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Plant Preferences of *Halictus* Latreille (Halictidae: Hymenoptera) in the Mediterranean Region of Southern Turkey

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ABSTRACT

Objective: Lack of information regarding the floral preferences of wild bees is one of the major problems in understanding plant–bee interactions. Therefore, we investigated the plant preferences of *Halictus* Latreille (Halictidae: Apoidea: Hymenoptera) species that are distributed in the Mediterranean Region of southern Turkey.

Materials and Methods: Bees were collected through field studies that were performed during the spring and summer seasons between 2008 and 2009. The flowers visited by bees were also recorded. In total, 516 bee specimens belonging to 19 species were collected, and 54 plant taxa were found to be related to these *Halictus* species. In addition to field study data, information collected from the literature was included in the study. The most commonly visited plant families, genera, and species are described using diversity indices scores in terms of the plant taxa preferences of the bees.

Results: A total of 516 bee and 195 plant specimens were sampled from 76 stations located in 14 provinces. In total, 54 plant taxa were found to be related to 19 *Halictus* species. Among such large plant taxa preferences, the most commonly visited ones were *Onopordum, Centaurea,* and *Carduus* members.

Conclusion: This study suggests that members of the genus *Halictus* primarily prefer to visit plants belonging to the Asteraceae family. However, they may also visit several other types of flowers such as those belonging to Rosaceae and Brassicaceae families.

Keywords: Apoidea, *Halictus*, plant preference, fauna, flora, Asteraceae, Mediterranean, Turkey

INTRODUCTION

The flowering plants need pollination to set fruits or seeds. Bees (Apiformes: Apoidea: Hymenoptera) are one the most important pollinator, in this respect (1). They generally feed their offspring with pollen which is a nutrient rich food source. Nearly 20.000 bee species exist, belonging to eight different families (1). Halictidae is one of the most diverse ones of all these families. It contains more than 70 genera and 3000 species found around the world (2). Among them, *Halictus* Latreille is one of the largest genera. It contains 74 species in the West Palaearctic Region. In addition, this genus is mostly distributed throughout the Mediterranean Region (3). Furthermore, there are 35 *Halictus* species in Turkey and 20 of them are found in Mediterranean Turkey (4). However, the studies for establishing the bee fauna of Turkey and data on the floral associations of these wild bees are insufficient.

The information on the plant preferences of bees is very important in two ways. Firstly, it helps researchers cap-

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ture bees more quickly by using the distribution data of plants which directly give the address of bees. Secondly, this kind of observations and records would give a broad perspective in evaluating the co-evolution of plants and bees. Since, some bee species show narrow host-plant preferences, it would be an informative step to expose bee-plant associations in relation with host-plant evolution. Therefore, we cannot ignore the importance of plant preferences data.

Halictidae members have a unique feature which is that they exhibit nearly every degree of sociality, ranging from solitary to eusocialilty, these kinds of life strategies might have caused diversity in food selections which could possibly be an important reason why Halictidae is one of the dominant pollinator of angiosperms. Moreover, the accumulation of this data also will be helpful in finding out the exact biogeographical explanations of diversification of bees and related plants. Due to the fact that the Mediterranean region is known for containing a large amount of plant diversity (5), the richness of the species in the genus *Halictus* of this region needs to be questioned in this respect. Hence, the main aim of this study is to analyze the plant preferences of the members of the genus *Halictus* species that were found in the Mediterranean region of Southern Turkey.

MATERIALS AND METHODS

The study comprised of all the habitats related with the Mediterranean region of southern Turkey (Figure 1). Fieldwork was carried out through Spring and Summer between 2008 and 2009. Bee material were collected via nets and aspirators. Meanwhile, the flowers that had been visited by bees were also collected for identification. In addition to field study records, foraging flower information (4,6-11) was reviewed and added to the study. Bee and plant specimens were inspected via stereo-microscopes for diagnosis. Identification of the bee specimens were made according to Pesenko, Pesenko et al., Amiet et al. and Ebmer (10,12-14). Plant identifications were made according to Davis and Güner et al. (15-17). Distribution map for the studied area was prepared via CFF 2.0 (18). Bee records were analyzed by ecological diversity indices via PAST (19). Shannon diversity (Shannon H) and Evenness (Evenness_e^H/S) indices were evaluated in order to find out the most preferred plant species.

RESULTS

In total, 516 bee and 195 plant specimens were sampled from 76 stations located in 14 provinces. As a result, 54 plant taxa (Table 1) were found related with 19 *Halictus* species (Table 2). From those plants, seven of them were endemic to Turkey, six of them were Irano-Turanian elements and eight of them were Mediterranean. All the rest were typical for many habitats in Turkey. From the collected bees, there was only one endemic species, *Halictus pentheri* Blüthgen, 1923 and one Mediterranean species, H. *berlandi* Pérez, 1903.

Diversity indices were performed to each taxa and the total numbers of bee individuals captured from plants were analyzed. Also presence/absence data matrix of relevant records was used to calculate more precise results. All those attempts figured out that *Centaurea iberica* Trev. ex Sprengel is the most preferred plant species (Table 3) and *Onopordum* L. is the most preferred plant genus by means of Shannon index scores (Shannon_H: *Onopordum* spp.: 1.986; *Centaurea* spp.: 1.923; *Echinops* spp.: 1.863; *Rubus* spp.: 1.749; *Picnomon* sp.: 1.667).

On the other hand, evaluation of the flower visit records for Halictus from literature (6-11) showed similar results (Table 4). *Centaurea* sp., *Carduus* sp., and *Onopordum* sp. were found as the most frequently visited plants.

DISCUSSION

Halictidae members exhibit nearly every degree of sociality ranging from solitary to eusocialilty (10). Michener (20) also reported that both solitary and primitively eusocial species are found in the genus *Halictus*. Such life strategy diversity might have caused diversification of food selections among *Halictus* members. Evaluating of the plant preference data of *Halictus* (Table 1) seems to confirm this idea. Such food diversity might also be one of the important reasons for their high abundance in nature.

For example, *H. maculatus* is reported as one of the most widely distributed species within Turkey (4). It is also known as a widespread species through Palaearctic region (10). According to the foraging plant or visited flower information this species was recorded to prefer more than 40 plant taxa belonging to various families (4). Pesenko at al. (10) reported that this species is known as primitively eusocial. Michener (20) reported that in such polylectic bees, even though they are primitively social, there is no any communication or social interaction to share the location of food source information. But such groups that have polylectic behavior (pollen loads contains a variety of flowers) show a tendency to forage on a single flower at each trip (20). That might be the possible explanation for their great amount of variation on visited flower information.

According to our study, *H. resurgens* is reported as the most common member of the group that is recorded from all around the Mediterranean region of southern Turkey (21). When we evaluate the foraging plant or visited flower data of this species, we see the same situation. At different stations we observed that different flower types are visited by members of this species.

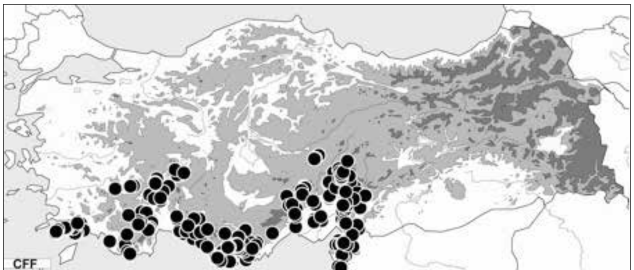

Figure 1. CFF map of studied area (black circles indicates the locations of stations).

Table 1. Determined plant taxa ("*" indicates the endemic species)

Acantholimon sp.	**Marrubium parviflorum* Fisch & Mey subsp. *oligodon* (Boiss.) Seybold
**Anchusa leptophylla* Roemer & Schultes subsp. *incana* (Ledeb.) Chamb	*Melilotus officinalis* (L.) Desr
Cardaria draba (L.) Desv. subsp. *draba*	*Mentha longifolia* (L.) Hudson subsp. *typhoides* (Briq.) Harley var. *typhoides*
Carduus nutans L. *nutans* sensu lato	*Mentha spicata* L. subsp. *spicata*
**Carduus olympicus* Boiss. subsp. *hypoleucus* (Bornm.) Davis	*Nasturtium officinale* R.Br.
Carduus pycnocephalus L. subsp. *albidus* (Bieb.) Kazmi	*Onopordum acanthium* L.
Centaurea iberica Trev. ex Sprengel	**Onopordum anatolicum* (Boiss.) Eig
Centaurea solstitialis L. subsp. *solstitialis*	**Onopordum boissieri* Willk.
**Centaurea solstitialis* subsp. *carneola* (Boiss.) Wagenitz	**Onopordum bracteatum* Boiss. & Heldr. var. *arachnoideum* Erik & Sümbül
Chondrilla juncea L. var. *acantholepis* (Boiss.) Boiss.	*Onopordum bracteatum* Boiss. & Heldr. var. *bracteatum*
Chondrilla juncea L. var. *juncea*	*Onopordum carduchorum* Bornm. & Beauverd
Chrysanthemum segetum L.	*Onopordum majori* Beauverd
Cichorium intybus L.	*Onopordum sibthorpianum* Boiss. & Heldr.
Convolvulus arvensis L.	*Peganum harmala* L.
Crepis alpina L.	*Picnomon acarna* (L.) Cass.
Crepis foetida L.	*Picris altissima* Delile
Crepis foetida L. subsp. *commutata* (Spreng.) Babcock	*Pulicaria arabica* (L.) Cass
Crepis foetida L. subsp. *rhoeadifolia* (Bieb.) Celak	*Ranunculus marginatus* d'Urv var. *trachycarpus* (Fisch. & Mey) Azn
Echinops orientalis Trautv.	*Reseda lutea* L. var. *lutea*
Echinops *pungens* Trautv. var. *pungens*	*Rubus canescens* DC. var. *glabratus* (Godron) Davis & Meikle
Echinops *ritro* L.	*Rubus sanctus* Schreber
Echinops viscosus DC. subsp. *bithynicus* (Boiss.) Rech.	*Scabiosa atropurpurea* L. subsp. *maritima* (L.) Arc
Eryngium campestre L. var. *virens* Link	*Scabiosa celocephala* Boiss.
Glaucium leiocarpum Boiss.	*Silene vulgaris* (Moench) Garche var. *vulgaris*
Hirschfeldia incana (L.) Lang.- Foss.	*Verbascum* sp.
Malva neglecta Wallr.	*Vicia villosa* Roth subsp. *eriocarpa* (Hausskn) P.W.Ball

Table 2. Determined *Halictus* species

Halictus adjikenticus Blüthgen, 1923	*Halictus pentheri* Blüthgen, 1923
Halictus alfkenellus Strand, 1909	*Halictus quadricinctus* (Fabricius, 1776)
Halictus asperulus Pérez, 1895	*Halictus resurgens* Nurse, 1903
Halictus berlandi Pérez, 1903	*Halictus sajoi* Blüthgen, 1923
Halictus brunnescens (Eversmann, 1852)	*Halictus sexcinctus* (Fabricius, 1775)
Halictus cochlearitarsis (Dours, 1872)	*Halictus simplex* Blüthgen, 1923
Halictus compressus (Walckenaer, 1802)	*Halictus squamosus* Lebedev, 1911
Halictus luganicus Blüthgen, 1936	*Halictus tetrazonianellus* Strand, 1909
Halictus maculatus Smith, 1848	*Halictus tetrazonius* (Klug, 1817)
Halictus patellatus Morawitz, 1874	

The Mediterranean region itself could be another factor for this diversity in food preference. Due to the fact that the Mediterranean region is characterized by a high diversity of plants (5), it is not surprising to see such a diversity of bees, and such different food choices in parallel with this diversity.

In this concept the most common visited flower families and genera were reviewed to analyze the plant preferences of *Halictus* species. The results showed that *C. iberica* is widely preferred by the *Halictus* species (Table 3). However, this selection is not so strict and cannot indicate a monolectic or oligolectic feeding behavior. The results also suggest that there is a choice on Asteraceae members on family level and especially a choice on the genera *Onopordum*, *Echinops* L., *Carduus* L., *Centaurea* L. and *Cirsium* Adans (Tables 3-4).

Table 3. Shannon diversity (*Shannon_H* scores) index scores of related plant species

Plant Species	***Shannon_H*** **Scores**
Centaurea iberica Trev. ex Sprengel	1.902
Onopordum carduchorum Bornm. & Beauverd	1.786
Onopordum acanthium L.	1.685
Picnomon acarna (L.) Cass.	1.667
Echinops orientalis Trautv	1.565
Onopordum bracteatum Boiss. & Heldr. var. *bracteatum*	1.465
Rubus canescens DC. var. *glabratus* (Godron) Davis & Meikle	1.427
Echinops pungens Trautv. var. *pungens*	1.396
Echinops ritro L.	1.388
Centaurea solstitialis L. subsp. *solstitialis*	1.24

Whether such results and the data recorded in the literature (6-11) display a wide oligolectic behavior on family level to Asteraceae, we do not have concrete results to suggest such a strict relation, or any sort of specialization either. According to Larkin et al. (22), even some polylectic bees may display a short-term specialization such as the "flower fidelity" behavior in honeybees.

After we analyzed our results according to Michener (20) and Larkin et al. (22) we can suggest that such short term foragers may have affected our results and displayed somehow specialization on certain plant taxa.

However, as our data did not depend on one single location and just a few samples, depending on our large sample size and sampling locations we can conclude that members of the genus *Halictus* mostly prefer to visit plants belonging to the Asteraceae family but also may visit many types of other flowers such as Rosaceae and Brassicaceae.

These results do not allow us to make concrete remarks on the foraging habit of this genus. However, the information on plant preferences of bees may help us design our further field studies more accurately since by knowing the direct address (the preferred flowers) may help us capture and follow bees more easily. Moreover, such further studies focusing on the plant-bee interactions, orientation of the food source and understanding the social behavior of bees would be more convenient by preferred plant data of the target bee species.

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Table 4. Shannon diversity scores of the data

Genera	$Shannon\_H_1$	Evenness_e^H/S	$Shannon\_H_2$	Genera	$Shannon\_H_3$
Onopordum	1.986	0.5604	2.565	*Centaurea*	2.398
Centaurea	1.923	0.5261	2.565	*Carduus*	2.197
Echinops	1.863	0.6446	2.303	*Onopordum*	2.197
Rubus	1.749	0.8212	1.946	*Taraxacum*	1.792
Picnomon	1.667	0.8831	1.792	*Cirsium*	1.609
Carduus	1.189	0.5471	1.792	*Salix*	1.609

$Shannon\_H_1$: The scores calculated by individual numbers; $Shannon\_H_2$: The scores calculated by presence/absence data; $Shannon\_H_3$: The scores calculated by presence absence data of the literature; Evenness_e^H/S: The Evenness index

Conflict of Interest: The authors have no conflict of interest to declare.

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