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Research article/Araştırma makalesi

Pollen analysis of honeys from Hatay/Turkey

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Abstract

This study presents pollen analysis of natural honey produced in Hatay province in Turkey. Honey samples were collected from 15 different localities in 2013 around Hatay and its environs. The pollen analysis was carried out using microscopical analysis. In all 100 taxa belonging to 40 different families were determined. Apiaceae, Asteraceae, Brassicaceae, Fabaceae, Lamiaceae, Poaceae, Rosaceae and *Trifolium* were the most represented taxa. In honey samples, dominant pollen types were from Fabaceae and *Petroselinum crispum* while Apiaceae, Asteraceae, Brassicaeae, Fabaceae, Rosaceae, Lamiacea, *Lathyrus* sp., *Erica manipuliflora*, *Arbutus andrachne*, *Olea europaea* and *Citrus aurantium* were recorded as secondary taxa. Among the 15 honey samples, only three samples collected from Üçgüllük (H01 honey sample), Kale (H02 honey sample), and Bektaşlı villages (H07 honey sample) were unifloral, because of having only one dominant and trace pollen, others were determined as multifloral honeys. The highest number of pollen was observed in the samples from Üçgüllük Village (96113 pollen grain).

Key words: melissopalynology, honey, pollen analysis, Hatay, Turkey

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Hatay/Türkiye ballarının polen analizi

Özet

Bu çalışma Türkiye'de Hatay ilinde üretilen doğal balların polen analizini sunmaktadır. 2013 yılında Hatay ve çevresinde 15 farklı lokaliteden bal örnekleri toplanmıştır. Polen analizi mikroskopik analiz kullanılarak gerçekleştirilmiştir. 40 farklı aileye ait toplam 100 takson belirlendi. Apiaceae, Asteraceae, Brassicaceae, Fabaceae, Lamiaceae, Poaceae, Rosaceae ve *Trifolium* en çok temsil edilen taksonlardır. Bal numunelerinde dominant polen tipleri Fabaceae ve *Petroselinum crispum* iken, Apiaceae, Asteraceae, Brassicaeae, Fabaceae, Rosaceae, Lamiaceae, *Lathyrus* sp., *Erica manipuliflora*, *Arbutus andrachne*, *Olea europaea* ve *Citrus aurantium* sekonder takson olarak kaydedilmiştir. 15 adet bal örneğinden sadece Üçgüllük (H01 bal örneği), Kale (H02 bal örneği) ve Bektaşlı köylerinden (H07 bal örneği) toplanan üç bal örneği dominant ve iz polenine sahip olduğundan unifloral, diğerleri ise multifloral baldır. Üçgüllük Köyü (96113 polen tanesi)'nden toplanan bal örneğinde en fazla polen tanesi gözlenmiştir.

Anahtar kelimeler: melisapalinoloji, bal, polen analiz, Hatay, Turkiye

1. Introduction

Honey is consumed all over the world, but adulteration and the false labelling are the problems we face globally (Song et al., 2012). Composition of honey is varies and from region and climatic features of the area. Therefore the evaluation of the chemical composition of honeys is necessary. The composition and physicochemical properties of honeys can be used to verify the botanical origin and microscopic characteristics (Bogdanov et al., 2004, 2007). Melissopalynology plays a great role in this connection, as it helps to find out the botanical and geographical origin of honey with the help of their pollen composition (Anklam, 1998, Song et al., 2012). Floral composition of a honey sample can be determined by characterization of pollen content and diversity.

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In order to determine the origin, above other properties as bitterness, aroma and flavor, color, and rapid crystallization status of honeys, pollen analysis is reported to be the best approach (Sorkun, 1985). Many countries all over the world have strict import and export laws that requires three types of certification. These are verification of the honey's floral type, quality, and precise place of origin. As a result of these obligations countries impose strict rules governing the importation and exportation of honey products. This situation makes these certifications very important. People use pollen analyses to determine these certifications (Jones and Bryant, 2004). Many investigations have been undertaken during the last few decades in this connection all over the world notable among these being; Terrab et al. (2004, 2005), Khan et al. (2006), Mandić et al. (2006), Sabo et al. (2011), Upadhyay and Bera (2012), Song et al. (2012) from Spain, Morocco, Pakistan, Croatia, India, and China.

In Turkey first scientific report on pollen analysis of honey was published by Qustrani in 1976 (Erdoğan et al., 2006). There are several reports from Turkey on the pollen spectrum of honeys (Silici and Gökçeoğlu, 2007; Ozturk et al., 2012). All melissopalinological studies have been carried out in different phytogeographical regions of Turkey as reviwed by Ozturk et al. (2012). In this study, pollen types belonging to total 244 plant taxa have been reported, listed as dominant and secondary pollen (Ozturk et al., 2012).

Our major aim here is to provide information on the type and plant sources in the honey collected from the Hatay (Turkey) and put forward a guide for beekeeping in the province.

2. Materials and methods

2.1. Study area

A determination of the floral diversity, flowering and nectar accumulation times are very important for an effective and conscious beekeeping. The province of Hatay in Turkey has a great potential due to the its varying geographical, topographical and ecological features (Genç, 1990). The State of Antakya (Antiochia) in the upper mesopotamian part of Turkey is located between 35˚48' N and 37˚00' N and between 35˚46' E and 36˚41' E in the most southern region of Turkey. The altitude varies from sea level to 2240 m. The Mediterranean Sea lies in its west, Syria in the south and east and Adana, Osmaniye and Gaziantep provinces in the North. The province is spread over an area of 5.559 km^2 and 46.1 percent of the land is mountain, 33.5 percent plain and 20.4 percent plateau and hillside (Korkmaz et al., 2012; Altay et al., 2011). The area is under the influence of the Mediterranean climate, annual average temperature varies between 15.1-20 ˚C and average annual rainfall between 562.2-1216.3 mm, most of which falls in winter months (Altay et al., 2011).

Shrubs are encountered between 0-500 m in the area and consist of species like *Quercus coccifera*, *Phillyrea latifolia*, *Pistacia terebinthus* ssp. *palestina*, *Myrtus communis*, *Paliurus spina-christi*, *Calicotome villosa*, *Nerium oleander*, *Cistus creticus*, *Spartium junceum* and *Cotinus coteneaster*. At higher altitudes (500-1000 m) we find plant taxa such as: *Pinus brutia*, *Laurus nobilis* and *Arbutus andrachne*; between 1000-1500 m the dominant cover is compposed of *Quercus* sp. and *Ostraya carpinifolia*, and between 1500-2000 m *Pinus nigra*, *Cedrus libani*, *Abies cilicica* forests are dominant representatives (Akman, 1973; Altay, 2015). The mountains run parallel to the coast line in the region and moisture values around Iskenderun are higher. We come across many woody plant taxa here such as *Laurocerasus officinalis*, *Fagus orientalis*, *Corylus avellana*, *Tilia argentea*, *Acer platanoides* and *Ilex colchica* in the east of Dörtyol, which are specific to the Black Sea region (Akman, 1973). The plant diversity of Hatay with about 250 endemic taxa (rate of endemism 12.5%) is composed of approximately 2000 natural vascular plant taxa (Altay, 2015).

2.2. Data analysis

A total of 15 natural honey samples (Appendix 1), were collected from nonmigratory beekeepers (members of the Hatay Beekeepers Association) in the Hatay province during 2013 and 2014. The preparation of honey samples was carried out according to the standardized method of Louveaux (1970), Pendleton (2006), Silici and Gökçeoğlu (2007). To analysis the pollen content of the honey samples methods outlined in detail by Ozturk et al. (1989, 2012), and Sorkun (2008) were followed. Honey samples (300 g) were collected from different locations was put into sterile jars. Samples were incubated at 65-70 ˚C in water baths to prevent crystallization and stirred to get homogeneous suspensions. From these suspensions, 10 g samples were mixed with 20 mL distilled water, incubated at 45 ˚C in water bath and continuously shaken to dissolve honey in water. The mixture was centrifuged at 6000-6500 rpm, upper water phase was discarded and pre-prepared glycerol-gelatin mixture (1:1.5) was added to the tubes. They were transferred to a slide, covered with coverslip and prepared, then analyzed by using Leica DM2500 light microscope (1000×) to determine and the pollen content (Şık et al., 2017).

Percentage of every pollen type in the pollen sediment was calculated for all honey samples. Pollen types were allocated to one of four frequency classes: (i) predominant pollen types (>45% of the total pollen content); (ii) secondary pollen types (16-45%); (iii) important minor pollen types (3-15%); and (iv) minor pollen types (<3%) (Song et al., 2012) (Appendix 2). The total amount of pollen grains in a honey sample was determined and the results were compared with the classification proposed by Louveaux et al. (1978). The five classes according to the pollen content in 10 g of honey

were: **I**: less than 20.000 pollen grains; **II**: 20.000 to 100.000 pollen grains; **III**: 100.000 to 500.000 pollen grains; **IV**: 500.000 to 1.000.000 pollen grains; **V**: over 1.000.000 pollen grains.

3. Results

During this study, a total of 100 pollen types belonging to 40 families were identified from 15 honey samples. The number of plant taxa (pollen types) present in each honey sample studied varied between 18 to 46 (Appendix 1).

The dominant families are **Fabaceae** (Fabaceae type, *Astragalus, Calicotome villosa, Ceratonia siliqua, Cicer arietinum, Glycyrrhiza glabra, Lathyrus, Medicago, Pisum sativum, Sophora, Trifolium* and *Vicia*), **Asteraceae** (Asteraceae type, *Anthemis, Aster, Carduus, Centaurea, Cichorium intybus, Helianthus annus, Lactuca, Tanacetum, Xeranthemum* and *Taraxacum*), **Lamiaceae** (Lamiaceae type, *Lavandula stoechas, Prunella, Rosmarinus officinalis, Salvia, Teucrium, Thymbra* and *Thymus*), **Brassicaceae** (Brassicaceae type, *Brassica, Isatis, Rapistrum rugosum, Raphanus raphanistrum* and *Sinapis*), **Rutaceae** (*Citrus* type, *Citrus aurantium, Citrus limon, Citrus nobilis, Citrus parasidi* and *Citrus sinensis*) and **Cucurbitaceae** (Cucurbitaceae type, *Citrullus lanatus, Cucumis sativus, Cucumis melo* and *Ecballium elaterium*) (Appendix 1).

Families that occurred in more than 50 percent of the honey samples included Cistaceae and Boraginaceae (60%, n=9), Rutaceae and Oleaceae (73.33%, n=11), Liliaceae (80%, n=12), Myrtaceae (86.67%, n=13); Rosaceae, Poaceae, Lamiaceae and Apiaceae (93.33%, n=14), and Fabaceae, Brassicaceae and Asteraceae (100%, n=15).

17 pollen types were found in more than one-half of the honey samples in the study area. These pollen types included *Citrus aurantium, Cistus salviifolius, Raphanus raphanistrum* and Boraginaceae type (53.33%, n=8), *Olea europaea, Myrtus communis, Eucalyptus camaldulensis* and *Centaurea* (66.67%, n=10), Liliaceae type (80%, n=12), Poaceae type (86.67%, n=13), Rosaceae type, Lamiaceae type, *Trifolium*, Asteraceae type and Apiaceae type (93.33%, n=14), and Brassicaceae type and Fabaceae type (100%, n=15).

Of the 15 honey samples, 12 were classified as multifloral and 3 as unifloral, represented by 2 predominant pollen types: *Petroselinum crispum* (n=2) and Fabaceae type (n=1) (Appendix 2).

Based on the absolute pollen content per 10 g of the honey samples, 73.33% (n=11) of the samples were found to belong to **Group I** (<20.000 pollen grains per 10 g honey) and 26.67% (n=4) to **Group II** (20.000-100.000) (Appendix 2).

The number of pollen grains per 10 g of honey, 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 samples generally "very poor" in grains represented 73.33% of all the samples (Appendix 2).

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4. Conclusions and discussion

Pollen content and the diversity is most important factor to determine the quality level of honey (Yan et al., 2001). Pollen present in the dominant and secondary group are primary contributors to the formation of honey while pollen content in quantities less than other pollen are added to the honey generally by external factors such as wind (Moar, 1985). The dominant and secondary groups determine the honey content and quality. According to Lieux (1972), the diversity of trace and minor groups has always been higher than diversity of dominant group pollen taxa. Our result show parallalelity with these findings.

The pollen composition of the honey samples revealed important information on the floral structure of the study area. Of the dominant pollen taxa group (>45%) *Petroselinum crispum* was present in two of the 15 samples, ranging from 77.2 to 93.62 percent (H01 and H02 honey samples). These honey samples are named locally as "**Maydanoz balı**" (honey name in turkish). It was present as secondary pollen in one sample (H08 honey sample) (Appendix 2). *Petroselinum crispum* is commonly cultivated in the study area. The honey samples were taken from the honey hives located near the parsley cultural fields. Similarly, it is reported for other species of the Apiaceae family in Turkey. Silici and Gökçeoğlu (2007) reported that *Pimpinella anisum* pollen were dominant in two honey samples from Antalya Province. It has also been reported similar to other countries in the Mediterranean basin. According to Tsigouri et al. (2004), *Pimpinella anisum* pollen were dominant in two honey samples from Greece and Apiaceae pollen were most frequently found in Algerian honeys (Ouchemoukh et al., 2005).

Fabaceae type was predominant in only one sample (H07 honey sample). It was also the secondary pollen in four samples (Appendix 2). Fabaceae type pollen has already been reported in the different phytogeographical regions in Turkey honeys by Ozturk et al. (2012). Twelve pollen types belonged to the secondary pollen group (16-45%): Apiaceae type (H03, H04 and H10), *Petroselinum crispum* (H08), Fabaceae type (H11, H12, H14 and H15), *Lathyrus* (H06), *Erica manipuliflora* (H09), *Arbutus andrachne* (H09), Lamiaceae type (H10, H11 and H12), Asteraceae type (H11), Brassicaceae type (H12, H13, H14 and H15), Rosaceae type (H06), *Citrus aurantium* (H04 and H05) and *Olea europaea* (H13) (Appendix 2).

The pollen types of Apiaceae, Asteraceae, Brassicaceae, Fabaceae, Lamiaceae and Rosaceae are present in almost all honey samples in the study area (Appendix 1) and these are considered as secondary pollen groups. Similarly,

these pollen types have also been reported as secondary pollen in other regions of Turkey (Ozturk et al., 2012). Ouchemoukh et al. (2005) reported that Apiaceae pollen is most frequently found in Algerian honeys. Atanassova et al. (2009) reported that Fabaceae, Lamiaceae, Brassicaceae and Rosaceae are the most represented families in honey from the Kazanlak region (Central Bulgaria). In addition, Atanassova et al. (2016) reported that Fabaceae, Rosaceae and Brassicaceae families were important for honey production from serpentine and nonserpentine areas in the Eastern Rhodopes Mt. (Bulgaria).

Asteraceae is one of the the richest families in terms of plant species and pollen types in the world. Similarly, pollen of this family have been most frequently found in honeys from Turkey (Ozturk et al., 2012). Brassicaceae is a cosmopolite family and it contains many natural and cultivated plant species in Turkey. Many members of the Brassicaceae are economically important for medicinal, ornamental, and economic purposes (Gugel and Falk, 2006; Warwick et al., 2007). 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 (Silici and Gökçeoğlu, 2007). Pollen grains of this family are very commonly present in honey samples. Previous studies have reported that pollen of this family is usually present in honey samples from Turkey (Sorkun and İnceoğlu, 1984b, c; Kaplan and İnceoğlu, 2002; Ozturk et al., 2012).

The number of honey plants belonging to Fabaceae family is less than other families, because the flowering period of the family is between April-September. Fabaceae plants have a long flowering period and are used as sources of pollen and nectar by bees, and are also frequently observed in honey (Silici and Gökçeoğlu, 2007). Many previous melissopalynological studies report that Fabaceae type pollen are frequently found in Turkey's different regions and neighboring countries with similar climate (Sorkun and İnceoğlu, 1984a; Sorkun and Yuluğ, 1985a, b; Göçmen and Gökçeoğlu, 1992; Kaplan and İnceoğlu, 2002).

The Lamiaceae family has more nectar bearing plants than other families in Turkey. It is one of the most important families as pollen and nectar source because it has long flowering period and very nice smell (Sorkun and Yuluğ, 1985b; Silici, 2004).

Rosaceae family has a large number of pollen and it is preferred by honeybees due to nectar and pollen source (Sorkun, 1988). The presence in our many honey samples could possibly be attributed to the fruit trees also in urban area (*Malus sylvestris, Prunus* spp., *Cerasus* sp.) to common (Taşkın and İnce, 2009).

Citrus aurantium pollen grains are present in eight samples and as secondary in two samples. Silici and Gökçeoğlu (2007) reported that there was no correlation between the percentage of *Citrus* pollen and the area of production. Likewise, Tsigouri et al. (2004) reported similar results. Although different *Citrus* varieties (*C. aurantium, C. limon, C. paradisi, C. nobilis* and *C. sinensis*) are cultivated throughout the study area, the pollen percentage was not high in our honey samples. This is due to the fact that *Citrus* pollen grains are underrepresented in honey. Silici and Gökçeoğlu (2007) have found similar results in Antalya Province (Turkey). Similarly, melissopalinological studies by different researchers especially Italy, Spain and Greece as well as other countries in the Mediterranean Basin are consistent with ours (Persano-Oddo et al., 1995, 1998, 2004a, b; Serra Bonvehi and Ventura Coll, 1995; Tsigouri et al., 2004). D'Albore (1997) has reported that percentage of pollen in Italian *Citrus* honeys is greater than 5 percent. *Olea europaea*, the most typical Mediterranean plant, is cultivated in coastal areas and its pollen was observed as secondary in one sample in the research area. Pollen from *O. europaea* has also been reported in variable frequencies in Spanish and Moroccan honeys (Debbagh, 1987; Muñuera-Giner and Carrion-Garcia, 1994; Cabreara-Ruiz et al., 1997; Terrab et al., 2003).

In Turkey, *Erica manipuliflora, Arbutus andrachne* (Ericaceae) and *Lathyrus* (Fabaceae) taxa growing along the coastal area are very important for honey bees as pollen and nectar source (Sorkun, 2008; Ozturk et al., 2012). *E. manipuliflora* and *A. andrachne* pollen were observed as secondary in one honey sample (H09), and *Lathyrus* pollen also was observed as secondary in one honey sample (H06) in the study area.

Twenty three pollen types belonged to the 'important minor' class. The pollen of Apiaceae, Asteraceae, Brassicaceae, Boraginaceae, Cucurbitaceae, Fabaceae, Lamiaceae, Poaceae, Polygonaceae, Rosaceae, *Anthemis, Arbutus andrachne, Cistus salviifolius, Citrus aurantium, Citrus sinensis, Erica manipuliflora, Eucalyptus camaldulensis, Lathyrus, Myrtus communis, Olea europaea, Raphanus raphanistrum, Trifolium* and *Vicia* are present in almost all honey samples in the study area (Appendix 2) and they can be considered as the important minor pollen.

The low number of the pollen in the honey samples is because of the short flowering period (Moar, 1985). However, nectars with lower sugar content are not preferred by honey bees. Small number of pollen grains affect the quality of honey. This is because of increase in the pollen species diversity. Taxa from 15 honey samples belong to "minor pollen" class except *Petroselinum crispum* (Appendix 2).

A total of 24 non-melliferous plant taxa found in our honey samples are: *Cedrus libani, Chenopodium album, Cistus, Cistus salviifolius, Cupressus sempervirens, Helianthemum nummularium, Hypericum, Juglans regia, Linum, Lycopersicon esculentum, Morus, Quercus* sp., *Quercus coccifera, Olea europaea, Phillyrea latifolia, Pinus brutia, Pistacia terebinthus, Poaceae, Populus, Rumex* sp., *Rumex acetosella* and *Typha* sp., *Vitis vinifera* and *Zea mays*. The presence of these pollen types is most likely from contamination by the bees from mainly wind-pollinates plants.

Honey is a local product so its botanical and geographical origin and many environmental factors have important effects on its quality (physical and chemical characteristics) (Bogdanov et al., 2007; Atanassova et al., 2016).

Melissopalynological analysis is still considered as a suitable method for honey evaluation. Many workers think that acidity and humidity are not the only significant parameters for honey quality; in addition pollen analysis gives important knowledge about the geographical and botanical origin (Persano Oddo and Piro, 2004a, b; Kaya et al., 2005; Silici and Gökçeoğlu, 2007), especially -if the plant is an endemic plant (Anklam, 1998). As emphasised by Mandić et al. (2006) Europe has more than 100 unifloral honeys but the honeys have local importance and people produce them periodically. Geographical and botanical properties play critical roles about their quality (Sabo et al., 2011). About 500 plants in Turkey are important nectar and pollen offering beekeeping plants. It is reported that all of this plants are important for beekeeping also 50-60 of them are economically dominant nectar and pollen yields (Sorkun, 2008; Ozturk et al., 2012).

In this study, two predominant pollen types (*Petroselinum crispum* and Fabaceae type) were recorded in three unifloral honeys. Local beekeepers designate honey samples as *Citrus, Eucalyptus, Petroselinum crispum, Calluna, Pinus, Capparis spinosa* and *Gossypium*" without melissapalynologycal analysis according to their botanical origins. They are considered as unifloral by the name, but our pollen analysis revealed that honey in some sites is multifloral and should be named as "Blossom".

Hatay province has a great potential in apiculture in terms of climate and vegetation. Cultivation of cash crops, garden plants and forage plants is intensive in the province. The vegetation of the province has a capacity which will serve for more than the number of existing bee colonies. However, the current potential of the province has not been adequately evaluated (Şahinler and Şahinler, 1996; Şahinler and Gül, 2005). Şahinler and Gül (2005) have reported that in different regions of Hatay, apiarists use big amounts of Mavrik, Kenaz, Perizin and Rulamit VA etc. to cure various diseases such as (varroa parasite, foulbrood). They have also reported that the reason of the situation was the fact that apiarists were uneducated, they lack experince and information, and they usually use unlicensed chemicals. Gül (2014) has also reported that such factors are of significiance as the most critical contributing causes diminution of bee populations in Turkey. In addition, the urbanization and industrialization, destruction of forests, coastal tourism, and greenhouse gases affect the beekeeping in Turkey. This situation is considered as the reason of the low quantities of pollen and taxa in samples. The lack of clean water supply also effects the spread of bee diseases (Yücel, 2008). In 3 km radius of the hive ecological vegetable production should be done and natural plant cover should exist for good honey production. Hives, should be placed away from industrial area, highways and from conventional agriculture using pesticides (Yücel, 2008). The beekeepers should produce honey in places that have plants with a lot of pollen and nectar and places which are suitable for bees. Orientation of beekeeper in this regard will play important role of mapping of appropriate pollen and nectar area for honey production and will provide food security (Yücel, 2008). Also helping pollination plays an active role in ensuring the diversity and continuity of generations (Kumova et al., 2001; Kambur and Kekeçoğlu, 2018).

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Appendix 1. Pollen taxa recovered from the honey samples and their frequency percentages

Pollen taxa	Sample no														
	H01	H02	H03	H04	H05	H06	H07	H08	H09	H10	H11	H12	H13	H14	H15
Anacardiaceae															
Pistacia terebinthus									**0.23**	**0.12**					
Apiaceae															
Apiaceae type	**0.73**	**2.22**	**34.53**	**23.2**	**10.18**	**2.33**	**2.51**	**3.67**	**3.41**	**20.11**	**9.58**	**4.6**	**7.32**		**6.63**
Petroselinum crispum	**93.62**	**77.2**						**36.05**							
Asteraceae															
Asteraceae type	**0.06**	**0.32**	**6**	**11.14**	**2.26**	**6.22**	**3.14**	**2.65**	**9.78**	**2.1**	**24.64**		**1.98**	**4.6**	**2.94**
Anthemis		**0.19**	**12.01**	**0.93**				**0.076**	**1.14**	**2.4**					
Aster											**0.07**				
Carduus	**0.001**														
Centaurea	**0.002**	**0.017**				**0.54**	**0.03**	**0.007**	**0.02**	**0.075**	**0.07**	**0.006**		**0.04**	
Cichorium intybus		**0.017**													
Helianthus annus									**0.01**	**0.06**	**0.14**		**0.05**	**0.19**	
Lactuca		**0.001**													
Tanacetum							**0.015**	**0.003**							
Xeranthemum										**0.03**					
Taraxacum				**0.025**			**0.06**								
Boraginaceae															
Boraginaceae type		**0.032**	**3**	**0.93**		**2.33**		**0.45**		**3.3**		**0.06**	**0.2**		
Anchusa								**0.003**							
Echium					**0.06**					**0.06**					
Brassicaceae															
Brassicaceae type	**0.12**	**7.13**	**3**	**3.71**	**13.58**	**3.9**	**3.77**	**5.98**	**8.42**	**10.5**	**12.32**	**35.66**	**20.76**	**16.86**	**24.3**
Rapistrum rugosum		**0.004**								**0.015**					
Raphanus raphanistrum		**2.29**			**2.26**			**3.56**		**1.8**	**2.74**	**0.29**		**10.73**	**5.15**
Sinapis														**0.04**	**0.04**
Brassica								**0.007**							
Isatis								**0.011**							
Capparaceae															
Capparis spinosa	**0.001**	**0.003**		**0.025**		**0.06**				**0.06**		**0.004**			
Chenopodiaceae															
Chenopodium album													**0.02**		**0.26**
Cistaceae															
Cistus							**0.03**			**0.13**					

Cistus salviifolius	**0.042**	**1.03**			**1.13**			**3.18**		**2.4**	**1.37**	**2.59**	**0.99**		
Helianthemum nummularium		**0.006**													
Cucurbitaceae															
Cucurbitaceae type												**0.35**		**3.06**	**5.15**
Citrullus lanatus								**0.02**							
Cucumis sativus								**0.003**				**0.03**			**0.29**
Cucumis melo															**0.26**
Ecballium elaterium		**0.017**					**0.06**								
Cupressaceae															
Cupressus sempervirens												**0.007**			
Ebenaceae															
Diospyros								**0.11**		**0.045**			**0.03**		
Elaeagnaceae															
Elaeagnus angustifolia															**0.04**
Ericaceae															
Erica manipuliflora		**0.064**							**42.09**	**3**		**0.09**		**1.53**	
Arbutus andrachne		**0.16**						**0.076**	**17.52**	**3.3**					
Fabaceae															
Fabaceae type	**0.83**	**0.84**	**15.01**	**9.28**	**9.05**	**14.01**	**47.8**	**4.54**	**7.96**	**2.7**	**16.43**	**23.13**	**15.82**	**30.65**	**24.3**
Astragalus		**0.009**	**0.04**			**0.43**		**0.038**							
Trifolium	**3.79**	**0.45**	**1.5**	**1.85**	**4.53**	**2.33**	**0.63**	**1.89**	**0.68**	**4.8**		**3.18**	**0.4**	**3.06**	**2.21**
Calicotome villosa							**0.047**	**0.015**		**0.21**	**0.14**			**0.11**	
Glycyrrhiza glabra															**0.07**
Sophora						**0.04**				**0.03**					
Lathyrus			**3**	**2.78**		**24.13**		**0.83**					**0.6**		
Medicago						**0.02**									
Vicia				**0.93**				**0.45**		**0.6**				**9.19**	**8.1**
Ceratonia siliqua										**0.34**					
Cicer arietinum															**0.11**
Pisum sativum															**0.15**
Fagaceae															
Quercus		**0.001**													
Quercus coccifera									**0.11**	**0.015**					**0.11**
Hypericaceae															
Hypericum						**0.02**									
Juglandaceae															
Juglans regia		**0.001**						**0.011**							
Lamiaceae															
Lamiaceae type	**0.042**	**3.38**	**4.5**	**4.64**	**4.53**	**9.34**	**9.43**	**2.34**		**18.31**	**21.9**	**28.29**	**9.1**	**7.66**	**8.84**
Lavandula stoechas	**0.001**	**0.003**						**0.003**							
Prunella						**0.02**							**0.04**		
Rosmarinus officinalis															**0.26**
Salvia		**0.001**													
Teucrium		**0.001**				**0.02**						**0.003**			
Thymus						**0.29**	**0.015**								
Thymbra											**0.14**				
Lauraceae															
Laurus nobilis		**0.001**			**0.11**			**0.003**	**0.93**		**0.14**	**0.001**			
Liliaceae															
Liliaceae type	**0.006**	**0.003**		**0.07**		**0.15**	**0.015**	**0.019**	**0.02**	**0.015**	**0.07**	**0.006**	**0.03**		**0.18**
Linaceae															
Linum								**0.011**							
Malvaceae															
Malvaceae type												**0.001**			
Gossypium															**0.11**
Moraceae															
Morus								**0.003**			**0.07**	**0.003**			

Myrtaceae															
Eucalyptus camaldulensis	**0.48**	**0.19**	**3**				**6.29**	**9.24**		**3.6**		**0.26**	**0.6**	**4.6**	**2.21**
Myrtus communis		**1.42**	**1.5**	**10.21**	**1.13**		**3.77**	**5.38**	**1.36**	**2.4**		**0.26**	**13.25**		
Oleaceae															
Olea europaea			**7.5**	**2.78**	**3.39**	**0.78**	**10.7**	**9.39**		**3**	**1.37**		**20.76**		**0.74**
Phillyrea latifolia									**0.4**						
Onagraceae															
Epilopium angustifolium		**0.001**													
Pinaceae															
Pinus brutia	**0.002**							**0.003**							
Cedrus libani						**0.02**									
Poaceae															
Poaceae type	**0.23**	**1.61**			**10.18**	**6.22**	**1.26**	**1.21**	**0.45**	**3.6**	**4.11**	**0.12**	**2.37**	**1.53**	**5.88**
Zea mays			**0.11**					**0.003**			**0.07**		**0.03**		**0.04**
Polygonaceae															
Polygonaceae type		**0.064**				**0.78**		**6.21**	**2.5**			**0.03**		**1.53**	
Rumex								**0.003**					**0.02**		
Rumex acetosella		**0.003**													
Polygonum						**0.04**		**0.1**	**0.09**						
Portulacaceae															
Portulaca oleracea	**0.001**	**0.001**													
Punicaceae															
Punica granatum						**0.02**	**0.03**	**0.003**		**0.015**					
Ranunculaceae															
Ranunculaceae type					**0.03**				**0.06**						
Ranunculus														**0.04**	
Rhamnaceae															
Paliurus spina-christii			**0.19**	**0.07**				**0.24**		**0.16**		**0.003**	**0.02**	**0.04**	
Rosaceae															
Rosaceae type	**0.021**	**0.93**	**1.5**	**3.71**	**6.79**	**25.69**	**10.07**	**0.98**	**0.91**	**5.4**	**4.11**	**0.32**	**4.94**	**3.06**	
Rutaceae															
Citrus							**0.03**			**0.39**		**0.004**		**0.34**	
Citrus aurantium		**0.096**	**3**	**23.2**	**20.37**			**0.83**	**1.82**	**3**		**0.06**			
Citrus limon		**0.001**			**0.06**					**0.015**		**0.003**			
Citrus paradisi								**0.003**					**0.01**		
Citrus nobilis												**0.001**			
Citrus sinensis		**0.032**			**10.18**					**1.5**		**0.59**	**0.4**		
Salicaceae															
Populus		**0.004**													
Solanaceae															
Nicotiana								**0.003**							
Solanum														**1.07**	**1.29**
Lycopersicon esculentum															**0.15**
Thypaceae															
Typha	**0.002**									**0.045**					
Verbenaceae															
Vitex agnus-castus			**0.04**	**0.05**				**0.019**				**0.001**			
Vitaceae															
Vitis vinifera											**0.07**				

Appendix 2. Pollen analytical data of honey samples from the study area

*Samples	Predominant pollen (>45%)	Secondary pollen (16-45%)	Important minor pollen (3-15%)	Minor pollen (<3%)	The total pollen number	Nature of Honey	Maurizio's classes	Feller-Demalsy et al. (1989)
H01	*Petroselinum crispum* (93.62%)		*Trifolium* (3.79%)	Fabaceae type, Apiaceae type, *Eucalyptus camaldulensis*, Poaceae type, Brassicaceae type, Asteraceae type, *Cistus salviifolius*, Lamiaceae type, Rosaceae type, Liliaceae type, *Centaurea*, *Pinus brutia*, *Typha*, *Capparis spinosa*, *Carduus*, *Lavandula stoechas*, *Portulaca oleracea*	**96113**	**Unifloral**	**II**	**normal**
H02	*Petroselinum crispum* (77.2%)		Brassicaceae type (7.13%), Lamiaceae type (3.38%)	*Raphanus raphanistrum*, Apiaceae type, Poaceae type, *Myrtus communis*, *Cistus salviifolius*, Rosaceae type, Fabaceae type, *Trifolium*, Asteraceae type, *Anthemis*, *Eucalyptus camaldulensis*, *Arbutus andrachne*, *Citrus aurantium*, *Erica manipuliflora*, Polygonaceae type, Boraginaceae type, *Citrus sinensis*, *Centaurea*, *Cichorium intybus*, *Ecballium elaterium*, *Astragalus*, *Helianthemum nummularium*, *Populus*, *Rapistrum rugosum*, *Capparis spinosa*, *Lavandula stoechas*, Liliaceae type, *Rumex acetocella*, *Epilobium angustifolium*, *Citrus limon*, *Lactuca*, *Laurus nobilis*, *Portulaca oleracea*, *Salvia*, *Juglans regia*, *Quercus*, *Teucrium*	**62040**	**Unifloral**	**II**	**normal**
H03		Apiaceae type (34.53%)	Fabaceae type (15.01%), *Anthemis* (12.01%), *Olea europaea* (7.5%), Asteraceae type (6%), Lamiaceae type (4.5%), Boraginaceae type (3%), Brassicaceae	*Myrtus communis*, Rosaceae type, *Trifolium*, *Paliurus spina-christii*, *Zea mays*, *Astragalus*, *Vites agnus-castus*	**2664**	**Multifloral**	**I**	**very poor**

			type (3%), *Eucalyptus camaldulensis* (3%), *Citrus aurantium* (3%), *Lathyrus* (3%)					
H04		Apiaceae type (23.2%), *Citrus aurantium* (23.2%)	Asteraceae type (11.14%), *Myrtus communis* (10.21%), Fabaceae type (9.28%), Lamiaceae type (4.64%), Brassicaceae type (3.71%), Rosaceae type (3.71%)	*Lathyrus, Olea europaea, Trifolium, Anthemis*, Boraginaceae type, *Vicia*, Liliaceae type, *Paliurus spina-christii, Vitex agnus-castus, Capparis spinosa, Taraxacum*	**4310**	**Multifloral**	**I**	**very poor**
H05		*Citrus aurantium* (20.37%)	Brassicaceae type (13.58%), Apiaceae type (10.18), *Citrus sinensis* (10.18%), Poaceae type (10.18%), Fabaceae type (9.05%), Rosaceae type (6.79%), Lamiaceae type (4.53%), *Trifolium* (4.53%), *Olea europaea* (3.39%)	Asteraceae type, *Raphanus raphanistrum, Cistus salviifolius, Myrtus communis, Laurus nobilis, Citrus limon, Echium*, Ranunculaceae type	**3535**	**Multifloral**	**I**	**very poor**
H06		Rosaceae type (25.69%), *Lathyrus* (24.13%)	Fabaceae type (14.01%), Lamiaceae type, (9.34%), Asteraceae type (6.22%), Poaceae type (6.22%), Brassicaceae type (3.9%)	Apiaceae type, Boraginaceae type, *Trifolium, Olea europaea*, Polygonaceae type, *Centaurea, Astragalus, Thymus*, Liliaceae type, *Capparis spinosa, Polygonum, Sophora, Cedrus libani, Hypericum, Medicago, Prunella, Punica granatum, Teucrium*	**5138**	**Multifloral**	**I**	**very poor**
H07	Fabaceae type (47.8%)		*Olea europaea* (10.7%), Rosaceae type (10.07%), Lamiaceae (9.43%), *Eucalyptus*	Apiaceae type, Poaceae type, *Trifolium, Ecballium elaterium, Taraxacum, Calicotome villosa, Centaurea, Cistus, Citrus, Punica granatum,* Liliaceae type, *Tanacetum, Thymus*	**6360**	**Unifloral**	**I**	**very poor**

		camaldulensis (6.29%), Brassicaceae type (3.77%), *Myrtus communis* (3.77%), Asteraceae type (3.14%)					
H08	*Petroselinum crispum* (36.05%)	*Olea europaea* (9.39%), *Eucalyptus camaldulensis* (9.24%), Polygonaceae type (6.21%), Brassicaceae type (5.98%), *Myrtus communis* (5.38%), Fabaceae type (4.54%), Apiaceae type (3.67%), *Raphanus raphanistrum* (3.56%), *Cistus salviifolius* (3.18%)	Asteraceae type, Lamiaceae type, *Trifolium*, Poaceae type, Rosaceae type, *Citrus aurantium*, *Lathyrus*, Boraginaceae type, *Vicia*, *Paliurus spina-christii*, *Diospyros*, *Polygonum*, *Anthemis*, *Arbutus andrachne*, *Astragalus*, *Citrullus lanatus*, Liliaceae type, *Vitex agnus-castus*, *Calicotome villosa*, *Isatis*, *Juglans regia*, *Linum*, *Brassica*, *Centaurea*, *Anchusa*, *Citrus paradisi*, *Cucumis sativus*, *Laurus nobilis*, *Lavandula stoechas*, *Morus*, *Nicotiana*, *Pinus brutia*, *Punica granatum*, *Rumex*, *Tanacetum*, *Zea mays*	**26406**	**Multifloral**	**II**	**normal**
H09	*Erica manipuliflora* (42.09%), *Arbutus andrachne* (17.52%)	Asteraceae type (9.78%), Brassicaceae type (8.42%), Fabaceae type (7.96%), Apiaceae type (3.41%)	Polygonaceae type, *Citrus aurantium*, *Myrtus communis*, *Anthemis*, *Laurus nobilis*, Rosaceae type, *Trifolium*, Poaceae type, *Phillyrea latifolia*, *Pistacia terebinthus*, *Quercus coccifera*, *Polygonum*, Ranunculaceae, *Centaurea*, Liliaceae type, *Helianthus annus*	**8791**	**Multifloral**	**I**	**very poor**

H10	Apiaceae type (20.11%), Lamiaceae type (18.31%)	Brassicaceae type (10.5%), Rosaceae type (5.4%), *Trifolium* (4.8%), *Eucalyptus camaldulensis* (3.6%), Poaceae type (3.6%), *Arbutus andrachne* (3.3%), Boraginaceae type (3.3%), *Citrus aurantium* (3%), *Erica manipuliflora* (3%), *Olea europaea* (3%)	Fabaceae type, *Anthemis*, *Cistus salviifolius*, *Myrtus communis*, Asteraceae, *Raphanus raphanistrum*, *Citrus sinensis*, *Vicia*, *Citrus*, *Ceratonia siliqua*, *Calicotome villosa*, *Paliurus spina-christii*, *Cistus*, *Pistacia terebinthus*, *Centaurea*, *Capparis spinosa*, *Echium*, *Helianthus annus*, *Diospyros*, *Typha*, *Sophora*, *Xeranthemum*, *Citrus limon*, Liliaceae type, *Quercus coccifera*, *Rapistrum rugosum*	**6664**	**Multifloral**	**I**	**very poor**
H11	Asteraceae type (24.64%), Lamiaceae type (21.9%), Fabaceae type (16.43%)	Brassicaceae type (12.32%), Apiaceae type (9.58%), Poaceae type (4.11%), Rosaceae type (4.11%)	*Raphanus raphanistrum*, *Cistus salviifolius*, *Olea europaea*, *Calicotome villosa*, *Helianthus annus*, *Laurus nobilis*, *Thymbra*, *Aster*, *Centaurea*, Liliaceae type, *Morus*, *Vitis vinifera*, *Zea mays*	**1461**	**Multifloral**	**I**	**very poor**
H12	Brassicaceae type (35.66%), Lamiaceae type (28.29%), Fabaceae type (23.13%)	Apiaceae type (4.6%), *Trifolium* (3.18%)	*Cistus salviifolius*, *Citrus sinensis*, Cucurbitaceae type, Rosaceae type, *Raphanus raphanistrum*, *Eucalyptus camaldulensis*, *Myrtus communis*, Poaceae type, *Erica manipuliflora*, Boraginaceae type, *Citrus aurantium*, *Cucumis sativus*, Polygonaceae type, *Cupressus sempervirens*, *Centaurea*, Liliaceae type, *Capparis spinosa*, *Citrus*, *Citrus limon*, *Morus*, *Paliurus spina-christii*, *Teucrium*, *Citrus nobilis*, *Laurus nobilis*, Malvaceae type, *Vitex agnus-castus*	**67864**	**Multifloral**	**II**	**normal**
H13	Brassicaceae type (20.76%), *Olea europaea* (20.76%)	Fabaceae type (15.82%), *Myrtus communis* (13.25%), Lamiaceae type (9.1%), Apiaceae type (7.32%),	Poaceae type, Asteraceae, *Cistus salviifolius*, *Eucalyptus camaldulensis*, *Lathyrus*, *Citrus sinensis*, *Trifolium*, Boraginaceae type, *Helianthus annus*, *Prunella*, *Diospyros*, Liliaceae type, *Zea mays*, *Chenopodium album*, *Paliurus*	**10114**	**Multifloral**	**I**	**very poor**

		Rosaceae type (4.94%)	*spina-christii, Rumex, Citrus paradisi*				
H14	Fabaceae type (30.65%), Brassicaceae type (16.86%)	*Raphanus raphanistrum* (10.73%), *Vicia* (9.19%), Lamiaceae type (7.66%), Asteraceae type (4.6%), *Eucalyptus camaldulensis* (4.6%), Cucurbitaceae type (3.06%), Rosaceae type (3.06%), *Trifolium* (3.06%)	*Erica manipuliflora*, Poaceae type, Polygonaceae type, *Solanum, Helianthus annus, Calicotome villosa, Centaurea, Paliurus spina-christii, Ranunculus, Sinapis*	**2610**	**Multifloral**	**I**	**very poor**
H15	Brassicaceae type (24.3%), Fabaceae type (24.3%)	Lamiaceae type (8.84%), *Vicia* (8.1%), Apiaceae (6.63%), Poaceae type (5.88%), Cucurbitaceae type (5.15%), *Raphanus raphanistrum* (5.15%)	Asteraceae type, *Eucalyptus camaldulensis, Trifolium, Solanum, Olea europaea, Cucumis sativus, Chenopodium album, Cucumis melo, Rosmarinus officinalis*, Liliaceae type, *Lycopersicon esculentum, Pisum sativum, Cicer, Gossypium, Quercus coccifera, Glycyrrhiza glabra, Elaeagnus angustifolia, Sinapis, Zea mays*	**2716**	**Multifloral**	**I**	**very poor**

*__**The localities of honey sample collection**__:
H01: Üçgüllük village-Arsuz, 28.05.2013; **H02**: Kale village-İskenderun, 29.06.2013; **H03**: Turunçlu village-Erzin, 30.06.2013; **H04**: Gökdere village-Erzin, 30.06.2013; **H05**: Dörtyol (Center), 30.06.2013; **H06**: Katranlı village-Hassa, 30.06.2013; **H07**: Bektaşlı village-Kırıkhan, 01.07.2013; **H08**: Gözlüce village-Yayladağı, 01.07.2013; **H09**: Keldağ-Yayladağı, 01.07.2013; **H10**: Meydan village-Samandağ, 02.07.2013; **H11**: Uzunalıç village-Serinyol, 06.07.2013; **H12**: Karlısu-Antakya, 17.08.2013; **H13**: Babatorun village-Altınözü, 15.07.2013; **H14**: Davutpaşa village-Reyhanlı, 03.07.2013; **H15**: Konuk village-Reyhanlı, 03.07.2013

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