ISSN 0373-580 X
Bol. Soc. Argent. Bot. 44 (1-2): 65 - 74. 2009

ASTERACEAE VISITED BY HONEYBEES IN ARGENTINA: A RECORD FROM ENTOMOPALYNOLOGICAL STUDIES

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Summary: Entomopalynological studies of Asteraceae in Argentina revealed that 64 taxa occurred in food stored by honeybees. The most visited plant tribes were classified according to both the type of reward provided by the different taxa and the intensity that such reward is collected by honeybees. Exotic plant taxa were intensely visited inside the disturbed areas (e.g. Cardueae and Cichorieae tribes), whereas native taxa (e.g. Barnadesioideae, Mutisieae, Astereae and Eupatorieae) were intensely visited in less disturbed areas. A large number of identified taxa of Asteraceae and the evaluation of its importance to honeybee nutrition were presented. The present study contributes to the knowledge of relationship between Asteraceae and honeybees.

Key words: pollen, nectar, Asteraceae, *Apis mellifera*, phytogeographical regions, Argentina.

Resumen: Asteraceae visitadas por abejas melíferas en Argentina: un registro a partir de estudios entomopalinológicos. A partir de estudios entomopalinológicos se encontró que 64 taxa pertenecientes a la familia Asteraceae están presentes en los alimentos almacenados por las abejas melíferas. Los representantes exóticos fueron intensamente visitados en las áreas más alteradas (e.g. Cardueae and Cichorieae), mientras que algunos representantes nativos (e.g. Barnadesioideae, Mutisieae, Astereae y Eupatorieae) fueron intensamente visitados en áreas menos alteradas. Se presenta un importante número de taxa de Asteraceae relevantes para la nutrición de las abejas melíferas. El presente trabajo contribuye a conocer la relación entre Asteraceae y abejas melíferas.

Palabras clave: polen, néctar, Asteraceae, *Apis mellifera*, regiones fitogeográficas, Argentina.

INTRODUCTION

Asteraceae is the most diverse of all plant families of Angiosperms; it includes 1700 genera and ca. 24000-30000 species of global distribution in almost all terrestrial ecosystems except for Antarctica (Funk *et al*., 2005). Although it is known that the pollen of Asteraceae is carried by different vectors such as insects, birds and wind (e.g. Faegri & van der Pijl, 1979), there are a few works about its pollination. Asteraceae present some difficulties in experimental handling, and have unremarkable pollination syndrome when compared with other families such as Orchidaceae (Lane, 1996). Entomopalynology provides a useful mean to study the relationship between insects and flowers (Jones & Jones, 2001) and, in our case, may contribute to knowledge of the interaction between Asteraceae and a generalist insect as the honeybee.

In Argentina, Asteraceae nowadays has 227 genera and ca. 1400 species (Katinas *et al*., 2007). Based on a significant number of entomopalynological publications that have been conducted in this country, we know that pollen of Asteraceae - beside of Fabaceae - is commonly present in honey and pollen loads collected by *Apis mellifera*. The purpose of the present article was to compile the information about the Asteraceae visited by honeybees in Argentina in order to obtain a record of (1) the

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different tribes which are represented in the food composition, (2) the taxa that provide nectar, pollen or both of them at the same time and, (3) if there is any relationship between the phytogeographical distribution of plant tribes and their use by honeybees.

Data were obtained from entomopalynological studies which have been conducted in different phytogeographical regions of Argentina (Cabrera, 1971). Most studies deal with the botanical origin of honey and pollen loads. We considered that the pollen present in honey comes from plants visited to obtain nectar, whereas the pollen present in corbicular loads came from plants visited to obtain pollen.

Materials and Methods

Data for the present record were obtained from studies supported by pollen reference collection, using the acetolysis technique (Erdtman, 1960) during treatment of samples. In addition, some of the studies of botanical and geographical origin of honey included detailed morphological analysis of pollen collected by honeybees (Andrada, 2001; Fagúndez, 2001, Fagúndez & Caccavari, 2003; Forcone, 2002a; Tellería, 1995; Tellería, 2000; Tellería & Forcone, 2002). In order to evaluate taxa as source of nectar, the following criteria were considered (1) if the percentage of pollen in the honey belongs to the dominant taxa (considered as "very important", with more than 15 % of total counted pollen according to Louveaux, 1978), (2) if the percentage of pollen in the honey belongs to the minor or trace category (considered as "secondary important", with less than 15 % of total pollen counted). The evaluation of taxa as supplier of pollen was assigned in several papers (Andrada, 2001, 2003; Andrada & Tellería, 2005; Basilio, 2000; Forcone, 2002a, b; Tellería, 1993). Phytogeographical regions follow the scheme of Cabrera (1971) (Fig. 1). Update of botanical names follows Zuloaga & Morrone (1999).

Results

In Argentina, most of the entomopalynological studies were carried out in relation to the botanical and geographical origin of honey, being scarce those made on pollen loads. The number of studies realized inside the phytogeographical regions is related to development of apiculture. Regions where this activity is more intensive such as Pampeana, Caldenal, and Monte have been the best studied; in consequence there is abundant information. On the other hand, there is little information in the Chaqueña region where the plants visited by honeybees has been poorly studied until now (Table 1).

Three subfamilies of Asteraceae were present in honey and pollen loads: Asteroideae, Cichorioideae and Barnadesioideae. From 64 morphological types 39 were determined at species level, 19 at genus and 6 at tribe level (Table 2).

The large number of identification at the species level was achieved by different reasons: (1) it was the only species in that area or the only species available during the apicultural period, (2) the pollen has had specific diagnostic features and, (3) the field observations. These observations were especially important to identify pollen from pollen loads. For instance, in the northwest of the Pampeana region *Centaurea solstitialis* and *Centaurea calcitrapa* live together and they cannot be distinguished from pollen features; however the colour of pollen loads allowed us to identify both species. Pollen loads are yellow if they to came from *C. soltitialis* whereas they are slightly violet if they came from *C. calcitrapa* (Tellería, 1993).

Taxa of Asteraceae used by Apis mellifera

The diversity of Asteraceae in different phytogeographical regions of Argentina is displayed by the pollen grains from the honey and corbicular pollen loads produced by honeybees. From 16 tribes currently recorded in Argentina (Katinas *et al*., 2007), 9 are represented in the honeybee food. In honey and pollen loads from Pampeana, Espinal, Monte and Patagonica regions, Asteraceae was found to be highly represented whereas it was scarcely represented in Chaqueña and Subantártica regions (Table 2; Figs 2-5).

Cardueae, Lactuceae and Anthemideae are the tribes more used by honeybees in all regions. Coincidently, these tribes comprise the highest number of exotic species (Katinas *et al*., 2007), and most of them are invasive plants. Cardueae is represented by "thistles" (*Carduus* sp., *Cirsium* sp., *Cynara* sp. and *Onopordum* sp.) and "knapweed" (*Centaurea* sp.), both invasive plants, native from Europe, that are very common in cattle breeding and disturbed areas. For this reason, honeys from

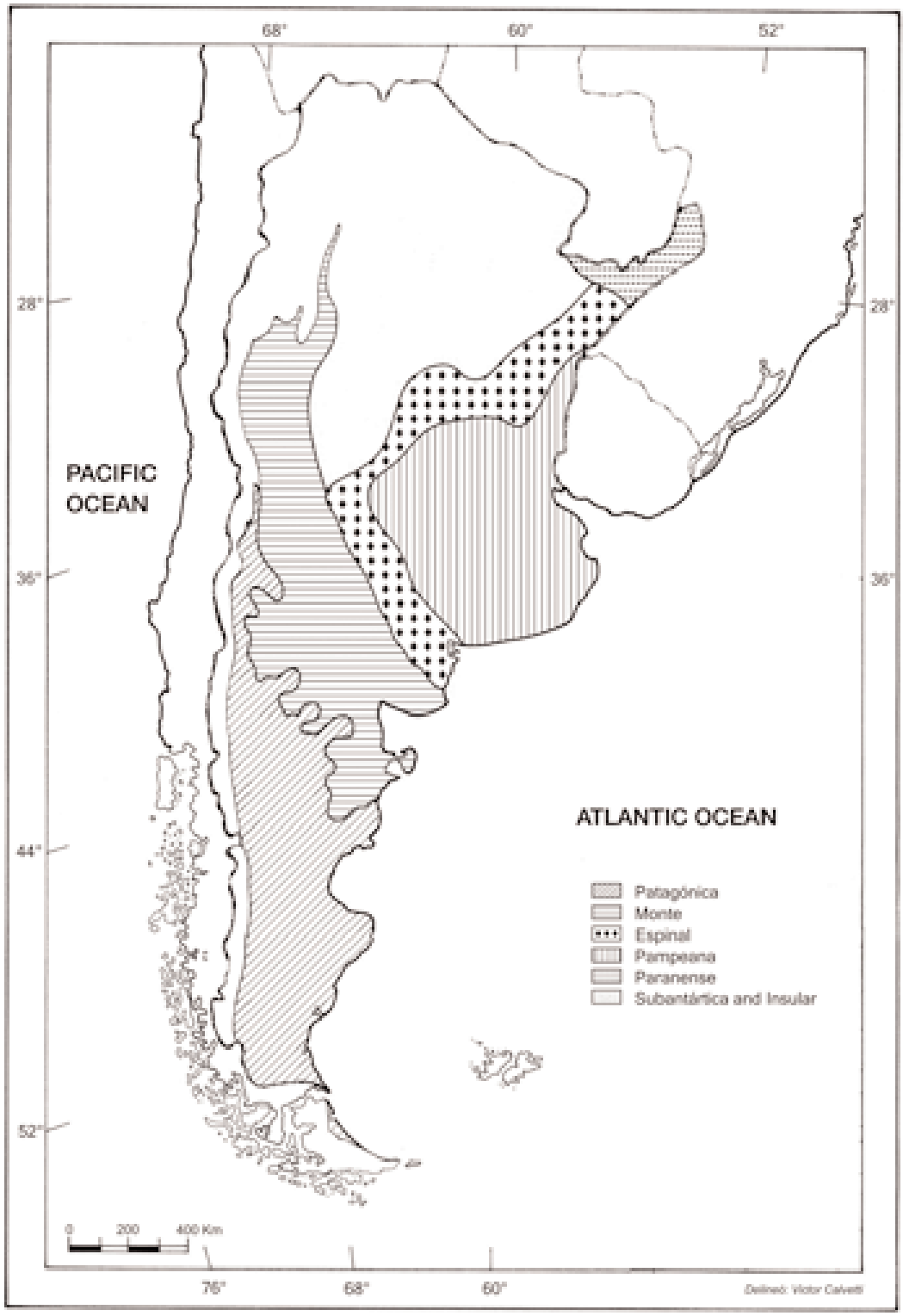

Fig. 1. Phytogeographical regions of Argentina where entomopalynological studies were carried out.

Table 1. Number of samples studied in different phytogeographical provinces.

Phytogeographical region	Honey samples studied
Pampeana	349
Espinal	189
Chaqueña	37
Paranense	9
Monte	116
Patagonia	19
Subantártica	58
TOTAL	777

Table 2. Asteraceae visited for nectar or pollen in different phytogeographical regions of Argentina. ++ very important, + secondary important. * introduced plants.

	Pampeana		Espinal		Monte		Patagónica	Subantártica	Chaqueña	Paranense
	Néctar	Pollen	Néctar	Pollen	Néctar	Pollen	Néctar	Néctar	Néctar	Néctar
ASTEROIDEAE										
Anthemideae			+							
Artemisia sp.			+							
Artemisia absinthium L.*	+				+	+		+		
Matricaria recutita L.*	+		+							
Matricaria sp.- *Anthemis* sp.	+		+		+	+	+	+		
Astereae	+		+		+	+	+	+		
Baccharis sp.	++		++						++	+
Grindelia sp.						++				
Grindelia tehuelches (speg.) Cabrera				++						
Heterotheca latifolia Buckley	+									
Hysterionica jasionoides Willd				+						
Plagiocheilus tanacetoides Haencke			+							
Solidago chilensis Meyen	++	++	+							
Eupatorieae										
Mikania sp.	++									
M.micrantha Kunth	++									
Helenieae										
Flaveria bidentis (L.) Kuntze					+					
Gaillardia megapotamica (Spreng.) Baker			+							

	Pampeana		Espinal		Monte		Patagónica	Subantártica	Chaqueña	Paranense
	Néctar	Pollen	Néctar	Pollen	Néctar	Pollen	Néctar	Néctar	Néctar	Néctar
Heliantheae	+	+	+							
Ambrosia sp.	+		+		+				+	++
Ambrosia tenuifolia Spreng.	+	++	+							
Helianthus annuus L.*	++	+	++							
H. petiolaris Nutt.	++									
Verbesina enceliodes (Cav.) Benth. & Hook.	+									
Wedelia glauca (Ortega) O. Hoffm.		+	+			+				
Xanthium sp.			+		+	+	+			
Xanthium cavanillesii Schouw	+									
Plucheeae										
Tessaria absinthioides (Hook. & Arn.) DC.			+		+					
Tessaria integrifolia (Griseb.) Cabrera		+							++	+
Senecioideae										
Senecio sp.			+		+		+	+		
S. grisebachii Baker		+	+			+			+	
CICHORIOIDEAE										
Cardueae	+									
Arctium minus (Hill) Bernh.*	+							+		
Carduus sp.*	++		+	++	++	++	+	+		
C. acanthoides L.*	++	++								
C. thoermeri Weinm.*	+		+							
Carthamus lanatus L.*	+		+							
Centaurea sp.	++		++		++	+	++	+		
C. calcitrapa L.*	++									
C. solstitialis L.*	++	++	++	++	++					
Cirsium vulgare (Savi) Ten.*	+	++	+		+	++	+	+		
Cynara cardunculus L.*	+		+		+					
Onopordum acanthium L.*	+		+	+	+	+	+	+		
Lactuceae					+			+		
Cichorium intybus L.*	+	++	+			+	+			
Hypochoeris sp.			+							
H. radicata L.*		++						+		
Lactuca sp.*		+				+	+			
Picris sp.*	+									
Picris echioides L.*		++								
Sonchus sp.*			+							
Taraxacum officinale Weber*		+	+		+	++	+	+		

	Pampeana		Espinal		Monte		Patagónica	Subantártica	Chaqueña	Paranense
	Néctar	Pollen	Néctar	Pollen	Néctar	Pollen	Néctar	Néctar	Néctar	Néctar
Mutisieae	+		+							
Ameghinoa patagonica Speg.							+			
Brachyclados lycioides D. Don			+							
Cyclolepis genistoides D. Don	+				+					
Holocheilus hieracioides (D. Don) Cabrera			+							
Hyalis argentea Hook. & Arn.	+		+		+					
Mutisia sp.								+		
Mutisia retrorsa Cav.							+			
Trichocline sp.			+							
Trixis sp.			+							
Vernonieae *Vernonia* sp.			+							
BARNADESIOIDEAE										
Chuquiraga sp.					+		+			
C. erinacea D. Don			++	++						
Literature references	1,2,3,4,5,6, 7,8,9,10,11	4,12,13, 14	15,16,1 7,5,18, 19,20	15,17, 21	22,23,24, 25,26	23,27,28, 29	24,28,30	31,32	33,28	28

Literature references : (1) Andrada *et al*. (1998 a); (2) Andrada *et al*. (1998 b); (3) Basilio and Romero (1996); (4) Basilio (1998); (5) Lusardi *et al*. (2005); (6) Tellería (1998); (7) Tellería (1992); (8) Tellería (1995); (9) Tellería (1996); (10)Tellería (2000); (11) Valle *et al*. (1995); (12) Basilio (2000); (13)Naab (1993); (14) Tellería (1993); (15) Andrada (2001); (16) Andrada and Tellería (2002); (17) Andrada (2003); (18) Naab *et al*. (2001); (19) Salgado and Pire (1999); (20) Tamame and Naab (2003); (21) Andrada and Tellería (2005); (22) Fagúndez and Caccavari (2003); (23) Fagúndez (2003); (24) Forcone and Tellería (1998); (25) Tellería and Forcone (2000); (26) Tellería and Forcone (2002); (27) Fagúndez and Caccavari (2006); (28) Forcone (2002a); (29) Forcone (2002b); (30) Forcone and Tellería (2000); (31) Forcone (2003); (32) Forcone *et al*. (2005); (33) Salgado and Pire (1998).

Argentina usually contain thistle and knapweed pollen. Lactuceae, which is represented by "dandelion" and "chicory" among others, is an important pollen supplier. Pollen from Anthemidae, mainly "chamomille" (*Matricaria* sp., *Anthemis* sp.) is common in the honey as traces. Concerning Heliantheae, *Helianthus annuus*, "sunflower", is the species mostly utilized by honeybees which collect its nectar and pollen. Capitula of *Ambrosia* sp. are wind pollinated and they lack nectar, however they are intensely visited regarding its pollen at the end of the summer when other attractive resources are scarce. Pollen of *Ambrosia* appears frequently in the honey as trace.

The other tribes appearing in honeybee collections showed high number of native species, such as Barnadesieae, Mutisieae, Astereae, Eupatorieae, Plucheeae, Helenieae, Senecioideae and Vernonieae. Within this group, Barnadesieae and Mutisieae are common in Patagonica region (Fig. 5), and are geographical markers of honey produced in this region. Barnadesieae tribe was only represented by *Chuquiraga* sp.; this species was an important source of pollen and nectar in Patagonia, south of Monte (Fig. 3) and Espinal (Fig. 4) regions. The Mutisieae tribe was common in Espinal and Monte regions, the latter evidenced a larger diversity of species, and this fact was reflected in honeybee

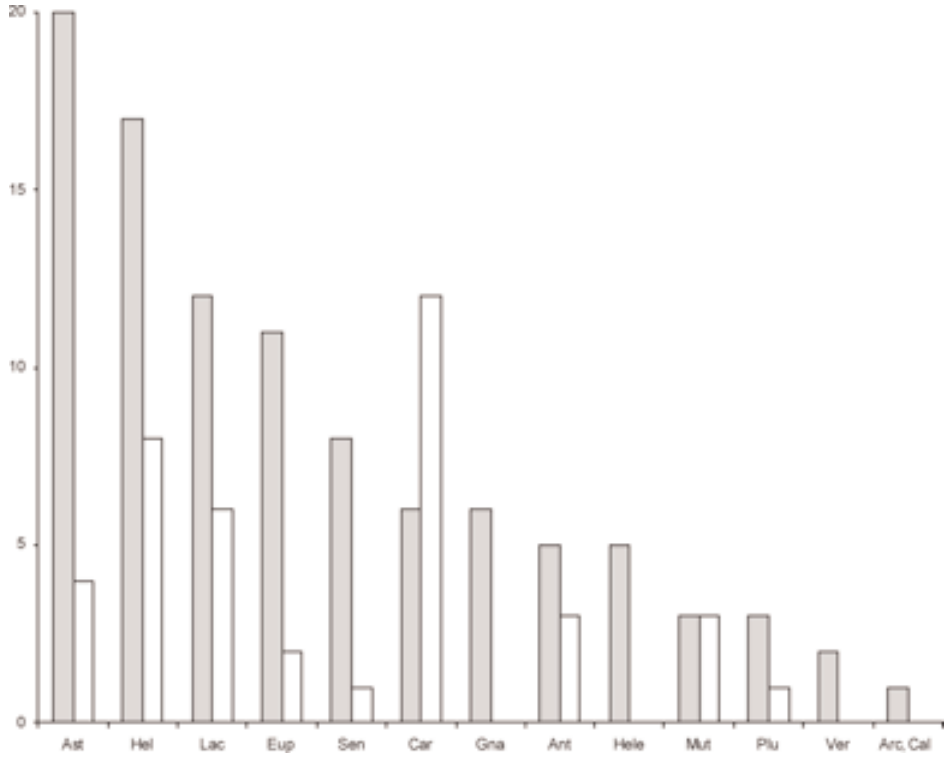

Fig. 2. Tribes of Asteraceae in the Pampeana region. Ast: Astereae; Lac: Lactuceae; Hel: Heliantheae; Car: Cardueae; Sen: Senecioideae; Mut: Mutisieae; Hele: Helenieae; Gna: Gnaphalieae; Ant: Anthemideae; Eup: Eupatorieae; Plu: Plucheae; Bar: Barnadesioideae; Cal: Calenduleae. % of species present. % of species visited by honeybees.

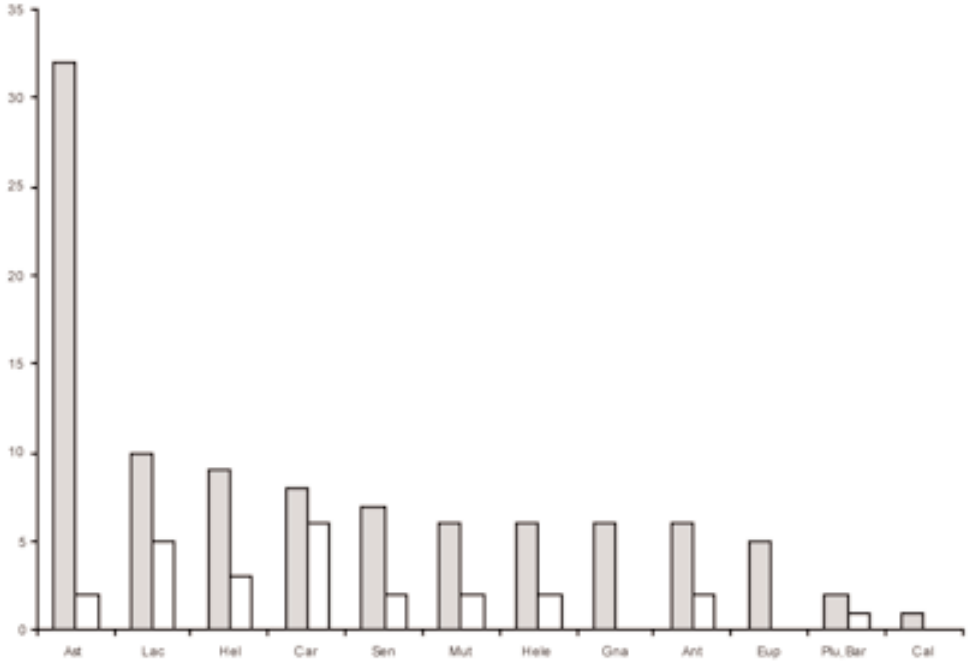

Fig. 3. Tribes of Asteraceae in the Monte region. % of species present. % of species visited by honeybees.

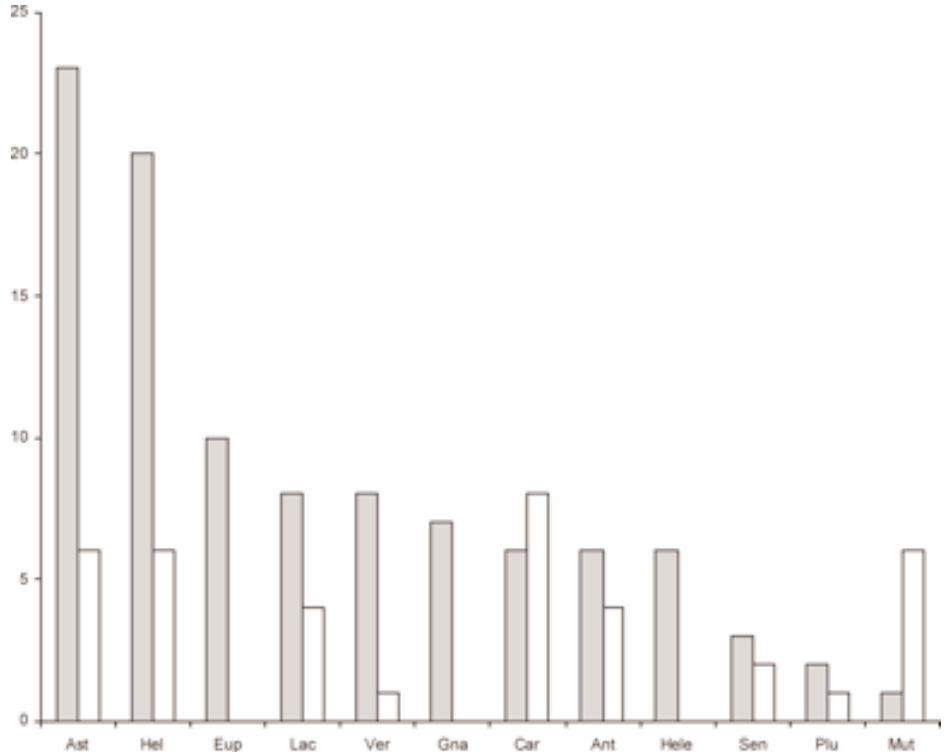

Fig. 4. Tribes of Asteraceae in the Espinal region. % of species present. % of species visited by honeybees.

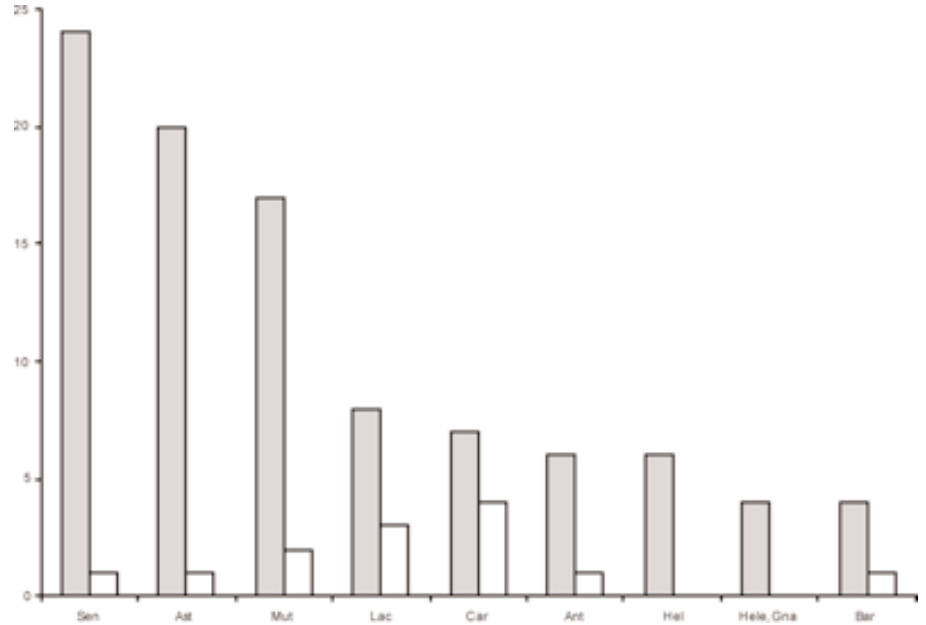

Fig. 5. Tribes of Asteraceae in the Patagonia region. % of species present. % of species visited by honeybees.

collections. Astereae, Eupatorieae, Plucheeae tribes are similar in pollen features (Skvarla *et al*., 1977) however in some cases, due the abundance and availability of some species, it was able to recognize species (e.g. *Solidago chilensis*, *Heterotheca latifolia* among others). Within Eupatorieae, only *Mikania* was recognized as important source of nectar in Delta del Paraná where it is abundant. Plucheeae, represented by *Tessaria* sp., is very used in Chaqueña region. Helenieae and Vernonieae tribes are scarcely used; Senecioideae is more common in foods reserves of honeybees.

Arctoteae and Calenduleae tribes did not appear in the collects. Both tribes only have exotic representatives (Katinas *et al*., 2007), and they are uncommon comparing to others which are more frequent in the collects.

Conclusions

Entomopalynological studies from Argentina have shown an insight into the relationship between honeybees and the Asteraceae family.

- From 16 tribes of Asteraceae recorded, 9 of them were found to be present in food reserves of honeybees.

- The number of tribes represented in food resources was high concerning Pampeana, Espinal, Monte and Patagonia regions, though it was found to be low in Subantarctic and Chaqueña regions, probably due to a poor sampling when compared to that in other regions.

- Exotic representatives were mostly present in those collections belonging to Cardueae, and Lactuceae tribes as well as Heliantheae which was mainly represented by the sunflower (*Helianthus annuus*).

- Tribes of Astereae, Eupatorieae and Plucheeae were likely sub represented due to their similar palynological features.

- The most visited native representatives were Barnadesieae, Mutisieae, Astereae, Eupatorieae and Plucheeae tribes and in a minor extent to Senecioideae, Helenieae and Vernonieae.

- A large number of taxa were found to be visited for obtaining both pollen and nectar, whereas other taxa provided only one type of reward. It must be noted that Astereae was shown to be pollen-nectariferous, Cardueae and Mutisieae were nectariferous, and Lactuceae was polliniferous.

- Although certain tribes may be underestimated, results might indicate that exotic invasive species of Asteraceae were mostly visited by honeybees rather than native species with the exception of some less disturbed areas such as Delta del Paraná and Patagonia. Most invasive plants are dominant in different environments and their flowering produces a strong visual impact. Similar results have been reported by Krend & Murphy (2003) studying the relationships between *Apis mellifera* and both native and exotic plants in Boulder, Colorado (USA). It is known that the introduction of honeybees along with invasive plants has had many negative implications to the native plants because they may cause the decline of native pollinators. In Argentina much remains to be elucidated about the relationships between exotic bees and native Asteraceae, however the knowledge of visited taxa of the sunflower family could be the first step to develop further studies on particular species.

Acknowledgements

I thank M. Barth for English improvements.

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Recibido 25 de septiembre de 2008, aceptado 20 de febrero de 2009.