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Pollen analysis of honeys from the northwest of Argentina: Province of Jujuy

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Abstract
The palynological characterisation of 157 honey samples from three northwest regions of Argentina (Prepuna, Yungas and Chaco) are presented to determine their botanical origin and species associations to be able to define their geographic origin. Samples were harvested during 2003–2011 and processed by means of melissopalynological conventional techniques. One-hundred and nine pollen types were identified. Representative pollen types with a frequency of occurrence greater than 50% in descending order of importance are: *Salix humboldtiana*, *Allophylus edulis*, *Baccharis*, Solanaceae, *Eucalyptus*, *Schinus*, Brassicaceae, Papilionoideae, *Celtis*, *Scutia*/*Condalia*-type and *Parapiptadenia excelsa*. The most important monofloral honeys are from the following: *Salix humboldtiana*, *Scutia*/*Condalia*-type, *Allophylus edulis*, *Baccharis*, *Blepharocalyx salicifolius*, *Gleditsia amorphoides*, Myrtaceae, *Sicyos*, *Ziziphus mistol*, *Schinopsis*-type, *Agonandra excelsa*, *Anadenathera colubrina*, *Mimosa*, all of them native species, and among introduced species are *Eucalyptus*, *Citrus* and *Tithonia*. Three apicultural zones and their corresponding pollen association indicators were determined: Zone I, Prepuna: *Arquita trichocarpa*, *Prosopis ferox*, *Schinus areira*, *Baccharis*, *Buddleja* and Mutisieae; Zone II, Yungas: Myrtaceae, *Parapiptadenia excelsa*, *Baccharis*, *Salix humboldtiana*, *Allophylus edulis*, *Scutia*/*Condalia*-type and *Zanthoxylum coco*; Zone III, transitional area Yungas-Chaco: *Prosopis*, *Salix humboldtiana*, *Schinus*, *Anadenanthera colubrina* and *Allophylus edulis*.

Keywords: *melissopalynology*, *Yungas*, *Chaco*, *Prepuna*, Apis mellifera

Argentina is one of the most important honey producer and exporter countries worldwide, commercialising more than 95% of its production (MAGYP 2015). Most of the honey production is harvested in the Pampean phytogeographic province, where research has been carried out regarding their botanical origin (Tellería 1992, 1995a, 1995b, 1996a, 1996b, 2000; Lusardi et al. 2005; Malacalza et al. 2005). Agricultural expansion in this area has led to highly anthropised environments reflected in the pollen composition of honeys with the predominance of introduced species. Similar studies have been carried out in other areas of the country where native vegetation is more relevant, such as Espinal (Costa de Bringas 1982; Costa et al. 1995; Andrada 2003; Fagúndez & Caccavari 2003, 2006; Tamame & Naab 2003; Naab et al. 2008), Chaco (Salgado & Pire 1998; Basilio & Noetinger 2002; Cabrera 2006; Salgado 2006), Delta del Parana (Basilio 1996; Basilio & Romero 1996; Fagúndez 2003), Monte (Forcone & Tellería 1998; Forcone 2003, 2008), Patagonia (Forcone & Tellería 2000; Forcone 2003, 2008) and the Subantartic Province (Forcone 2008).

In the north-western region of Argentina, apiculture is performed in the traditional way fulfilling an economic and social role as a complementary activity. In this context, the volume of honey produced and commercialised is small when comparing it with the rest of the country (MAGYP 2015); therefore, characterisation of honeys provides the opportunity to add value to this important product of the hive. To this end, melissopalynological studies of honeys from different environments have been conducted in Jujuy (Sánchez & Lupo 2011; Sánchez 2013). The aim of this study is to characterise honeys from this

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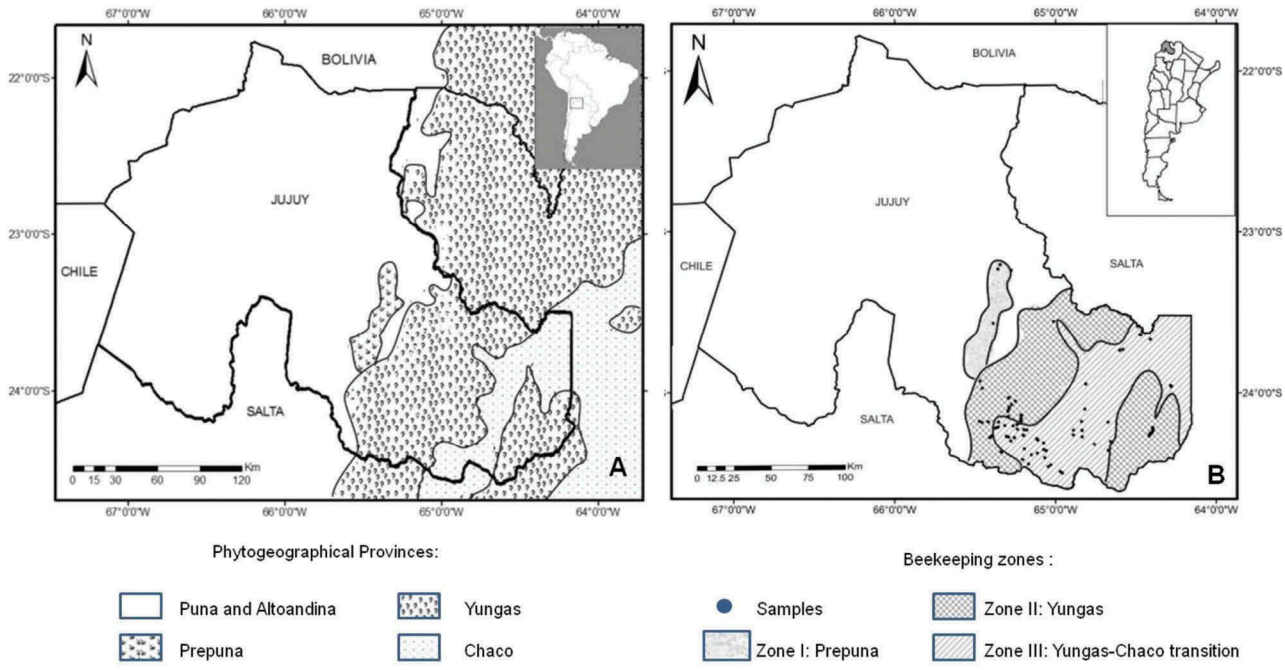

Figure 1. Phytogeographic provinces and beekeeping zone of Jujuy.

region to determine the food resources used by *Apis mellifera* L. and to identify species associations to establish their geographical origin.

Material and methods

The study area presents a wide variety of environments, from rainforest in the lower areas to high altitude xerophilous environments with grassy or shrub steppes and desserts. In Jujuy (Figure 1A), five phytogeographic provinces can be identified (Cabrera 1976): Yungas, Chaco, Prepuna, Puna and Altoandina. This study deals with the first three provinces (Table I).

The pollen content of 157 honey samples produced by *Apis mellifera* was studied, 57 from Chaco, 92 from Yungas and eight from Prepuna. The samples, obtained by centrifugation, were provided by beekeepers between 2003 and 2011. The amount of each sample was 250 g. Qualitative analysis of the sample was carried out following the method described by Louveaux et al. (1978) using the acetolysis method. Pollen sediment was mounted in glycerine and sealed with paraffin. Observations were made with a Zeiss KF2 ICS light microscope and photographs were taken with a Leica DM500 microscope with a built-in Leica ICC50 camera. To determine the frequency classes, 600 pollen grains were counted (Louveaux et al. 1978).

Pollen types were identified by comparing them with the palynotheca of the Facultad de Ciencias Agrarias, Universidad Nacional de Jujuy (PALJUA), San Salvador, Argentina, and also consulting the atlases of Markgraf and d'Antoni (1978) and Pire et al. (1998, 2002, 2006). *Scutia/Condalia*-type includes *Scutia buxifolia* Reissek and *Condalia buxifolia* Reissek both species are found in the area and are difficult to differentiate in light microscopy. In the same way, *Schinopsis*-type includes *Schinopsis lorentzii, Astronium urundeuva* Engl. and *Lithraea molleoides* (Vell.) Engl. In the study area, Myrtaceae family includes ten native genera with 20 species (Rotman 1986). There is no comprehensive study of Myrtacee and therefore, differentiating *Blepharocalyx salicifolius*, of which a full description exists, from Myrtaceae-type, which includes the remaining native genera of Myrtaceae whose generic identity is not defined, is considered as a standard.

The following frequency classes were defined: predominant pollen 'D' (> 45%), secondary pollen 'S' (16–45%), important minor pollen 'M' (3–15%), trace pollen 'T' (< 3%) (Louveaux et al. 1978). Honeys were considered as monofloral if there was a predominant pollen type, except *Citrus* sp. with 10% (Louveaux et al. 1978) and *Eucalyptus* sp. with 70% (Resolution 274/95; SAGPyA 1995). Frequency of occurrence (Feller-Demalsy et al. 1987) was established as the percentage of the total of a pollen type present in all the samples together: very frequent 'MF' (> 50%), frequent 'F' (20–50%), less frequent 'LF' (10–20%) and rare 'R' (< 10%).

In order to establish their origin, pollen types were classified according to their phytogeographic origin

Table I. Phytogeographic provinces of Jujuy.

Phytogeographic province	Districts	Vegetation type	Elevation (m a.s.l.)	Main species	Samples
CHACO	Chaqueño Occidental and Chaco Serrano	Xerophilous forests	300–1500	*Schinopsis lorentzii* (Griseb.) Engl. *Aspidosperma quebracho-blanco* Schltdl. *Ziziphus mistol* Griseb. *Cercidium praecox* (Ruiz et Pav. ex Hook.) Harms *Prosopis alba* Griseb.	**T1, T7, T11, T14, T15, T24, T25, T28, T30, T33, T34, T35, T50, T55, T56, T58, T71, T74, T75, T76, T80, T83, T84, T85, T86, T87, T91, T93, T95, T96, T97, T99, T100, T102, T105, T112, T113, T115, T117, T119, T120, T123, T125, T126, T127, T130, T131, T132, T133, T134, T136, T137, T139, T144, T149, T151, T157**
YUNGAS	Selva de Transición	Monsoon forests	350–500	*Phyllostylon rhamnoides* (J.Poiss.) Taub. *Calycophyllum multiflorum* Griseb. *Anadenanthera colubrina* (Vell.) Brenan *Parapiptadenia excelsa* (Griseb.) Burkart *Handroanthus* spp.	**T32, T40, T48, T59, T60, T61, T62, T98, T121, T135, T148**
	Selva Montana	Cloud forests	1300–1800	*Blepharocalyx salicifolius* (Kunth.) O.Berg *Cinnamomum porphyrium* (Griseb.) Kosterm. *Myrcianthes* spp. *Ilex argentina* Lillo	**T2, T3, T4, T5, T6, T8, T9, T16, T17, T18, T19, T20, T21, T22, T23, T26, T29, T31, T36, T37, T38, T39, T41, T42, T43, T44, T45, T46, T47, T49, T51, T52, T53, T54, T57, T63, T64, T65, T66, T67, T68, T69, T70, T72, T73, T77, T78, T79, T88, T89, T92, T94, T103, T104, T106, T107, T108, T109, T110, T111, T114, T122, T124, T128, T138, T140, T141, T143, T145, T146, T147, T150, T152, T153, T154, T155, T156, T158**
	Bosque Montano	Cloud forests	1200–2500	*Podocarpus parlatorei* Pilg. *Alnus acuminta* Kunth. *Juglans australis* Griseb. *Polylepis australis* Bitter.	**T90, T101, T129**
PREPUNA	—	Shrub steppes	2000–3400	*Caesalpinia trichocarpa* Griseb. *Cercidium andicola* Griseb. *Trichocereus* spp. *Prosopis ferox* Griseb. *Schinus areira* L. *Baccharis salicifolia* (Ruiz et Pav.) Pers.	**T10, T12, T13, T27, T81, T118, T142, T159**

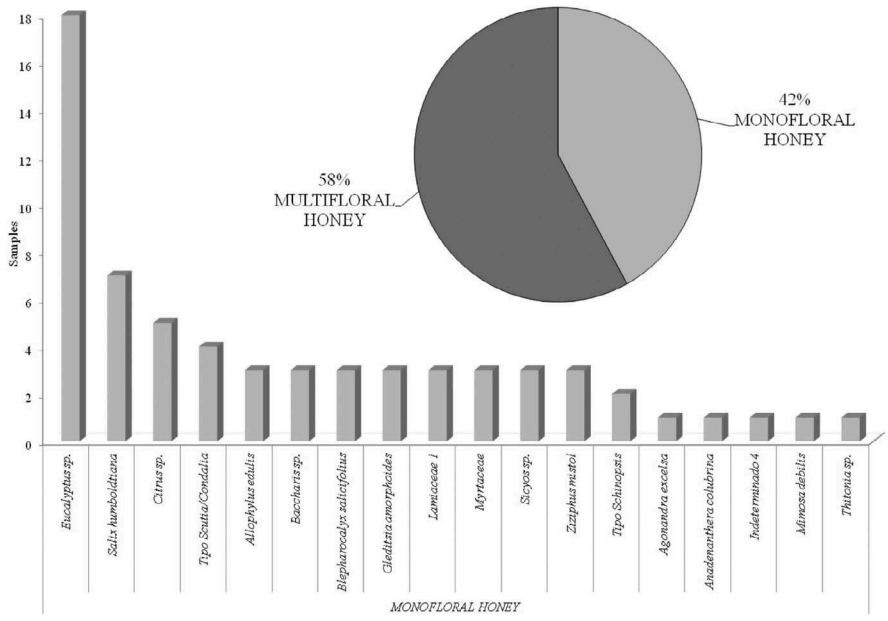

Figure 2. Botanical origin of honey from Jujuy, northwest Argentina.

as follows: Yungas (Y), Chaco (CH) and Prepuna (P) with exclusive elements from each of these provinces. Yungas and Chaco (Y-CH) comprises common species of both provinces. Yungas, Chaco and Prepuna (Y-CH-P) comprises common pollen types, most of them identified to family, genus and tribe. Anthropic pollen types (A) includes species related to human activities and unknown origin (UO; Table II).

The TILIA 1.7.14 software package was used for the data analysis and dendrogram (Grimm 1992). Standardised coefficients of dissimilarity were applied using the Euclidian distance and non-constrained (without sample ordination), incremental sum of squares analysis was performed. Pollen types in class frequency of less than 3% were not included, because these types are present throughout the pollen spectrum and do not contribute to the differentiation of the groupings. In this way, sample groupings were established presenting affinity among them. Groups were described according to abundance and frequency of their pollen types, considering as association indicators (Braun-Blanquet 1979) those with a frequency of occurrence greater than 50% and those recorded as predominant.

A canonical correspondence analysis (CCA) was performed to establish the relationship between the samples studied and sampling sites. The CANOCO 4.5 software package was used (Lepš & Šmilauer 2003) taking the environmental characteristics mean annual temperature, mean annual rainfall and altitude above sea level as external variables (Bianchi & Yañez 1992; Bianchi 1996).

Results

Botanical origin

From the 157 honey samples analysed, 109 pollen types belonging to 54 botanical families, one class and four undetermined, were identified. Among these families, Fabaceae and Asteraceae presented 17 and 14 pollen types, respectively, Solanaceae 4, Euphorbiaceae and Myrtaceae 3, and the remaining ones, one pollen type each (Table II). According to their frequency class, 66 samples were monofloral (42%) and 91 multifloral (58%). Pollen types found to be predominant are: *Eucalyptus* (18 samples), *Salix humboldtiana* Willd. (seven samples), *Citrus* (five samples), *Scutia/Condalia*-type (four samples), *Allophylus edulis* (A.St.-Hil., A.Juss. et Cambess.) Hieron. ex Niederl. (three samples), *Baccharis* (three samples), *Blepharocalyx salicifolius* (three samples), *Gleditsia amorphoides* (Griseb.) Traub. (three samples), Lamiaceae 1 (three samples), Myrtaceae (three samples), *Sicyos* (three samples), *Ziziphus mistol* (three samples), *Schinopsis*-type (two samples), *Agonandra excelsa* Griseb. (one sample), *Anadenanthera colubrina* (one sample), Indeterminate 4 (one sample), *Mimosa* (one sample) and *Tithonia* (one sample) (Figure 2).

Pollen diversity varied between five and 36 pollen types per sample, with an average of 19 pollen types. Eighty percent of samples presented between 11 and 28 different pollen types. In the total number of samples, 11 very frequent pollen types (> 50%) were identified: *Salix humboldtiana* (75%), *Allophylus edulis* (70%), *Baccharis* (70%), Solanaceae (69%), *Eucalyptus* (68%), *Schinus* (68%), Brassicaceae (58%), Papilionoideae (58%), *Celtis* (57%), *Scutia/Condalia*-type (56%) and

Table II. Pollen types identified in 157 honeys samples and their frequency classes and frequency of occurrence.

Family	Pollen type	Origin	Frequency classes				FO
			D	S	M	T	
Acanthaceae	*Justicia*	Y-CH				9	6
	Ruellia	Y-CH			1	9	6
Amaranthaceae	Amaranthaceae-Chenopodiaceae (*)	A			4	47	32
	Chamissoa altissima (*)	Y				8	5
	Gomphrena (*)	A				18	11
Anacardiaceae	*Schinus areira*	P		1	4	1	4
	Schinus	Y-CH		11	25	72	68
	Schinopsis-type	CH	2	2	3	3	6
Apiaceae	Apiaceae	UO			5	28	21
Apocynaceae	*Aspidosperma quebracho-blanco*	CH				2	1
Aquifoliaceae	*Ilex argentina*	Y				18	11
Asteraceae	Asteraceae	UO		2	20	41	40
	Baccharis	Y-CH-P	3	12	39	58	70
	Carduus	A				3	2
	Cichorium intybus	A				2	1
	Eupatorium	Y-CH		1	12	43	35
	Mutisieae	Y-CH-P		1	1	10	8
	Parthenium hysterophorus	Y-CH-P			1	4	3
	Senecio cremeiflorus	Y-CH-P				4	3
	Senecio rudbeckiiefolius	Y		1		30	19
	Senecio tilcarensis	P				1	1
	Taraxacum officinale	A				5	3
	Tithonia	A	1	1		3	3
	Vernonanthura squamulosa	Y-CH				16	10
	Viguiera	Y-CH-P			4	22	16
Berberidaceae	*Berberis*	Y				2	1
Betulaceae	*Alnus acuminata* (*)	Y				19	12
Brassicaceae	Brassicaceae	UO		2	24	66	58
Boraginaceae	Boraginaceae	Y-CH-P		1	8	53	39
Buddlejaceae	Buddleja	Y-CH-P			7	19	16
Cactaceae	Cactaceae	Y-CH				4	3
	Trichocereus	P				3	2
Capparidaceae	*Capparis*	CH		1	4	11	10
Caricaceae	*Carica quercifolia*	Y-CH				5	3
Celtidaceae	*Celtis* (*)	Y-CH			5	85	57
Convolvulaceae	*Convolvulus*	A				2	1
	Ipomoea	Y-CH-P				9	6
Cucurbitaceae	*Sicyos*	Y	3	3	2	12	13
Euphorbiaceae	Euphorbiaceae	UO		2	8	29	25
	Croton	Y-CH			1	17	11
	Sapium haematospermum	Y-CH		1	9	47	36
	Sebastiania brasiliensis	Y-CH			4	27	19
Fabaceae	*Acacia*	Y-CH-P		1	9	70	50
	Anadenanthera colubrina	Y-CH	1	5	6	63	47
	Arquita trichocarpa	P		1	2	2	3
	Caesalpinia paraguariensis	CH				6	4
	Caesalpinoideae	UO		1	2	16	12
	Cercidium andicola	P				2	1
	Cercidium praecox	CH		1	3	12	10
	Enterolobium contortissiliquum	Y-CH				2	1
	Geoffroea decorticans	CH			4	13	11
	Gleditsia amorphoides	Y-CH	3	16	16	3	24
	Mimosa	Y-CH	1	3	14	25	27
	Papilionoideae	UO		5	8	79	58
	Parapiptadenia excelsa	Y		5	19	59	52
	Prosopis ferox	P		1	4	1	4
	Prosopis	CH		2	15	42	37
	Tipuana tipu	Y-CH		1	1	32	21
Juglandaceae	*Juglans australis* (*)	Y			2	52	34

(*Continued*)

Table II. (*Continued*).

Family	Pollen type	Origin	Frequency classes				FO
			D	S	M	T	
Lamiaceae	Lamiaceae 1	UO	3	8	15	44	44
	Lamiaceae 2	UO				3	2
	Clinopodium bolivianum	Y				1	1
Lauraceae	Lauraceae	OI				24	15
Loranthaceae	*Ligaria cuneifolia*	Y-CH-P			2	4	4
Lythraceae	*Cuphea calophylla*	Y-CH				1	1
Malpighiaceae	*Heteropterys*	Y-CH				10	6
Malvaceae	Malvaceae	UO				17	11
Meliaceae	Meliaceae	UO				1	1
Myrtaceae	Myrtaceae	Y	3	15	17	14	31
	Blepharocalyx salicifolius	Y	3	2	3	12	13
	Eucalyptus	A	18	20	37	33	68
Oleaceae	*Fraxinus*	A				9	6
	Ligustrum lucidum	A		1	1	8	6
Opiliaceae	*Agonandra excelsa*	Y-CH	1		4	15	13
Onagraceae	*Oenothera*	Y-CH			1	1	1
Oxalidaceae	Oxalidaceae	UO			2	6	5
Papaveraceae	*Bocconia integrifolia*	Y				1	1
Plantaginaceae	*Plantago*	A			2	3	3
Poaceae	Poaceae (*)	UO			2	65	42
Podocarpaceae	*Podocarpus parlatorei* (*)	Y				1	1
Polygonaceae	*Polygonum*	A				1	1
Proteaceae	*Grevillea robusta*	A				1	1
Ranunculaceae	*Clematis*	Y-CH-P			5	30	22
Rhamnaceae	Rhamnaceae	A			1		1
	Scutia/Condalia-type	Y-CH	4	16	32	37	56
	Ziziphus mistol	CH	3	1	9	16	18
Rosaceae	Rosaceae	UO				30	19
	Prunus tucumanensis	Y			3	6	6
Rubiaceae	Rubiaceae	UO				3	2
Rutaceae	*Citrus*	A	5		8	27	25
	Zanthoxylum coco	Y-CH		3	15	46	40
Salicaceae	*Salix humboldtiana*	Y-CH-P	7	10	36	67	75
	Xylosma pubescens	Y				1	1
Sapindaceae	*Allophylus edulis*	Y-CH	3	13	39	57	70
	Serjania	Y			2	21	14
Sapotaceae	*Sideroxylon obtusifolium*	Y-CH			3	9	8
Scrophulariaceae	*Veronica*	A			2	23	16
Solanaceae	Solanaceae	UO		1	17	92	69
	Cestrum	Y-CH				6	4
	Lycium	Y-CH-P				2	1
	Nicotiana glauca	Y-CH-P			1	2	2
Ulmaceae	*Ulmus* (*)	A			1	10	7
Urticaceae-Moraceae (*)	Urticaceae-Moraceae (*)	UO			9	54	40
Verbenaceae	Verbenaceae	UO			1	24	16
	Duranta serratifolia	Y				2	1
Monocotyledonea	Monocotyledonea	UO			3	32	22
	Undetermined 1	UO			8	49	36
	Undetermined 2	UO		1	2		2
	Undetermined 3	UO			1	4	3
	Undetermined 4	UO	1	1		1	2

Note: D, dominant pollen (> 45%); S, secondary pollen (16–45%); M, important minor pollen (3–15%); T, traces pollen (< 3%). Y, Yungas; CH, Chaco; P, Prepuna; A, anthropic; UO, unknown origin; *, anemophilous species.

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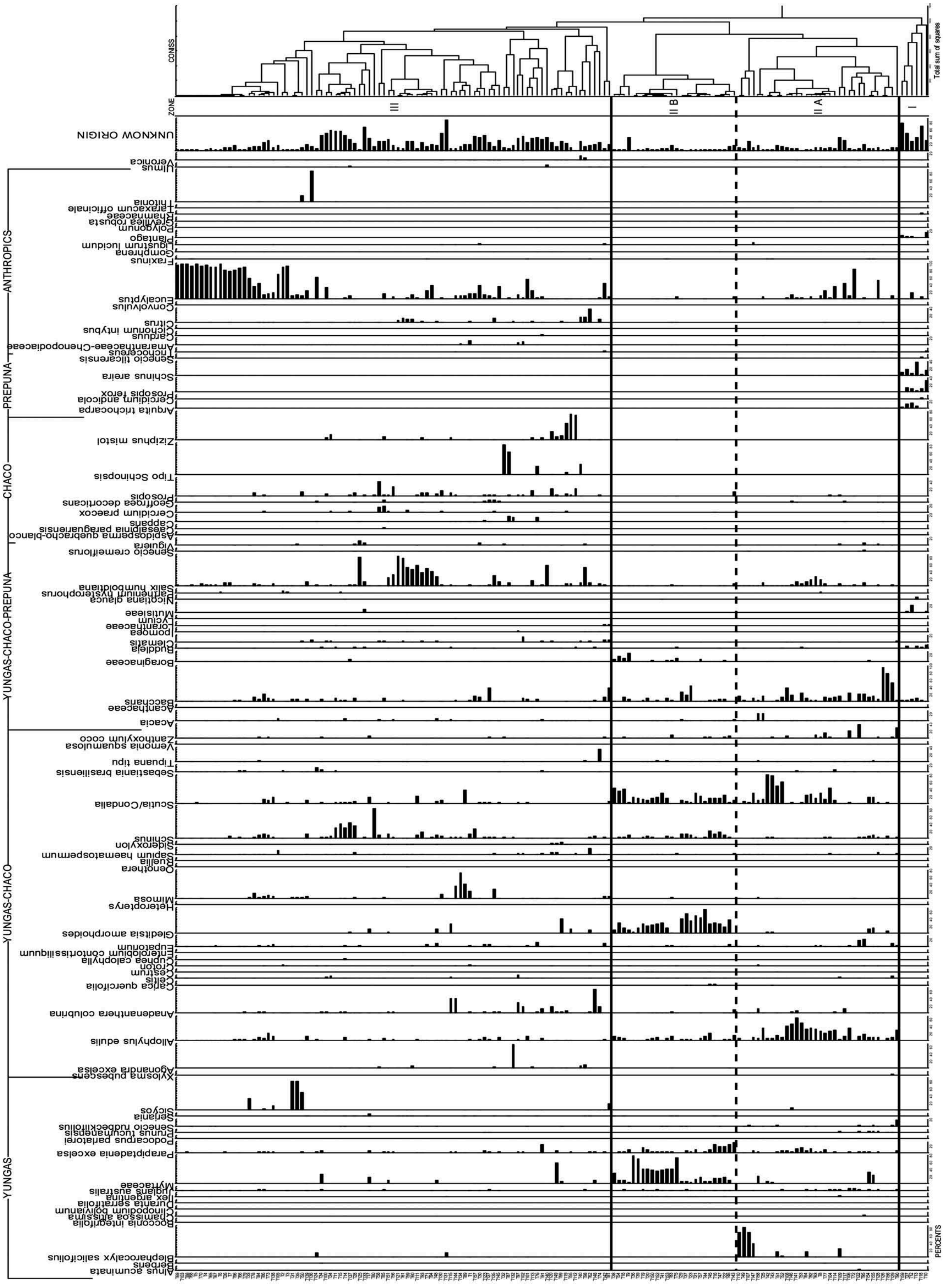
Figure 3. Dendrogram of honey from Jujuy, northwest Argentina.



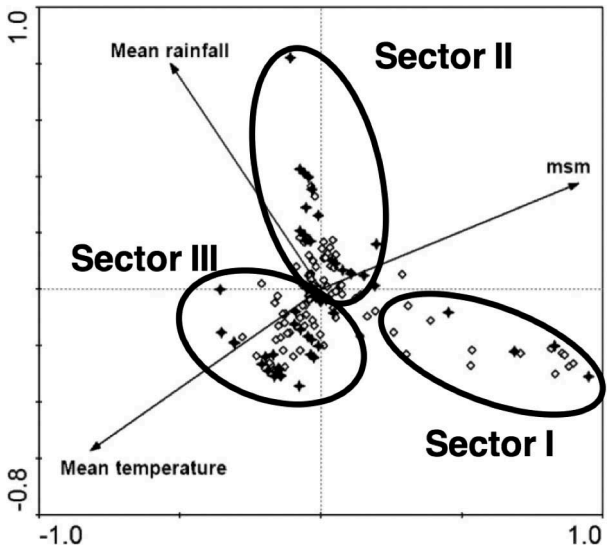


Figure 4. Canonical correspondence analysis (CCA) of honey from Jujuy, northwest Argentina.

Parapiptadenia excelsa (52%). Twenty-two pollen types were frequent (20–50%), 23 were less frequent (10–20%) and 52 rare (< 10%) (Table II).

Geographic origin

From the total number of pollen types recorded, 66% belong to native species while anthropic and unknown origin pollen types represent 17%, respectively. Two well differentiated groups (groups I and II) can be observed in the dendrogram (Figure 3). In group I, pollen types with frequency of occurrence higher than 50% are: *Arquita trichocarpa* (Griseb.) E. Gagnon, G.P.Lewis et C.E.Hughes (67%), *Prosopis ferox* (83%), *Schinus areira* (100%), *Baccharis* (100%), *Buddleja* (67%) and Mutisieae (50%) among the native species and Brassicaceae and *Plantago* among the anthropic ones. No predominant pollen type was recorded.

Group II is characterised by the presence of elements from Y-CH and Y-CH-P in all samples. It can be divided into groups IIA and IIB. In group IIA, pollen types belonging to Yungas are present in 97% of the samples, Chaco in 18% and Anthropics in 63%. Very frequent pollen types are: *Parapiptadenia excelsa* (72%) and Myrtaceae (55%) from Yungas; *Allophylus edulis* (93%), *Schinus* (72%) and *Scutia/Condalia*-type (77%) from Y-CH and *Baccharis* (76%) from Y-CH-P. At the same time, this group can be divided into group IIA_1 characterised by the presence of Myrtaceae (53%) comprising *Blepharocalyx salicifolius* and *Parapiptadenia excelsa* (65%) from Yungas, *Allophylus edulis* (94%), *Schinus* (50%) and *Scutia/Condalia*-type (68%) from Y-CH, *Baccharis* (79%), *Salix humboldtiana* (82%) from Y-CH-P and Anthropic *Eucalyptus* (59%). Predominant types recorded are: *Eucalyptus* in one sample, *Allophylus edulis*, *Baccharis* and *Blepharocalyx salicifolius* one of each in three samples and *Scutia/Condalia*-type in four. Group IIA_2 presents Myrtaceae (96%) and *Parapiptadenia excelsa* (77%) from Yungas, *Allophylus edulis* (96%), *Gleditsia amorphoides* (92%), *Schinus* (92%) and *Scutia/Condalia*-type (96%) from Y-CH, *Baccharis* (79%) and Boraginaceae (73%) from Y-CH-P. Predominant pollen types recorded are Myrtaceae and *Gleditsia amorphoides* in three samples each.

In group IIB, elements from Yungas are found in 78% of the samples, Chaco in 59% and Anthropics in 96%. This group presents four sectors: group IIB_1 with only two samples having in common *Mimosa* from Y-CH, *Baccharis, Clematis* and *Ligaria cuneifolia* (Ruiz et Pav.) Tiegh. from Y-CH-P and *Eucalyptus* among the Anthropics. No predominant pollen type is recorded. Group IIB_2 is characterised by the presence of *Anadenanthera colubrina* (82%) and *Sapium haematospermum* Müll. Arg. (55%) from Y-CH, *Acacia* (64%) and *Salix humboldtiana* (73%) from Y-CH-P and *Ziziphus mistol* (82%) from Chaco. Predominant pollen types are: *Anadenanthera colubrina* in one sample, *Ziziphus mistol* in two and *Citrus* (anthropic) in three. Group IIB_3 is characterised by the presence of *Anadenanthera colubrina* (80%) from Y-CH, *Baccharis* (60%) from Y-CH-P and *Eucalyptus* (80%) among the Anthropics. Predominant pollen types in this sector are: *Agonandra excelsa* and *Salix humboldtiana* in one sample each and *Schinopsis*-type in two. Group IIB_4 is characterised by the presence of *Allophylus edulis* (65%), *Anadenanthera colubrina* (50%) and *Schinus* (60%) all from Y-CH, *Bacharis* sp. and *Salix humboldtiana* (75%) from Y-CH-P and *Eucalyptus* sp. (78%) among the Anthropics. Predominant pollen types are: *Mimosa*, Indeterminate 4, *Schinus, Tihtonia* found in one sample each, *Citrus* in two samples, Lamiaceae 1 and *Sicyos* in three samples, *Salix humboldtiana* in seven samples and *Eucalyptus* in 17 samples.

The CCA was very significant (Monte Carlo Test), both the first canonical axis as well as all of the axes. The percentage of variance pollen types-environment variables is 47.4% for the first axis, 33.3% for the second and 19.3% for the third; the first two axes explain the greatest percentage of variance. From pollen type distribution and samples (Figure 4), three sectors can be established. In sector I, the environmental determinants are: greater altitude together with low rainfall and temperature. The main pollen types are: *Arquita trichocarpa*, Cactaceae, *Cercidium andicola, Cichorium intybus* L., *Lycium*, Mutisieae, *Nicotiana glauca* Graham, *Plantago*,

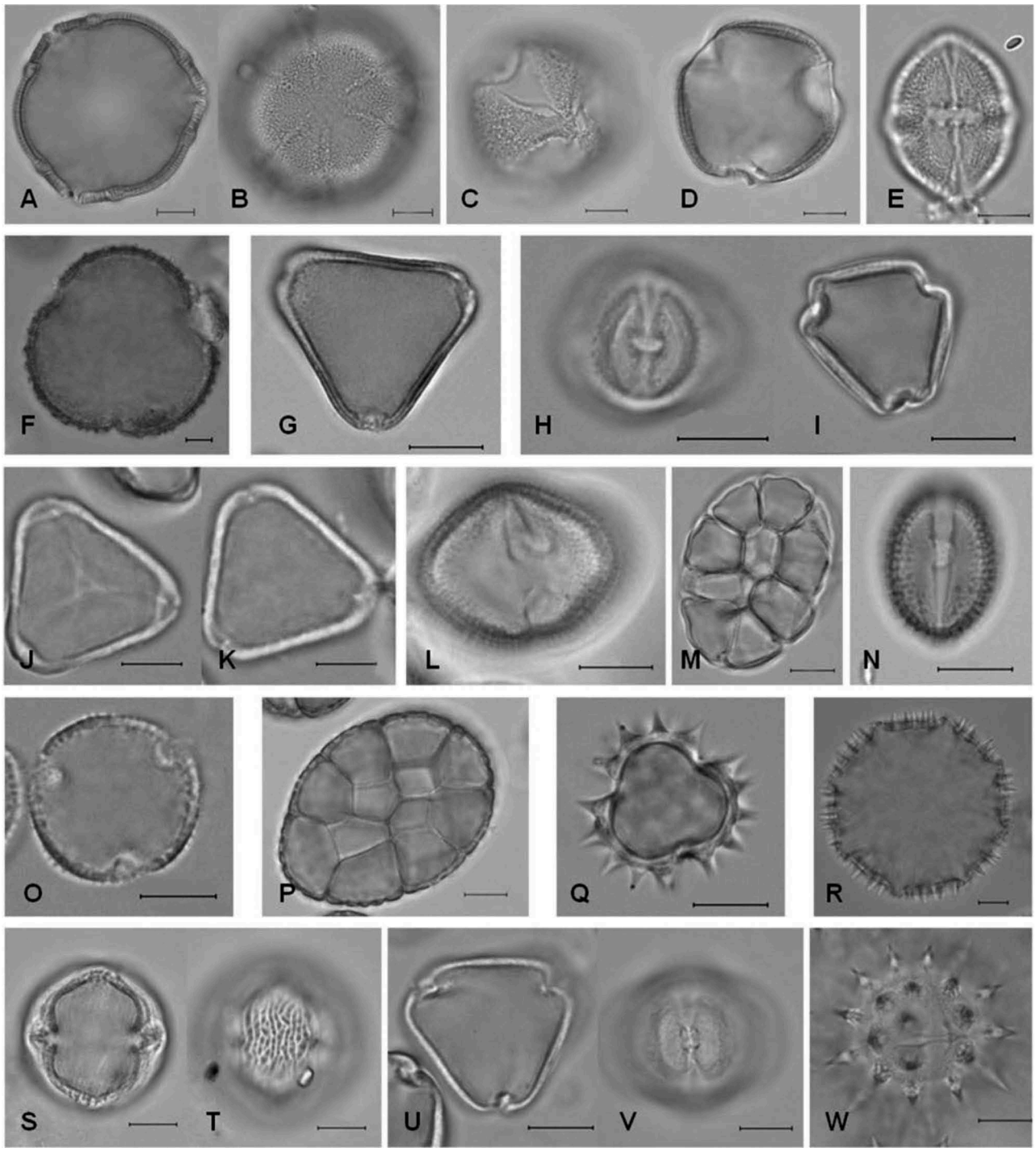


Figure 5. Micrographs of pollen types: **A, B.** *Arquita trichocarpa*. **C, D.** *Prosopis ferox*. **E.** *Schinus areira*. **F.** *Trichocereus*. **G.** *Allophylus edulis*. **H, I.** *Scutia/Condalia*-type. **J, K.** *Blepharocalyx salicifolius*. **L.** *Gleditsia amorphoides*. **M.** *Parapiptadenia excelsa*. **N.** *Salix humboldtiana*. **O.** *Agonandra excelsa*. **P.** *Anadenanthera colubrina*. **Q.** *Baccharis*. **R.** *Sicyos*. **S, T.** *Schinopsis*-type. **U, V.** *Ziziphus mistol*. **W.** *Tithonia*. Scale bars – 10 μm.

Prosopis ferox and *Schinus areira*. Sector II presents the highest rainfall from all samples studied as well as higher temperatures and less altitude than in the previous sector. In the higher and more humid area of this sector, samples belong to Selva Montana of the Yungas, while in the lower and less humid one, they belong to the

transitional area with the Chaco Serrano, with mainly pollen types of the Yungas: *Allophylus edulis*, *Blepharocalyx salicifolius*, Myrtaceae, *Eupatorium*, *Ilex argentina*, *Juglans australis*, *Parapiptadenia excelsa*, *Scutia*/*Condalia*-type, *Senecio rudbeckiaefolius* Meyen et Walp., *Zanthoxylon coco* Gillies ex Hook.f. et Arn. and *Xylosma pubescens* Griseb. Sample distribution in sector III is related to lower altitude and greater temperature when comparing it with the other sectors. It is characterised by the following pollen types: *Agonandra excelsa*, *Anadenanthera colubrina*, *Aspidosperma quebracho-blanco*, *Caesalpinia paraguariensis* Griseb., *Capparis* sp., *Celtis* sp., *Cercidium praecox*, *Geoffroea decorticans* (Gillies ex Hook. et Arn.) Burkart, *Mimosa*, *Prosopis*, *Salix humboldtiana*, *Sapium haematospermum*, Sapotaceae, *Schinus*, *Baccharis*, *Sideroxylon*, *Schinopsis*-type, *Tipuana tipu* (Benth.) Kunze and *Ziziphus mistol*.

Discussion

Botanical origin

The diversity of pollen types recorded in honeys from the Jujuy province is closely related to food resources available in the area. Zuloaga et al. (1999) recorded 2831 species of vascular plants in this province, so *Apis mellifera* uses at least 4% of the total resources. Among the pollen types found in the samples analysed, Fabaceae and Asteraceae families are best represented due to the abundance of these two families in the area with 17 and 4%, respectively, of the total resource mentioned by Zuloaga et al. (1999). This characteristic is shared with honeys from other phytogeographic provinces of the country: Pampean (Tellería 1992, 1995a, 1996a, 1996b; Lusardi et al. 2005), Monte (Forcone & Tellería 1998; Naab & Tamame 2007), Espinal and Pampean (Fagúndez & Caccavari 2003, 2006), Chaco (Salgado & Pire 1998; Cabrera 2006), Patagonian, Subantartic and Monte (Forcone 2008), Paraná River Delta (Basilio & Romero 1996).

In the study area, *Apis mellifera* shows a preference for the native flora, which is related to the abundance and availability of this resource. Exotic species are associated to productive activities in the region such as producing *Eucalyptus* honeys in forested areas and *Citrus* honeys in the citrus cultivation areas. *Tithonia* is introduced into the local flora, it is widely distributed in the province, grows spontaneously in modified soils, and it flowers towards the end of summer. Beekeepers make use of its flowering period for a late harvest when weather conditions so allows it and occasionally produces monofloral honeys. The remaining anthropic pollen types found in honeys are related to crop weeds, not reaching meaningful frequency class or occurrence frequency values. The following pollen types of native origin were found to be predominant: *Agonandra exelsa*, *Allophylus edulis* (Sapindaceae), *Anadenthera colubrina* var. *cebil* (Fabaceae), *Gleditsia amorphoides* (Fabaceae) and *Sicyos* (Cucurbitaceae), of which no records have been found in the literature.

Mimosa (Fabaceae) has not been mentioned as predominant for other areas of the country, only traces of *Mimosa* in honeys from the Chaco phytogeographical province (Salgado & Pire 1998; Cabrera 2006), but for the phytogeographical province of Caatinga in Brazil, Oliveira and Santos (2014) mention four pollen types of *Mimosa* as dominant, none present in the flora of Jujuy (Zuloaga et al. 2008). These investigations demonstrate the value of *Mimosa* as a food resource in the Chaco Dominion.

Two types of honeys can be identified for the Myrtaceae family: *Blepharocalyx salicifolius* honey produced in forests, where this species is abundant, and those from native Myrtaceae in forests, where the diversity of this family is greater. In Argentina, Myrtaceae monofloral honeys have only been recorded for the Subantartic phytogeographical province (Forcone 2008), but they are from different species to those in Jujuy. Honeys from the Entre Ríos province can have Myrtaceae in their composition but in a percentage lower than 15% (Fagúndez & Caccavari 2003, 2006).

In Jujuy, three samples of monofloral honeys from *Baccharis* (Asteraceae), related to altered environments such as abandoned crop fields or roadsides, were recorded. This is considered to be an important nectar resource in other places of Argentina (Costa et al. 1995; Basilio & Romero 1996; Salgado & Pire 1998; Wingenroth 2004; Cabrera 2006), monofloral honey from this has been recorded for the province of Entre Ríos (Fagúndez & Caccavari 2003, 2006).

Salix humboldtiana (Salicaceae) is widely distributed in Argentina along rivers and humid areas; it is considered an important pollen and nectar source. In this paper, seven samples were recorded with this pollen type as predominant, while it is frequently mentioned as pollen of lesser importance or traces in other places in the country (Basilio & Romero 1996; Tellería 1996a, 1996b; Salgado & Pire 1998; Fagúndez & Caccavari 2003, 2006; Forcone 2003; Cabrera 2006).

In the Jujuy province, two honeys from Rhamnaceae can be identified: *Ziziphus mistol* honey from the phytogeographic province of Chaco (Basilio & Noetinger 2002; Cabrera 2006; Salgado 2006) and *Scutia*/*Condalia*-type honey with pollen type composed of *Scutia*

buxifolia and *Condalia buxifolia*. Tellería et al. (2006) considers Rhamnaceae honeys from *Discaria americana* Gillies et Hook. (province of Espinal) and *Scutia buxifolia* (provinces of Espinal and Pampean) as being fetid, this is not the case for honeys from Jujuy as they are characterised by a strong floral aroma and intense flavour.

Schinopsis-type, from Anacardiaceae, includes *Lithraea molleoides* (Vell.) Engl., *Schinopsis lorentzii* and *Astronium urundeuva*. This pollen type is recorded as predominant in two samples of honey from Jujuy. In Argentina, *Astronium balansae* Engl., *Schinopsis balansae* Engl. and *Schinopsis lorentzii* honeys in the Chaco phytogeographical province (Salgado & Pire 1998; Basilio & Noetinger 2002; Cabrera 2006; Salgado 2006).

Anemophilous pollen types found in honey are reported in traces or important minor pollen are related to local vegetation in the study area, among them Amaranthaceae-Chenopodiaceae and Poaceae are from the herbaceous stratum, Ulmaceae and *Fraxinus* from exotic trees, *Celtis* sp. from the native shrub stratum and *Alnus acuminata*, *Juglans australis* and *Podocarpus parlatorei* from native tree stratum in the Bosque Montano of the Yungas.

Geographic origin

The characteristic pollen types in Jujuy honeys are those recorded as very frequent: *Salix humboldtiana*, *Allophylus edulis*, *Baccharis*, Solanaceae, *Eucalyptus*, *Schinus*, Brassicaceae, Papilionoideae, *Celtis*, *Scutia*/*Condalia*-type and *Parapiptadenia excelsa*. Native taxa are of greater importance in the production of honeys giving them characteristics of each of the environments of the region. This means that pollen associations can be established as indicators of their geographical origin. From the analysis and interpretation of the dendrogram, sectors identified in the CCA and the comparison among phytogeographic provinces (Cabrera 1976), three zones can be differentiated (Figure 1B):

Zone I. — It can be observed that group I is correlated with sector I presenting pollen and environmental characteristics of the Prepuna phytogeographic province. This region lies between 2000 m and 3000 m above sea level (a.s.l.) with mean rainfall between 130 mm and 160 mm and mean annual temperatures between 12 °C and 13 °C. The indicator types are: *Arquita trichocarpa*, *Prosopis ferox* and *Schinus areira*, being all of them Prepuna native vegetation and accompany by *Baccharis*, *Buddleja* and Mutisieae, Fabaceae and Poaceae. No monofloral honeys are recorded (Figure 5A, B).

Zone II. — Group IIA comprises samples found in sector II of the CCA. This area comprises species from Selvas Montanas of the Yungas. It lies between 1200 m and 1500 m a.s.l., climbing the southern mountainside to up to 2000 m a.s.l. Mean annual rainfall is greater than 900 mm and mean annual temperature varies between 14 °C and 17 °C. The association indicators are: Myrtaceae (including *Blepharocalyx salicifolius*), *Parapiptadenia excelsa*, *Allophylus edulis*, *Schinus*, *Scutia*/*Condalia*-type, *Baccharis* and *Salix humboldtiana*, producing monofloral honeys from *Allophylus edulis*, *Baccharis*, *Gleditsia amorphoides*, Myrtaceae and *Scutia*/*Condalia*-type. In this zone, sample distribution can be divided into two areas: Zone IIA, which coincides with group IIA_1 in the western region of Yungas, with *Blepharocalyx salicifolius* as characteristic Myrtaceae accompanied by *Parapiptadenia excelsa*, and Zone IIB, coinciding with group IIA_2 on the east of the province with Myrtaceae and *Gleditsia amorphoides* as main pollen types (Fig-Figures 1B, 5C, D).

Zone III. — Group IIB includes samples from CCA sector III. They are distributed along the San Francisco river valley ascending the ravines up to 1500 m a.s.l. Mean rainfall values are lower than 800 mm and annual mean temperature varies between 17 °C and 21 °C. This is the most populated area of the Jujuy Province and it is also where the main agricultural activities take place. This zone is characterised by a great number of pollen types shared by Yungas and Chaco and many elements of anthropic origin being the sector of the dendrogram where pollen types from Chaco Group are concentrated. Although it can be subdivided, this division cannot be justified by environmental variables or spatial distribution of samples, consequently, it is regarded as one zone. According to Cabrera (1976), the sample distribution area, which lies between 300 m and 1500 m a.s.l., corresponds to the following phytogeographic provinces and districts: Selva de Transicion district (350–500 m a.s.l.) and Selvas Montanas district (550–1500 m a.s.l.) of the Yungas and Chaco, the Chaqueño Occidental district in the easternmost area of Jujuy and Chaco Serrano district on the first mountain ranges in the east of Jujuy forming an ecotone area together with the Yungas. It is not possible to make such differentiation in the grouping but a transitional area between Yungas and Chaco provinces can be observed having elements common to these two phytogeographic and anthropic provinces. The indicator pollen types are: *Celtis*, *Salix humboldtiana*, *Schinus*, *Eucalyptus*, Lamiaceae 1 and Poaceae accompanied by *Prosopis*, *Ziziphus mistol*, *Parapiptadenia excelsa*, *Anadenanthera colubrina* var.

cebil, *Allophylus edulis*, *Scutia*/*Condalia*-type, *Mimosa*, *Sapium haematospermum* and *Sebastiania brasiliensis* Spreng. Monofloral honeys from *Anadenathera colubrina*, *Mimosa*, *Salix humboldtiana*, *Ziziphus mistol*, *Sicyos*, *Schinopsis*-type and *Agonandra excelsa* are recorded (Figure 5E, F).

The presence of pollen types related to human activities is evident through the whole spectrum analysed, being more frequent in Zone III. In this area, *Citrus* monofloral honey is recorded in the area of production of that crop, *Eucalyptus* honey in areas of afforestation and *Tithonia* honey in areas where this important invasive weed is not controlled. Brassicaceae are frequent and they are related to crop weeds such as *Rapistrum rugosum* (L.) All. or *Raphanus sativus* L. both naturalised in Jujuy. The remaining types identified are not relevant in the production of honey.

Conclusions

In the Jujuy Province, the native flora is a very important component in the production of *Apis mellifera* honeys. It is of greater value than exotic species due to the number of pollen types as well as frequency and occurrence class recorded. Representative pollen types of honeys from Jujuy are those recorded as very frequent: *Salix humboldtiana*, *Baccharis*, *Allophylus edulis*, Solanaceae, *Schinus*, *Eucalyptus*, Brassicaceae, Papilionoideae, *Celtis*, *Scutia*/*Condalia*-type and *Parapiptadenia excelsa*. According to their geographical origin, three beekeeping zones can be established. Zone I: Prepuna, its association of indicator pollen types is *Caesalpinia trichocarpa*, *Prosopis ferox*, *Schinus areira*, *Baccharis*, *Buddleja* and Mutisieae accompanied by Brassicaceae, *Plantago*, Fabaceae and Poaceae. Zone II: Yungas, with the following association of indicator pollen types: native Myrtaceae (including *Blepharocalyx salicifolius*), *Parapiptadenia excelsa*, *Baccharis*, *Salix humboldtiana*, *Allophylus edulis*, *Scutia*/*Condalia*-type and *Zanthoxylum coco*. Zone III: Transition between Yungas and Chaco, with *Celtis*, *Salix humboldtiana*, *Schinus*, *Eucalyptus*, Lamiaceae 1 and Poaceae accompanied by *Prosopis Ziziphus mistol*, *Parapiptadenia excelsa*, *Anadenanthera colubrina*, *Allophylus edulis*, *Scutia*/*Condalia*-type, *Mimosa*, *Sapium haematospermum* and *Sebastiania brasiliensis*. The production of unifloral honeys belonging to the following native species is highlighted: Zone II: *Allophylus edulis*, *Baccharis*, *Gleditsia amorphoides*, Myrtaceae and *Scutia*/*Condalia*-type; Zone III: *Anadenathera colubrina*, *Mimosa*, *Salix humboldtiana*, *Ziziphus mistol*, *Sicyos*, *Schinopsis*-type and *Agonandra excelsa* were recorded. Except for *Ziziphus mistol* honeys, which are produced in Chaco, the remaining ones constitute the first reference of those honeys.

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References

Andrada AC. 2003. Flora utilizada por *Apis mellifera* L. en el sur del Caldenal (Provincia fitogeográfica del Espinal), Argentina. Revista del Museo Argentino de Ciencias Naturales-Nueva serie 5: 329–336. doi:10.22179/REVMACN.5.63.

Basilio AM. 1996. Polen de las especies hidrófitas en las mieles del delta del Río Paraná (Argentina). Boletín de la Sociedad Argentina de Botánica 31: 231–234.

Basilio AM, Noetinger M. 2002. Análisis polínico de las mieles de la Región Chaqueña: Comparación del origen floral entre las zonas; domo central y esteros, cañadas y selvas de ribera. Revista de Investigaciones Agropecuarias 31: 127–134.

Basilio AM, Romero EJ. 1996. Contenido polínico en las mieles de la región del Delta del Paraná (Argentina). Darwiniana 34: 113–120.

Bianchi AR. 1996. Temperaturas medias estimadas para la región Noroeste Argentino. Salta: INTA.

Bianchi AR, Yañez CE. 1992. Las precipitaciones en el Noroeste Argentino. Salta: INTA.

Braun-Blanquet J. 1979. Fitosociología, bases para el estudio de las comunidades vegetales. Madrid: Blume.

Cabrera AL. 1976. Regiones fitogeográficas Argentinas. Enciclopedia Argentina de Agricultura y Jardinería 2: 1–85.

Cabrera MM. 2006. Caracterización polínica de las mieles de la Provincia de Formosa, Argentina. Revista del Museo Argentino de Ciencias Naturales-Nueva serie 8: 135–142. doi:10.22179/REVMACN.8.312.

Costa MC, Decolatti N, Godoy F. 1995. Análisis polínico de las mieles del norte de la Provincia de San Luis (Argentina). Kurtziana 24: 133–144.

Costa de Bringas MC. 1982. Contribución al conocimiento de la Flora Melífera de la Provincia de córdoba. I, Departamento de Río Segundo. Boletín de la Sociedad Argentina de Botánica 21: 247–258.

Fagúndez GA. 2003. Diagnosis polínica de especies características de mieles "de isla" de la provincia de Entre Ríos. Argentina. Revista del Museo Argentino de Ciencias Naturales, Nueva Serie 5: 351–361. doi:10.22179/REVMACN.5.65.

Fagúndez GA, Caccavari MA. 2003. Caracterización polínica y organoléptica de algunas mieles monoflorales del centro de la provincia de Entre Ríos, Argentina. Polen 12: 77–95.

Fagúndez GA, Caccavari MA. 2006. Pollen analysis of honeys from the central zone of the Argentine province of Entre Ríos. Grana 45: 305–320. doi:10.1080/00173130601086636.

Feller-Demalsy M, Parent J, Strachan A. 1987. Microscopic analysis of honeys from Alberta, Canada. Journal of Apicultural Research 26: 123–132. doi:10.1080/00218839.1987.11100748.

Forcone A. 2003. Floración y utilización de la flora apícola en el Valle inferior del Río Chubut (Patagonia, Argentina). Boletín de la Sociedad Argentina de Botánica 38: 301–310.

Forcone A. 2008. Pollen analysis of honey from Chubut (Argentinean Patagonia). Grana 47: 147–158. doi:10.1080/10652460802106340.

Forcone A, Tellería MC. 1998. Caracterización palinológica de las mieles del valle inferior del Río Chubut (Argentina). Darwiniana 36: 81–86.

Forcone A, Tellería MC. 2000. Caracterización palinológica de las mieles del la llanura del Río Senguerr (Chubut, Argentina). Darwiniana 38: 267–271.

Grimm EC. 1992. Tilia and Tilia-graph: Pollen spreadsheet and graphics programs. Abstracts of the 8th International Palynological Congress, Aix-en-Provence, France, 6–12 September 1992, 56.

Lepš M, Šmilauer P. 2003. Multivariate analysis of ecological data using CANOCO. Cambridge: Cambridge University Press.

Louveaux J, Maurizio A, Vorwohl G. 1978. Methods of melissopalynology. Bee World 59: 139–157. doi:10.1080/0005772X.1978.11097714.

Lusardi M, Prado D, Gattuso S. 2005. Contenido polínico de las mieles del sur de la Provincia de Santa Fe (Argentina). Boletín de la Sociedad Argentina de Botánica 40: 85–90.

MAGYP. 2015. Ministerio de Agricultura, Ganadería y Pesca. República Argentina. Alimentos Argentinos. Sector Apícola 2013. Informe de Coyuntura 3. http://www.alimentosargentinos.gob.ar/contenido/sectores/otros/apicola/informes/2014.pdf; accessed 13 May 2015.

Malacalza NH, Caccavari MA, Fagúndez GA, Lupano CE. 2005. Unifloral honeys of the province of Buenos Aires, Argentine. Journal of the Science of Food and Agriculture 85: 1389–1396. doi:10.1002/(ISSN)1097-0010.

Markgraf V, d'Antoni H. 1978. Pollen flora of Argentina. Tucson, AZ: The University of Arizona Press.

Naab O, Tamame MA. 2007. Flora apícola primaveral en la región del Monte de la Provincia de La Pampa (Argentina). Boletín de la Sociedad Argentina de Botánica 42: 251–259.

Naab O, Tamame MA, Caccavari M. 2008. Palynological and physicochemical characteristics of three unifloral honey types from central Argentina. Spanish Journal of Agricultural Research 6: 566–576. doi:10.5424/sjar/2008064-351.

Oliveira PP, Santos FAR. 2014. Prospecção palinológica em méis da Bahia. Feira de Santana: Print Mídia.

Pire SM, Anzótegui LM, Cuadrado GA. 1998. Flora polínica del Nordeste Argentino. Volume 1. Corrientes: EUDENE-UNNE.

Pire SM, Anzótegui LM, Cuadrado GA. 2002. Flora polínica del Nordeste Argentino. Volume 2. Corrientes: EUDENE-UNNE.

Pire SM, Anzótegui LM, Cuadrado GA. 2006. Flora polínica del Nordeste Argentino. Volume 3. Corrientes: EUDENE-UNNE.

Rotman AD. 1986. Las Myrtaceae del Noroeste Argentino. Darwiniana 27: 507–526.

SAGPyA (Secretaría de Agricultura, Ganadería, Pesca y Alimentación). 1995. Resolución 274/95. Sistema de clasificación de miel teniendo como base su origen botánico. Boletín Oficial 28268: 2.

Salgado CR. 2006. Flora melífera de la Provincia de Chaco. Provincia de Chaco: PROSAP. Ministerio de la Producción.

Salgado CR, Pire SM. 1998. Análisis polínico de las mieles del noroeste de la Provincia de Corrientes (Argentina). Darwiniana 36: 87–93.

Sánchez AC. 2013. Caracterización botánica y geográfica de las mieles de *Apis mellifera* L. en la provincia de Jujuy. PhD thesis, Universidad Nacional de Salta, Salta, Argentina.

Sánchez AC, Lupo LC. 2011. Origen botánico y geográfico de las mieles de El Fuerte, Departamento de Santa Bárbara, Provincia de Jujuy. Argentina. Boletín de la Sociedad Argentina de Botánica 46: 105–111.

Tamame MA, Naab O. 2003. Mieles monoflorales pampeanas de *Condalia microphylla* Cav. y *Centaurea solstitiales* L.: Análisis melisopalinológicos relacionados con dos caracteres fisicoquímicos. Revista del Museo Argentino de Ciencias Naturales, Nueva Serie 5: 371–381. doi:10.22179/REVMACN.5.148.

Tellería MC. 1992. Caracterización botánica y geográfica de las mieles de la provincia fitogeográfica Pampeana (Republica Argentina) I: Distrito Oriental. Darwiniana 31: 345–350.

Tellería MC. 1995a. Plantas de importancia apícola del distrito oriental de la región pampeana (Argentina). Boletín de la Sociedad Argentina de Botánica 30: 131–136.

Tellería MC. 1995b. El polen de las mieles del noroeste de la Provincia de Buenos Aires, Argentina. Darwiniana 33: 347–364.

Tellería MC. 1996a. Caracterización botánica y geográfica de las mieles de la provincia fitogeográfica Pampeana (Republica Argentina) II: Tandilla. Boletín de la Sociedad Argentina de Botánica 32: 91–94.

Tellería MC. 1996b. Caracterización botánica y geográfica de las mieles de la provincia fitogeográfica Pampeana (Republica Argentina) – III. Noroeste de la Provincia de la Pampa. Darwiniana 34: 245–249.

Tellería MC. 2000. Contribución a la identificación del polen de las mieles pampeanas. Boletín de la Sociedad Argentina de Botánica 35: 125–136.

Tellería MC, Salgado CR, Andrada AC. 2006. Rhamnaceae asociadas a mieles fétidas en Argentina. Revista del Museo Argentino de Ciencias Naturales, Nueva Serie 8: 237–241.

Wingenroth MC. 2004. Flora apícola, La Asunción, Lavalle, Mendoza, Argentina. Mendoza: Zeta editores.

Zuloaga FO, Morrone ON, Belgrano MJ, Marticorena C, Marchesi E. 2008. Catálogo de las plantas vasculares del Cono Sur (Argentina, Sur de Brasil, Chile, Paraguay y Uruguay). Monographs in Systematic Botany from the Missouri Botanical Garden 107: 1–3348.

Zuloaga FO, Morrone ON, Rodriguez D. 1999. Análisis de la biodiversidad de plantas vasculares de la Argentina. Kurtziana 27: 17–167.