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Pollen analysis of honeys from Mediterranean region of Anatolia

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Abstract

Twenty-five samples of honey from different localities of the province, Anatolia, in the Mediterranean were examined for pollen content. Eleven samples were unifloral (>45% pollen of one taxon in sample) with three being unifloral for Apiaceae, two for *Pimpinella anisum*, two for *Raphanus raphanistrum*, one for *Eucalyptus* spp. one for *Cirsium* sp., one for *Plantago* sp. and one for *Ulmus* sp. Pollen analysis indicated 91 pollen forms of which 70 came from nectariferous and 21 from nectarless plants. The honeys had contained 14 to 36 different types of pollen. The average number of pollen types per honey was 22. Secondary pollen components were from 11 taxa: *Anthemis* sp., *Astragalus* sp., *Citrus* sp., *Euphorbia* sp., *Ferula* sp., *Rosa* sp., *Rhamnus* sp., *Olea europaea*, *Salix* sp., *Pimpinella anisum* and *Trifolium* sp. Fifty-nine pollen types occurred as 'important minor' types. Apiaceae, Asteraceae, Fabaceae and Rosaceae were the most represented families. Although, the honeys of citrus were collected throughout southern Anatolia, *Citrus* sp. was not particularly attractive to foragers nor was it major pollen or nectar sources in this region.

Keywords: *Anatolian mediterranean honey, honeybees, Antalya Province, pollen analysis, nectariferous plants, foraged Pollen, anemophilous plants, Citrus honey*

The variability of honey types produced in a region depends upon the diversity of nectar sources present in the region. Melissopalynology, the microscopic analysis of honey sediment, was the first method used for determining the botanical and geographical origin of honey. More valuable information about the characterization of honeys can be obtained from melissopalynological studies. The characterization of unifloral honeys is necessary for both scientific and commercial interest. Generally, blossom honey is considered to be from one source if the pollen frequency of that plant is more than 45% (Louveaux et al., 1978).

In Anatolia, melissopalynological studies date from the 1980s (Sorkun & Inceoglu, 1984; Sorkun & Yuluğ, 1985). Recently, studies identified nectariferous plants through pollen analysis in honey samples from Central Anatolia (Sorkun & Inceoglu, 1984), Aegean region (Göçmen & Gökçeoğlu, 1992), Black Sea region (Sorkun et al., 1989) and the eastern and south-eastern regions (Dogan & Sorkun, 1999).

Antalya Province is located in South Anatolia, in the Mediterranean phytogeographic region. It has typical Mediterranean climate which is hot and dry in summer and tepid and rainy in winter. Vegetation gradually changes from the coast to the peak of mountains. The coastal zone is formed by *Centaurea maritimum* L., *Eryngium maritimum* L., *Polygonum maritimum* L. and *Medicago marina* L. The 'frigana zone' lies next to the coastal zone and consists of shrubs and semi-shrubs, including *Erica manipuli-flora* Salisb., *Sarcopoterium spinosum* L., *Quercus coccifera* L., *Cistus parviflorus* L., *Thymus capitatus* L., and *Salvia triloba* L. The maquis zone follows and consists of *Erica arborea* L., *Cistus creticus* L., *Myrtus communis* L., *Olea europaea* L. and *Paliurus spina-christi* Miller, which are green trees and shrubs. The forest zone follows the maquis zone with an altitude range from 600 to 1600 m a.s.l. The most important elements of this zone are *Pinus bruti* Ten., *Cedrus libani* A. Rich. and *Juniperus excelsa* Bieb. In the peak of Taurus Mountains (2000 m) there are various species of *Astragalus*, *Verbascum*, *Euphorbia*

and *Acantholimon*. Agricultural species in the region are *Citrus* sp., *Morus alba* L., *Eucalyptus* sp., *Acacia* sp.

Antalya region has favourable climate and vegetation for beekeeping. There are thousands of hectares of citrus orchards and *Eucalyptus* forests as well as wild flowers such as *Astragalus*, *Thymus*, *Salvia*, *Verbascum* and others. Most of the beekeepers are semiprofessional and keep colonies for extra income. Moreover thousands of colonies are brought to the region by migratory beekeepers from different regions for wintering and early colony development in the spring. Beekeepers harvest citrus honey during spring and early summer in this region then migrate to the foothills and mountains of other regions to produce multifloral honey.

There has been a limited research on pollen analyses of Turkish honeys and more are needed to determine the pollen and plant sources in different regions. The aim of this study was to determine the type of honey and their plant sources in the honeys produced in Mediterranean region of Anatolia.

Material and methods

Honey samples and reference slides

The honey samples were collected from mountain areas, coastal areas and plain areas (Table I). They

Table I. Samples of Antalya honeys and their botanical origin.

Samples	Location	Botanical origin
H01	Elmali (Armutlu)	Blossom (monofloral)
H02	Elmali (Avsar)	Blossom (multifloral)
H03	Elmali (Avsar)	Blossom (multifloral)
H04	Elmali (Yakaciftlik)	Blossom (monofloral)
H05	Elmali (Yuva)	Blossom (multifloral)
H06	Elmali (Kizilbel)	Blossom (monofloral)
H07	Korkuteli (Taskesigi)	Blossom (multifloral)
H08	Korkuteli (Yesilyayla)	Blossom (monofloral)
H09	Saklikent	Blossom (multifloral)
H10	Kas	Blossom (monofloral)
H11	Kale	Blossom (monofloral)
H12	Finike (Gunceli)	Blossom (multifloral)
H13	Finike (Trese)	Blossom (multifloral)
H14	Finike (Turuncova)	Blossom (multifloral)
H15	Kumluca	Blossom (multifloral)
H16	Cakirlar	Blossom (multifloral)
H17	Serik	Blossom (multifloral)
H18	Manavgat (Degirmenli)	Blossom (monofloral)
H19	Manavgat (Tasagil)	Blossom (monofloral)
H20	Akseki (Kuyucak)	Blossom (monofloral)
H21	Akseki (Cimikoy)	Blossom (multifloral)
H22	Akseki (Taslica)	Blossom (multifloral)
H23	Gundogmus	Blossom (multifloral)
H24	Alanya (Okurcalar)	Blossom (monofloral)
H25	Alanya (Mahmutseydi)	Blossom (monofloral)

were mostly composite samples from apiaries although some were from individual colonies. The studied area was chosen for being representative of typical Mediterranean vegetation.

Plants were identified and stored in the herbarium at the Akdeniz University. Reference slides of pollen from plants were made according to the direct method (Louveau, 1970). Anthers were removed from flower buds of fresh and herbarium plants and the pollen were concentrated using a drop of alcohol in the center of a glass slide. The grains were then placed in glycerin jelly on glass slides and sealed with paraffin. These slides were included in the reference slide collection at the Akdeniz University herbarium for later comparison with the pollen types found in the honey samples. Pollen grains were identified with the aid of this reference collection and with the use of microphotographs from the literature (Maurizio, 1975; Sawyer, 1988; Ricciardelli D'Albore, 1997).

Extraction of honey sediment for microscopic analysis

The preparation of honey samples followed the standardized method of Louveau (1970): 10 g of well homogenized honey were dissolved in 20 ml of distilled water and centrifuged for 10 min at 1 350 g at ca. 2 500 rpm (Pendleton, 2006). The decanted sediment was washed with 5 to 10 ml of distilled water. After another centrifugation, the sediment was resuspended in 5 ml of 1:1 glycerin:distilled water and then centrifuged again, decanted, and mounted with glycerin jelly on microscope slides which were sealed with paraffin.

The pollen types present in the honey samples were identified, counted, and classified, according to their percentages, as dominant pollen (more than 45% of the total pollen grains counted), secondary pollen (from 16 to 45%), important minor pollen (from 3 to 15%), and minor pollen (less than 3%). Counts were expressed as percentages after counting a minimum 1 000 pollen grains on four slides from sample. The examination of the pollen slides were carried out with an optical microscope at $\times 400$ and $\times 1\,000$, in order to make sound identification of the pollen types. The origin of the samples and the geographical distribution are given in Figure 1. The pollen from nectarless plant species was counted separately. Such nectarless plants included *Quercus*, Conifers, *Olea europaea*, *Papaver* spp., *Plantago* spp., Poaceae, *Ulmus* spp. and Cistaceae. A similar distinction between pollen from nectarless and nectariferous species was previously made by Ricciardelli D'Albore (1998) to characterised various honey types.

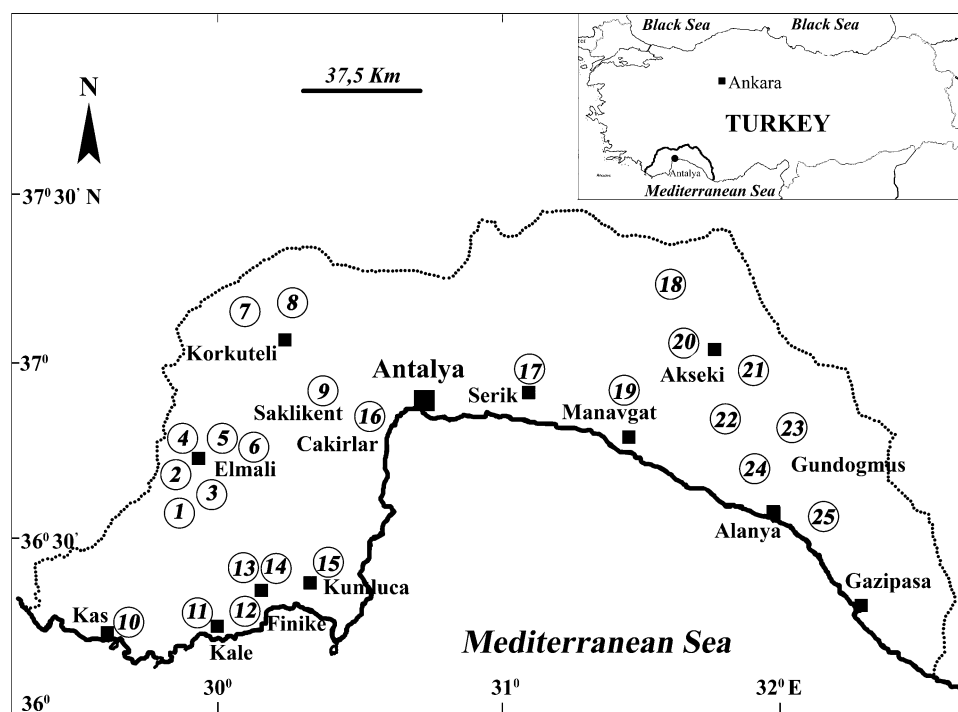


Figure 1. The Antalya Province (Anatolian Mediterranean region) localities of the analysed honey samples (see Table I for references).

Results

During this study, 25 honey samples produced in the province of Antalya (Mediterranean region of Anatolia) were analyzed (Figure 1). Ninety-one pollen types were recognized in the quantitative analysis (Table II). Eleven of the 25 samples analyzed were considered to be unifloral; *Pimpinella anisum* L. (n=2), Apiaceae (n=3), *Raphanus raphanistrum* L. (n=2), *Eucalyptus* sp. (n=1), *Cirsium* sp. (n=1), *Plantago* spp. (n=1) and *Ulmus* spp. (n=1). The most widely represented families were Apiaceae (*Pimpinella anisum*, *Apium*, *Eryngium*, *Matthiola*, *Ferula*), Asteraceae (*Achillea*, *Anthemis*, *Cirsium*, *Centaurea*, and *Tanacetum*), Fabaceae (*Trifolium*, *Lotus*, *Vicia*, *Onobrychis*, *Astragalus*, *Ceratonia siliqua* L.), Lamiaceae (*Thymus*, *Mentha*, *Teucrium*, *Salvia*) and Rosaceae (*Rosa*, *Pyrus*, *Prunus*, *Rubus*, *Potentilla*).

The number of taxa (pollen types) present in each honey sample studied was from 14 to 36. Microscopic analysis showed 91 morphological pollen types, of which 70 from were nectariferous, and 21 from nectarless species as *Olea europaea*, *Plantago* spp., *Ulmus* spp., *Pinus* sp., *Papaver* spp., and Poaceae. A specific pollen type was predominant for the 44% of the honeys analyzed. There was one case of unknown pollen, classified as 'minor' pollen in six samples, and pollen type could not be identified due to breakage and/or folding for two samples. The mean number of pollen types both

from melliferous and non-melliferous sources was 22. Most samples (64%) had 20–28 pollen types, although some had as many as 36. The number of botanical elements was not determined but interestingly the samples H01 and H02 contained a lot of honeydew elements: fungal spores and mycelium. The fungal spores used to characterize Antalya honeys were not in abundance in any of the samples analyzed.

The number of pollen grains per 10 g of honey, PAC-10, extended from the 'very poor' (<20 000) to the 'very rich' category (500 000–1 000 000) (Feller-Demalsy et al., 1989). In our study, honey very rich or very poor in grains represented 4% of the samples.

Discussion

Pollen spectra of Antalya honeys revealed a variety of not only nectariferous but also nectarless sources available to bees and included taxa whose presence indicated their Mediterranean origin (*O. europaea*, *Eucalyptus* sp., *Quercus* sp.). Regarding the amount and diversity of pollen present in honey, it should also be emphasized that the Antalya province is very rich in vegetation due to its climate and geographical location.

The pollen composition of the honeys studied revealed important information on the flora of the province. Apiaceae pollen was the most frequently

Table II. Pollen types in the honey samples (in percentages).

Samples	Predominant pollen (>45%)	Secondary pollen (16–45%)	Important minor pollen (3–15%)	Minor pollen (<3%)
H01	<i>Pimpinella</i> 85		Brassicaceae 4, <i>Mathiola</i> 7	<i>Allium</i> , <i>Anthemis</i> , <i>Artemisia</i> , <i>Brassica</i> , <i>Cirsium</i> , <i>Centaurea</i> , <i>Convolvulus</i> , <i>Gentiana</i> , <i>Rumex</i> , <i>Rubus</i> , <i>Ranunculus</i> , <i>Raphanus raphanistrum</i> , <i>Salvia</i> , <i>Tanacetum</i> , <i>Teucrium</i>
H02		<i>Ferula</i> 29	Brassicaceae 4, <i>Cirsium</i> 6, <i>Lactuca</i> 7, <i>Mathiola</i> 11, <i>Onobrychis</i> 8, <i>Olea europaea</i> 5, <i>Tamarix</i> 4, <i>Tanacetum</i> 3	<i>Achillea</i> , <i>Apiaceae</i> , <i>Artemisia</i> , <i>Astragalus</i> , <i>Centaurea</i> , <i>Convolvulus</i> , <i>Gentiana</i> , <i>Knautia</i> , <i>Lamiaceae</i> , <i>Lotus</i> , <i>Mentha</i> , <i>Paliurus spina-christi</i> , <i>Papaver</i> , <i>Pimpinella</i> , <i>Poaceae</i> , <i>Raphanus raphanistrum</i> , <i>Rumex</i> , <i>Rubus</i> , <i>Salvia</i>
H03			<i>Convolvulus</i> 3, <i>Eryngium</i> 4, <i>Onobrychis</i> 8, <i>Olea europaea</i> 12, <i>Paliurus spina-christi</i> 17, <i>Tanacetum</i> 4,	<i>Achillea</i> , <i>Anthemis</i> , <i>Astragalus</i> , <i>Brassica</i> , <i>Campanula</i> , <i>Centaurea</i> , <i>Cirsium</i> , <i>Cistus</i> , <i>Dianthus</i> , <i>Eryngium</i> , <i>Echium</i> , <i>Erica</i> , <i>Euphorbia</i> , <i>Ferula</i> , <i>Galium</i> , <i>Lotus</i> , <i>Mentha</i> , <i>Plantago</i> , <i>Pimpinella</i> , <i>Pinus brutia</i> , <i>Potentilla</i> , <i>Primula</i> , <i>Raphanus raphanistrum</i> , <i>Rumex</i> , <i>Salvia</i> , <i>Silene</i> , <i>Trifolium</i> , <i>Tamarix</i> , <i>Teucrium</i> , <i>Vitex agnus-castus</i>
H04	<i>Mathiola</i> 63	<i>Pimpinella</i> 17	<i>Raphanus raphanistrum</i> 5, <i>Salvia</i> 3, <i>Teucrium</i> 3	<i>Artemisia</i> , <i>Astragalus</i> , <i>Brassica</i> , <i>Chenopodium</i> , <i>Convolvulus</i> , <i>Galium</i> , <i>Mentha</i> , <i>Onobrychis</i> , <i>Primula</i> , <i>Pyrus</i> , <i>Ranunculus</i> , <i>Rhamnus</i> , <i>Rosa</i> , <i>Salvia</i> , <i>Tanacetum</i>
H05		<i>Rosa</i> 15	<i>Anthemis</i> 11, <i>Brassica</i> 5, <i>Chenopodium</i> 3, <i>Cistus</i> 5 <i>Erica</i> 3, <i>Gentiana</i> 3, <i>Mentha</i> 5, <i>Onobrychis</i> 7, <i>Olea europaea</i> 3, <i>Pimpinella</i> 8, <i>Pinus brutia</i> 3, <i>Pyrus</i> 3, <i>Ranunculus</i> 5	<i>Juniperus</i> , <i>Rumex</i> , <i>Scabiosa</i>
H06	<i>Pimpinella</i> 91			<i>Achillea</i> , <i>Astragalus</i> , <i>Campanula</i> , <i>Centaurea</i> , <i>Chenopodium</i> , <i>Cistus</i> , <i>Dianthus</i> , <i>Eryngium</i> , <i>Fraxinus</i> , <i>Juniperus</i> , <i>Mathiola</i> , <i>Papaver</i> , <i>Plantago</i> , <i>Poaceae</i> , <i>Pyrus</i> , <i>Rhamnus</i> , <i>Rumex</i> , <i>Rosa</i> , <i>Rubus</i> , <i>Tanacetum</i> , <i>Teucrium</i>
H07		<i>Rhamnus</i> 15, <i>Euphorbia</i> 22	<i>Apiaceae</i> 3, <i>Brassica</i> 3, <i>Campanula</i> 11, <i>Echium</i> 3, <i>Lotus</i> 3, <i>Polygonum</i> 3, <i>Pinus</i> 6, <i>Trifolium</i> 11, <i>Vicia</i> 4, <i>Vitex agnus-castus</i> 3	<i>Acacia</i> , <i>Anthemis</i> , <i>Apium</i> , <i>Cedrus</i> , <i>Echium</i> , <i>Juniperus</i> , <i>Lilium</i> , <i>Myosotis</i> , <i>Pimpinella</i> , <i>Raphanus</i> , <i>Thymus</i> , <i>Poa</i>
H08	<i>Apiaceae</i> 51		<i>Apium</i> 3, <i>Gentiana</i> 3, <i>Lotus</i> 9, <i>Raphanus</i> 3, <i>Rosaceae</i> 4, <i>Trifolium</i> 7	<i>Anthemis</i> , <i>Centaurea</i> , <i>Echium</i> , <i>Fraxinus</i> , <i>Lilium</i> , <i>Onobrychis</i> , <i>Polygonum</i> , <i>Quercus</i> , <i>Scabiosa</i> , <i>Tamarix</i> , <i>Teucrium</i> , <i>Thymus</i>
H09			<i>Allium</i> 4, <i>Apium</i> 10, <i>Anchusa</i> 4, <i>Apiaceae</i> 7, <i>Astragalus</i> 4, <i>Brassica</i> 4, <i>Lotus</i> 4, <i>Mentha</i> 4, <i>Onobrychis</i> 4, <i>Rosa</i> 7, <i>Rosaceae</i> 10, <i>Thymus</i> 4, <i>Teucrium</i> 7, <i>Vitex agnus-castus</i> 14	<i>Vicia</i>
H10	<i>Raphanus raphanistrum</i> 49	<i>Pimpinella</i> 26	<i>Anchusa</i> 4, <i>Apiaceae</i> 4, <i>Onobrychis</i> 4, <i>Salvia</i> 7, <i>Vitex agnus-castus</i> 14	<i>Anchusa</i> , <i>Anthemis</i> , <i>Brassica</i> , <i>Cedrus</i> , <i>Pinus</i> , <i>Centaurea</i> , <i>Cirsium</i> , <i>Cynoglossum</i> , <i>Chenopodium</i> , <i>Cistus</i> , <i>Convolvulus</i> , <i>Echium</i> , <i>Erica</i> , <i>Fagus</i> , <i>Phleum</i> , <i>Primula</i> , <i>Pyrus</i> , <i>Rhamnus</i> , <i>Ranunculaceae</i> , <i>Rosmarinus</i> , <i>Rubia</i> , <i>Rumex</i> , <i>Salix</i> , <i>Teucrium</i> , <i>Thymus</i>
H11	<i>Apiaceae</i> 85			<i>Anthemis</i> , <i>Allium</i> , <i>Brassica</i> , <i>Carex</i> , <i>Cedrus</i> , <i>Centaurea</i> , <i>Chenopodium</i> , <i>Cistus</i> , <i>Citrus</i> , <i>Convolvulus</i> , <i>Erica</i> , <i>Ficus</i> , <i>Fraxinus</i> , <i>Gentiana</i> , <i>Lotus</i> , <i>Plantago</i> , <i>Quercus</i> , <i>Raphanus raphanistrum</i> , <i>Ranunculus</i> , <i>Rosa</i> , <i>Rumex</i> , <i>Salix</i> , <i>Thymus</i> , <i>Trifolium</i> , <i>Ulmus</i> , <i>Vicia</i>

Table II. (Continued.)

Samples	Predominant pollen (>45%)	Secondary pollen (16–45%)	Important minor pollen (3–15%)	Minor pollen (<3%)
H12		<i>Pimpinella</i> 16, <i>Trifolium</i> 17	Apiaceae 3, <i>Campanula</i> 3, <i>Erica</i> 7, <i>Plantago</i> 4,	<i>Anthemis</i> , <i>Brassica</i> , <i>Chenopodium</i> , <i>Citrus</i> , <i>Convolvulus</i> , <i>Eucalyptus</i> , <i>Echium</i> , <i>Juniperus</i> , <i>Lotus</i> , <i>Raphanus</i> , <i>Scabiosa</i> , <i>Onobrychis</i> , <i>Quercus</i> , <i>Papaver</i> , <i>Pinus</i> , <i>Pyrus</i> , <i>Ranunculus</i> , <i>Rhamnus</i> , <i>Rubia</i> , <i>Rubus</i> , <i>Salix</i>
H13		<i>Citrus</i> 16, <i>Olea europaea</i> 36,	<i>Ceratonia siliqua</i> 10, <i>Salix</i> 3	<i>Anthemis</i> , <i>Brassica</i> , <i>Campanula</i> , <i>Centaurea</i> , <i>Cirsium</i> , <i>Echium</i> , <i>Erica</i> , <i>Eucalyptus</i> , <i>Onobrychis</i> , <i>Papaver</i> , <i>Pimpinella</i> , <i>Pinus</i> , <i>Potentilla</i> , <i>Prunus</i> , <i>Pyrus</i> , <i>Quercus</i> , <i>Raphanus</i> , <i>Rosa</i> , <i>Rubus</i> , <i>Tamarix</i> , <i>Trifolium</i> , <i>Teucrium</i> , <i>Thymus</i> , <i>Tordylium</i>
H14		<i>Anthemis</i> 31	Asteraceae 6, <i>Centaurea</i> 3, <i>Lotus</i> 7, <i>Pimpinella</i> 4, <i>Plantago</i> 3, <i>Raphanus</i> 8, <i>Rosa</i> 3, <i>Rubus</i> 9	<i>Campanula</i> , <i>Cirsium</i> , <i>Citrus</i> , <i>Echium</i> , <i>Erica</i> , <i>Papaver</i> , <i>Pimpinella</i> , <i>Prunus</i> , <i>Quercus</i> , <i>Ranunculus</i> , <i>Rubia</i> , <i>Trifolium</i> , <i>Thymus</i> , <i>Vitex agnus-castus</i>
H15		<i>Trifolium</i> 16	Apiaceae 12, <i>Astragalus</i> 4, <i>Brassica</i> 6, <i>Convolvulus</i> 4, <i>Ceratonia siliqua</i> 4, <i>Echium</i> 7, <i>Gentiana</i> 6, <i>Lotus</i> 6, <i>Onobrychis</i> 6, <i>Papaver</i> 4, <i>Verbascum</i> 7	<i>Cupressus</i> , <i>Quercus</i>
H16		<i>Citrus</i> 16, <i>Salix</i> 16	<i>Brassica</i> 4, <i>Ficus</i> 4, <i>Olea europaea</i> 3, <i>Raphanus raphanistrum</i> 6, <i>Rhamnus</i> 3	<i>Acacia</i> , <i>Anthemis</i> , <i>Cistus</i> , <i>Centaurea</i> , <i>Fagus</i> , <i>Juniperus</i> , <i>Lamium</i> , <i>Myrtus</i> , <i>Plantago</i> , <i>Platanus</i> , <i>Pinus</i> , <i>Pyrus</i> , <i>Rosa</i> , <i>Rubus</i> , <i>Scandix</i> , <i>Trifolium</i> , <i>Tamarix</i> , <i>Vitex agnus-castus</i>
H17		<i>Pimpinella</i> 18	<i>Aster</i> 4, <i>Ceratonia siliqua</i> 5, <i>Citrus</i> 3, <i>Echium</i> 3, <i>Eucalyptus</i> 5, <i>Trifolium</i> 3, <i>Thymus</i> 3, <i>Rosa</i> 3, <i>Myrtus communis</i> 14, <i>Ranunculus</i> 5	<i>Anthemis</i> , <i>Allium</i> , <i>Asphodelus</i> , <i>Brassica</i> , <i>Bunium</i> , <i>Campanula</i> , <i>Cistus</i> , <i>Chenopodium</i> , <i>Euphorbia</i> , <i>Onobrychis</i> , <i>Plantago</i> , <i>Primula</i> , <i>Pyrus</i> , <i>Rumex</i> , <i>Silene</i> , <i>Verbascum</i>
H18	<i>Cirsium</i> 59		<i>Galium</i> 3, <i>Raphanus raphanistrum</i> 3	<i>Achillea</i> , <i>Anthemis</i> , <i>Apium</i> , <i>Anchusa</i> , <i>Arbutus</i> , <i>Andrachne</i> , <i>Brassica</i> , <i>Centaurea</i> , <i>Cirsium</i> , <i>Cistus</i> , <i>Citrus</i> , <i>Echium</i> , <i>Erica</i> , <i>Eryngium</i> , <i>Lamium</i> , <i>Lotus</i> , <i>Mathiola</i> , <i>Mentha</i> , <i>Onobrychis</i> , <i>Papaver</i> , <i>Pimpinella</i> , <i>Pinus</i> , <i>Plantago</i> , <i>Primula</i> , <i>Prunus</i> , <i>Pyrus</i> , <i>Quercus</i> , <i>Ranunculus</i> , <i>Rubus</i> , <i>Salvia</i> , <i>Salix</i> , <i>Thymus</i> , <i>Vicia</i> , <i>Vitex agnus-castus</i>
H19	<i>Eucalyptus</i> 73		<i>Myrtus communis</i> 13	<i>Anthemis</i> , <i>Centaurea</i> , <i>Cirsium</i> , <i>Cistus</i> , <i>Convolvulus</i> , <i>Ceratonia siliqua</i> , <i>Citrus</i> , <i>Ficus</i> , <i>Lamium</i> , <i>Olea europaea</i> , <i>Pinus</i> , <i>Plantago</i> , <i>Primula</i> , <i>Potentilla</i> , <i>Raphanus raphanistrum</i> , <i>Rhamnus</i> , <i>Rosa</i> , <i>Trifolium</i> , <i>Vicia</i> , <i>Vitex agnus-castus</i>
H20	Apiaceae 67		<i>Echium</i> 4, <i>Onobrychis</i> 4	<i>Anthemis</i> , <i>Brassica</i> , <i>Cistus</i> , <i>Convolvulus</i> , <i>Dianthus</i> , <i>Euphorbia</i> , <i>Eucalyptus</i> , <i>Galium</i> , <i>Lactuca</i> , <i>Lotus</i> , <i>Mentha</i> , <i>Myosotis</i> , <i>Onobrychis</i> , <i>Olea europaea</i> , <i>Papaver</i> , <i>Rumex</i> , <i>Salvia</i> , <i>Silene</i> , <i>Trifolium</i> , <i>Teucrium</i> , <i>Thymus</i>
H21			<i>Echium</i> 3, <i>Lotus</i> 4, <i>Plantago</i> 6, <i>Rumex</i> 4, <i>Ranunculus</i> 6, <i>Trifolium</i> 5, <i>Verbascum</i> 11, <i>Teucrium</i> 5	<i>Anthemis</i> , <i>Anchusa</i> , <i>Dianthus</i> , <i>Euphorbia</i> , <i>Lactuca</i> , <i>Myrtus communis</i> , <i>Potentilla</i> , <i>Rosa</i> , <i>Rubus</i> , <i>Vitex agnus-castus</i>
H22		<i>Anthemis</i> 26	Boraginaceae 13, <i>Achillea</i> 3, <i>Brassica</i> 5, <i>Convolvulus</i> 3, <i>Salvia</i> 5, <i>Onobrychis</i> 4, <i>Trifolium</i> 4, <i>Thymus</i> 3	Brassicaceae, <i>Eucalyptus</i> , <i>Myrtus communis</i> , <i>Pinus</i> , <i>Rumex</i> , <i>Rhamnus</i> , <i>Solanaceae</i> , <i>Vicia</i> , <i>Vitex agnus-castus</i>
H23		<i>Astragalus</i> 31, <i>Trifolium</i> 16	<i>Convolvulus</i> 4, <i>Euphorbia</i> 6, <i>Lamiaceae</i> 3, <i>Lotus</i> 12	<i>Anchusa</i> , <i>Asphodelus</i> , <i>Brassica</i> , <i>Dianthus</i> , <i>Echium</i> , <i>Fraxinus</i> , <i>Marrubium</i> , <i>Onobrychis</i> , <i>Olea</i> , <i>Ornithogalum</i> , <i>Papaver</i> , <i>Pinus brutia</i> , <i>Polygonum</i> , <i>Potentilla</i> , <i>Ranunculus</i> , <i>Rhamnus</i> , <i>Rosa</i> , <i>Rubus</i> , <i>Rumex</i> , <i>Salvia</i> , <i>Silene</i> , <i>Trifolium</i> , <i>Teucrium</i> , <i>Thymus</i> , <i>Sarcopoterium</i> , <i>Tamarix</i> , <i>Vitex agnus-castus</i>

Table II. (Continued.)

Samples	Predominant pollen (>45%)	Secondary pollen (16–45%)	Important minor pollen (3–15%)	Minor pollen (<3%)
H24	<i>Plantago</i> 77		<i>Rosa</i> 4, <i>Trifolium</i> 10,	<i>Centaurea</i> , <i>Cedrus libani</i> , <i>Convolvulus</i> , <i>Euphoria</i> , <i>Knautia</i> , <i>Onobrychis</i> , <i>Olea europaea</i> , <i>Pinus brutia</i> , <i>Quercus</i> , <i>Rumex</i> , <i>Rosa</i> , <i>Scabiosa</i> , <i>Thymus</i> , <i>Trifolium</i>
H25	<i>Ulmus</i> 60		<i>Euphorbia</i> 10, <i>Prunus</i> 3, <i>Trifolium</i> 7	<i>Allium</i> , <i>Cistus</i> , <i>Cedrus libani</i> , <i>Malva</i> , <i>Pinus</i> , <i>Plantago</i> , <i>Pyrus</i> , <i>Rosa</i> , <i>Salvia</i> , <i>Teucrium</i> , <i>Thymus</i>

observed in all samples. It was predominant in five of the 25 samples, ranging from 67 to 91%. It was also the secondary pollen in six samples. The pollen of *Pimpinella anisum* (anise) was present in half (52%) of the samples. Two cases of predominance were detected in the west of the province, where the pollen of this species reached more than 80% of all pollen in the sample and secondary pollen was not found. *Pimpinella anisum* is commonly cultivated in this region. Similarly, Tsigouri et al. (2004) reported that *P. anisum* pollens were dominant in two honey samples from Greece and Apiaceae pollen were most frequently found in Algerian honeys (Ouchemoukh et al., 2005).

The pollen of *Raphanus raphanistrum* (wild radish) was predominant in Elmali (63.5%) and Kas (49.25%) samples. The pollen of Brassicaceae present in almost all of the samples (76%) probably comes from the cultivated members of the family, such as canola, rape or mustard. *R. raphanistrum* has the reputation of contributing large quantities of pollen to honey (Maurizio, 1951). Cabrera-Ruiz et al. (1997) reported that this taxon was an important pollen type in their Spanish honey samples. Brassicaceae family members are common plants along the roads and highways and they are important bee plants not only for honeybees but also for the bumbles in this region. Sorkun and Yulug (1984) claimed that members of this family were also frequently observed in honeys from Central Anatolia.

The third predominant taxon *Cirsium* (thistle) was found in the Manavgat sample (south-east Antalya). *Cirsium* pollen has already been reported in Central Anatolia honeys by Sorkun and Inceoglu (1984).

The pollen of *Eucalyptus* was predominant in the Manavgat (East Antalya) sample. The pollen grains of *Eucalyptus* spp. found in the one sample were predominant (73%). *Eucalyptus* is cultivated on the coast of the Aegean and Mediterranean region of Anatolia and their flowering season is between May and September. Ramalho et al. (1991) stated that *Eucalyptus* honey plays a key role in beekeeping economy in many countries. *Eucalyptus* sp. has already been noticed by Dogan and Sorkun (2001) in the Aegean region of Anatolia. Similar results have been reported in earlier studies for the Brazilian

honeys from Zona da Mata (Bastos, 1995), the Spanish honeys (Cabrera-Ruiz et al., 1997) and the Argentinean honeys (Andrada et al., 1998). Terrab et al. (2001) reported predominant pollen of *Eucalyptus* sp. in seven samples from north-eastern Morocco.

Two other very frequent pollen types were *Plantago* spp. (plantain) and *Ulmus* spp. (elm) which occurred in 40% and 8% of the samples, respectively. Both *Ulmus* and *Plantago* were only very common in Alanya honeys from the south-east Antalya, but were minor or important minor in honeys from the other parts of region. In accordance with our results, *Plantago* spp. pollen was found in honeys from Aegean and Marmara region of Anatolia (Dogan & Sorkun, 2001). However in our study the Aegean was characterized by high frequencies of nectarless *Ulmus* spp. and *Plantago* spp. Pollen from *Plantago* spp. has also been reported in citrus honeys of the Sequira basin and in Spanish honeys (Munuera-Giner & Carrion-Garcia, 1994), but it was not predominant.

The class of 'secondary pollen' (i.e. present in 16–45% of samples) reveals 11 taxa; *Anthemis* sp. (marguerite daisy), *Astragalus* sp. (milkvetch), *Citrus* sp., *Euphoria* sp. (spurge), *Ferula* sp. (fennel), *Rosa* sp., *Rhamnus* sp. (buckthorn), *Olea europaea* (olive), *Salix* sp. (willow), *Pimpinella* sp. and *Trifolium* sp. (clover). Pollen of *Anthemis*, which is a Euro-Mediterranean plant was frequently (25%) observed in honey samples studied. *Pimpinella* pollen in four honey samples was found as secondary. From the same family, *Ferula* pollen was found as secondary in only one sample. In spite of the high pollen type and count, all of the Fabaceae family pollens were found to be much less common than the pollen of above mentioned families and they were considered to be secondary pollen. *Trifolium* spp. pollen in 14 samples (56%) and *Astragalus* spp. pollen in five samples (20%) were found, and *Trifolium* pollen in three samples, *Astragalus* pollen in only one sample was found to be secondary. Species such as *Trifolium*, *Lotus* (trefoil), and *Astragalus*, which have a long flowering period and are used as sources of pollen and nectar by bees, were also frequently observed. Andrada et al. (1998) reported that Fabaceae,

Asteraceae and Brassicaceae were the most presented families in honeys from Argentina.

Citrus sp. pollens found in six samples (24%) and were secondary in two samples. Our results showed that there was no correlation between the percentage of *Citrus* pollen and the area of production. These findings are in agreement with the results of a previous study (Tsigouri et al., 2004). Although different *Citrus* varieties are cultivated throughout the region, the pollen percentage was not high in our honey samples. This is consistent with the observation by Persano-Oddo et al. (1995), Accorti et al. (2000), Serra Bonvehí & Ventura Coll. (1995) and Tsigouri et al. (2004) for honey samples in Italy, Spain and Greece. The pollen percentage reported for Italian *Citrus* honeys is usually > 5% (Ricciardelli D'Albore et al., 1997).

Olea europaea, the most typical Mediterranean plant, is cultivated in coastal areas and its pollen was observed as secondary in one sample from Finike (36%). Pollen from *O. europaea* has also been reported in variable frequencies in Spanish and Moroccan honeys (Debbagh, 1987; Muñuera-Giner et al., 1994; Cabreara-Ruiz et al., 1997; Terrab et al., 2003).

Fifty-nine pollen types were in the 'important minor' class. As far as the pollen of non-melliferous plants was concerned, 21 types include *Quercus* spp. (oak), *Pinus* sp. (pine), *Juniperus* spp. (juniper), *Pinus brutia*, Poaceae, *Fraxinus* spp. (ash), *Cupressus* spp. (cypress), *Cedrus* spp. (cedar), and *Salix* sp. were common and they were generally in the important minor class. Their presence in our samples is most likely to be from contamination. However, it is possible to find pollen of many wind pollinated plants such as *Quercus* spp. and *Pinus* sp. in honey. Anemophilous plants such as *Olea* sp., Pinaceae, *Quercus* sp. and *Cistus* sp. (rock rose) are also included in Algerian honeys (Ouechemaukh et al., 2005).

Conclusions

The fact that honey bees have preferences for particular plants means that the presence, frequency, or absence of some taxa in the honeys does not represent the true nature of their occurrence in the flora of the region. The main types of Anatolian honeys from the Mediterranean region consist of nectariferous *Pimpinella anisum*, *Raphanus raphanistrum*, Apiaceae, *Eucalyptus* and *Cirsium* as well as nectarless *Plantago* and *Ulmus* sp. Most of the samples were characterized by the presence of taxa typical of the Mediterranean region such as *Eucalyptus*, *Olea europaea*, *Citrus* and Lamiaceae. The samples examined showed that the flowering of

trees and shrubs (*O. europaea*, *Citrus*, *Cistus*) was followed by the flowering of other shrubs and herbaceous species (Asteraceae, Fabaceae, and Apiaceae). Honeybees appeared to exploit a large number of entomophilous flowers in every season and the representations of their pollen are found in the local plant population. Moreover the presence of wind-pollinated *Plantago* and *Ulmus* pollen in the same part of the region allows the differentiation of these honeys from those with other parts of Mediterranean region of Anatolia.

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