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Flower election by honeybee and floral morphology

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Resumen: De Sá Otero, M. P., Díaz Losada, E. & Armesto Baztán, S. *Elección floral por abejas y su relación con la morfología corolina. Lazaroa 25: 113-123 (2004).*

El objetivo de este trabajo fue determinar cuáles son las preferencias de *Apis mellifera* L. en su elección de fuentes polínicas. Se estudió la importancia relativa del color y la forma de la corola, presencia o ausencia de nectarios en las flores visitadas, y la abundancia relativa de las plantas elegidas en colmenas localizadas al N.O. de España. En este trabajo de investigación se estudió el polen corbicular transportado por las abejas a la colmena. Los resultados del análisis de polen fueron testados por métodos estadísticos no paramétricos. Se confirmó que el color amarillo fue el preferido junto con el blanco, tanto por la diversidad de especies visitadas con éstas características como por la cantidad de polen recogido desde ellas. La presencia de nectarios florales no es un factor decisivo en la selección de plantas fuente de polen.

Abstract: De Sá Otero, M. P., Díaz Losada, E. & Armesto Baztán, S. *Flower election by honeybee and floral morphology. Lazaroa 25: 113-123 (2004).*

The aim of this research was to determine which are the *Apis mellifera* L. preferences in their choosing of pollen sources. The relative importance of the corolla colour and shape, presence or absence of floral nectaries in the visited flowers, and the chosen plant species relative abundance were studied in hives located in northwest Spain. The corbicular pollen carried to the hive by the honeybee was studied in this research work. The results of pollen analysis tested through non-parametric statistic studies. Yellow was confirmed as the preferred colour together with white, both by the diversity of the visited species that have these characteristics and the amount of pollen collected from them. The presence of floral nectaries is not a decisive factor in the selection of plant sources for pollen.

INTRODUCTION

Honeybees, *Apis mellifera* L., collect the pollen necessary for the hive from the flowering plants that grow around the apiary. The bee avoids certain species and collects different amounts from the selected species present in the area. If the surrounding vegetation is rich and attractive, the trips that it makes to look for pollen are usually short (within 2 km), but if necessary, the bees can fly from 5 to 13.5 km looking for the most select pollen (SCHUA, 1952; O'NEAL & WALLER, 1984).

Honeybees use the flowers as a source of pollen and nectar, and the bee behaves as any other insect visitor. In the species of entomophylic pollination, in particular *Apis mellifera*, the corolla shape and its colour, morphological characters that the honeybee perceives as a whole (WASER & *al.*, 1996), and the nectar accessibility determine the class of pollinator insect that visit the flower. On the other hand, the honeybee needs that the flower form to permit the landing, the colour and the shape of the flower to attract its attention and the smell of pollen to be easily identified (PROCTOR, 1973). Moreover other works studied the importance of the corolla colours (OSCHE, 1983) and shapes as an element of attraction to the pollinating insects.

In this sense, it's considered that the bee chooses the pollen source plants firstly for visual stimuli and, after landing; the bee will harvest pollen if its smell and taste are acceptable (VON FRISCH, 1984; WADDINGTON, 1983). The identification is innate and serves as a reference to the bee to find the food source again (RIBBANDS, 1951; PELLIN & *al.*, 1990). It is also important that the pollen presents certain characteristics regarding its chemical composition

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and its nutritive value, namely that it has a high quantity of protein (BOSI & RICCIARDELLI, 1975; RICCIARDELLI & D'AMBROSIO, 1979).

With regard to the corolla shape, the visual organs of honeybees do not perceive clear forms, but rather they perceive outlines and especially, colours (NEESE, 1968) — with more diversity of tones than the human eye —. In some situations, certain aspects of the pollen morphology, such as the echinated pollen of the cotton plant (VAISSIÈRE & VINSON, 1994), determine the refusal or the selection of particular sources.

The olfactory relationship between plants and pollinator insects raises interesting reflections both as in the case of honeybees (BERGSTRÖM & *al.*, 1995) as of solitary bees (DOBSON, 1987). It will not be treated in this study but, though the olfatory guides are very interesting, it's a land excessively ample and its research deserves a study's own.

The present study was designed to contribute to the knowledge of what vegetation related factors condition the flora election process by *Apis mellifera*. The collection of honeybee pollen in the area was studied from March to October, this is the most intensive foraging period in the Iberian Peninsula NW (DÍAZ & *al.*, 1997; DÍAZ & *al.*, 1998). The relative value of each category of each character – colour, shape, flowers abundance and floral nectaries presence – was determined. This ranking was based on the amount of the pollen collected from each species and the knowledge of the local flora, the characteristics of the corolla (form and colour) and the presence or absence of nectaries.

A study has been made of the relationship that exists between the percentage of pollen from each source species supplied to the hive by the honeybee and certain floral characteristics that could be related to foraging: the degree of local coverage (relative abundance) of the different species, the morphological characteristics of the flower (shape and corolla colour), and the production of floral nectar.

MATERIAL AND METHODS

The rhythm of honeybee pollen collecting is conditioned by the physiological factors of the hive, the meteorological conditions and the availability of pollen (BATTAGLINI & RICCIARDELLI D'ALBORE, 1970; O'NEAL & WALLER, 1984; BARROS, 1985; SABATINI & *al.*, 1985; BRANDT & GOTTSBERGER, 1988; GOODWIN & TEN HOUTEN, 1981; MONTENEGRO & *al.*, 1992; MONTERO & TORMO, 1993; LAVERTY & HIEMSTRA, 1998). In the areas studied here, foraging activity begins at the winter end and becomes insignificant in October; this coincides with the spring and summer flowering of the local flora (DÍAZ & *al.*, 1995). Samples of pollen loads carried by the honeybee *Apis mellifera* L. were obtained between March and October during several years, by installing pollen traps in beehives in different locations in Spain NW. The trap used had a vertical grid, with round holes (4 mm of diameter) of 10% efficiency (LOUVEAUX, 1958), which was situated in the hive entrance. The trap was kept active from dawn to dusk during every day of the survey — twice in the month —. It was assumed that pollen loads of different size had the same possibility of being retained (O'NEAL & WALLER, 1984). Each sample was analysed separately. One gram, catch to the chance, of each sample were acetolysed according to ERDTMAN'S method (1960). After, it's made the preparations for the microscope; 1200 pollen grains were counted by sample and the percentages for each vegetal species was calculated.

The 22 beehives were located in the NW of the Iberian Peninsula where the Eurosiberian biogeographical regions meet (RIVAS-MARTÍNEZ & *al.*, 1987; IZCO, 1987) landscapes very influenced by human populations and also smallholdings typical of this region. *Cytisus multiflorus* (L'Hér.) Sweet, *Cytisus scoparius* (L.) Link and *Genista polygaliphylla* Brot. form the degraded thicket observed today. The heathland here is composed of *Erica australis* subsp. *aragonensis* (Willk.) Cout, *Erica cinerea* L., *Halimium alyssoides* (Lam.) C. Koch, and *Genista tridentata* L., and depending on the topography can include *Ruscus aculeatus* L., *Arbutus unedo* L., *Pistacia therebinthus* L., *Phillyrea angustifolia* L., *Cistus salvifolius* L., *Cistus psilosepalus* Sweet, or *Cistus ladanifer* L., *Thymus mastichina* L., *Genista hystrix* Lange, and *Lavandula stoechas* subsp. *sampaiana* Rozeira.

The proposal made by DÍAZ (1995) has been taken as the database of flora that is potentially available in the Spain NW. For each of the considered species, there are potential sources of pollen, the degree of floral coverage in the area, the corolla colour and shape and the presence or absence of nectar production in floral nectaries has been determined (MUELLER & ELLENBERG, 1974).

A data matrix that groups the categories of each character of all identified species was constructed. A value was given to each of the taxa in accordance with the percentage of pollen collected by the honeybee: «4» in frequencies of between 25-45%; «3» for those between 5-25%; «2» for frequencies of 1-5% and a value of «1» for those with frequencies of less than 1%. Three categories were established for the degree of local coverage: «3» for a high degree; «2» for a medium degree and «1» for a low degree. For the colour of the corolla: «1» white, «2» yellow, «3» blue and violet, «4» rose coloured, and «5» others. For the shape of the corolla: «1» for free petals shape, «2» papilionaceous, «3» urceolate, «4» campanulate, «5» tubular, «6» apetalous, and «7» two lipped shape. For floral nectaries, «1» present, «0» absent.

The frequency of all established categories of each character — corolla colour and shape, presence or absence of floral nectaries and, degree of local coverage (Waddington, 1983) (though the visual observation of each species relative abundance) — was determined with regard to the corbicular pollen percentage harvested by the honeybees. Also, each established category of corbicular pollen percentage brought by the honeybee to the hive and for the different degrees of coverage or relative abundance of species were confronted to the frequencies of corolla colours and shapes, and to visited flower frequencies within or without floral nectaries

RESULTS

The results of the palynological analysis of the hives studied are shown in Table 1, there the most important taxa (high percentages of harvesting) are in italics. The contingency Tables 2–8 show the relation between different characters of floral morphology.

The flowers of the papilionaceous corolla and the apetalous flowers supplied high quantities of pollen to the beehive (frequencies between 25-45%). In 8 of 13 visited species with flowers of papilionaceous corolla, high quantities of pollen have collected; in 4 of 11 visited species with apetalous flowers, pollen in high quantity has been harvested. The plants of papilionaceous corolla represented the third place in species diversity, all of them contributed a high quantity of pollen to the hive and all had a high coefficient of local coverage. Apetalous flowers plants represented the fourth ranking in order of importance with regard to the present species diversity; in the four species that contributed high quantities of pollen were found in high local coverage.

Plants with free petals shape, campanulate, apetaly, urceolate and papilionaceous corolla, have supplied moderate quantities of pollen to the hive (frequencies between 5-25%). In 8 of 46 species visited of free petals corolla, media quantities were harvested. Free petals corolla category presented a high diversity of species in the surroundings of the hive, two of these species were a high local coverage (it was considered that *Prunus* and *Rubus* had medium local coverage).

The plants of tubular corolla contributed low quantities of pollen although this category was the second in species diversity. All of them were found in a medium local coverage ranking.

With regard to the corolla colour (Table 3), the yellow or the white corolla flowers are the ones that contributed with high quantity of pollen. High quantities of pollen have been harvested in 9 out of 36 visited species of yellow corolla. And in 1 out of 30 visited species of white corolla, the honeybees harvested high amounts of pollen.

Species with blue or pink flower's corolla were hardly visited and they contributed medium and low quantities of pollen to the hive. SCHEMSKE & BRADSHAW (1999) showed the *Apis mellifera* has low preference for corollas of petals with high content in anthocian and carotenoid pigments. The honeybee is capable to distinguish shade variations in the petals colour, produced for the different proportions of pigment composition at the sepal and petal plastids (PROCTOR, 1973). In their interesting study about genetic influence to the pollinators and biology process of flowers evolution, SCHEMSK & BRADSHAW (1999) concluded that the final allele, that increases petal carotenoid pigments, reduce bee's visitation by 80 %. Those plants represented the third and fourth source in species diversity; an important number of these were found with high and medium local coverage. This is the case of *Echium vulgare* L., blue and campanulate corolla, harvested as main species in one of the hives. This species has been considered in this category, species with flowers of campanulate corolla, for the slight irregularity of its corolla with regard to the others species of the same category. *Echium vulgare* has a big corolla, with an easy access to the bees, blue colour and the medium local coverage in the region. These plants are found in bloom for long times (spring and the beginning of summer).

Table 1
Relation of the percentages of the contributed pollen in the hives, referred to five class:
1, < 1%; 2, 1% - 5%; 3, 5% - 25%; 4, 25% - 45%; and +, presence.
I, degree of cover (3, high; 2, mid and 1, low). II, colour of corolla (1, white; 2, yellow; 3, blue; 4, pink and 5, other). III, form of corolla (1, free petals shape ; 2, papilionaceous shape; 3, urceolate shape; 4, campanulate shape; 5, tubular shape; 6, apetalous shape and 7, two–lipped shape). IV, existence of nectaries (0, no and 1 yes)

TAXA	%	I			II					III							IV	
		3	2	1	1	2	3	4	5	1	2	3	4	5	6	7	0	1
Acer pseudoplatanus	2			+	+					+								+
Adenocarpus complicatus	4	+				+					+						+	
Aesculus hippocastanum	1			+	+									+				+
Ajuga reptans	1			+			+							+				+
Allium cepa	1			+	+					+								+
Anthemis arvensis L.	1		+			+								+				+
Bellis perennis L.	1			+		+								+				+
Brassica napus L.	2			+	+					+								+
Calamintha sylvatica Bromf.	1			+				+								+		+
Calluna vulgaris (L.) Hull	3	+						+		+								+
Carex sp. L.	1			+					+						+		+	
Castanea sativa Miller	4	+				+									+			+
Centaurea calcitrapa L.	2		+					+						+				+
Chenopodium album L.	+			+					+	+							+	
Cistus ladanifer L.	+			+	+					+								+
Cistus psilosepalus L.	2			+	+					+								+
Convolvulus arvensis L.	+			+	+								+					+
Crataegus monogyna Jacq.	2			+	+					+								+
Crepis capillaris (L.) Wallr.	1			+		+								+				+
Cytisus multiflorus	4	+			+						+						+	
Cytisus scoparius (L.) Link	4	+				+					+						+	
Cytisus striatus (L.) Rothm.	4	+				+					+						+	
Daphne gnidium L.	2	+			+									+				+
Daucus carota L.	2			+	+					+								+
Echium plantagineum L.	3		+				+						+					+
Echium vulgare L.	3		+				+						+					+
Erica arborea L.	2_	+			+							+						+
Erica australis L.	1	+						+				+						+
Erica cinerea L.	2_	+						+				+						+
Erica tetralix L.	2			+				+				+						+
Erica umbellata L.	3	+						+				+						+
Erica vagans L.	2	+					+					+						+
Erodium cicutarium (L.) L'Hér.	1		+					+		+								+
Eucalyptus globulus Labill.	4	+				+									+			+
Filipendula vulgaris Moench	+			+	+					+								+
Fragaria vesca L.	2			+	+					+								+
Frangula alnus Miller	1			+					+	+								+
Fraxinus excelsior L.	+			+					+						+		+	
Fumaria muralis Sonder ex Koch	1			+				+								+		+
Genista florida L.	4	+				+					+						+	
Genista tridentata L.	4	+				+					+						+	
Gentiana pneumonanthe L.	+			+			+							+			+	
Geranium lucidum L.	2			+				+		+								+
Geranium robertianum L.	+			+				+		+								+
Halimium alyssoides	3	+				+				+								+
Hedera helix L.	2			+					+	+								+
Helianthemum nummularium	2		+			+				+								+
Helianthemum salicifolium	+		+			+				+								+
Hypericum perforatum L.	1			+		+				+							+	
Ilex aquifolium L.	1			+	+									+				+
Jasminum fruticans L.	1			+		+								+				+
Lamium amplexicaule L.	1		+					+								+		+
Laurus nobilis L.	+			+	+					+								+

Table 1 (Cont.)

TAXA	%	I			II					III							IV	
		3	2	1	1	2	3	4	5	1	2	3	4	5	6	7	0	1
Lavandula stoechas L.	+			+			+									+		+
Lepidium heterophyllum	3			+	+					+								+
Lithodora prostrata	1			+			+							+				+
Lotus corniculatus L.	3			+		+					+							+
Magnolia grandiflora L.	+			+	+					+								+
Malva sylvestris L.	+			+				+		+								+
Medicago sativa L.	1			+				+			+							+
Mentha aquatica L.	1			+			+									+		+
Mentha pulegium L.	1			+			+									+		+
Oxalis corniculata L.	+			+		+								+				+
Plantago coronopus L.	1			+		+				+							+	
Plantago lanceolata L.	3			+		+				+							+	
Polygonum aviculare L.	1			+					+					+				+
Polygonum persicaria L.	+			+				+						+				+
Prunella vulgaris L.	+			+			+									+		+
Prunus avium L.	2		+		+					+								+
Prunus cerasus L.	2		+					+		+								+
Prunus domestica L.	2		+		+					+								+
Prunus spinosa L.	2		+		+					+								+
Pyrus communis L.	2		+		+					+								+
Quercus pyrenaica Willd.	3	+				+									+		+	
Quercus robur L.	3	+				+									+		+	
Ranunculus bulbosus L.	1			+		+				+								+
Ranunculus ficaria L.	2			+		+				+								+
Ranunculus peltatus Schrank	1			+				+		+								+
Ranunculus repens L.	1			+		+				+								+
Raphanus raphanistrum L.	3		+			+				+								+
Rhododendron ponticum L.	1			+				+						+				+
Rosa canina L..	2			+				+		+								+
Rosmarinus officinalis L.	+			+			+									+		+
Rubus sp L.	3			+	+					+								+
Salix alba L.	2			+					+						+			+
Salix atrocinerea Brot.	2			+					+						+			+
Salix fragilis L.	+			+					+						+			+
Salvia verbenaca L.	+			+			+									+		+
Sambucus nigra L.	1			+	+									+			+	
Saxifraga granulata L:	1			+	+					+								+
Scabiosa columbaria L.	1			+			+							+				+
Scilla autumnalis L.	2			+			+							+				+
Sedum acre L.	3			+		+				+								+
Senecio jacobea L.	1		+			+								+				+
Senecio sylvaticus L.	1		+			+								+				+
Senecio vulgaris L.	1		+			+								+				+
Sisymbrium officinale (L.) Scop.	3			+		+				+								+
Sonchus oleraceus L.	+			+		+								+				+
Spergularia rubra	2			+				+		+								+
Stellaria media (L.) Vill.	2			+	+					+								+
Succisa pratesis Moench	+			+			+							+				+
Taraxacum officinalis Weber	1			+		+								+				+
Teucrium scorodonia L.	+			+					+							+		+
Tilia platyphyllos Scop.	+			+	+					+								+
Trifolium pratense L.	1		+					+			+							+
Trifolium repens L.	1		+		+						+							+
Ulex europaeus L.	4	+				+					+						+	
Ulex minor Roth	4	+				+					+						+	
Urtica dioica L.	1			+					+	+								+
Verbascum pulverulentum Vill.	1			+		+								+			+	
Viburnum tinus L.	+			+	+									+				+
Vitis vinifera L.	1			+					+						+			+
Zea mays L.	2		+			+									+		+	

Table 2
Representation of the corolla shape of flowers visited by *Apis mellifera* in relation to the percentage of harversted pollen from each species. The number of species classified by category is indicated in brackets

Contributed polled in hive	COROLLA SHAPE						
	Free Petals	Papilion.	Urceola.	Campan.	Tubular	Apetaly	Lipped
45% - 25%	-	7% (8)	-	-	-	1.7% (2)	-
25% - 5%	7% (8)	0.9% (1)	0.9% (1)	1.7% (2)	-	1.7% (2)	-
5% - 1%	16.6% (19)	-	3.5% (4)	-	2.6% (3)	2.6% (3)	-
< 1%	16.6% (19)	2.6% (3)	0.9% (1)	0.9% (1)	20.2% (23)	3.5% (4)	8.8% (10)

Table 3
Representation of the corolla colour of flowers visited by *Apis mellifera* in relation to the percentage of harvested pollen from each species. The number of species classified by category is indicated in brackets

Contributed polled in hive	COROLLA COLOUR				
	White	Yellow	Blue	Pink	Other
45% - 25%	0.9 % (1)	7.9% (9)	-	-	-
25% - 5%	1.7% (2)	7% (8)	1.7% (2)	1.7% (2)	-
5% - 1%	12.3% (13)	2.6% (4)	1.7% (2)	6.1% (7)	2.6% (3)
< 1%	11.4% (13)	14% (16)	9.7% (11)	10.5% (12)	7.9% (9)

Although in the studied places, the diversity of species and the variety of shapes and colours were very high, the honeybee harvested high quantities of pollen from a reduced number of species — this supports the idea of the honeybee's fidelity to the species of the useful plants for it (FREE,1963; WADDINGTON & HOLDEN, 1978; O'NEAL & WALLER, 1984; WEBER EL GHOBARY, 1984; MONTENEGRO & *al.*, 1992; MONTERO & TORMO, 1993) — which are chosen in function of the members coverage, with available flowers, of one same species for area unity.

In this experience, the honeybee harvested high quantities of pollen (frequencies between 25-45%) from plants with flowers without nectaries (Table 4). According to PROCTOR (1973), in the honeybee case, the nectar function is necessary to the stigma pollination, but that is indifferent at the pollen harvesting process at the protandry flowers. In this case (protandry flowers), the bee harvests the pollen when the stamens are matured, before that the nectaries commence to function, this happens when the stigma is receptive (CRESSWELL & ROBERTSON, 1994). However the number of visited flowers with nectaries was more that the plants without floral nectaries; 83.4% with nectaries and 16.6% without them, such as *Adenocarpus complicatus* (L.) Gay, *Cytisus scoparius*, *Cytisus multiflorus*, *Genista tridentata* L., *Ulex europaeus* L.

There is an important relationship between the local population coverage of available plants and the possibility of being selected by the honeybees (Table 5). Highest contributions of pollen were obtained from plants of dense population. However, not all the species with a high degree of coverage were used as the main source of pollen. The 20.2% of the selected species which involved medium contributions of pollen to the hive (1-25%), were found in low local coverage and, however, a 1% of species of dense populations involved the contributions of less than 1% of total beehive pollen.

However the local coverage appeared as an important character in the external factors of the pollen harvest. Then, it's interesting to analyse the relation between the harvested pollen percentage and the studied morphological characters, maintaining the coverage of each species as fixed variable. The tables 6-8 show the results of this analysis.

In table VI is showed that the species with papilionaceous and apetalous flowers and high local coverage in the surrounding of the beehives, contribu-

Table 4
Representation of the nectar production of the flowers visited by *Apis mellifera* in relation to the percentage of harvested pollen from each species. The number of species classified by category is indicated in brackets

Contributed polled in hive	NECTARIES	
	Abstent	Present
45% - 25%	7% (8)	1.7% (2)
25% - 5%	2.6% (3)	9.7% (11)
5% - 1%	0.9% (1)	24.6% (28)
< 1%	6.1% (7)	47.4% (54)

Table 5
Representation of the cover of flowers visited by *Apis mellifera* in relation to the percentage of harvasted pollen from each species. The number of species classified by category is indicated in brackets

Contributed polled in hive	COVER		
	High	Mid	Low
45% - 25%	8.8% (10)	-	-
25% - 5%	4.4% (5)	2.6% (3)	5.3% (6)
5% - 1%	3.4% (4)	7% (8)	14.9% (17)
< 1%	0.9% (1)	7.9% (9)	44.7% (51)

Table 6
Percentage representation of the relationship between corolla shape, amount of honeybee pollen collected and cover of local vegetation in the case study. The number of species classified by category is indicated in brackets

Contributed polled in hive	Degree of cover	COROLLA SHAPE						
		Free Petals	Papilion.	Urceola.	Campan.	Tubular	Apetaly	Lipped
45% - 25%	high	-	40% (8)	-	-	-	10% (2)	-
	mid	-	-	-	-	-	-	-
	low	-	-	-	-	-	-	-
25% - 5%	high	10% (2)	-	5% (1)	-	-	10% (2)	-
	mid	5% (1)	-	-	10% (2)	-	-	-
	low	6.8% (5)	1.3% (1)	-	-	-	-	-
5% - 1%	high	-	-	15% (3)	-	5% (1)	-	-
	mid	30% (6)	-	-	-	5% (1)	5% (1)	-
	low	17.6% (13)	-	1.3% (1)	-	1.3% (1)	2.7% (2)	-
< 1%	high	-	-	5% (1)	-	-	-	-
	mid	10% (2)	10% (2)	-	-	20.% (4)	-	5% (1)
	low	23% (17)	1.3% (1)	-	1.3% (1)	25.7% (19)	5.4% (4)	12.2% (9)

ted with high quantities of pollen. The species of free petals corolla and high coverage involved medium contributions of pollen.

With regard to the colour (Table 7), the species of yellow or white corolla, and high local coverage represented high contributions of pollen. The species of pink corolla, some of yellow corolla and high coverage, contributed with medium quantities, as well as the species of yellow, blue or pink corolla and medium degree of local coverage.

Table 7
Percentage representation of the relationship between corolla colour, amount of honeybee pollen collected and local vegetation in our case study. The number of species classified by category is indicated in brackets

Contributed polled in hive	Degree of cover	COROLLA COLOUR				
		White	Yellow	Blue	Pink	Other
45% - 25%	high	5% (1)	45% (9)	-	-	-
	mid	-	-	-	-	-
	low	-	-	-	-	-
25% - 5%	high	-	15% (3)	-	10% (2)	-
	mid	-	5% (1)	10% (2)	-	-
	low	2.7% (2)	5.4% (4)	-	-	-
5% - 1%	high	5% (1)	-	5% (1)	5% (1)	-
	mid	20% (4)	10% (2)	-	10% (2)	-
	low	12.2% (9)	1.3% (1)	1.3% (1)	5.4% (4)	4% (3)
< 1%	high	5% (1)			5% (1)	
	mid	5% (1)	25% (5)		15% (3)	
	low	14.9% (11)	14.9% (11)	14.9% (11)	10.8% (8)	12.2% (9)

Table 8
Percentage representation of the relationship between nectary existence, amount of honeybee pollen collected and local vegetation in our case study. The number of species classified by category is indicated in brackets

Contributed polled in hive	Degree of cover	NECTARIES	
		Absent	Present
45% - 25%	high	40% (8)	10% (2)
	mid	-	-
	low	-	-
25% - 5%	high	10% (2)	15 % (3)
	mid	-	15% (3)
	low	1.3% (1)	6.8% (5)
5% - 1%	high	-	20% (4)
	mid	5% (1)	35% (4)
	low	-	22.9% (17)
< 1%	high	-	5% (1)
	mid	-	45% (9)
	low	9.5% (7)	59.5% (44)

The major number of high contributions (with high and medium percentages) was represented by the species of the flowers without nectaries and high coverage (Table 8).

Non species of medium and low local coverage has presented majority contributions of pollen to the beehives, however any species of high coverage have presented medium and low contributions. It seem to indicate that high coverage is an important attractive for the bee, but it's not the only key factor.

DISCUSSION

This survey indicates that the honeybee harvests larger amounts pollen from species in dense populations and even more so if they have wide and continued flowerings. If the species that constitute the vegetable community have similar shape and corolla colour, and the flowering periods of community species follow one another, so that the honeybee has similar available flowers during its annual period of harvest (from March to October, in the Iberian Peninsula NW), and this will represent a very important potential source of pollen. The experienced foraging bee finds its bearing by the flower shape, possibly associating this to the memory of smell and corolla colour (FAEGRI & VAN DER PIL, 1979) and associated to the pollen smell in the foraging bumblebee (DOBSON, 1987; DOBSON & *al.*, 1999). Harvest efficiency during the main period of pollen crop is important to the honeybee (LINSLEY, 1978), for this reason, the honeybee in flight is guided by the visual characteristics that the plants offer and only avoids the pollen of the plants with similar flowers if they have a deterrent smell, as is the case with *Lupinus* for the foraging bumblebee (DOBSON, 1987). This behaviour, justifies the selection of the *Papilionaceae* with yellow or white flowers, which form part of regional shrub, and the selection of apetalous flowers such as *Castanea* or *Eucalyptus*, whose inflorescences are abundant in each member and have an intense yellow colour. In the region in question, the *Ericaceae* also form extensive shrub whose flowerings follow one another, and their stamens are more accessible than those of the *Papilionaceae.* The members of the *Ericaceae* have a high number of inflorescences and yet, the *Ericaceae* are not a main component of the bee pollen in this experiment. It is possible that the reason for that is related to the fact that the honeybees have discovered more easily the food sources with bigger corolla. The *Papilionaceae* of small size, such as *Lotus*, *Medicago* and *Trifolium*, which are also abundant in the region, in meadows and abandoned soils, did not register pollen contributions as high as the *Papilionaceae* shrub (*Cytisus*, *Ulex*, etc.) in spite of being papilionaceous and having a yellow colour. A problem of olfactory refusal is not considered because, in places with different vegetation characteristics, they were a main component of corbicular pollen (DÍAZ & *al.*, 1998).

For others authors, the entomophilous character of the species are a condition in the selection process (STANLEY & LINSKENS, 1974). In this study, this has not been demonstrated as being a determinant. The honeybee has harvested large amounts of pollen in anemophilous plants in which a possible attraction factor is the brightness and colour of the inflorescence.

However, in other places, the species with two-lipped and urceolate corolla have been important sources of pollen (ORTIZ, 1988, 1990; ORTIZ & FERNÁNDEZ, 1992). This is perhaps because *Lamium*, *Stachys*, and other two-lipped species that form dense populations have an early blossom and are not widely available during the most intensive foraging period in the region.

The dyalipetaly flowers have easily accessible stamens. And, in addition to this, in the local flora the diversity of species with dyalipetaly corollas it's wide. But, in spite of that some species, are frequent in the region, the pollen amount harves is moderate.

Despite the long periods in which the papilionaceous flower populations are available, the honeybees have collected large amounts of pollen in just a few species of apetalous flowers. It is the case of the some arboreal plants – they are very abundant in the region – of short florescence that foragers visit them assiduously. In these flowers, the stamens are easily accessible, the inflorescence is long and easily visible and frequently of a bright yellow colour. It could be supposed that, in this case, the visual attraction is due to the recognition of the colour yellow (LEPAGE & BOCH, 1968).

Yellow is confirmed as the preferred colour together with white, both by the diversity of species visited that have these characteristics and the amount of pollen collected from them.

One of the frequent topics found in specialised literature relates the presence of floral nectaries with the interest to the honeybee (PERCIVAL, 1955; BOLCHI SERINI, 1987; GOODWIN & TEN HOUTEN, 1991; MONTERO & TORMO, 1993). In this study, it can see clearly that the pollen, which represents the highest percentage, comes from flowers without nectaries (see O'NEAL & WALLER, 1984; SERRA BONVEHÍ, 1988). In fact, they do use a large number of plants with floral nectaries but they only collect medium or low pollen amounts from them.

The corolla colour and shape, in other words its visual characteristics, play an important roll in the process of attraction. However, once the honeybee has landed on the flower, it may decide, in relation to other factors, whether to collect the pollen or not.

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