

Bee-plant community in a xeric ecosystem in Argentina

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ABSTRACT. The bee-plant community in a xeric ecosystem in northwestern Argentina was studied concerning diversity, relative abundance, floral preference and phenology. Fifty-seven bee species were recorded, 42.1% of them endemic to arid regions of southern South America, visiting flowers of 11 plant species. The most abundant bees were *Canephorula apiformis* (Friese, 1908), *Isomalopsis niveata* (Friese, 1908) and *Melectoides bellus* (Jørgensen, 1912). No strictly specialist bee was observed. Some aspects of bee-flowers associations and distribution patterns are discussed.

KEY WORDS. Bee-plant interaction, Monte Province, arid ecosystem, biogeography

The arid and semiarid habitats, especially in the subtropics, support complex and peculiar communities of bees-plants. In South America, the arid and semiarid regions are located chiefly in southwestern parts of the continent, predominantly in Argentina and Chile, as well as in Bolivia and Peru, but there are also arid regions in Venezuela-Colombia and northeastern Brazil. In Argentina, the deserts and subdeserts constitute a long pre-Andean belt, the "Cordilleranos", ranging from north to south of the country. This area is believed to comprise "refuges" for groups associated with arid conditions (STANGE *et al.* 1976).

Some aspects of the apifauna of xeric places of Argentina and adjacent areas were studied by JØRGENSEN (1912), STANGE *et al.* (1976), MOLDENKE (1976b, 1979b) and MICHENER (1979). Nevertheless, no systematic survey of the bee-plant community was carried out.

The objective of this work was to help fill this gap, by means of a standardized survey of the bee fauna, of an area in western Argentina, regarding composition, relative abundance, phenology and associations with flowers. Brief considerations about the distribution patterns of the bee fauna and associated flora are also presented.

MATERIAL AND METHODS

Study Site

The study site (1.0 ha) is situated in the Valley of Zonda – Ullum (68°40'W, 31°33'S), in the Monte Biogeographic Province (CABRERA & WILLINK 1973), close to the western slope of the "Sierra Chica de Zonda" (Fig. 1), in San Juan, Argentina. The valley constitutes a tectonic depression (altitude 900m), characterized by the

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accumulation of quaternary lacustrine sediments (APARICIO 1966, 1984). In the dry areas of the Zonda Valley, predominate the “matorrales”, a shrubby xerophytic vegetation (Fig. 2) characterized by species of *Larrea*, *Bulnesia* (Zygophyllaceae) and *Prosopis* (Leguminosae). At more humid places, at the banks of a seasonally dry river (“Zonda swamp”), species such as *Tessaria absinthioides*, *Baccharis salicifolia* (Compositae), *Tamarix gallica* (Tamaricaceae) and *Proposis strombulifera* (Leguminosae) are found.

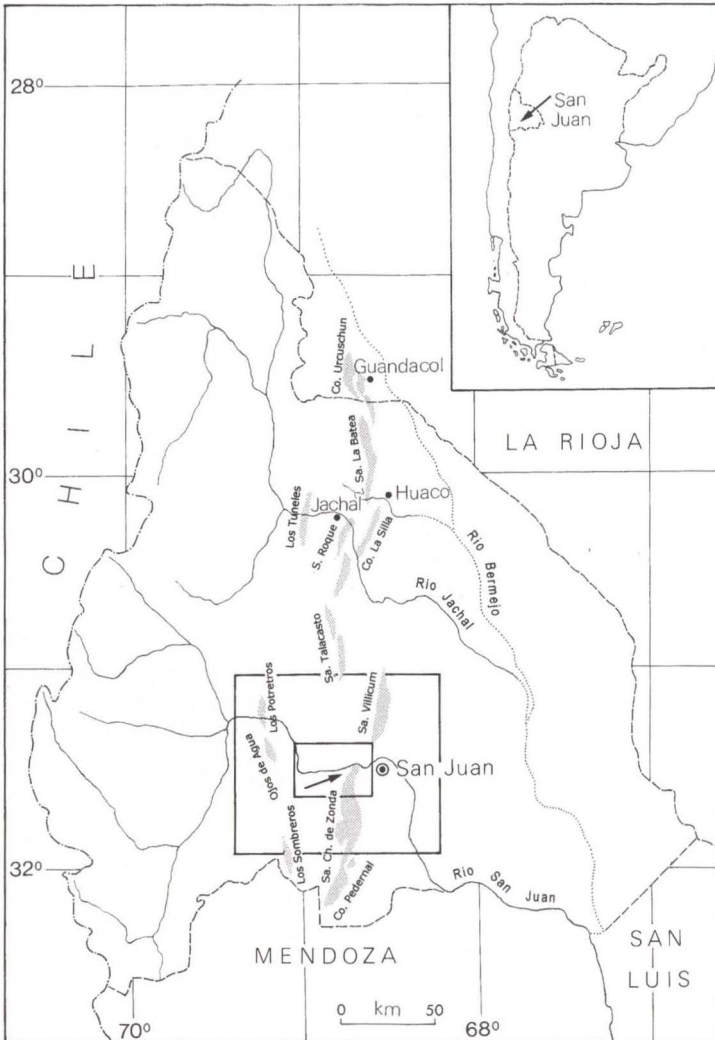


Fig. 1. Location of the Valley of Zonda – Ullum (indicated by arrow), San Juan, Argentina.

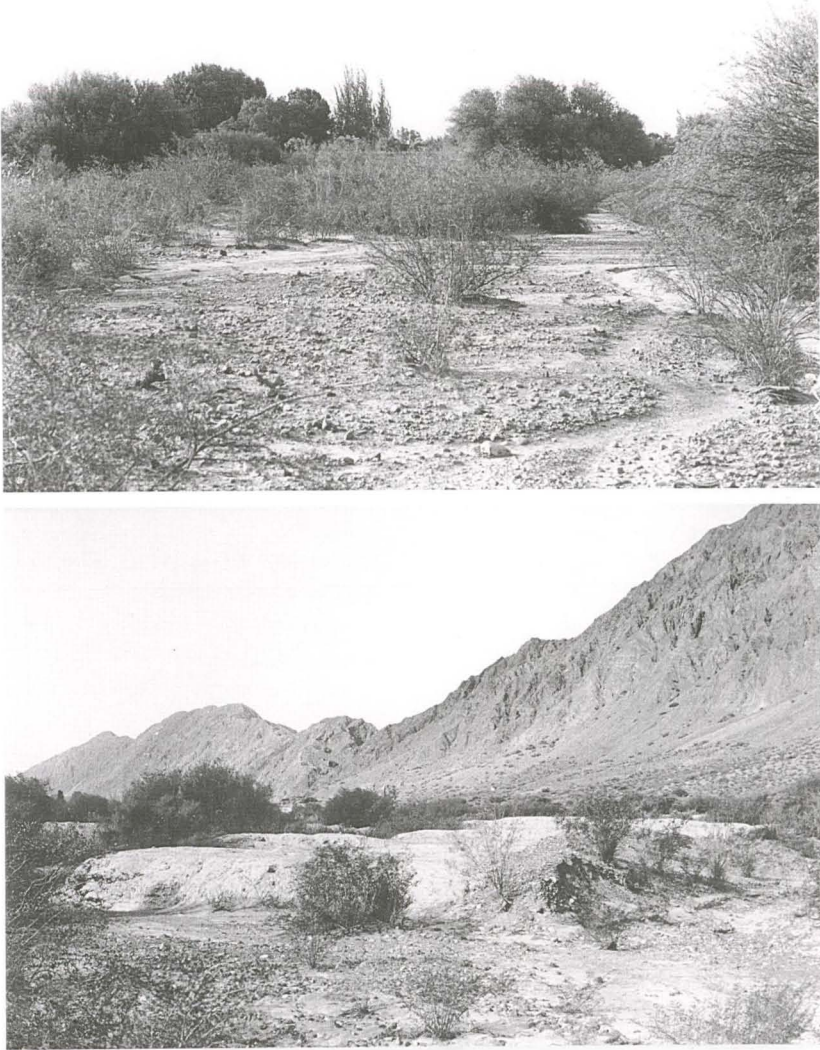


Fig. 2. Landscapes of the Valley of Zonda – Ullum, San Juan, Argentina.

The Zonda Valley has a desert climate (BWk, Köppen classification). Rains occur primarily from January through March, with an annual average precipitation of 96.3 mm. During the sampling period (May/1993 to April/1994) the precipitation was 76.9 mm, with a peak of 48.0 mm in February. The mean temperature was 15°C. January was the warmest month, with an average of 26°C, and July the coldest, with 6.5°C; the maximum temperature (41°C) was recorded in December and the minimum (0.6°C) in July (Fig. 3).

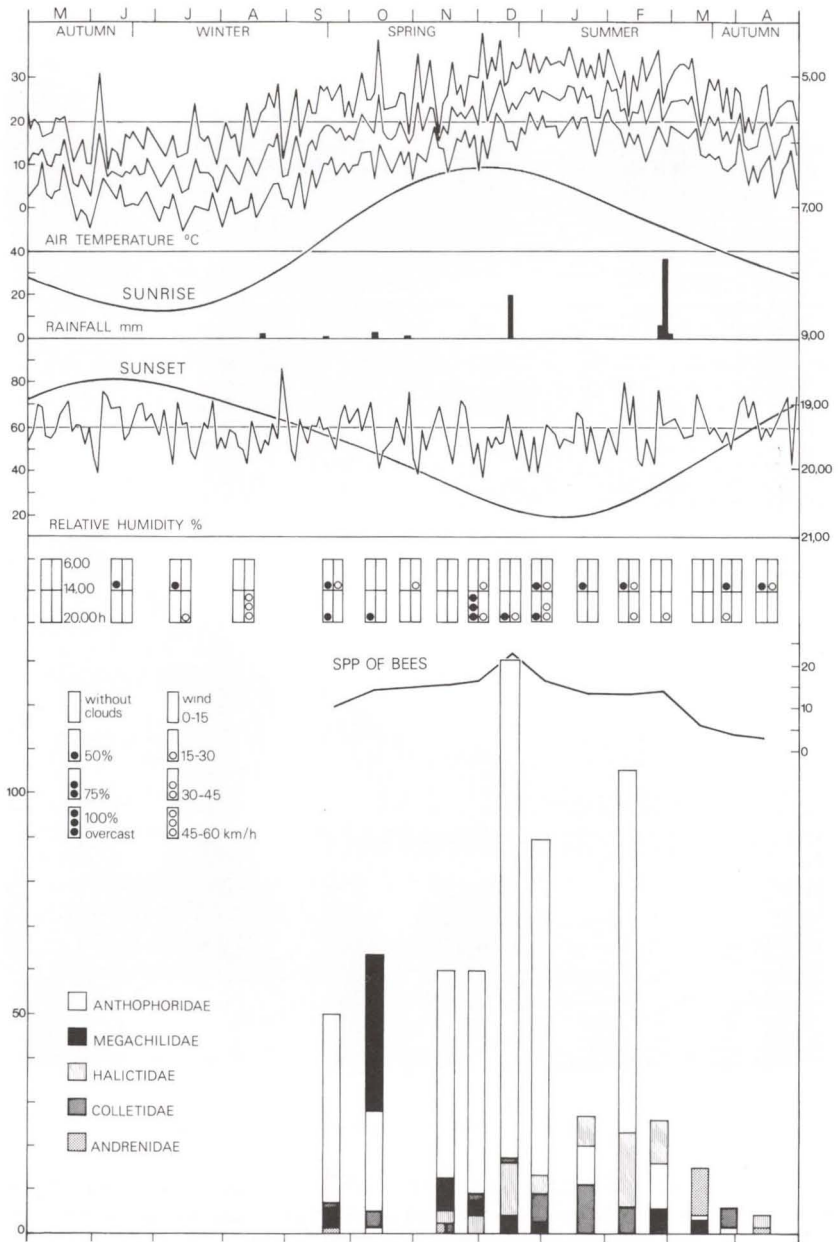


Fig. 3. Relative abundance of bees in Zonda Valley, San Juan, Argentina, and daily climatic data, from May 1993 to April 1994. The columns indicates the total of individuals per family collected in each sampling.

Bee and plant sampling

The samples were taken every 15 days from May 1993 to April 1994. According to the season, the sampling period lasted from 10 to 15 hours (for the longest days of the year, divided into two periods, from 6:00 to 14:00 h on the first day, and from 14:00 to 21:00 on the second). The bees were collected with nets on flowers in a systematic sampling scheme. The whole area was covered by one collector at one-hour intervals, staying 3 to 5 minutes at each plant regardless of the bee frequency there.

Bees and voucher specimens of the plants are deposited in the Departamento de Biologia, Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto – USP, São Paulo, Brasil (RPSP).

RESULTS

Apifauna: diversity, phenology, frequency and floral associations

During the survey, 924 bees of 57 species (30 genera, 6 families) were collected (Tab. I). The family best represented in number of species as well as individuals, was Anthophoridae, followed by Halictidae, Megachilidae, Colletidae, Andrenidae and Apidae (Tab. I). Most of the species sampled (45.6%) were represented by two to eight individuals, and 22.8% by only one. The most abundant species were *Canephorula apiformis* (211 individuals), *Isomalopsis niveata* (133) and *Melectoides bellus* (102) (Tab. I).

Bees were active from September to April (Figs 3, 4). Anthophoridae and Colletidae were recorded from September to March, Halictidae from November to April, and Andrenidae in September, November, March and April. Megachilidae exhibited two periods of activity, the first from September to December, and the second, with a much smaller number of individuals, between February and March. The largest number of species and individuals were recorded in December, when there was a predominance of Anthophoridae. This family was the most abundant in other months also, except in October when Megachilidae predominated and in January and March when Colletidae and Andrenidae, respectively, were the best represented families (Figs 3, 4).

Bees visited mainly flowers of Compositae plants (309 bee specimens of the total sampled), Zygophyllaceae (280), Capparaceae (221) and Leguminosae (108) (Tab. II).

The frequencies of bees on flowers of different plant species are summarized in table I. Andrenidae visited exclusively the flowers of Zygophyllaceae: *Larrea divaricata* (27.3%) and *Bulnesia retama* (72.7%). Megachilidae visited preferentially *L. divaricata* (84.2%), Halictidae, *Baccharis salicifolia* (39.5%) and *L. divaricata* (24.4%) and Anthophoridae, *Atamisquea emarginata* (31.0%) and *Tessaria absinthioides* (30.4%). Colletidae visited preferentially *B. salicifolia* (32.4%) and *Prosopis strombulifera* (25.7%). Most of bee species visited exclusively or preferentially flowers of Zygophyllaceae, mainly *L. divaricata* and *B. retama* (Tab. I), such as *Lonchopria robertsi* (Michener, 1989), *Colletes longiceps* Friese, 1910 (100% of the individuals), all species of Andrenidae (100%), most of Megachilidae [*Megachile* spp. (93%), *Anthidium* spp. (100%)], *Centris muralis* Burmeister, 1876 (97.3%), and all species of *Xylocopa* Latreille, 1802 (95.5%).

Table I. Number of bees collected on flowers in the arid valley of Zonda, San Juan, Argentina, from May 1993 to April 1994. (A) *Prosopis strombulifera*, (B) *Cassia aphylla*, (C) *Tessaria absinthioides*, (D) *Baccharis salicifolia* (E) *Larrea divaricata*, (F) *Larrea cuneifolia*, (G) *Bulnesia retama*, (H) *Atamisquea emarginata*, (I) *Solanum sisymbriifolium*, (J) *Atriplex* sp., (K) *Phoradendron* sp., (*) Species; (**) genus endemic to desert areas of western and central Argentina; (+) genus; (++) subgenus with amphitropical distribution: southern South America and southwestern United States and northwestern Mexico.

Bee taxa	Distribution	Plant taxa*											Females	Males	n	
		A	B	C	D	E	F	G	H	I	J	K				
Colletidae (Diphaglossinae)																
<i>Caupolicana mystica</i> (Schrottky, 1902)	*+	-	-	-	-	-	-	-	6	-	-	-	2	4	6	
<i>Willinkapis chalybaea</i> (Friese, 1906)	*	-	-	-	-	-	-	1	-	-	-	-	-	1	1	
Colletidae (Colletinae)																
<i>Leioproctus (Nomiocolletes) jenseni</i> (Friese, 1906)	*	19	-	5	6	-	-	-	-	-	1	-	27	4	31	
<i>Leioproctus (Nomiocolletes) joergenseni</i> (Friese, 1908)	*	-	-	-	7	-	-	-	-	-	-	-	2	5	7	
<i>Leioproctus (Bicolletes) neotropicus</i> (Friese, 1908)	*	-	-	-	11	-	-	-	-	-	-	-	5	6	11	
<i>Leioproctus (Bicolletes) sp.</i>	*	-	-	-	-	-	-	2	-	-	-	-	-	2	2	
<i>Lonchopria (Biglossa) chalybaea</i> (Friese, 1906)	*	-	-	-	-	-	-	-	5	-	-	-	4	1	5	
<i>Lonchopria (Biglossa) robertsi</i> (Michener, 1989)	*	-	-	-	-	1	-	4	-	-	-	-	2	3	5	
<i>Colletes cf. longiceps</i> Friese, 1910	*	-	-	-	-	3	-	2	-	-	-	-	3	2	5	
Colletidae (Xeromelissinae)																
<i>Chilicola</i> sp.	-	-	-	-	1	-	-	-	-	-	-	-	1	-	1	
Total of Colletid bees		19	-	5	24	5	-	8	12	-	1	-	46	28	74	
Andrenidae (Panurginae)																
<i>Parasarus</i> sp.	*	-	-	-	1	-	15	-	-	-	-	-	6	10	16	
<i>Callonychium (Paranychium) minutum</i> Friese, 1906	*	-	-	-	2	-	-	-	-	-	-	-	-	2	2	
<i>Calliopsis (Liopoeum) argentina</i> (Jørgensen, 1912)	+	-	-	-	3	-	1	-	-	-	-	-	2	2	4	
Total of Andrenid bees		-	-	-	6	-	16	-	-	-	-	-	8	14	22	
Halictidae (Halictinae)																
<i>Augochloropsis argentina</i> (Friese, 1908)		1	-	-	10	1	-	-	-	-	-	-	12	-	12	
<i>Augochloropsis</i> sp. 1		-	-	-	2	-	-	-	-	-	-	-	2	-	2	
<i>Augochloropsis</i> sp. 2		-	-	-	-	1	-	-	-	-	-	-	1	-	1	
<i>Dialictus (Chloralictus) autranellus</i> Vachal, 1904		-	-	-	1	-	-	-	4	-	-	-	5	-	5	
<i>Dialictus (Chloralictus) phaedrus</i> (Schrottky, 1910)		6	-	6	19	11	-	-	2	-	-	-	39	5	44	

Continue

Table I. Continued. (A) *Prosopis strombulifera*, (B) *Cassia aphylla*, (C) *Tessaria absinthioides*, (D) *Baccharis salicifolia* (E) *Larrea divaricata*, (F) *Larrea cuneifolia*, (G) *Bulnesia retama*, (H) *Atamisquea emarginata*, (I) *Solanum sisymbriifolium*, (J) *Atriplex* sp., (K) *Phoradendron* sp., (*) Species; (**) genus endemic to desert areas of western and central Argentina; (+) genus; (++) subgenus with amphitropical distribution: southern South America and southwestern United States and northwestern Mexico.

Bee taxa	Distribution	Plant taxa											Females	Males	n	
		A	B	C	D	E	F	G	H	I	J	K				
<i>Dialictus (Chloralictus) opacus</i> (Moore, 1940)		2	–	1	11	5	–	–	7	–	–	3	24	5	29	
<i>Dialictus (Chloralictus) aff. opacus</i> (Moore, 1940)		–	–	–	–	8	–	–	4	–	–	–	12	–	12	
<i>Dialictus (Chloralictus) hualtchu</i> (Holmberg, 1886)		1	–	1	–	1	–	–	–	–	–	–	3	–	3	
<i>Dialictus (Chloralictus) cf. phleboleucus</i> (Moore, 1956)		–	–	–	1	–	–	–	–	–	–	–	–	1	1	
<i>Dialictus (Chloralictus) cf. rhytidophorus</i> (Moore, 1956)		–	–	2	–	–	–	–	–	–	–	–	2	–	2	
<i>Dialictus (Chloralictus) sp. 1</i>		–	–	–	1	2	–	–	1	–	–	1	3	2	5	
<i>Caenohalictus thauca</i> (Schrottky, 1913)		–	–	–	1	–	–	–	1	–	–	–	1	1	2	
<i>Sphecodes (Austrosphcodes) sp. 1</i>		–	–	–	1	–	–	–	–	–	–	–	–	1	1	
Total of Halictid bees		10	–	10	47	29	–	–	19	–	–	4	104	15	119	
Megachilidae (Megachilinae)																
<i>Megachile (Chrysosarus) cf. obdurata</i> Mitchell, 1930		–	–	–	–	–	–	–	2	–	–	–	–	2	2	
<i>Megachile (Chrysosarus) pseudanthidioides</i> Moore, 1943		–	–	–	–	–	–	–	1	–	–	–	1	–	1	
<i>Megachile (Chrysosarus) sp. 1</i>		–	1	–	–	46	1	3	–	–	–	–	45	6	51	
<i>Megachile (Chrysosarus) sp. 2</i>		–	–	–	–	3	–	–	–	–	–	–	3	–	3	
<i>Megachile (Chrysosarus) sp. 3</i>		–	–	–	–	1	–	–	–	–	–	–	1	–	1	
<i>Megachile (Chrysosarus) sp. 4</i>		–	–	–	–	2	–	2	–	–	–	–	4	–	4	
<i>Megachile (Chrysosarus) sp. 5</i>		–	1	–	–	6	–	2	–	–	–	–	9	–	9	
<i>Megachile (Leptorachis) sp.</i>		–	–	–	–	1	–	–	–	–	–	–	1	–	1	
<i>Epanthidium cf. bicoloratum</i> (Smith, 1879)		1	–	–	–	1	–	–	1	–	–	–	1	2	3	
<i>Anthidium sp. 1</i>		–	–	–	–	29	–	2	–	–	–	–	14	17	31	
<i>Anthidium sp. 2</i>		–	–	–	–	2	–	–	–	–	–	–	2	–	2	
Total of Megachilid bees		1	2	–	–	91	1	9	4	–	–	–	81	27	108	
Anthophoridae (Anthophorinae)																
<i>Canephorula apiformis</i> (Friese, 1920)	**	3	–	110	36	22	–	–	40	–	–	–	43	168	211	
<i>Svastra (Svastra) bombilans</i> Holmberg, 1884	*	3	–	1	–	–	–	–	27	–	–	–	1	30	31	
<i>Svastrides zebra</i> (Friese, 1908)	*	–	–	–	–	1	–	–	–	–	–	–	1	–	1	

Continue

Table I. Continued. (A) *Prosopis strombulifera*, (B) *Cassia aphylla*, (C) *Tessaria absinthioides*, (D) *Baccharis salicifolia* (E) *Larrea divaricata*, (F) *Larrea cuneifolia*, (G) *Bulnesia retama*, (H) *Atamisquea emarginata*, (I) *Solanum sisymbriifolium*, (J) *Atriplex* sp., (K) *Phoradendron* sp., (*) Species; (**) genus endemic to desert areas of western and central Argentina; (+) genus; (++) subgenus with amphitropical distribution: southern South America and southwestern United States and northwestern Mexico.

Bee taxa	Distribution	Plant taxa											Females	Males	n
		A	B	C	D	E	F	G	H	I	J	K			
<i>Melissoptila (Ptilomelissa) dama</i> (Vachal, 1904)		-	-	-	3	-	-	-	-	-	-	-	3	-	3
<i>Isomalopsis niveata</i> (Friese, 1908)	**	13	4	-	1	4	-	-	111	-	-	-	39	94	133
<i>Eremapis parvula</i> (Ogloblin, 1956)	**	9	1	-	-	2	-	-	2	-	-	-	13	1	14
<i>Exomalopsis (Exomalopsis) sp.</i>		-	-	-	-	-	-	-	1	-	-	-	-	1	1
<i>Mesonychium sp.</i>		-	-	1	-	-	-	-	-	-	-	-	-	1	1
<i>Centris (Paracentris) lyngbyei</i> Jensen-Haarup, 1908	*(+)	1	1	-	-	-	-	-	-	-	-	-	2	-	2
<i>Centris (Paracentris) brethesi</i> Schrottky, 1902	*(+)	-	-	-	-	3	-	1	4	-	-	-	1	7	8
<i>Centris (Hemisiella) sp.</i>		-	-	-	-	1	-	-	-	-	-	-	1	-	1
<i>Centris (Wagenknechtia) muralis</i> Burmeister, 1876	*	-	-	-	-	18	1	18	-	-	-	-	20	17	37
Anthophoridae (Xylocopinae)															
<i>Xylocopa (Neoxylocopa) mendozana</i> Enderlein, 1913	*	-	1	-	-	4	-	5	-	1	-	-	9	2	11
<i>Xylocopa (Neoxylocopa) sp.</i>		-	-	-	-	-	-	3	-	-	-	-	3	-	3
<i>Xylocopa (Nanoxylocopa) ciliata</i> Burmeister, 1876		-	-	-	-	3	-	-	-	-	-	-	3	-	3
<i>Xylocopa (Schoenherria) splendidula</i> Lepeletier, 1841		-	-	-	-	5	-	23	-	-	-	-	2	26	28
<i>Ceratina volitans</i> (Schrottky, 1907)		-	-	8	-	-	-	-	-	-	-	-	6	2	8
Anthophoridae (Nomadinae)															
<i>Melectoides bellus</i> (Jørgensen, 1912)	*	39	-	62	-	-	-	-	1	-	-	-	10	92	102
<i>Doeringiella bipunctata</i> (Friese, 1908)	*	1	-	-	-	-	-	-	-	-	-	-	-	1	1
Total of Anthophorid bees		69	7	182	40	63	1	50	186	1	-	-	157	442	599
Apidae (Apinae)															
<i>Bombus opifex</i> Smith, 1859	*	-	-	1	-	1	-	-	-	-	-	-	2	-	2
Total of Apid bees		-	-	1	-	1	-	-	-	-	-	-	2	-	2
Total bee sample		99	9	198	111	195	2	83	221	1	1	4	398	526	924

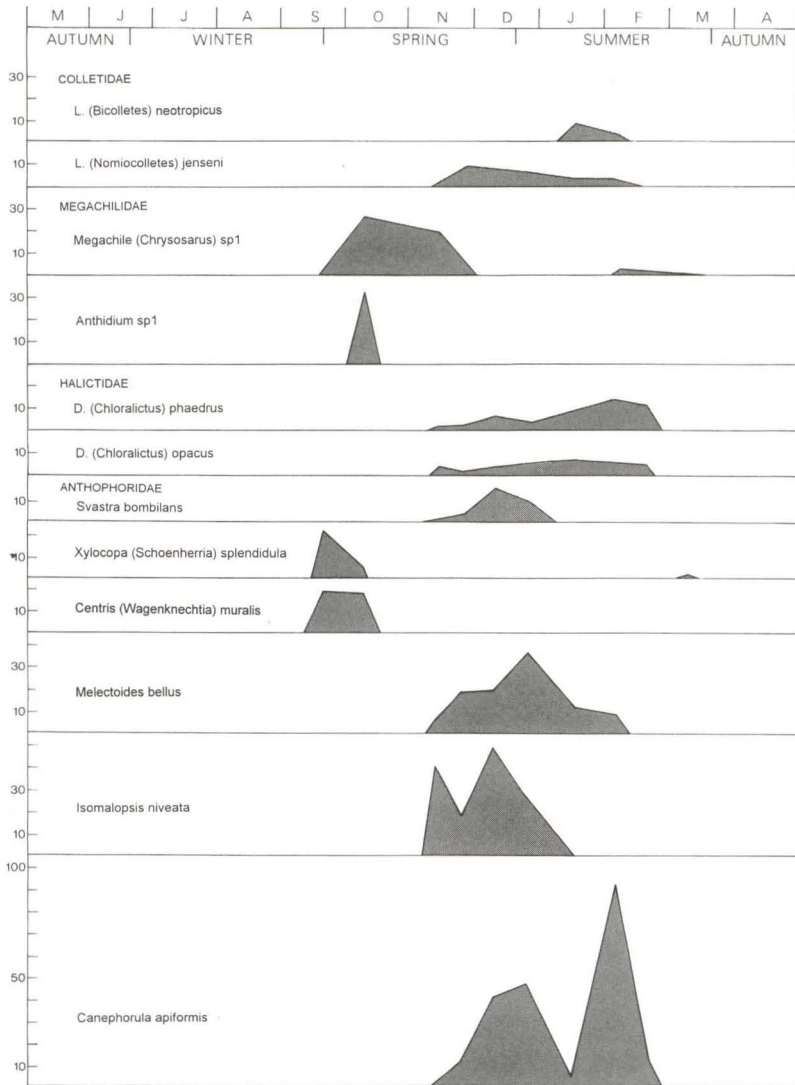


Fig. 4. Phenology of the most abundant bee species in Zonda Valley, San Juan, Argentina, from May 1993 to April 1994. The y-axis indicates the total number of individuals collected per sampling.

The Andrenidae and the most abundant species of Megachilidae were active mainly in the blooming periods of Zygophyllaceae flowering (Figs 3-4, Tabs I-II). The Panurginae, *Parasarus* Ruz, in Ruz and Rozen, 1993 (one unidentified species) and *Callonychium minutum* Friese, 1906, were active in late summer and *Calliopsis argentina* (Jørgensen, 1912) in the spring, all visiting *L. divaricata* and *B. retama*.

Table II. Number of bees sampled monthly per plant species, in the arid valley of Zonda, San Juan, Argentina, from May 1993 to April 1994. Black lines indicate flowering periods.

Plant taxa	1993				1994				n bees
	September	October	November	December	January	February	March	April	
Zygophyllaceae									
<i>Bulnesia retama</i> (1)	59	4				0	20		83
<i>Larrea cuneifolia</i> (2)	1	1							2
<i>Larrea divaricata</i> (3)	3	91	45	1		49	5	1	195
Leguminosae									
<i>Cassia aphylla</i> (4)	0	4	5						9
<i>Prosopis strombulifera</i> (5)			70	29					99
Capparaceae									
<i>Atamisquea emarginata</i> (6)			45	175	0	1			221
Solanaceae									
<i>Solanum sisymbriifolium</i>			1				0	0	1
Compositae									
<i>Baccharis salicifolia</i> (7)				5	38	61	7		111
<i>Tessaria absinthioides</i> (8)				104	19	75			198
Chenopodiaceae									
<i>Atriplex</i> sp. (9)						1			1
Loranthaceae									
<i>Phoradendron</i> sp.								4	4
Total bee sample	63	100	166	314	57	187	32	5	924

*) Geographic distribution of plants according to KIESLING (1994): 1) Argentina to Peru; 2) Deserts and semideserts in Chile, Peru and Bolivia, in Argentina from Salta to Chubut; 3) Deserts and semideserts in Argentina, Chile, Peru and Bolivia; 4) Argentina, one of the most abundant elements in the "Monte" vegetation; 5) Chile, Peru, western Argentina, from Salta to Neuquen, Buenos Aires; 6) Bolivia, Chile and Argentina (all provinces north of Rio Negro), northern Mexico and southwestern USA; 7) South America; 8) Bolivia, Chile, Uruguay and Argentina; 9) The genus is widely distributed, inhabiting arid and saline soils.

Two Paracolletini, *Leioproctus (Nomiocolletes) joergenseni* (Friese, 1908) and *L. (Bicolletes) neotropicus* (Friese, 1908), visited exclusively the flowers of *B. salicifolia* (Tab. 1). Among the Anthophoridae, *Isomalopsis niveata* and *Svastra bombilans*, were more abundant on flowers of *A. emarginata* (83.5% and 87.1% respectively). The other taxa were more generalist, such as the Halictidae and most of the Anthophoridae species. *Canephorula apiformis* was more abundant on flowers of *T. absinthioides*, *A. emarginata*, *B. salicifolia* and *L. divaricata*, and *Melectoides bellus* on flowers of *T. absinthioides* and *P. strombulifera*.

Flora: diversity and flowering phenology

Plants of 23 species belonging to 11 families were sampled in the study site, but only 11 species were visited by bees (Tabs I, II). The most diverse families were Leguminosae (7 spp.), Compositae (4 spp.) and Zygophyllaceae (3 spp.).

The flowering was restricted to Spring-Summer (September to April). Some species presented two blooming periods; the most important, by their predominance in the ecosystem, were *Larrea divaricata* and *Bulnesia retama* (Tab. II). In September and October, only Zygophyllaceae species were flowering, except for some individuals of *Cassia aphylla* (Leguminosae). In November, flowering plants of Leguminosae were dominant, in December, Capparaceae (with a single species, *Atamisquea emarginata*) and Compositae, and from January to February flowering Compositae were most abundant (Tab. II).

Besides the plants visited by bees, listed in table II, the following species were also recorded in the area: *Prosopis chilensis*, *P. flexuosa*, *Acacia aroma*, *Cercidium praecox*, *Mimosa ephedroides* (Leguminosae), *Hyalis argentea*, *Tagetes* sp. (Compositae), *Tamarix gallica* (Tamaricaceae), *Bougainvillea spinosa* (Nyctaginaceae), *Verbena mendocina* (Verbenaceae), *Phoradendron liga* (Loranthaceae) and *Brassica* sp. (Cruciferae).

DISCUSSION

Bee diversity and distribution

The bee fauna recorded in a restricted area of Zonda Valley is not directly comparable, in terms of diversity (only 57 species), with that of other arid and semiarid regions, where extensive studies have been made. Sampling in some of these regions covered much larger geographic areas and longer periods. In the desert areas of California, 688 species have been recorded (MOLDENKE 1976 a,b), 229 in central-western Argentina (JÖRGENSEN 1912) and 176 in the desert areas of Chile (MOLDENKE 1979b).

Despite the small number of species recorded in Zonda Valley, the data reveal a hybrid community, including elements with distinct biogeographical histories, such as taxa (tribes and genera) of austral distribution, autochthonous or with gondwanic affinities, Neotropical, amphitropical and widespread taxa, like *Colletes* Latreille, 1802, that occurs in all continents, except in the Orient and Australia (*cf.* MICHENER 1979).

The Paracolletini (Colletidae), one of the most conservative groups of bees, has a disjunct distribution in the austral terranes (Australian region and southern part of South America, principally), which could indicate the presence of a common ancestral biota, before the fragmentation of the southern terranes of the Gondwana continent (MICHENER 1979: 302, 1989). In the study area this tribe was represented by six species, belonging to two genera, *Leioproctus* Smith, 1853 and *Lonchopria* Vachal, 1905. Some of these taxa present, possibly, a disjunct distribution in South America: *Leioproctus* (*Nomiocolletes*) Brèthes, 1909, is found mainly in central Argentina and in Bolivia, with one species of this subgenus recorded from the Diamantina region, Minas Gerais, Brazil (Dr. J.S. Moure, pers. comm.), and another

one, *L. (Nomiocolletes) cearensis* (Ducke, 1908) in the Brazilian northeast (Ducke 1910). On the other hand, *Lonchopria (Biglossa)* Friese, 1906 is distributed through western South America, from Argentina (Mendoza) to Colombia, in the Andean and subandean eastern regions (MICHENER 1989).

Another interesting group of the Colletidae, is the genus *Caupolicana* Spinola, 1851 (Caupolicanini), with amphitropical distribution (MICHENER 1979). In South America it occurs in Argentina, Chile, southern Brazil, and recently one species was found in central-eastern Brazil, in Serra do Cipó – Minas Gerais (Faria, inf. pessoal), and it also appears in the desert areas of North America (MICHENER 1979).

The Panurginae (Andrenidae) are very diversified in the Western Hemisphere, with the majority of the species occurring in arid or subarid regions. Among the bees of this subfamily collected in the present work, the genus *Calliopsis* Smith, 1853, also shows amphitropical distribution (MICHENER 1979), though more extended when compared to *Caupolicana*. The Panurginae present on both continents (North and South America) exhibit great differentiation, with few genera in common, which indicates that disjunction could have occurred, in very ancient times, before the continental connection through the Panama isthmus (MICHENER 1979).

Some genera of Anthophoridae recorded in the Zonda Valley, like *Xylocopa* and *Ceratina* Latreille, 1802, are widely distributed, but there are groups with more restricted distributions (Tab. I), such as *Centris (Wagenknechtia)* Moure, 1950, *Svastra (Svastra)* Holmberg, 1884, *Svastrides* Michener, LaBerge & Moure, 1955 and the parasitic genus *Melectoides* Taschenberg, 1883, which are found in Argentina and Chile (MOURE 1950; ROIG-ALSINA 1991) and the monotypic genera *Canephorula* Jörgensen, 1909, *Isomalopsis* Michener & Moure, 1957 and *Eremapis* Ogloblin, 1956, endemic to Argentina (MICHENER *et al.* 1955; MICHENER & MOURE 1957; SILVEIRA 1995). The subgenus *Paracentris* Cameron, 1903, exhibits amphitropical distribution, though it has a more extensive range, considering that it extends as far as the Ecuadorian Andes. About eight species of this subgenus were registered in desert areas of the southwestern United States (HURD & LINSLEY 1975; SNELLING 1974, 1984). The species of *Paracentris* collected in Zonda Valley, *C. (Paracentris) lynghyei* Jensen-Haarup, 1908 (= *C. tricolor* Friese, 1900, *partim*) and *C. (Paracentris) brethesi* Schrottky, 1902, occur mainly in central and western Argentina (JÖRGENSEN 1912), but one other species of this group, *C. (Paracentris) klugi* Friese, 1900, was registered in xeric regions of central-eastern Brazil, associated with areas above 1400 m (SILVEIRA & CURE 1993). This pattern of disjunction between the central-eastern Brazil and Argentinian xeric areas, as in the case of *Paracentris*, could be the result of recent vicariance events, probably in the Pleistocene.

Ten percent of the genera (*Canephorula*, *Isomalopsis* and *Eremapis*) recorded and 42.1% of the species are endemic to arid and semiarid areas of Argentina (Tab. I). According to STANGE *et al.* (1976), the Anthidiini in northwestern Argentina exhibits a high degree of endemism (60% of the species); in the case of *Anthidium* Fabricius, 1804, only one species is not endemic (STANGE *et al.* 1976).

Floral associations

The melittophilous flora has a low diversity in the studied area, with only eight species of four families (Compositae, Zygophyllaceae, Capparaceae and Leguminosae) predominating in terms of abundance and accounting for almost the totality of the bee visits. Among these species, *Cassia aphylla*, with poricidal anthers, offers only pollen; the other plants offer both nectar and pollen. Some bee species had their period of activity clearly synchronized with the flowering period of Zygophyllaceae and Capparaceae species. *Centris muralis*, most of the Megachilidae, mainly *Anthidium* sp. 1, and all species of Andrenidae (Panurginae), were active only during the spring bloom of *Larrea* spp. and *Bulnesia retama*, whereas *Xylocopa splendidula* Lepeletier, 1841 and one species of *M. (Chryosarus)* Mitchell, 1943 [*M. (Chryosarus)* sp. 1] were present in both seasons, spring and late summer. *Isomalopsis niveata* and *Svastra bombilans* had their peak of activity (Fig. 4) associated with the flowering of *Atamisquea emarginata* (Tab. II).

The question of the floristic relationships between deserts of southwestern North America and southern South America has been largely discussed in the literature since the pioneer works by GRAY & HOOKER (1880), ENGLER (1896) and BRAY (1898, 1900). *Larrea* and *Atamisquea*, both abundant elements in the Zonda region, are plants of amphitropical distribution (RAVEN 1963; SOLBRIG 1972, 1983; SIMPSON & NEFF 1985; KIESLING 1994). In deserts of southwestern North America the vicariant species of *Larrea* (*L. tridentata*) is visited by about 90 species of bees, 22 of them oligolectic or preferential visitors (HURD & LINSLEY 1975). Such association of specialist bees, observed by Hurd and Linsley, in the North American deserts, is very distinct, in terms of taxonomic guilds, from that verified in the Zonda Valley; there are only two genera in common: *Calliopsis* and *Colletes*. Hurd and Linsley verified also *Caupolicana yarrowi* (Cresson, 1875) as a regular visitor of *Larrea*, however in Zonda, species of this genus were never seen on *Larrea*, although one relatively common species, *C. mystica* (Schrottky, 1902), occurs there – besides the six individuals collected in this survey, another 10 were recorded in additional samplings, but none of them on *Larrea* flowers.

In the case of *Atamisquea emarginata*, on the other hand, there is no record of bee visits in North American deserts [only MOLDENKE (1979a) mentions *Anthophora* Latreille, 1803, *Centris* Fabricius, 1804 and *Perdita* Smith, 1853 as visitor of Capparaceae], whereas in the Zonda Valley, flowers of this species were targets of 33% of the bee species collected (24% of the individuals).

CONCLUSION

In a general way, the bee community of the pre-Andean arid valley of Zonda is structured in two distinct seasonal cycles associated with the different plant blooming periods. Some bee species are active in the early Spring associated with the first bloom of Zygophyllaceae, among them, two reappear in the second bloom, in late Summer. The other bee species, like *Canephorula apiformis* and *Isomalopsis niveata*, are active from mid Spring to Summer, associated mainly with other plant species, but there is no species-specific associations with the flowers, as recorded for several bees in North American deserts, like many of the visitors of *Larrea tridentata* (HURD & LINSLEY 1975; MOLDENKE 1976b, 1979b).

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