403*) 86, 121	2/3					2/3	2/3		1	a	n	r	r
Hypochaeris variegate (Lam.) Baker (*404*) 44, 86, 90	2/2		1/1			3/3	3/3		2	sb	n	r	r
Porophyllum lanceolatum DC. (*405*) 79, 86, 126, 130, 155, 176	4/4	2/4				6/8	6/8		3	sb	n	f	r
Pterocaulon alopecuroides (Lam.) DC. (*406*) 173		1/1				1/1	1/1		1	a	n	r	r
Schlechtendalia luzulaefolia Less. (*407*) 95, 113, 116, 121, 124, 126, 139	7/19					7/19	7/19		4	a	n	f	f
Senecio leptolobus DC. (*408*) 37, 40, 79, 134, 136, 144, 146, 177, 206	5/16	1/4	2/17		1/1	9/38	9/38		2	a	n	f	f
Stevia cinerascens Sch. Bip. Ex Baker (*409*) 79, 86, 115, 127	4/6					4/6	4/6		3	sb	n	r	r

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Family/Specie	Visitors					spp/ind per Plant sp	spp/ind per Plant gen	spp/ind per Plant fam	obs Time (h)	F.p.	F.r.	V.f. spp/ind	
	Bees spp/ind	Wasps spp/ind	Flies spp/ind	Beetles spp/ind	Butterflies spp/ind								
Symphyopappus cuneatus (DC.) Sch. Bip. ex Baker (*410*) 3, 79, 86, 121, 134, 146, 204	5/14			1/2	1/1	7/17	7/17		2	a	n	f	f
Verbesina subcordata DC. (*411*) 79, 109, 116, 140, 147, 176, 189, 202, 209, 217	4/24	2/2			4/4	10/30	10/30		4	a	n	f	f
Vernonia flexuosa Sims (*412*) 14, 15, 79, 88, 102, 109, 113, 141, 164	6/11	1/1	2/5			9/17	22/86		6	a	n	f	f
Vernonia nitidula Less. (*413*) 15, 16, 37, 79	1/40		3/5			4/45			3	a	n	r	f
Vernonia nudiflora Less. (*414*) 29, 37, 52, 189, 196, 200			3/7		3/3	6/10			7	a	n	f	r
Vernonia polyphylla Sch. Bip. ex Baker (*415*) 32, 85, 86, 113, 142, 203	4/11		1/1		1/2	6/14			4	a	n	f	f
Viguiera anchusaefolia (DC.) Baker (*416*) 10, 32, 37, 79, 86, 94, 102, 109, 113, 117, 121, 126, 142, 146, 153, 186, 188, 190, 203, 210	11/31	1/1	2/2	1/12	5/8	20/54	20/57		4	a	n/p	vf	vf
Viguiera nudicaulis (Pers.) Baker (*417*) 86	1/3					1/3			1	a	n	r	r
Wedelia montevidensis (Spreng.) B. L. Turner (*418*) 32, 38, 39, 59, 79, 86, 109, 113, 118, 126, 139, 144, 203, 204, 206	8/42		4/6		3/3	15/51	15/51		9	c	n/p	vf	vf
BEGONIACEAE	3/4							3/4					
Begonia cucullata Willd. (*419*) 122, 126, 131	3/4					3/4	3/4		8	sb	p	r	r
BORAGINACEAE	3/62	3/12	1/1		1/1			8/76					
Cordia verbenacea DC. (*420*) 37, 79, 91, 93, 173, 176, 177, 207	3/62	3/12	1/1		1/1	8/76	8/76		4	a	n/p	f	vf

continue

continuation

Family/Specie	Visitors					spp/ind per Plant sp	spp/ind per Plant gen	spp/ind per Plant fam	obs Time (h)	F.p.	F.r.	V.f. spp/ind	
	Bees spp/ind	Wasps spp/ind	Flies spp/ind	Beetles spp/ind	Butterflies spp/ind								
BROMELIACEAE	3/4							3/4					
Dyckia maritima Baker (*421*) 79, 102, 126	3/4					3/4	3/4		1	a	n/p	r	r
CACTACEAE	4/5							5/6					
Opuntia monacantha (Willd.) Haw. (*422*) 79, 98, 109, 112, 168	4/5					4/5	4/5		1	a	p	r	r
CELASTRACEAE		1/11	3/5					4/16					
Maytenus cassineformis Reissek (*423*) 28, 29, 50, 177		1/11	3/5			4/16	4/16		1	a	n	r	f
COMMELINACEAE	3/5		1/1					4/6					
Commelina sp. (*424*) 32, 126	1/3		1/1			2/4	2/4		7	sb	p	r	r
Tradescantia sp. (*425*) 86, 107	2/2					2/2	2/2		3	a	p	r	r
CONVOLVULACEAE	16/24		2/3					18/27					
Evolvulus glomeratus Nees & Mart. (*426*) 32, 53, 73, 75, 76, 79, 78, 86, 93, 107, 113, 114, 115, 121, 122, 126, 129, 134	16/24		2/3			18/27	18/27		8	sb	n	vf	f
ERICACEAE	1/1							1/1					
Agarista eucalyptoides (Cham. & Schltdl.) G.Don (*427*) 79	1/1					1/1	1/1		2	a	n	r	r
EUPHORBIACAE	14/107	8/15	9/13					32/135					
Croton gnaphalii Baill. (*428*) 18, 26, 36, 37, 38, 41, 43, 44, 53, 74, 79, 86, 93, 107, 112, 115, 116, 117, 121, 122, 124, 126, 162, 167, 170, 171, 173, 177, 181, 182	13/104	8/15	9/13			30/132	31/132		12	c	n/p	vf	vf
Euphorbia selloi (Klotzsch & Garcke) Boiss. (*429*) 78, 86	2/3					2/3	2/3		7	sb	p	r	r
FABACEAE	10/15							10/15					
Desmodium cuneatum Hook. & Arn. (*430*) 146	1/1					1/1	1/1		2	sb	n	r	r

continue

continuation

Family/Specie	Visitors					spp/ind per Plant sp	spp/ind per Plant gen	spp/ind per Plant fam	obs Time (h)	F.p.	F.r.	V.f. spp/ind	
	Bees spp/ind	Wasps spp/ind	Flies spp/ind	Beetles spp/ind	Butterflies spp/ind								
Mimosa schleidenii Herter (*431*) 74, 79, 115	3/4					3/4	3/4		3	a	p	r	r
Zornia linearifoliolata N. Mattos (*432*) 73, 83, 135, 137, 138, 141	6/10					6/10	6/10		3	a	n/p	f	r
GESNERIACEAE	5/16							5/16					
Sinningia allagophylla (Mart.) Wiehler (*433*) 81, 82, 83, 86, 92	5/16					5/16	5/16		7	a	n	r	f
IRIDACEAE	11/42							11/42					
Cipura cf. *paludosa* Aubl. (*434*) 86, 134	2/3					2/3	2/3		1	a	p	r	r
Cypella herberti Hook. (*435*) 80, 130	2/2					2/2	2/2		1	a	p/o	r	r
Herbertia pulchella Sweet (*436*) 79, 125, 126, 128, 134	5/13					5/13	5/13		2	a	p/o	r	f
Sisyrinchium macrocephalum Graham (*437*) 78, 86, 115	3/7					3/7	4/24		2	a	p/o	r	r
Sisyrinchium micranthum Cav. (*438*) 78, 90	2/2					2/2			2	a	p/o	r	r
Sisyrinchium osteniamum Beauv. (*439*) 115	1/5					1/5			1	a	p	r	r
Sisyrinchium scariosum I.M. Johnst. (*440*) 78, 86, 90	3/4					3/4			2	a	p/o	r	r
Sisyrinchium sellowianum Klatt (*441*) 78, 90, 115	3/6					3/6			2	a	p/o	r	r
LAMIACEAE	8/29	4/7						12/36					
Glechon marifolium Benth. (*442*) 73, 78, 79, 86, 93, 126, 130, 145, 169, 173, 177, 178	8/29	4/7				12/36	12/36		10	c	n	vf	f
MELASTOMATACEAE	1/1							1/1					
Tibouchina gracilis (Bonpl.) Cogn. (*446*) 125	1/1					1/1	1/1		7	a	p	r	r

continue

continuation

Family/Specie	Visitors					spp/ind per Plant sp	spp/ind per Plant gen	spp/ind per Plant fam	obs Time (h)	F.p.	F.r.	V.f. spp/ind	
	Bees spp/ind	Wasps spp/ind	Flies spp/ind	Beetles spp/ind	Butterflies spp/ind								
MYRTACEAE	2/13		6/17	4/12	1/1			13/43					
Blepharocalyx salicifolius (Kunth.) O. Berg (*447*) 13				1/1		1/1	1/1		2	a	p	r	r
Campomanesia aurea O. Berg (*448*) 12, 32, 37, 39, 79	1/4		3/3	1/3		5/10	5/10		2	a	p	r	r
Myrcia palustris DC. (*449*) 32, 37, 79, 214	1/2		2/7		1/1	4/10	4/10		2	a	p	r	r
Myrciaria cuspidata O. Berg (*450*) 2, 33, 37, 39, 54, 79, 93	2/7		4/7	1/1		7/15	7/15		5	sb	p	f	f
Psidium cattleyanum Sabine (*451*) 5, 13				2/7		2/7	2/7		1	a	tf	r	r
OROBANCHACEAE	2/2							2/2					
Buchnera longifolia Kunth (*465*) 86, 126	2/2					2/2	2/2		6	sb	n	r	r
ORCHIDACEAE					1/1			1/1					
Epidendrum fulgens Brongn. (*452*) 204					1/1	1/1	1/1		7	a	wr	r	r
OXALIDACEAE	6/24		6/11					12/35					
Oxalis sp.1 (*453*) 32, 38, 39, 53, 86, 113, 129	3/6		4/5			7/11	12/35		3	a	p	r	f
Oxalis sp.2 (*454*) 44, 50, 86	1/1		2/2			3/3			5	a	p	r	r
Oxalis sp.3 (*455*) 53, 74, 77, 86, 113, 126	5/15		1/4			6/19			1	a	p	f	f
Oxalis sp.4 (*456*) 86, 126	2/2					2/2			2	a	p	r	r
PLANTAGINACEAE	3/5		1/1					4/6					
Angelonia integerrima Spreng. (*464*) 126	1/1					1/1	1/1		3	a	p/o	r	r
Mecardonia montevidensis (Spreng.) Pennell (*466*) 86, 126	2/2					2/2	2/2		4	a	p/o	r	r
Scoparia dulcis L. (*467*) 44, 115, 126	2/2		1/1			3/3	3/3		7	sb	p	r	r
POLYGALACEAE	10/51							10/51					
Monnina oblongifolia Arechav. (*457*) 79, 95, 97, 99, 102, 107, 108, 115, 142, 143	10/51					10/51	10/51		12	c	n/p	f	vf

continue

continuation

Family/Specie	Visitors					spp/ind per Plant sp	spp/ind per Plant gen	spp/ind per Plant fam	obs Time (h)	F.p.	F.r.	V.f. spp/ind	
	Bees spp/ind	Wasps spp/ind	Flies spp/ind	Beetles spp/ind	Butterflies spp/ind								
RUBIACEAE	17/48	10/16	6/8					33/72					
Borreria brachystemonoides Cham. & Schltdl. (*458*) 38, 48, 86, 113	2/6		2/3			4/9	4/12		8	sb	n	r	r
Borreria capitata (Ruiz & Pav.) DC. (*459*) 86	1/3					1/3			5	a	n	r	r
Chiococca alba (L.) Hitchc. (*460*) 112	1/1					1/1	1/1		5	a	n	r	r
Faramea marginata Cham. (*461*) 37, 79, 109, 110, 111, 112, 117, 126, 152, 157, 169, 173, 174, 177	7/14	6/8	1/1			14/23	14/23		3	a	n	vf	f
Galianthe fastigiata Griseb. (*462*) 17, 39, 44, 86, 113, 116, 119, 121, 124, 125, 126, 127, 130, 160, 169, 173, 176, 177, 182	10/21	6/7	3/3			19/31	19/31		3	a	n	vf	f
Richardia grandiflora (Cham. & Schltdl.) Steud. (*463*) 44, 84, 86, 130, 148	3/3	1/1	1/1			5/5	5/5		6	sb	n	r	r
STYRACACEAE	7/16							7/16					
Styrax leprosus Hook. & Arn. (*468*) 79, 92, 93, 96, 112, 117, 121	7/16					7/16	7/16		1	a	p	f	f
TURNERACEAE	1/1							1/1					
Piriqueta selloi Urb. (*469*) 90	1/1					1/1	1/1		4	sb	p	r	r
VALERIANACEAE	4/4		7/14					11/18					
Valeriana chamaedryfolia Cham. & Schltdl. (*470*) 29, 32, 37, 39, 45, 53, 69, 79, 107, 111, 132	4/4		7/14			11/18	11/18		3	a	n/p	vf	f
VERBENACEAE	11/29	1/1	5/6		14/18			31/54					
Lantana camara L. (*471*) 112	1/1					1/1	1/1		5	c	n	r	r

continue

continuation

Family/Specie	Visitors					spp/ind per Plant sp	spp/ind per Plant gen	spp/ind per Plant fam	obs Time (h)	F.p.	F.r.	V.f. spp/ind	
	Bees spp/ind	Wasps spp/ind	Flies spp/ind	Beetles spp/ind	Butterflies spp/ind								
Lippia angustifolia Cham. (*472*) 32, 53, 86, 113, 121, 142, 180	4/15	1/1	2/2			7/18	7/18		6	a	n	f	f
Stachytarpheta cayennensis (Rich.) Vahl (*473*) 35, 44, 79, 85, 92, 96, 184, 186, 187, 191, 192, 193, 194, 195, 200, 202, 203, 204, 208, 211	4/8		2/3		14/18	20/29	20/29		5	a	n	vf	f
Verbena lindmanii Briq. (*474*) 49, 78, 86	2/3		1/1			3/4	3/4		8	c	n	r	r
Verbena sp. (*475*) 86, 91	2/2					2/2	2/2		2	sb	n	r	r
Total	74/1815	37/298	59/459	13/125	37/71				404				

The number of visitors varied from 357 individuals recorded in flowers of *Butia capitata*, to a single visitor recorded in flowers of 15 plant species. The number of insect species varied from 30 species recorded in flowers of *Croton gnaphalii*, to one, recorded in flowers of 18 plant species. A total of 42.4% of plant species were visited by two groups of insects, while 40.6% by three groups, and 17.0% by only one. According to the frequency of floral visitors, from the total of 106 visited plant species, 56.0% and 55.7% were rarely visited by species and individuals, respectively, 19.8% and 31.1% were frequently visited by species and individuals, respectively, and 23.6% and 13.2% were very frequently visited by species and individuals, respectively. Considering the frequency of floral visitors recorded for each plant species, 40 species could be considered important resources for the floral visitors' community in the study area due to high number of, both, species and individuals recorded in their flowers (species frequently and/or very frequently visited, table 1).

Nectar was the main resource of 41.5% of plant species, followed by nectar and/or pollen (27.3%) and pollen (21.6%). Oil flowers were registered in eight plant species, but oil-bees were recorded in only three species. Floral tissues were consumed in only one species of Myrtaceae (table 1).

During the study period, a wide array of flower visitors was recorded on flowers. There was a pronounced decrease in the number of species of floral visitors during the dry season in the winter when lowest temperatures were recorded (figure 1-2). In this season, bee species were less abundant than wasps and flies, while beetles and butterflies were not recorded. On the other hand, an increase in the number of species of floral visitors was observed in the beginning of the wet season, in September, with a high number of species recorded during the warmest period of the year (figure 1-2). Overall, the number of individuals recorded followed the same pattern observed for the number of species, except in July when an increase in the number of individuals was recorded by the sampling of many specimens of *Trigona spinipes*.

A total of 1,815 bees belonging to 74 species were collected. Among the five bee families, Apidae (18 spp., N = 1,268) and Halictidae (26 spp., N = 433) presented the highest number of species and individuals of floral visitors, followed by Colletidae (12 spp., N = 49), Megachilidae (12 spp., N = 31), and Andrenidae (6 spp., N = 34) (table 2). The majority of bee individuals recorded belonged to social bees *Apis mellifera* (23.0%), *Trigona spinipes* (21.0%), and *Plebeia emerina* (13.0%). Flies were the second group of floral visitor most rich and abundant on flowers, represented by 12 families, 59 species

and 459 individuals. Syrphidae was the predominant family (23 spp., $N = 277$) and some species mainly in the genera *Allograpta*, *Palpada*, *Pseudodorus* and *Toxomerus* that feed on nectar and pollen were recorded in different plant species (table 2). Other abundant flies in search of nectar were represented by Muscidae, Sarcophagidae and Tachinidae. Wasps that feed on nectar were represented by eight families, 36 species and 297 individuals. The family Vespidae was the most representative (l6 spp., $N = 272$) (table 2). Some social species in this family, represented by the genera *Brachygastra*, *Mischocyttarus*, *Polistes* and *Polybia*, showed high abundance of individuals that visited several plant species (table 2). Species of beetles representing eight families (13 spp., $N = 125$) were recorded (table 2). Almost all species of beetles were represented by few individuals, and the number of visited plant species was consequently low. In this group of floral visitors, Oedemeridae sp. 1 was responsible for 70.0% (87) of all individuals recorded, and was observed, almost exclusively, feeding on nectar and pollen on flowers of *Butia capitata* (81). Twelve individuals of a special genus of beetle, *Nemognatha nigrotarsata* (Meloidae), which has its mouth-parts adapted to form a slender tube (12 mm long) to reach deep-seated nectar (Ennes 1956, Proctor *et al.* 1996), were recorded. Seven families of butterflies (37 spp., $N = 71$) were recorded (table 2). The families Hesperidae (15 spp., $N = 27$) and Nymphalidae (8 spp., $N = 23$) were predominant. Although this floral visitors represented about 17.0% (37) of all insect species recorded in the present study, few individuals of each species were collected, thus the diversity of plant species visited by each species of butterfly was low (table 2).

Table 2. Flower visitors recorded in a grassy community in Southern Brazil, between December 2002 and November 2003. In parentheses: (number of insect specimens/number of plant species visited).

Species number	Flower visitors
	COLEOPTERA
1	Buprestidae sp. 1 (1/1)
2	Cantharidae sp. 1 (7/2)
3	Cantharidae sp. 2 (4/3)
4	Cantharidae sp. 3 (1/1)
5	Chrysomelidae sp. 1 (4/1)
6	Curculuonidae sp. 1 (1/1)
7	Curculuonidae sp. 2 (1/1)
8	Elateridae sp. 1 (1/1)
9	Elateridae sp. 2 (1/1)
10	*Nemognatha nigrotarsata* (Fairmaire & Germain) (12/1) Meloidae
11	Nitidulidae sp. 1 (1/1)
12	Oedemeridae sp. 1 (87/4)
13	Scarabaeidae sp. 1 (4/2)
	DIPTERA
14	Acroceridae sp. 1 (4/1)
15	Acroceridae sp. 2 (2/2)
16	Bombyliidae sp. 1 (2/1)
17	Calliphoridae sp. 1 (9/6)
18	Calliphoridae sp. 2 (2/1)
19	Chamaemyiidae sp. 1 (1/1)
20	Empididae sp. 1 (10/2)
21	Muscidae sp. 1 (1/1)
22	Muscidae sp. 2 (1/1)
23	Muscidae sp. 3 (1/1)
24	Muscidae sp. 4 (1/1)
25	Muscidae sp. 5 (1/1)
26	Muscidae sp. 6 (16/8)
27	Sacrophagidae sp. 1 (1/1)
28	Sacrophagidae sp. 2 (29/11)
29	Sacrophagidae sp. 3 (60/12)
30	Sacrophagidae sp. 4 (1/1)
31	Sacrophagidae sp. 5 (1/1)
32	*Allograpta exotica* (Wiedemann, 1830) (59/26) Syrphidae
33	*Copestylum compactum* (Curran, 1925) (1/1) Syrphidae
34	*Copestylum* sp. 1 (1/1) Syrphidae
35	*Copestylum* sp. 2 (2/1) Syrphidae
36	*Palpada furcata* (Wiedemann, 1819) (2/2) Syrphidae
37	*Palpada* sp. 1 (77/21) Syrphidae
38	*Palpada* sp. 2 (17/8) Syrphidae
39	*Palpada* sp. 3 (12/12) Syrphidae
40	*Palpada* sp. 4 (13/5) Syrphidae
41	*Palpada* sp. 5 (7/4) Syrphidae
42	*Palpada* sp. 6 (2/1) Syrphidae
43	*Palpada* sp. 7 (1/1) Syrphidae
44	*Pseudodoros clavatus* (Fabricius, 1794) Syrphidae (24/12)
45	Syrphidae sp. 1 (1/1)
46	Syrphidae sp. 2 (1/1)
47	Syrphidae sp. 3 (1/1)
48	Syrphidae sp. 4 (1/1)
49	*Syrphus phaeostigma* Wiedemann, 1830 (2/2) Syrphidae
50	*Toxomerus politus* (Say, 1823) (20/6) Syrphidae
51	*Toxomerus* sp. 1 (2/1) Syrphidae

continuation

Species number	Flower visitors
52	*Toxomerus* sp. 2 (1/1) Syrphidae
53	*Toxomerus* sp. 3 (28/15) Syrphidae
54	*Trichopsomyia* sp. 1 (1/1) Syrphidae
55	Tabanidae sp. 1 (1/1)
56	Tachinidae sp. 1 (3/1)
57	Tachinidae sp. 2 (6/4)
58	Tachinidae sp. 3 (10/2)
59	Tachinidae sp. 4 (1/1)
60	Tachinidae sp. 5 (1/1)
61	Tachinidae sp. 6 (3/3)
62	Tachinidae sp. 7 (1/1)
63	Tachinidae sp. 8 (2/1)
64	Tachinidae sp. 9 (1/1)
65	Tachinidae sp. 10 (2/1)
66	Tephritidae sp. 1 (3/2)
67	Tephritidae sp. 2 (2/2)
68	Tephritidae sp. 3 (1/1)
69	Tipulidae sp. 1 (1/1)
70	Tipulidae sp. 2 (1/1)
71	Diptera sp. 1 (1/1)
72	Diptera sp. 2 (1/1)
	HYMENOPTERA
	APOIDEA
73	*Anthrenoides* sp. 14 (7/3) Andrenidae
74	*Anthrenoides* sp. 17 (8/3) Andrenidae
75	*Anthrenoides* sp. 18 (1/1) Andrenidae
76	*Callonychium petuniae* Cure & Wittmann, 1990 (1/1) Andrenidae
77	*Rhophitulus reticulates* (Schlindwein & Moure, 1998) (3/1) Andrenidae
78	*Rhophitulus* sp. 1 (14/8) Andrenidae
79	*Apis mellifera* Linnaeus, 1758 (481/40) Apidae
80	*Arysoceble picta* (Friese, 1899) (1/1) Apidae
81	*Centris* (*Trachina*) *fuscata* Lepeletier, 1841 (1/1) Apidae
82	*Centris* (*Trachina*) *proxima Friese, 1899* (1/1) Apidae
83	*Centris* (*Hemisiella*) *tarsata* Smith, 1874 (3/2) Apidae
84	*Ceratina* (*Crewella*) *asuncionis* Strand, 1910 (2/2) Apidae
85	*Ceratina* (*Crewella*) *paraguariensis* Schrottky, 1907 (6/4) Apidae
86	*Ceratina asunciana* Strand, 1910 (135/41) Apidae
87	*Gaesischia* (*Gaesischia*) *fulgurans* (Holmberg, 1903) (1/1) Apidae
88	*Gaesischia* (*Gaesischiopsis*) *sparsa* Bréthes, 1910 (1/1) Apidae
89	*Gaesischia* sp. (1/1) Apidae

continue

continuation

Species number	Flower visitors
90	*Lanthanomelissa clementis* Urban, 1995 (6/5) Apidae
91	*Plebeia emerina* (Friese, 1900) (234/11) Apidae
92	*Thygather* (*Thygather*) *analis* (Lepeletier, 1841) (6/3) Apidae
93	*Trigona spinipes* (Fabricius, 1793) (382/13) Apidae
94	*Trophocleptria* sp. (1/1) Apidae
95	*Xylocopa* (*Neoxylocopa*) *augusti* Lepeletier, 1841 (2/2) Apidae
96	*Xylocopa* (*Neoxylocopa*) *nigrocineta* Smith, 1854 (4/2) Apidae
97	*Caupolicana* sp. (1/1) Colletidae
98	*Cephalocolletes rugata* Urban, 1995 (1/1) Colletidae
99	*Cephalocolletes* sp. (1/1) Colletidae
100	*Colletes cyaneus* Holmberg, 1903 (1/1) Colletidae
101	*Colletes furfuraceus* Holmberg, 1886 (2/2) Colletidae
102	*Colletes* sp. 10 (20/4) Colletidae
103	*Hexantheda enneomera* Urban & Graf, 2000 (1/1) Colletidae
104	*Hylaeus rivalis* (Schrottky, 1906) (6/5) Colletidae
105	*Hylaeus* sp. 16 (4/2) Colletidae
106	*Hylaeus* sp. 17 (2/1) Colletidae
107	*Sarocolletes* sp. 6 (7/5) Colletidae
108	*Sarocolletes* sp. 7 (3/1) Colletidae
109	*Augochlora* (*Augochlora*) *amphitrite* (Schrottky, 1909) (6/6) Halictidae
110	*Augochlora* (*Augochlora*) *daphinis* Smith, 1853 (1/1) Halictidae
111	*Augochlora* (*Augochlora*) sp. 13 (3/3) Halictidae
112	*Augochlora* (*Augochlora*) *tantilla* Moure, 1943 (12/7) Halictidae
113	*Augochlora* (*Oxystoglosella*) *semiramis* Schrottky, 1910 (39/15) Halictidae
114	*Augochlorella michaelis* (Vachal, 1911) (1/1) Halictidae
115	*Augochlorodes* sp. 2 (24/10) Halictidae
116	*Augochloropsis anisitsi* (Schrottky, 1908) (6/4) Halictidae
117	*Augochloropsis cupreola* (Cockerell, 1900) (9/6) Halictidae
118	*Augochloropsis euterpe* (Holmberg, 1886) (2/2) Halictidae
119	*Augochloropsis* sp. 14 (1/1) Halictidae
120	*Augochloropsis* sp. 20 (1/1) Halictidae
121	*Augochloropsis* sp. 21 (30/13) Halictidae
122	*Augochloropsis sympleres* (Vachal, 1903) (8/4) Halictidae

continue

continuation

Species number	Flower visitors
123	*Caenohalictus* sp. 6 (2/1) Halictidae
124	*Ceratalictus* sp. 2 (10/6) Halictidae
125	*Dialictus* sp. 4 (30/14) Halictidae
126	*Dialictus* sp. 9 (108/33) Halictidae
127	*Dialictus parvus* (Cresson, 1865) (6/6) Halictidae
128	*Dialictus* sp. 16 (1/1) Halictidae
129	*Dialictus* sp. 30 (99/14) Halictidae
130	*Dialictus* sp. 31 (8/7) Halictidae
131	*Dialictus* sp. 32 (1/1) Halictidae
132	*Dialictus travassosi* (Moure, 1940) (1/1) Halictidae
133	*Neocorynura* (*Neocorynura*) *aenigma* (Gribodo, 1894) (7/2) Halictidae
134	*Paroxystoglossa brachysera* Moure, 1960 (17/8) Halictidae
135	*Ananthidium dilmae* Urban, 1991 (2/1) Megachilidae
136	*Coelioxys* (*Glyptocoelioxys*) *pampeana* Holmberg, 1903 (1/1) Megachilidae
137	*Epanthidium nectarinioides* (Schrottky, 1902) (1/1) Megachilidae
138	*Epanthidum tigrinum* (Schrottky, 1905) (2/1) Megachilidae
139	*Megachile* (*Acentron*) sp. (4/3) Megachilidae
140	*Megachile* (*Austromegachile*) sp. (1/1) Megachilidae
141	*Megachile* (*Dactylomegachile*) sp. (2/2) Megachilidae
142	*Megachile* (*Leptorachis*) sp. 1 (7/4) Megachilidae
143	*Megachile* (*Leptorachis*) sp. 2 (1/1) Megachilidae
144	*Megachile* (*Moureapis*) sp. (2/2) Megachilidae
145	*Megachile* (cfr. *Neochelinia*) sp. (2/2) Megachilidae
146	*Megachile* (*Pseudocentron*) sp. (6/4) Megachilidae
	CHALCIDOIDEA
147	Chalcididae sp. 1 (1/1)
148	Chalcididae sp. 2 (1/1)
149	Eurytomidae sp. 1 (1/1)
	ICHNEUMONOIDEA
150	Ichneumonidae sp. 1 (1/1)
151	Ichneumonidae sp. 2 (1/1)
	SPHECOIDEA
152	Sphecidae sp. 2 (2/2)
153	Sphecidae sp. 3 (1/1)
154	Sphecidae sp. 5 (1/1)
155	Sphecidae sp. 6 (2/2)
156	Sphecidae sp. 7 (2/2)

continue

continuation

Species number	Flower visitors
	VESPOIDEA
157	Pompilidae sp. 1 (1/1)
158	Pompilidae sp. 3 (2/1)
159	Pompilidae sp. 4 (1/1)
160	Pompilidae sp. 5 (1/1)
161	Pompilidae sp. 6 (1/1)
162	Pompilidae sp. 7 (1/1)
163	Pompilidae sp. 8 (1/1)
164	Scolliidae sp. (1/1)
165	Tiphiidae sp. 1 (2/2)
166	Tiphiidae sp. 2 (2/1)
167	Alphamenes sp. 1 (1/1) Vespidae
168	*Brachygastra lecheguana* (Latreille, 1824) (36/11) Vespidae
169	*Mischocyttarus drewseni* Saussure, 1857 (19/10) Vespidae
170	*Omicron* sp. (4/3) Vespidae
171	*Pachodynerus guadulpensis* (Saussure, 1853) (2/1) Vespidae
172	*Parancistrocerus* sp. (3/3) Vespidae
173	*Polistes billardieri ruficornis* Saussure, 1853 (44/14) Vespidae
174	*Polistes cinerascens* Saussure, 1854 (12/6) Vespidae
175	*Polistes lanio* (Fabricius, 1775) (6/4) Vespidae
176	*Polybia ignobilis* (Haliday, 1836) (17/10) Vespidae
177	*Polybia scutellaris* (White, 1841) (109/20) Vespidae
178	*Polybia sericea* Oliver, 1922 (3/3) Vespidae
179	*Polybia* sp. 1 (2/2) Vespidae
180	*Stenodynerus* sp. (4/3) Vespidae
181	*Zeta argillaceum* (Linnaeus, 1758) (2/2) Vespidae
182	*Zethus schrottkyanus* (Von Ihering, 1911) (8/4) Vespidae
	LEPIDOPTERA
183	*Achlyodes mithridates thraso* (Hübner, [1807]) (1/1) Hesperiidae
184	*Codatractus aminias* (Hewitson, 1867) (1/1) Hesperiidae
185	*Gorgythion begga begga* (Prittwitz, 1868) (1/1) Hesperiidae
186	*Hylephila phyleus phyleus* (Drury, 1773) (5/2) Hesperiidae
187	*Nisoniades* sp. 1 (1/1) Hesperiidae
188	*Nyctelius nyctelius nyctelius* (Latreille, 1824) (1/1) Hesperiidae
189	*Panoquina lucas* (Fabricius, 1793) (4/3) Hesperiidae

continue

continuation

Species number	Flower visitors
190	*Polites vibex catilina* (Plötz, 1886) (1/1) Hesperiidae
191	*Urbanus proteus proteus* (Linnaeus, 1758) Hesperiidae (1/1)
192	Hesperiidae sp. 1 (1/1)
193	Hesperiidae sp. 2 (1/1)
194	Hesperiidae sp. 3 (2/2)
195	Hesperiidae sp. 4 (2/1)
196	Hesperiidae sp. 5 (1/1)
197	*Emesis* sp. 1 (1/1) Lycaenidae
198	*Albergina vanessoides* (Prittwitz, 1865) (1/1) Lycaenidae
199	*Strymon* sp. 1 (1/1) Lycaenidae
200	*Agraulis vanillae maculosa* (Stichel, 1907) (2/2) Nymphalidae
201	*Anarthia amathea roeselia* (Eschscholtz, 1821) (1/1) Nymphalidae
202	*Dryas iulia alcionea* (Cramer, 1779) (2/2) Nymphalidae
203	*Junonia evarete* (Cramer, 1779) (9/6) Nymphalidae
204	*Vanessa braziliensis* (Moore, 1883) (5/5) Nymphalidae
205	*Vanessa myrinna* (Doubleday, 1849) (1/1) Nymphalidae
206	*Yphthimoides celmis* (Godart, [1824]) (4/4) Nymphalidae
207	Nymphalidae sp. 1 (1/1)
208	*Battus polydamas polydamas* (Linnaeus, 1758) (2/1) Papilionidae
209	*Parides bunichus perrhebus* (Boisduval, 1836) (1/1) Papilionidae
210	*Colias lesbia lesbia* (Fabricius, 1775) (2/1) Pieridae
211	*Rhabdodryas trite banksi* (Breyer, 1939) (1/1) Pieridae
212	Lepidoptera sp. 1 (1/1)
213	Lepidoptera sp. 2 (1/1)
214	Lepidoptera sp. 3 (1/1)
215	Lepidoptera sp. 4 (3/2)
216	Lepidoptera sp. 5 (1/1)
217	Lepidoptera sp. 6 (1/1)
218	Lepidoptera sp. 7 (4/1)
219	Lepidoptera sp. 8 (2/2)

Discussion

The climate conditions during the dry season are considerably adverse to phenological events, especially by the water restrictions in this period. The climate in Southern Brazil is seasonal, and in addition to water shortage, the dry season is a period of low temperatures in comparison to other regions of the country. Thus, a great reduction in the number of flowering species in the dry season, as observed in the present study, was expected. The seasonal flowering pattern observed here is in accordance with the flowering data observed in other grassland communities in southeastern Brazil, where the dry and rainy seasons are also well defined (Freitas & Sazima 2006, Tannus *et al*. 2006).

According to Peres (2000), seasonality is an important event for the availability of resources, and the seasonality in flowering period would be an important factor to demonstrate the existence of key-species in determined period of the year. According to this criterium, *Baccharis rufescens*, *B. patens*, *B. cultrata* and *Croton gnaphalii*, large shrubs with many flowers, could be considered key-species in the studied plant community. In the winter, where a low number of flowering species was recorded, these plant species were the exclusive or main resource consumed by insects that were active flyers during cold months, as social bees, social wasps, and some flies.

The prevalence of nectar as the main resource in the study was also recorded in others ecosystems, such as *campo rupestre* (Faria 1994), *cerrado* (Barbosa 1997), *caatinga* (Machado & Lopes 2004) and high-altitude grasslands (Freitas & Sazima 2006). In fact, nectar is the main floral resource offered by the plants to their pollen vectors (Proctor *et al*. 1996) and is the most used floral resource by a great variety of floral visitors (Simpson & Neff 1981, Endress 1994). The percentage of species offering pollen as the main floral resource was also similar to that recorded in *campo rupestre*, *cerrado*, *caatinga* and hight-altitude grasslands (Faria 1994, Barbosa 1997, Machado & Lopes 2004, Freitas & Sazima 2006). However, pollen-flowers in study area were rare in comparison to these other communities, where the families Melastomataceae, Fabaceae, Solanaceae are represented by several species with poricidal anthers. The percentage of flowers offering both pollen and nectar as floral resource (pollen in this class being intentionally collected) was similar to others grassy communities (Barbosa 1997, Freitas & Sazima 2006) and much higher than that observed in the *caatinga* (Machado & Lopes 2004). In this study eight species of oil-flowers were recorded, but oil-bees were recorded only in three plant species from the family Iridaceae and Scrophulariaceae. The percentage of this group of plants was similar to that recorded in high-altitude grasslands (Freitas & Sazima 2006), in *cerrado* (Silberbauer-Gottsberger & Gottsberger 1988), and in the *campo rupestre* (Faria 1994) but lower

than the recorded in *caatinga* where several species of Malpighiaceae and Scrophulariaceae are found (Machado & Lopes 2004).

In the studied environment, as also recorded in others grassland communities (Barbosa 1997, Freitas & Sazima 2006), Asteraceae was the family with the highest number of plant species and the most visited by a wide range of floral visitors. In surveys on bee-plant interaction, Asteraceae has been considered by several authors one of the most important sources of floral resources, with the highest number of visited plant species, and the highest richness and abundance of bees recorded (Martins 1995, Schlindwein 1995, Bortoli & Laroca 1990, Carvalho & Bego 1997, Alves-dos-Santos 1999, Barbola *et al.* 2000, Faria-Mucci *et al.* 2003, Antonini & Martins 2003). Asteraceae was also found to be the richest, and the most visited family by flies (Arruda & Sazima 1996, Souza-Silva *et al.* 2001), and wasps (Hermes & Köhler 2006). The preference for Asteraceae flowers was probably due to characteristics that make these plants more attractive to floral visitors in comparison to plants in other families: their inflorescences with a large number of flowers were more attractive to floral visitors than scattered single flowers, also serving as landing area for these animals; the floral traits (*i.e.* floral tube size with few millimeters and the secondary pollen presentation) allow the free access to the resources to a broad range of floral visitors (Endress 1994, Proctor *et al.* 1996). Moreover, Asteraceae is the largest among angiosperms, and is one of the dominant families in the herbaceous and bushy strata in open habitats (Boldrini 1997, Matzenbacher 2003), similarly to the present study, where this family had the highest number of species.

In this study, the plant taxa with a large number of flowers and with nectar and pollen easily accessed were the most visited by species and individuals of flower visitors. Similarly to the flowers of Asteraceae, the flowers in the families Apiaceae, Arecaceae, and Euphorbiaceae, were also small and had readily accessible resources. In addition, during the flowering period, species of *Baccharis*, *Butia*, *Croton*, and *Eryngium* produced many flowers grouped in large inflorescences. Such inflorescences could greatly enhance the floral display, attracting different visitors and potential pollinators (Proctor *et al.* 1996). Thus, the flowers presenting the features mentioned above were usually visited by a wide spectrum of insects, including species with proboscis shorter than those found in bees, such as wasps and flies. So, this kind of flowers can be pollinated by different groups of floral visitor (Endress 1994, Proctor *et al.* 1996) and are called polyphilic species (Faegri & van der Pijl 1979). Conversely, plant species with few flowers and floral resources less accessible were less visited, and/or had their floral resources used by more specific floral visitors. Such flowers were found mainly in some species of the families Iridaceae, Oxalidaceae, Fabaceae, Gesneriaceae and Polygalceae.

The number of insect species and individuals recorded followed climate variations, decreasing in the dry season when the conditions were less favorable (*i.e.* low temperatures), and increasing in the warmest period of the year in the wet season. However, several other factors could influence insect seasonality. The seasonal variation in flower visits is almost certainly related to resource availability (Souza-Silva *et al.* 2001). In this study, for example, the variation in the number of insects followed the seasonal pattern of flowering in the community, and consequently a decrease or increase in the availability of floral resources may have influenced floral visitors' seasonality. In addition, insect seasonality in a community could be also influenced by reproductive phenology of different species of floral visitors (Wolda 1988).

Since bees depend exclusively on floral resources for their survival, they are the most frequent visitors found on flowers, and were reported as the most diverse and abundant group of floral visitors, as well as the main pollinators in several plant communities (Ramirez 1989, Barbosa 1997, Momose *et al*. 1998, Oliveira & Gibbs 2000, Machado & Lopes 2004, Ramirez 2004, Freitas & Sazima 2006). Flies and wasps, after bees, were the predominant floral visitors recorded in this study, as well as in *cerrado* and high-altitude grasslands (Barbosa 1997, Freitas & Sazima 2006), while beetles and lepidopterans were less represented in all three communities.

Although the goals of this study are not to compare different sampling methods for floral-visitors, the method applied here showed visit frequencies on flowers very similar to the recorded in other plant communities (Faria 1994, Schlindwein 1995, Arruda & Sazima 1996, Carvalho & Bego 1997, Alves-dos-Santos 1999, Barbola *et al.* 2000, Souza-Silva *et al.* 2001, Faria-Muci *et al.* 2003, Hermes & Köhler 2006), where the plant species with floral resources easily accessed, and many flowers, were also the most visited. Thus, resource accessibility and quantity may determine how many floral visitors will be attracted to the flowers. Hence, in an addition to the method, the abundance of flowers could be used as an indicator of resource availability in each plant species in the plant community.

The great richness and the abundance of visits recorded in the Asteraceae flowers, indicated that this family was the main resource used for anthophilous insects, mainly generalist foragers, in this plant community.

However, the importance of plant species as source of floral resources cannot be measured only by abundance and richness of floral visitors recorded in the flowers. Plant species less frequently visited, for example, may reserve their resources for more specialized floral visitors, maximizing pollination. Thus, these plant species are very important for their visitors, since the exclusion of non effective visitors will decrease the resource competition effect for their legitimate visitors (= pollinators). Moreover, in the community studied, floral oils were recorded in few plants that received few visits. However, these plant species are a very important food source for the maintenance of the diversity of specialized floral visitors such as oil-colleting bees (*i.e.* Centridini, Tapinotaspidini and Tetrapediini) (Machado & Lopes 2004, Schlindwein 2000).

The great majority of plant species (ca. 83%) in the studied community had a floral structure that allowed a free access to the floral resources, such as small size, brush, short-tube (mainly in Asteraceae species), inconspicuous and disc types (Pinheiro 2005). Thus, these plant species were visited by two or more insect groups. Among the 97 plant species visited by bees, for example, 56.6% (n = 60) received, in addition to bees, other groups of floral visitors, mainly wasps and flies. In addition, only 2.9% and 5.8% of the plant species visited by wasps and flies, respectively, were not visited by bees, but were visited by other insect groups. Small, open flowers have a larger range of interactions with different species of insects, and are potentially more generalists, than flowers with floral traits that protect them from depletion by forager robbers (Corbet 2006). Thus, in this plant community, the predominance of polyphilic species may result in a considerable degree of generalization between plant-pollinators interactions.

The results of this work highlights the importance of some plant species in terms of supporting a large number of insect visitors and have, consequently, great importance for contribution to the maintenance of insect population and diversity in the community studied. This kind of information can be used as an alternative on habitat management, where is essential to include plants with floral rewards to attract and support pollinator communities.

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