Arch Biol Sci. 2023;75(2):221-236 https://doi.org/10.2298/ABS230331018T

Apifloristic diversity in the eastern Mediterranean region: implications for biodiversity conservation and use

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Received: March 31, 2023; **Accepted**: April 14, 2023; **Published online**: May 16, 2023

Abstract: The ecological role of honeybees in the world and their value for sustainable agriculture and food industry are more important than ever. For this reason, we study the apiflora in the eastern Mediterranean region of Türkiye in the context of planning bee forests aimed at biodiversity conservation. The results show that honeybee forests are quite rich in both endemism and apifloristic diversity. A total of 511 plant taxa belonging to 264 genera and 59 families were identified, of which 335 (65%) taxa were evaluated as nectar (N) and/or pollen (P) bearing honey plants (45 N, 54 P, and 236 N&P). In terms of apiflora, the richest families are Fabaceae (n=76, 3 N, 73 N&P), Lamiaceae (n=57, 19 N, 38 N&P) and Asteraceae (n=44, 1 N, 10 P, 33 N&P). Nectariferous plants were more common at higher elevations, while polleniferous plants were more common at lower elevations. According to the Shannon-Wiener diversity index, the highest diversity values were found in honeybee forests at higher elevations and the lowest diversity values at lower elevations. Sorensen analysis also showed that floristic similarities among honeybee forests ranged from 1% to 42%. Cluster analysis supported these differences by dividing the forests into two separate groups.

Keywords: apiflora, plant conservation, endemic species, plant diversity, Türkiye

Keywords: nectar (N); pollen (P), both nectar and pollen (N&P), endangered (EN), vulnerable (VU), near threatened (NT), least concern (LC)

INTRODUCTION

The loss of bee colonies and rising food prices due to global climate change have drawn attention to future approaches and theories that support beekeeping in today's world [1-5]. In this sense, forest ecosystems have become important for beekeeping, as they are a constant source of pollen and nectar for both wild and domesticated honeybees [6-12]. In terms of forest cover, Türkiye has about 23 million hectares of forest land and a quarter of the annual honey production is obtained from these areas [13]. Approximately 10.2 million hectares of these forest areas show degraded structure or unproductive forest characteristics due to unsuitable geomorphological structures such as rocky and stony areas or karst topography [14, 15]. Although this is an unfavorable situation for the forestry sector, it provides a unique opportunity for the development of the beekeeping industry and the utilization of honeybee plants [8]. To this end, the honeybee forest (HBF) approach has been applied to the forest areas of Türkiye to achieve visible progress in the beekeeping sector. Under the bee forests action plan, a total of 513 HBFs (66,863 ha) were established across the country, and these practices had two main objectives [8]. The first was to create a sustainable source of income from beekeeping and contribute to the sustainability of honeybees and the beekeeping sector by preserving plant diversity. Second, it aims to support the increase of honey plant populations (especially endemic species) through *in situ* conservation measures.

Our aim was to determine the apifloristic characteristics and the value of plant diversity in the HBFs of Mersin province in the eastern Mediterranean region. The main objectives can be described as follows: (i) to discuss the applicability of the HBF approach in the Mediterranean climate basin; (ii) to determine the plant species diversity (Shannon-Wiener index) of the HBFs and compare them in relation to the apiflora; (iii) to identify endemic honey plants and discuss *in situ* conservation measures to ensure the persistence of endemism; (iv) to determine the effects of altitude on honey plant composition.

MATERIALS AND METHODS

The purposeful sampling method [16] was used to select the HBFs to be studied. Some criteria such as the representation of all districts and two altitude levels (low/high), which are extensively used by beekeepers, were considered. In cases where the HBFs were very close to each other or in areas with the same ecological characteristics, the most appropriate one in terms of vegetation characteristics was included in the study. The selected HBFs are listed in Supplementary Table S1, and the locations are given in Supplementary Fig. S1 [21].

Study area

Mersin province is an important point for beekeeping due to its high endemism with a total of 560 endemic plant taxa [18-21] and its geophyte richness [22]. It lies between 36-37° north latitude and 33-35° east longitude and is surrounded by rather high, rugged and rocky western and central Taurus mountains. Its area is 15,485 km^2, which is 2% of the area of Turkey. According to the monthly average temperature values, Mersin has the required temperature range for honeybees to collect pollen and nectar for nine months, except for December, January and February (Supplementary Fig. S2). Thanks to the Mediterranean climate, the vegetation period and the flight time of bees in this region are much longer than in other climatic zones of the country [23-25].

Plant sampling

The number of sample plots to be created for each HBF was determined using the equation (Eq. 1) according to the size of the plots [26].

$$n = \frac{\mathrm{A} \times \mathrm{t}^2 \times \mathrm{Cv}^2}{(\mathrm{A} \times \mathrm{m}^2) + (\mathrm{a} \times \mathrm{t}^2 \times \mathrm{Cv}^2)} \quad \text{(Eq. 1)}$$

where the "n" is the number of sample plots; "A" is the total area; "a" is the size of the sample plot; "t" is the confidence level; "Cv" is the coefficient of variation; "m" is the percentage of error.

A total of 78 sample plots were assigned to the ten honeybee forests and applied in the field (Supplementary Table S1). Sample plots were randomly distributed within HBFs to allow convenient comparison in terms of apifloristic richness. Plant specimens (trees, shrubs and herbs) were then recorded from nested quadrats in the sample plots and collected for identification. These are as follows: 400 m^2 (20×20 m) for trees, 100 m^2 (10×10 m) for shrub species, 4 m^2 (2×2 m) for herbaceous species. In addition, honeybee visits to each plant species were recorded simultaneously by direct observation.

Plant samples and identification

The field studies were planned taking into account the altitude differences in the region and the different vegetation types. To determine the plant species diversity, studies were carried out in the sample plots during the optimum vegetation periods. When collecting plant specimens for both plant identification and nectarium/pollen determination, attention was paid to the presence of generative organs. For plant identification, Flora of Turkey and the East Aegean Islands [27-29] was used as the main reference; recent taxonomic updates were also checked [30]. The threat categories of endemic and rare plants were revealed according to the Red Data Book of Turkish Plants [31] and were revised according to the IUCN [32]. The plant specimens were mounted on herbarium sheets and stored in the KASOF herbarium (Kahramanmaraş Sütçü Imam University, Faculty of Forestry) [33].

Apiflora and honeybee visits

The plants that produce honey substances are called Apiflora. These plants can be divided into three groups: nectariferous only (N), polleniferous only (P), and both nectariferous and polleniferous (N&P) plants [34]. The flowering periods of honey plants were first determined from the Flora of Turkey [27-29]. The relevant literature was then examined and all information was combined with the field observations [9,35-38,39-48]. During the field observations, at least two plant specimens were collected for both identification and examination of the presence of the nectaria in the lower periphery of the ovaries. The examinations were carried out in the laboratory with the aid of a stereomicroscope with 80× magnification.

Plant species diversity

To determine plant species diversity values in HBFs, plant species were recorded in nested quadrats and listed as presence or absence data. The Shannon-Wiener index values were calculated using the BioDiversity Pro 2 package program [49].

Floristic similarities

To find the similarities between the HBFs, the presence/absence data were used again and the Sorensen index values were determined [50]. Subsequently, Bray-Curtis cluster analysis was performed to classify the HBFs [49]. Bray-Curtis analysis uses a hierarchical clustering technique, i.e., the sequential combination of clusters, groups or subgroups that are combined only once in a hierarchical order [51]. Hierarchical results are shown as tree diagrams.

RESULTS

A total of 511 plant taxa belonging to 59 families and 264 genera were determined. Of the total taxa, 23 are trees, 27 shrubs, 422 herbs, 38 grasses and one sage plant. The richest families were Fabaceae (82 taxa), Asteraceae (81 taxa), Lamiaceae (60 taxa), Poaceae (38 taxa) and Caryophyllaceae (21 taxa) (Table 1). The three leading families correspond to 44% of the total plant species pool. The richest genera were *Trifolium* (15 taxa), *Astragalus* (10 taxa) and *Salvia* (9 taxa).

Table 1. Richest plant families and genera (taxa number ≥5).

Family	Taxa number*	Genera	Taxa number
Fabaceae	82	*Trifolium*	15
Asteraceae	81	*Astragalus*	10
Lamiaceae	60	*Salvia*	9
Poaceae	38	*Bromus*	8
Caryophyllaceae	21	*Galium*	7
Brassicaceae	20	*Medicago*	7
Rosaceae	18	*Silene*	7
Boraginaceae	16	*Teucrium*	7
Apiaceae	15	*Alyssum*	6
Rubiaceae	11	*Crepis*	6
Ranunculaceae	10	*Lotus*	6
Geraniaceae	8	*Ononis*	6
Cistaceae	7	*Phlomis*	6
Papaveraceae	7	*Trigonella*	6
Plantaginaceae	7	*Anthemis*	5
Asparagaceae	6	*Campanula*	5
Campanulaceae	6	*Centaurea*	5
Caprifoliaceae	6	*Euphorbia*	5
Euphorbiaceae	6	*Hypericum*	5
Cupressaceae	5	*Lathyrus*	5
Hypericaceae	5	*Minuartia*	5
Iridaceae	5	*Sideritis*	5
Subtotal	**440**	**Subtotal**	**146**

*Number of taxa for richest 22 families (n=440 taxa)

Apiflora and endemism

As a result of the research, literature review and field observations, a total of 335 taxa (65%) were found to have the potential to be used by honeybees as nectar and pollen sources. Among them, there are dominant forest trees, woody vines (liana), tall Mediterranean shrubs, as well as many dwarf Lamiaceae shrubs and herbaceous plants that provide nectar (N) and pollen (P) or both (N&P) in this region. According to the data set of the present study, 71% N&P (236 taxa), 16% P (54 taxa), and 13% N (45 taxa) taxa reward *Apis mellifera*. It was also revealed that the richest families in terms of honey plants were Fabaceae (n=76, 23%), Lamiaceae (n=57, 17%) and Asteraceae (n=44, 13%). These families are also rich in both nectar and pollen (N&P) ratios (96%, 68% and 75%, respectively). While the Lamiaceae family is prominent in nectariferous plants (19 N), the Asteraceae family leads in polleniferous plants (10 P) (Table 2).

The richest HBFs in terms of apiflora are Ağaçkese (87 of 121) and Arpaalanı (85 of 135) (Fig. 1). The highest rates for honey plants were found in HBFs with fragmented pastures in forest clearings at higher elevations. These areas contain bee pastures rich in

Table 2. Distribution of taxa numbers to families according to apifloristic features (N, P, N&P).

Family	Taxa Number (n=511)	Honey Plants (n=334)	N (n=44)	P (n=54)	N&P (n=236)
Amaranthaceae	3	3	-	-	3
Amaryllidaceae	2	2	-	2	-
Anacardiaceae	3	2	-	1	1
Apiaceae	15	9	1	-	8
Asparagaceae	6	5	-	3	2
Asteraceae	81	44	1	10	33
Boraginaceae	16	8	4	-	4
Brassicaceae	20	6	2	-	4
Campanulaceae	6	5	-	-	5
Caprifoliaceae	6	3	-	-	3
Caryophyllaceae	21	5	1	4	-
Cistaceae	7	6	-	6	-
Convolvulaceae	2	1	-	-	1
Crassulaceae	1	1	-	-	1
Cupressaceae	5	1	-	1	-
Elaeagnaceae	1	1	-	-	1
Ericaceae	2	2	-	-	2
Euphorbiaceae	6	6	4	-	2
Fabaceae	82	76	3	-	73
Fagaceae	3	3	-	3	-
Geraniaceae	8	4	-	-	4
Hypericaceae	5	5	-	5	-
Iridaceae	5	5	-	4	1
Lamiaceae	60	56	18	-	38
Linaceae	3	2	-	-	2
Malvaceae	4	4	-	-	4
Myrtaceae	2	2	1	-	1
Oleaceae	4	3	-	3	-
Orchidaceae	1	1	1	-	-
Papaveraceae	7	3	1	1	1
Pinaceae	4	4	-	4	-
Plantaginaceae	7	5	-	1	4
Polygonaceae	2	2	-	1	1
Primulaceae	2	2	-	-	2
Ranunculaceae	10	6	-	3	3
Resedaceae	1	1	-	-	1
Rhamnaceae	1	1	-	-	1
Rosaceae	18	18	-	1	17
Rubiaceae	11	7	7	-	-
Salicaceae	1	1	-	-	1
Scrophulariaceae	4	3	-	-	3
Smilacaceae	1	1	-	-	1
Solanaceae	3	2	-	-	2
Styracaceae	1	1	-	1	-
Thymelaeaceae	2	2	-	-	2
Xanthorrhoeaceae	4	4	-	-	4
Subtotal	459	334	44	54	236

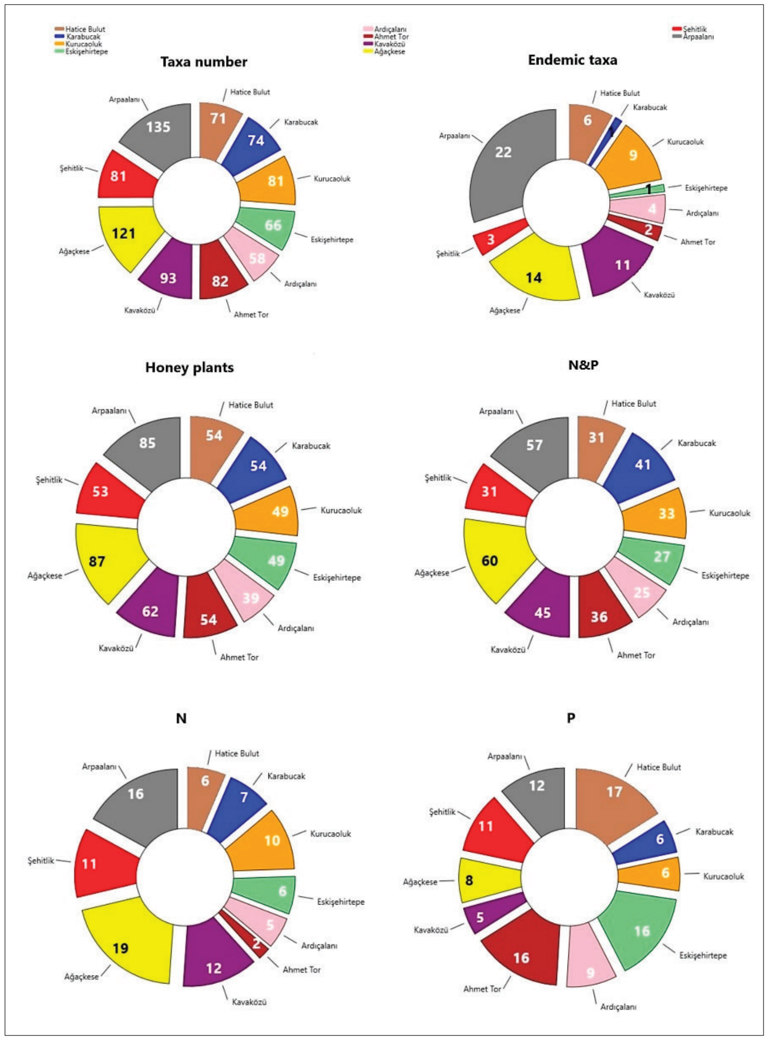

Fig. 1. Floristic and apifloristic comparison of the honeybee forests (N, P, N&P).

flowering herbaceous and woody plants, which are of great importance for honeybee colonies and therefore honey production, with trees as a permanent pollen source for the honeybees [52].

Fifty plant taxa in the species pool were determined as endemic (endemism 9.8%) (Fig. 1). The abundance of endemic species varied from 1.4 to 16.3% among ten HBFs. In terms of endemism, Arpaalanı is the richest HBF with 22 taxa (16.3%). Only one endemic taxon was found in the HBFs of Karabucak and Eskişehirtepe, *Hammatolobium lotoides* Fenzl (1.4%) and *Iris stenophylla* Hausskn. ex Baker subsp. *stenophylla* (1.4%).

According to the red list categories and criteria of IUCN [32], one taxon is in the endangered (EN) category, 4 taxa are in the vulnerable (VU), 12 taxa are in the near threatened (NT), and 33 taxa are in the least concern (LC) category (Table 3). The endangered *Verbascum orbicularifolium* Hub.-Mor. is located in Şehitlik HBF (in Silifke) (Fig. 2). In addition, five rare plant taxa were found in the HBFs. These are: *Centaurea aegialophila* Boiss. & Heldr. ex Boiss. (EN category), *Lotus creticus* L., *Gladiolus anatolicus* (Boiss.) Stapf and *Teucrium montbretii* Benth. (VU category) and *Crepis aspera* L (DD category).

Table 3. Distribution of endemic plants in honeybee forests according to apifloristic characteristics and IUCN threat categories.

Endemic plants			Endemic honey plants			
IUCN	Taxa number	Ratio	N	P	N&P	Total
EN	1	2.0	-	-	1	1
VU	4	8.0	2	1	1	4
NT	12	24.0	-	-	9	9
LC	33	66.0	3	1	17	21
Total	50	100.0	5	2	28	35

HBFs are also of great importance for the *in situ* conservation of endemic honey plants and the balanced use of plant resources. More than half of these endemic species (35 taxa, 70%) are used by honeybees as a source of pollen or nectar (or both). Of these species, 15 (43%) were directly observed in the study area.

Flowering periods

Flowering calendars for beekeeping are a timeline that shows the beekeeper the approximate date and duration of flowering of important pollen- and nectar-bearing honey plants in an area [52]. Accordingly, the flowering periods of 335 honey plants were determined. As a result, the most intense harvesting months are June with 239 taxa and May with 230 taxa (Fig. 3). The richest blooming seasons are summer with 258 taxa and spring with 244 taxa. Beekeepers traditionally come to lower altitude HBFs for wintering in the autumn, and then, when the weather gets warmer in mid spring (before May), they move their bee colonies to the Central Taurus forests and highlands.

Honeybee visits

According to direct observations, 138 plant taxa (belonging to 95 genera and 30 families) were visited by honeybees (see Supplementary Figs. S3-S6 and

Fig. 2. Threatened plant species in the honeybee forests. **A** – *Verbascum orbicularifolium* Hub.-Mor. **B** – *Sideritis rubriflora* Hub.-Mor. **C** – *Sideritis vuralii* H.Duman & Başer. **D** – *Asphodeline cilicica* Tuzlaci. Vulnerable (VU), endangered (EN).

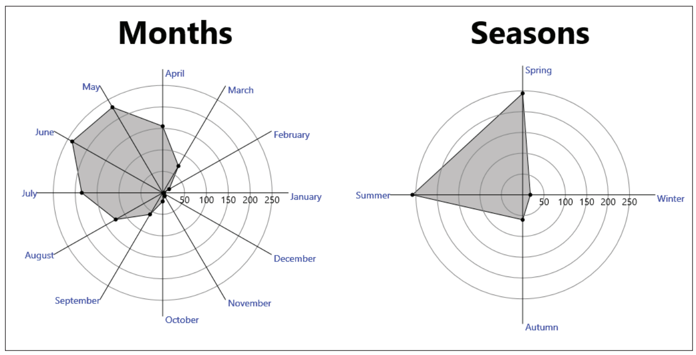

Fig. 3. Radar charts of the monthly and seasonal blooming species.

Supplementary Table S2 for the original dataset used to conduct this analysis). The six most visited families were Fabaceae (36 taxa), Lamiaceae (31 taxa), Asteraceae (10 taxa), Boraginaceae (8 taxa), Brassicaceae (8 taxa), and Rosaceae (8 taxa) (Fig. 4). These families accounted for 73% of the total number of taxa visited by honeybees. The Fabaceae and Lamiaceae families rank first and second in all HBFs in terms of the number of taxa visited by honeybees. The richest genera in terms of honeybee visits were Trifolium (21 taxa), Astragalus (10 taxa), and Salvia (9 taxa). These three genera are also among the two richest families (Fabaceae and Lamiaceae).

Apart from that, the most frequent bee visitation observations for the lower altitude HBFs (Group A,

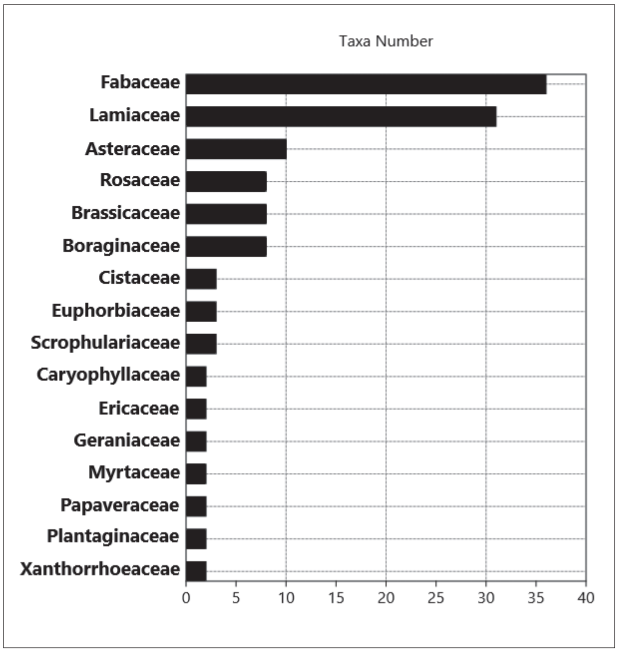

Fig. 4. Honeybee visits to the plant families (taxa number >1).

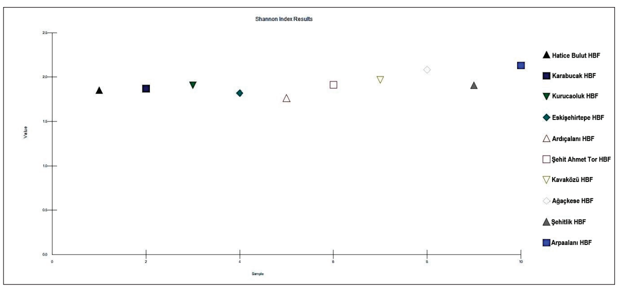

Fig. 5. Species diversity values according to the Shannon-Wiener index.

including 61 taxa) were made on the following species: *Quercus coccifera* L., *Cistus creticus* L., *Cistus salviifolius* L., *Erica manipuliflora* Salisb., *Calicotome villosa* (Poir.) Link, *Inula viscosa* (L.) Aiton and *Reseda lutea* L. var. *lutea*, and for the upper altitude HBFs (Group B, including 100 taxa), *Teucrium chamaedrys* L., *Medicago sativa* L. subsp. *sativa*, *Orlaya daucoides* (L.) Greuter, *Cotoneaster nummularius* Fisch. & C.A. Mey., *Euphorbia rigida* M.Bieb., *Astragalus angustifolius* Lam. subsp. *angustifolius* and *Rosa canina* L.

It was found that 25 taxa are visited by honeybees in Karabucak HBF dominated by artificial eucalypt forests (out of group), and 10 of them are specific to this honeybee forest: *Ochthodium aegyptiacum* (L.) DC., *Sinapis arvensis* L., *Eucalyptus camaldulensis* Dehnh. subsp. *camaldulensis*, *Silybum marianum* (L.) Gaertn. subsp. *marianum*, *Raphanus raphanistrum* L. subsp. *raphanistrum*, *Carduus argentatus* L., *Medicago arabica* (L.) Huds, *Geranium asphodeloides* Burm.f. subsp. *asphodeloides*, *Ballota saxatilis* Sieber ex C.Presl subsp. *saxatilis* and *Calendula arvensis* (Vaill.) L.

Group A (lower altitude HBFs) has 41.25% similarity with Group B (upper elevation HBFs), while it has 27.90% similarity with the Karabucak HBF, which is clustered as out of group. In addition, there is 11.0% similarity between Group B and Karabucak HBF.

Patterns of plant species diversity in the honeybee forests

The plant species diversity values of each HBF were calculated by the Shannon-Wiener index (Fig. 5). When comparing the HBFs in terms of plant species diversity, the highest Shannon-Wiener index values were found in the Arpaalanı (2.13) and Ağaçkese (2.08) HBFs. In addition, these HBFs contain the most nectar- and pollen-bearing plants and rank first in terms of the total taxa number. The lowest diversity values (1.76) were calculated in Ardıçalanı (1.76) and Eskişehirtepe (1.82) HBF.

Sorensen similarities

Based on the plant species collected from the sample plots in the HBFs, similarities (distances) were determined with the Sorensen index. The similarity ratios varied between 1.03% and 42.11% among the HBFs. In terms of plant composition, the closest HBFs were determined as Kavaközü and Arpaalanı with 42.1%, and the most distant HBFs were Karabucak and Ağaçkese with 1.03%. According to the Sorensen similarity matrix, Arpaalanı, Kurucaoluk, Ağaçkese and Kavaközü HBFs show moderate similarity rates between 28-42%. We can explain this by the fact that the ecological and habitat conditions are more limited and similar at higher elevations. Similarity ratios between other HBFs at lower altitudes are in the lower range of 7-37%. This is probably because habitats at lower elevations are more distinct from one another, degraded under the influence of higher population density. Arpaalanı, Kurucaoluk, Ağaçkese and Kavaközü HBFs showed low similarities with Şehitlik, Şehit Teğmen Ahmet Tor, Hatice Bulut, Eskişehirtepe, and Karabucak HBFs between

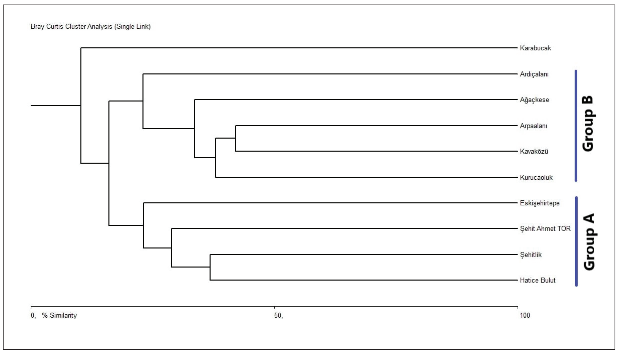

Fig. 6. Bray-Curtis cluster analysis of honeybee forests using floristic data.

the ranges of 1.03-16.13%. These minor similarities are due to the fact that altitude marks a clear limit to the vertical spread of the plant species.

The Bray-Curtis cluster analysis compared honeybee forests according to their similarity and dissimilarity in terms of plant species composition (Fig. 6). The forests closest to each other in terms of floristic composition are connected in the dendrograms to the same point in a row. Accordingly, it was observed that Hatice Bulut, Eskişehirtepe, Şehit Teğmen Ahmet Tor and Şehitlik HBFs (grouped as A) are located in the same cluster, while Arpaalanı, Ağaçkese, Kavaközü and Kurucaoluk HBFs (grouped as B) are located in a separate cluster. Ardıçalanı HBF is associated with group B, but its similarity ratios are below 20%.

On the other hand, Karabucak HBF, dominated by *Eucalyptus camaldulensis*, differs from all other HBFs in terms of plant composition and is out of the groups. Because the Karabucak HBF is established in artificial eucalypt forests on heavily structured alluvial soil, which is ecologically different, it exhibited very low similarities, ranging from 1.03-11.53% with the other HBFs. If we exclude the Karabucak HBF, the other HBFs are divided into two main groups based on lower and higher elevations and different forest vegetation types that are dominated by *Pinus brutia*, *P. pinea* at lower elevations, and by *Pinus nigra*, *Cedrus libani*, *Juniperus foetidissima* at upper elevations.

DISCUSSION

High plant diversity is important as a food source for honeybees as well as for all living creatures. In addition, the high potential of Apiflora is a factor that increases the benefits of nature. Honeybees visit flowers to collect nectar for their carbohydrate needs and pollen for their protein needs [35]. At the same time, the nectar and pollen substances of endemic species improve the quality of honey, characterize its taste and give it a unique identity [53,54].

In order to obtain a high yield from beekeeping in a region, colony performance, productivity and labor input of bees should be high, and nectar and pollen sources should be diverse and abundant [44]. The presence of honey plants is essential both for the survival of the bee colony and for efficient apiculture. The ratios of honey plants in flora are also considered as one of the ecological-environmental subcriteria in determining the localities of HBFs [55]. At least 450 plant species important to beekeeping have been reported in studies conducted in Türkiye [36-39, 48,56-58].

The HBFs in this study differ in terms of apifloristic features and plant species diversity. In addition, the pollen and nectar capacities of these forests are quite different. This difference is observed at different levels. In the HBFs, plant diversity is higher in the upper elevations, but lower in the lower elevations. Also, HBFs in the upper elevations are more diverse in terms of apiflora than those in the lower elevations. The composition of plant species also differs between the two altitude levels. In the upper elevations, the number of nectariferous plants is higher than the number of polleniferous plants, while in the lower elevations, polleniferous plants are more numerous than nectariferous plants. This knowledge has revealed that the elevational distribution of plants that are sources of nectar and pollen is of great importance in determining the location of HBFs. These floristic outputs can be used as a guide in the advanced management of HBFs. In this context, the herbaceous and woody plants that we recommend for use in HBFs in the Mediterranean ecosystems are listed as follows: herbaceous honey plants: *Onobrychis oxyodonta* Boiss., *Trifolium purpureum* Lois. var. *purpureum*, *Thymus cilicicus* Boiss. & Balansa, *Satureja thymbra* L., *Salvia multicaulis* Vahl, *Salvia viridis* L., *Nepeta nuda* subsp. *albiflora* (Boiss.) Gams, *Trifolium campestre* Schreb. subsp. *campestre* and *Teucrium p*olium L.; shrubby honey plants: *Erica manipuliflora* Salisb., *Phlomis fruticosa* L., *Rosmarinus officinalis* L., *Cistus salviifolius* L., *Cistus creticus* L., *Cotoneaster nummularius* Fisch. & C.A. Mey., *Berberis crataegina* DC., *Rosa canina* L., *Calicotome villosa* (Poir.) Link, *Arbutus andrachne* L., *Quercus coccifera* L. and *Paliurus spina-christi* P. Mill. In particular, *Quercus coccifera* L. is a very valuable pollen plant. This species is dominant in the karst ecosystems of the Mediterranean and has a wide distribution area.

The Mediterranean region of Türkiye is suitable for beekeeping with its long vegetation period (around 250-300 days), more favorable temperature averages and the greater number of sunny days compared to other regions [25]. It also has higher plant species richness and more diverse vegetation structures [20, 48]. Comparing the current study with other regional studies, e.g. in the Black Sea region, the Fabaceae rank first among the richest families despite phytogeographical and climatic differences in both the Mediterranean and Black Sea regions. The Lamiaceae family ranks second in the Mediterranean region (as reported in the present study), while it ranks fourth in the Black Sea region [45]. The most likely explanation is that the rainy Black Sea climate, unlike the Mediterranean climate, does not provide suitable habitat conditions for the Lamiaceae family. Özkan et al. [45] gave the ranking as Fabaceae (34 taxa), Asteraceae (22 taxa) and Rosaceae (21 taxa). According to another study in the Aegean region [37], family distributions were given as Fabaceae (129 taxa), Asteraceae (57 taxa) and Lamiaceae (49 taxa). In another study [44] conducted in northern central Anatolia, the Rosaceae family ranked first followed by Asteraceae, Fabaceae and Lamiaceae. This is due to the natural distribution of most of the Rosa taxa in Türkiye in Central Anatolia. Yıldız & Fakir [48] stated that the Lamiaceae and Fabaceae families, which are rich in medicinal and aromatic plants, are the most important families in terms of beekeeping. Our findings are also consistent with this earlier result of the study conducted in the western Mediterranean region of Türkiye. The results of the three studies mentioned above are consistent with our study, except for some regional differences in families containing nectar and pollen sources. In Türkiye, the ranking of plant families visited by bees varies little, but other ecological regions such as Africa have more diverse plant families in terms of bee visitation, thus, for example, the Fabaceae, Asteraceae, Acanthaceae, Myrtaceae, Euphorbiaceae and Poaceae families are the major contributors of bee plants in Kenya [59].

CONCLUSIONS

Beekeeping activities are under threat due to global climate fluctuations and losses in bee colonies. Regional developments and new perspectives on this topic should be presented in both theoretical and scientific detail in a way that can influence the entire ecosystem. In this way, a holistic data set can be obtained and the bee-ecosystem-honey production triangle can be planned efficiently. We determined significant differences between the apiflora diversity of HBFs and the taxonomic distribution patterns of nectariferous and polleniferous plants as a separate evaluation criterion in the selection of HBF locations. It also showed that the presence of endemic species in apiflora is an important value to obtain unique honey properties. The best example of this is that the Arpaalanı HBF, the richest honeybee forest in this study, is located in the Mersin Eğriçayır region, which was awarded first place in the world for its unique honey flavor and properties by the International Beekeeping Congress (Apimondia-2019) in Canada. It can be expected that the predetermination of plant species diversity will both increase the utilization rate of honey plants and improve the quality and quantity of honey.

This study is a part of national initiatives of the Ministry of Agriculture and Forestry to promote beekeeping in Turkish forestry. Türkiye has recently launched a program for the use and conservation of forests with the participation of the country's beekeepers' associations. The honey forest action plan, created with the participation of NGOs to expand the network for the conservation of HBFs and plants, was treated as a nationwide program based on forest areas. However, descriptive data such as the amount of nectar obtained from a unit of honey plant flowers are not precisely defined. More research is needed on the rarity and extinction rates of these plants, threats to the taxa, population size and habitat types. An interactive conservation platform should be created that deals with endemic honey plants unique to Türkiye. These are not only biological factors, but also important players in the history of honey in Türkiye, with a more holistic approach that takes into account that honey plants have a creative impact on the present and future.

Funding: This study was supported by the General Directorate of Forestry of Türkiye (20.1611 / 2016-2018-2019).

Acknowledgments: We are grateful to the General Directorate of Forestry for their support. We thank Ali Durmaz for accompanying the fieldwork, and Engül Özer for the material supply. In the identification process, we would like to thank Dr. Ahmet İlçim (Mustafa Kemal Univ.) and Dr. Zeki Aytaç (Gazi Univ.), plant genera experts, for their valuable help.

Author contributions: Conceptualization, AU and AT; methodology, AU; software, AU; validation, AU, AT, and OP; investigation, AT, AU and OP; resources, AT; data curation, AT; writing, original draft preparation, AT and AU; writing, review and editing, AT, AU and OP; visualization, AT; supervision, AU; project administration, AT; funding acquisition, AT. All authors have read and agreed to the published version of the manuscript.

Conflict of interest disclosure: The authors declared no conflict of interest.

Data availability: The data presented in this study can be accessed via the following link: https://www.serbiosoc.org.rs/NewUploads/Uploads/Topal%20et%20al_8627-Data%20Set.xlsx

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SUPPLEMENTARY MATERIAL

Supplementary Table S1. Vegetation, bedrock/soil, elevation, areal size and total number of sampled plots of honeybee forests examined.

No	Name and District	Vegetation	Bedrock /Soil	Elevation (m)	Slope (%)	Area (ha)	Number of sample plots
1	Hatice Bulut (Gülnar)	Afforested with *Pinus brutia* after a fire in 2008	Limestone / medium and lightly textured	200-350	21-40	67.5	9
2	Karabucak (Tarsus)	Artificially afforested with *Eucalyptus spp.* in 2017	Its past was swamp, now alluvial. heavy soil, rich in organic matter	5	0	55	7
3	Kurucaoluk (Toroslar)	Afforestation site which has degraded *Cedrus libani* forest	Limestone / soil is light and medium-textured	1600-1650	0-20	74	9
4	Eskişehirtepe (Tarsus)	Afforested with *Pinus pinea* in 2006-2007	Sandstone / soil is light sandy in terms of organic matter	160-200	0-40	55	7
5	Ardıçalanı (Bozyazı)	Naturally rejuvenated *Pinus brutia* afforestation site	Limestone / soil has medium-light textured	750-1000	30-60	29	4
6	Şehit Piyade Teğmen Ahmet Tor (Anamur)	Young or mature aged *Pinus brutia* forest (open or closed canopy closure)	Limestone / soil has medium-light textured	140-400	41-60	53.5	7
7	Kavaközü (Mut)	Degraded juniper-stony place and also unsuccessful *Cedrus libani* afforestated area	Limestone / soil has medium-light textured	1700	21-40	60	8
8	Ağaçkese (Tarsus)	Afforested with *Cedrus libani* and *Pinus nigra* between 2000-2002	Limestone / soil has medium-light textured	1750-2150	0-50	66	8
9	Şehitlik (Silifke)	Afforested with *Pinus brutia*	Limestone	70-240	0-40	60	8
10	Arpaalanı (Erdemli)	Rehabilitated and afforested in 2012	Limestone	1800 - 1950	0-20	100	13
Total						620	78

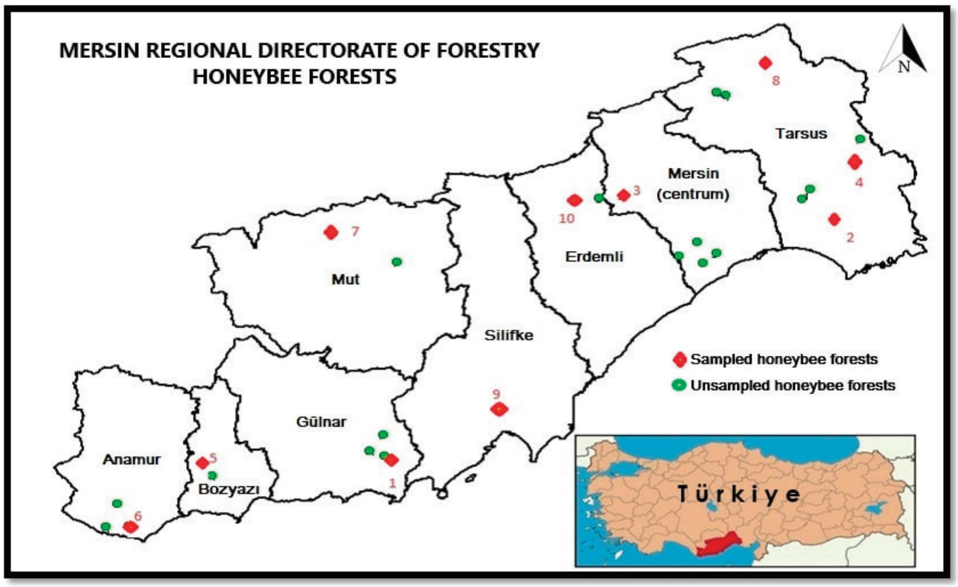
Supplementary Table S2. Honeybee visits and frequency values of taxa.

No	Family name	Taxa	Endemic	Honeybee forests										Frequency of bee visits
				Hatice BULUT	Karabucak	Kurucaoluk	Eskişehirtepe	Ardıçalanı	Şehit Ahmet TOR	Kavaközü	Ağaçkese	Şehitlik	Arpaalanı	
1	Amaryllidaceae	*Allium orientale* Boiss.	-	-	-	1	-	1	-	1	-	-	-	3
2	Anacardiaceae	*Rhus coriaria* L.	-	1	-	-	-	1	-	-	-	1	-	3
3	Apiaceae	*Orlaya daucoides* (L.) Greuter	-	1	-	1	-	1	1	1	1	1	1	8
4	Asparagaceae	*Ornithogalum pyrenaicum* L.	-	-	-	-	-	1	-	1	-	-	-	2
5	Asteraceae	*Senecio vernalis* Waldst. & Kit.	-	-	1	-	1	-	-	1	1	-	1	5
6	Asteraceae	*Inula oculus-christi* L.	-	-	-	1	-	-	-	1	1	-	1	4
7	Asteraceae	*Senecio doriiformis* DC. subsp. *doriiformis*	-	-	-	-	-	-	-	-	1	-	1	2
8	Asteraceae	*Inula viscosa* (L.) Aiton	-	1	1	-	1	-	1	-	1	1	-	6
9	Asteraceae	*Silybum marianum* (L.) Gaertn. subsp. *marianum*	-	-	1	-	-	-	-	-	-	-	-	1
10	Asteraceae	*Carduus argentatus* L	-	-	1	-	-	-	-	-	-	-	-	1
11	Asteraceae	*Achillea coarctata* Poir.	-	-	-	-	-	-	-	-	1	-	-	1
12	Asteraceae	*Anthemis pauciloba* var. *sieheana* (Eig) Grierson	-	-	-	-	-	-	-	1	-	-	-	1
13	Asteraceae	*Onopordum boissierianum* Raab-Straube & Greuter	-	-	-	-	-	-	1	-	-	-	-	1
14	Asteraceae	*Calendula arvensis* (Vaill.) L.	-	-	1	-	-	-	-	-	-	-	-	1
15	Boraginaceae	*Anchusa hybrida* Ten.	-	-	-	-	-	-	-	-	-	-	1	1
16	Boraginaceae	*Lithodora hispidula* subsp. *versicolor* Meikle	-	1	-	-	1	-	-	-	-	1	-	3
17	Boraginaceae	*Alkanna orientalis* (L.) Boiss. var. *orientalis*	-	-	-	1	-	1	-	-	1	-	-	3
18	Boraginaceae	*Cynoglossum creticum* Mill.	-	-	-	1	1	-	-	-	1	-	1	4
19	Boraginaceae	*Alkanna aucheriana* A.DC.	**E**	-	-	1	-	-	-	-	-	-	1	2
20	Boraginaceae	*Myosotis refracta* subsp. *paucipilosa* Grau	-	-	-	-	-	-	-	-	-	-	1	1
21	Boraginaceae	*Echium italicum* L.	-	1	-	1	-	-	-	-	-	-	-	2
22	Boraginaceae	*Alkanna tinctoria* (L.) Tausch subsp. *tinctoria*	-	-	-	-	-	-	-	-	-	1	-	1
23	Brassicaceae	*Aethionema capitatum* Boiss. & Balansa	-	-	-	-	-	-	-	-	-	-	1	1
24	Brassicaceae	*Alyssum strictum* Willd.	-	-	-	1	-	1	-	-	1	-	1	4
25	Brassicaceae	*Ochthodium aegyptiacum* (L.) DC.	-	-	1	-	-	-	-	-	-	-	-	1
26	Brassicaceae	*Sinapis arvensis* L.	-	-	1	-	-	-	-	-	-	-	-	1
27	Brassicaceae	*Raphanus raphanistrum* L. subsp. *raphanistrum*	-	-	1	-	-	-	-	-	-	-	-	1
28	Brassicaceae	*Erysimum crassipes* Fisch. & C.A.Mey.	-	-	-	-	-	-	-	-	-	-	1	1
29	Brassicaceae	*Isatis frigida* Boiss. & Kotschy	-	-	-	-	-	-	-	-	-	-	1	1
30	Brassicaceae	*Lepidium draba* L.	-	-	-	-	-	-	-	-	-	-	1	1
31	Caprifoliaceae	*Scabiosa micrantha* Desf.	-	1	-	1	1	-	-	-	1	-	-	4
32	Caryophyllaceae	*Telephium imperati* subsp. *orientale* (Boiss.) Nyman	-	-	-	-	-	-	-	1	1	-	-	2
33	Caryophyllaceae	*Eremogone ledebouriana* (Fenzl) Ikonn.	-	-	-	-	-	-	-	1	1	-	1	3
34	Cistaceae	*Cistus creticus* L.	-	1	-	-	1	-	1	-	-	1	-	4
35	Cistaceae	*Cistus salviifolius* L.	-	1	-	-	1	-	1	-	-	1	-	4
36	Cistaceae	*Helianthemum stipulatum* (Forssk.) C.Chr.	-	1	-	-	1	-	-	-	-	-	-	2
37	Crassulaceae	*Sedum album* L.	-	-	-	1	-	-	-	1	1	-	1	4
38	Ericaceae	*Erica manipuliflora* Salisb.	-	1	-	-	1	-	1	-	-	1	-	4
39	Ericaceae	*Arbutus andrachne* L.	-	1	-	-	-	-	1	-	-	-	-	2
40	Euphorbiaceae	*Euphorbia rigida* M.Bieb.	-	-	-	1	-	1	-	1	1	1	1	6
41	Euphorbiaceae	*Mercurialis annua* L.	-	-	1	-	1	-	-	-	-	-	-	2
42	Euphorbiaceae	*Euphorbia helioscopia* L. subsp. *helioscopia*	-	-	1	-	-	-	-	-	-	1	-	2

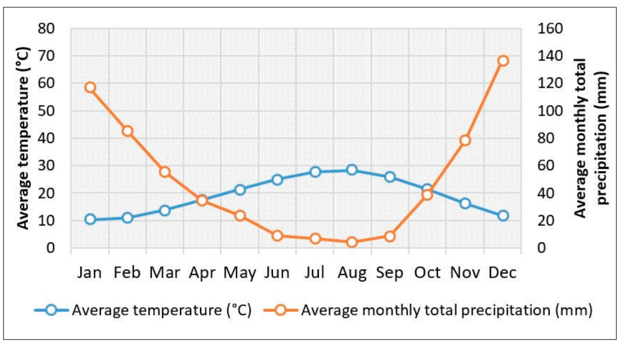
43	Fabaceae	*Genista involucrata* Spach	**E**	-	-	-	-	-	-	1	-	-	1	2
44	Fabaceae	*Astragalus angustifolius* Lam. subsp. *angustifolius*	-	-	-	1	-	1	-	1	1	-	1	5
45	Fabaceae	*Onobrychis cornuta* (L.) Desv.	-	-	-	-	-	-	-	1	-	-	1	2
46	Fabaceae	*Trigonella kotschyi* Fenzl	**E**	1	-	-	-	-	-	-	-	-	1	2
47	Fabaceae	*Astragalus angustiflorus* K.Koch subsp. *angustiflorus*	-	-	-	-	-	-	-	-	-	-	1	1
48	Fabaceae	*Lotus palustris* Willd.	-	-	-	-	-	-	1	1	1	-	1	4
49	Fabaceae	*Onobrychis oxyodonta* Boiss.	-	-	-	1	1	-	-	1	-	-	1	4
50	Fabaceae	*Astragalus condensatus* Ledeb.	**E**	1	-	1	-	-	-	1	1	-	1	5
51	Fabaceae	*Astragalus amoenus* Fenzl	**E**	-	-	1	-	-	-	1	1	-	1	4
52	Fabaceae	*Astragalus plumosus* Willd.	-	-	-	1	-	-	-	-	-	-	1	2
53	Fabaceae	*Trifolium pratense* L. var. *pratense*	-	-	1	-	-	-	1	-	-	1	-	3
54	Fabaceae	*Calicotome villosa* (Poir.) Link	-	1	-	-	1	-	1	-	-	1	-	4
55	Fabaceae	*Glycyrrhiza echinata* L.	-	-	1	-	-	-	-	-	1	-	-	2
56	Fabaceae	*Lotus corniculatus* L. var. *corniculatus*	-	-	-	1	-	-	-	1	1	-	-	3
57	Fabaceae	*Medicago sativa* L. subsp. *sativa*	-	1	1	1	-	1	-	1	1	-	1	7
58	Fabaceae	*Securigera varia* (L.) Lassen	-	-	-	1	1	-	-	-	1	-	-	3
59	Fabaceae	*Trifolium repens* L. var. *repens*	-	-	-	-	1	-	-	-	1	-	-	2
60	Fabaceae	*Trifolium ochroleucum* Huds.	-	-	-	-	-	-	-	-	1	-	-	1
61	Fabaceae	*Onobrychis caput-galli* (L.) Lam.	-	1	-	-	1	-	-	-	1	1	-	4
62	Fabaceae	*Astragalus mesogitanus* Boiss.	**E**	-	-	-	-	-	-	1	1	-	1	3
63	Fabaceae	*Trifolium purpureum* Lois. var. *purpureum*	-	-	-	-	-	-	1	-	1	-	-	2
64	Fabaceae	*Ononis spinosa* L.	-	-	-	-	-	-	-	1	-	1	-	2
65	Fabaceae	*Trifolium arvense* L. var. *arvense*	-	-	1	-	-	1	1	-	-	-	-	3
66	Fabaceae	*Vicia cassia* Boiss.	-	1	1	-	1	-	1	-	-	-	-	4
67	Fabaceae	*Lathyrus setifolius* L.	-	-	-	-	-	-	1	-	-	-	-	1
68	Fabaceae	*Trifolium campestre* Schreb. subsp. *campestre*	-	1	-	-	1	-	1	-	-	-	-	3
69	Fabaceae	*Vicia cracca* Vel. subsp. *stenophylla*	-	-	-	-	-	-	1	-	-	-	-	1
70	Fabaceae	*Lotus creticus* L.	-	-	-	-	-	1	-	-	-	-	1	2
71	Fabaceae	*Securigera securidaca* (L.) Degen & Dorfl.	-	1	1	1	1	1	1	-	-	-	-	6
72	Fabaceae	*Trigonella foenum-graecum* L.	-	-	-	1	-	-	-	-	-	-	-	1
73	Fabaceae	*Cercis siliquastrum* subsp. *siliquastrum* L.	-	1	-	-	-	1	-	-	-	-	-	2
74	Fabaceae	*Bituminaria bituminosa* (L.) C.H.Stirt.	-	-	-	1	-	1	1	-	-	-	-	3
75	Fabaceae	*Tripodion tetraphyllum* (L.) Fourr.	-	1	-	-	-	-	1	-	-	-	-	2
76	Fabaceae	*Trifolium angustifolium* L.	-	1	-	-	-	-	1	-	-	1	-	3
77	Fabaceae	*Trifolium patens* Schreb.	-	-	-	-	1	-	-	-	-	-	-	1
78	Fabaceae	*Medicago arabica* (L.) Huds.	-	-	1	-	-	-	-	-	-	-	-	1
79	Fagaceae	*Quercus coccifera* L.	-	1	-	-	1	1	1	-	-	1	-	5
80	Geraniaceae	*Geranium tuberosum* L.	-	-	-	-	-	-	-	-	1	-	1	2
81	Geraniaceae	*Geranium asphodeloides* Burm.f. subsp. *asphodeloides*	-	-	1	-	-	-	-	-	-	-	-	1
82	Hypericaceae	*Hypericum amblysepalum* Hochst.	-	-	-	-	-	-	-	-	-	-	1	1
83	Lamiaceae	*Marrubium globosum* Montbret & Aucher ex Benth. subsp. *globosum*	**E**	-	-	1	-	-	-	1	1	-	1	4
84	Lamiaceae	*Teucrium chamaedrys* L.	-	-	-	1	-	1	-	1	1	-	1	5
85	Lamiaceae	*Thymus cilicicus* Boiss. & Balansa	-	-	-	1	1	-	-	1	1	1	1	6
86	Lamiaceae	*Stachys lavandulifolia* Vahl	-	-	-	-	-	-	-	1	-	-	1	2
87	Lamiaceae	*Thymus brachychilus* Jalas	**E**	-	-	-	-	-	-	1	1	-	1	3
88	Lamiaceae	*Sideritis syriaca* subsp. *nusairiensis* (Post) Hub.-Mor.	**E**	-	-	1	-	-	-	1	-	-	1	3
89	Lamiaceae	*Scutellaria orientalis* subsp. *pinnatifida* J.R.Edm.	-	-	-	-	-	-	-	1	1	-	1	3
90	Lamiaceae	*Salvia multicaulis* Vahl	-	-	-	1	-	-	-	-	1	-	1	3
91	Lamiaceae	*Lallemantia iberica* (M.Bieb.) Fisch. & C.A.Mey.	-	-	-	-	-	-	-	1	-	-	1	2

92	Lamiaceae	*Nepeta nuda* subsp. *albiflora* (Boiss.) Gams	-	-	-	1	-	-	-	1	1	-	1	4
93	Lamiaceae	*Salvia blepharochlaena* Hedge & Hub.-Mor.	**E**	-	-	-	-	-	-	1	-	-	1	2
94	Lamiaceae	*Salvia sclarea* L.	-	-	-	1	-	-	-	1	-	-	1	3
95	Lamiaceae	*Satureja thymbra* L.	-	1	-	-	-	-	1	1	-	1	1	5
96	Lamiaceae	*Thymbra spicata* L. subsp. *spicata*	-	1	-	-	1	-	-	-	-	1	-	3
97	Lamiaceae	*Origanum syriacum subsp. bevanii* (Holmes) Greuter & Burdet	-	-	-	-	-	-	-	-	1	1	-	2
98	Lamiaceae	*Phlomis fruticosa* L.	-	1	-	-	-	1	-	-	-	1	1	4
99	Lamiaceae	*Rosmarinus officinalis* L.	-	-	-	-	1	-	1	-	-	1	-	3
100	Lamiaceae	*Nepeta caesarea* Boiss.	**E**	-	-	1	-	1	-	-	1	-	1	4
101	Lamiaceae	*Mentha longifolia* subsp. *typhoides* (Briq.) Harley	-	-	-	-	-	-	-	-	1	-	1	2
102	Lamiaceae	*Salvia viridis* L.	-	1	-	-	1	-	1	-	1	-	1	5
103	Lamiaceae	*Salvia hypargeia* Fisch. & C.A.Mey.	**E**	-	-	-	-	-	-	-	1	-	1	2
104	Lamiaceae	*Teucrium chamaedrys* subsp. *tauricola* Rech.f.	-	-	-	-	-	-	-	1	-	-	-	1
105	Lamiaceae	*Nepeta isaurica* Boiss. & Heldr. ex Benth.	**E**	-	-	-	-	1	-	-	-	-	-	1
106	Lamiaceae	*Teucrium creticum* L	-	1	-	-	1	-	1	-	-	-	-	3
107	Lamiaceae	*Satureja hortensis* L.	-	-	-	1	-	-	-	-	-	-	-	1
108	Lamiaceae	*Marrubium astracanicum* Jacq. subsp. *astracanicum*	-	-	-	1	-	-	-	-	-	-	1	2
109	Lamiaceae	*Thymus sipyleus* Boiss.	-	-	-	-	-	-	-	-	-	-	1	1
110	Lamiaceae	*Mentha pulegium* L.	-	-	-	-	-	-	-	-	1	-	-	1
111	Lamiaceae	*Salvia verticillata* subsp. *amasiaca* (Freyn & Bornm.) Bornm.	-	-	-	-	-	-	-	-	1	-	-	1
112	Lamiaceae	*Stachys cretica* subsp. *garana* (Boiss.) Rech.f.	-	-	-	1	-	1	-	-	1	-	-	3
113	Lamiaceae	*Ballota saxatilis* Sieber ex C.Presl subsp. *saxatilis*	-	-	1	-	-	-	-	-	-	-	-	1
114	Linaceae	*Linum strictum* L. var. *strictum*	-	1	-	1	-	-	-	-	-	1	1	4
115	Malvaceae	*Malva neglecta* Wallr.	-	-	1	-	-	-	-	1	-	-	1	3
116	Myrtaceae	*Myrtus communis* L. subsp. *communis*	-	1	-	-	1	-	-	-	-	-	-	2
117	Myrtaceae	*Eucalyptus camaldulensis* Dehnh. subsp. *camaldulensis*	-	-	1	-	-	-	-	-	-	-	-	1
118	Papaveraceae	*Glaucium corniculatum* (L.) Rudolph var. *corniculatum*	-	-	-	1	-	-	-	1	-	-	1	3
119	Papaveraceae	*Fumaria parviflora* Lam.	-	-	1	1	-	-	-	-	-	-	-	2
120	Plantaginaceae	*Linaria genistifolia* subsp. *praealta* (Boiss.) P.H.Davis	**E**	-	-	-	-	-	-	-	-	-	1	1
121	Plantaginaceae	*Veronica pectinata* var. *glandulosa* Riek ex M.A.Fisch.	-	-	-	1	-	-	-	-	1	-	-	2
122	Resedaceae	*Reseda lutea* L. var. *lutea*	-	1	-	-	1	-	1	-	1	1	-	5
123	Rhamnaceae	*Paliurus spina-christi* P. Mill.	-	-	-	-	1	-	-	-	-	-	-	1
124	Rosaceae	*Berberis crataegina* DC.	-	-	-	1	-	-	-	1	-	-	1	3
125	Rosaceae	*Rosa canina* L.	-	-	-	1	-	1	-	1	1	-	1	5
126	Rosaceae	*Cotoneaster nummularius* Fisch. & C.A.Mey.	-	-	-	1	1	1	-	1	1	-	1	6
127	Rosaceae	*Sarcopoterium spinosum* (L.) Spach	-	1	-	-	-	-	-	-	-	1	-	2
128	Rosaceae	*Prunus spinosa* L.	-	-	-	1	-	1	-	-	-	-	-	2
129	Rosaceae	*Rubus sanctus* Schreb.	-	1	1	-	-	-	-	-	-	-	-	2
130	Rosaceae	*Crataegus orientalis* Pall. ex M.Bieb.	-	-	-	1	-	-	-	-	-	-	-	1
131	Rosaceae	*Potentilla speciosa* Willd.	-	-	-	-	-	-	-	1	-	-	-	1
132	Rubiaceae	*Galium verum* subsp. *glabrescens* Ehrend.	-	-	-	-	-	-	-	-	1	-	1	2
133	Scrophulariaceae	*Verbascum galilaeum* Boiss.	-	-	1	-	1	-	-	-	-	-	-	2
134	Scrophulariaceae	*Scrophularia canina* subsp. *bicolor* (Sm.) Greuter	-	-	-	1	-	-	-	-	-	-	1	2
135	Scrophulariaceae	*Scrophularia cryptophila* Boiss. & Heldr.	-	-	-	-	-	-	-	1	-	-	-	1
136	Solanaceae	*Solanum americanum* Mill.	-	-	1	-	1	-	-	-	-	-	-	2
137	Xanthorrhoeaceae	*Asphodeline cilicica* E.Tuzlacı	E	-	-	1	1	-	-	1	1	-	1	5
138	Xanthorrhoeaceae	*Asphodelus aestivus* Brot.	-	-	-	-	1	1	-	-	-	1	-	3
	Total	**138**	**15**	**33**	**25**	**44**	**33**	**24**	**26**	**42**	**49**	**26**	**61**	

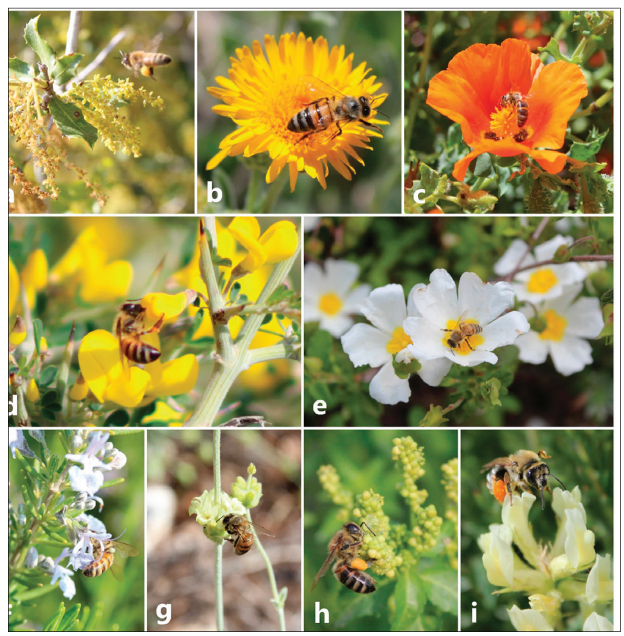
Supplementary Figures



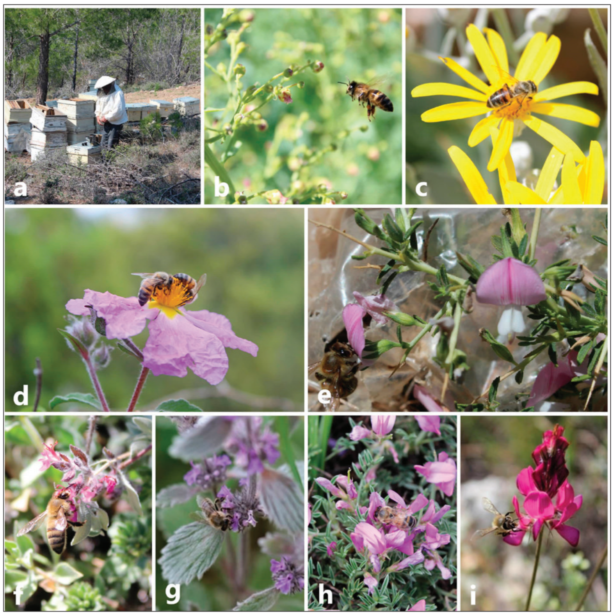
Supplementary Fig. S1. The study area.



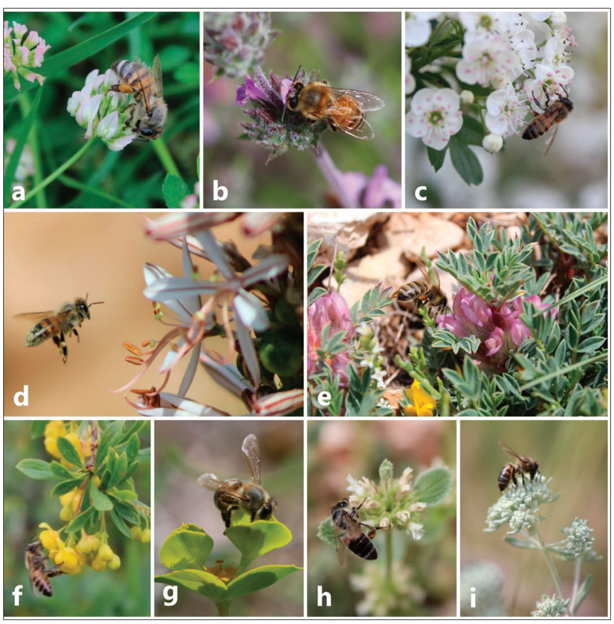
Supplementary Fig. S2. The climatic data covering the period of 1940-2018 for Mersin province [24,25].



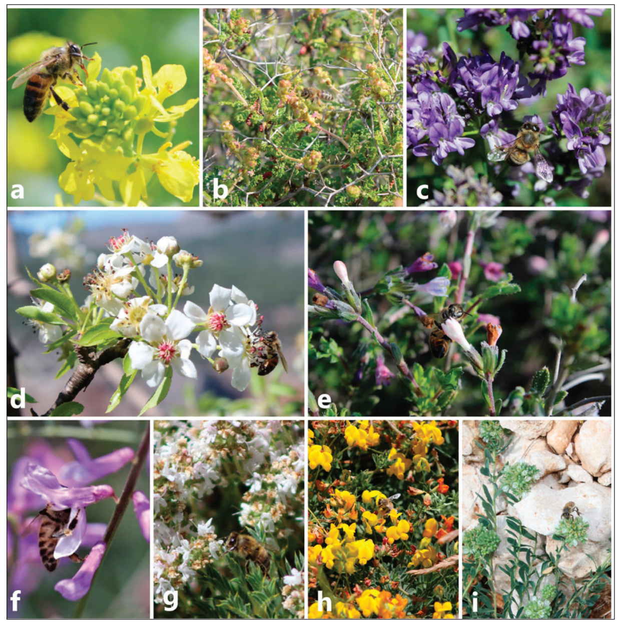
Supplementary Fig. S3. **a** – *Quercus coccifera*, **b** – *Inula oculus-christi*, **c** – *Glaucium corniculatum* var. *corniculatum*, **d** – *Calicotome villosa*, **e** – *Cistus salviifolius*, **f** – *Rosmarinus officinalis*, **g** – *Sideritis libanotica* subsp. *linearis*, **h** – *Mercurialis annua*, **i** – *Astragalus angustifolius* subsp. *angustifolius*.



Supplementary Fig. S4. **a** – *Local beekeeper*, **b** – *Scrophularia canina* subsp. *bicolor*, **c** - *Senecio doriiformis* subsp. *orientalis*, **d** – *Cistus creticus*, **e** – *Ononis spinosa*, **f** – *Teucrium chamaedrys*, **g** – *Marrubium astracanicum* subsp. *astracanicum*, **h** – *Onobrychis cornuta*, i- *Onobrychis oxyodonta*.



Supplementary Fig. S5. **a** – *Trifolium repens*, **b** – *Satureja thymbra*, **c** – *Crataegus azarolus*, **d** – *Asphodeline cilicica*, **e** – *Astragalus plumosus*, **f** – *Berberis crataegina*, **g** – *Euphorbia rigida*, **h** – *Marrubium globosum* subsp. *globosum*, **i** – *Teucrium polium*.



Supplementary Fig. S6. **a** – *Ochthodium aegyptiacum*, **b** – *Sarcopoterium spinosum*, **c** – *Medicago sativa* subsp. *sativa*, **d** – *Prunus avium*, **e** – *Lithodora hispidula*, **f** – *Vicia cassia*, **g** – *Thymus sipyleus*, **h** – *Lotus corniculatus* var. *corniculatus*, **i** – *Telephium imperati* subsp. *orientale*.