POLLEN ANALYSIS OF THE HONEY FROM SOUTH ANATOLIA
Güney Anadolu Bölgesine ait Ballarda Polen Analizleri

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ABSTRACT

For pollen analysis, 19 honey samples were collected from different localities in Ereğli, Karapınar, Ayrancı and Ulukışla regions of Konya, Karaman and Ulukışla, respectively, in November 2015. All investigated honey samples were multifloral because they contained secondary and minor pollen groups. The dominant group of pollen grains were determined as the families of Fabaceae in 2 samples and Scrophulariaceae in 5 other samples, *Helianthus annuus* in 1 sample and *Zea mays* in 1 sample. Secondary pollen groups consisted of the families of Amaranthaceae, Brassicaceae, Fabaceae, Poaceae, Rosaceae, Scrophulariaceae and genera of *Centaurea*, *Cistus*, *Eucalyptus* and *Linaria*. Pollen of 55 plant taxa were identified in examined honey samples of which 21 were classified on the family level, 30 were on the genera level, 1 was on the tribe level and 3 were on the species level. The total number of pollen (TPN-10) in 10 grams of honey ranged from 332 to 42496. According to the results of the TPN-10 analysis in honey samples, 3 samples were normal and others were poor. The taxa of *Zea mays*, *Cistus*, Poaceae, Scrophulariaceae and Amaranthaceae were found in pollen sources. *Helianthus annuus* and Brassicaceae were found in nectar sources. Fabaceae, Rosaceae*, Eucalyptus*, *Centaurea* were found in nectar and pollen sources and were identified in the honeys.

Key words: Melissopalynology, TNP-10, Pollen Analysis, South Anatolia Region, Turkey

ÖZ

Ereğli, Karapınar, Ayrancı ve Ulukışla ilçelerinin farklı lokalitelerindeki 19 bal üreticisinden polen analizi yapmak için Kasım 2015'de bal örnekleri temin edilmiştir. İncelenen örneklerin tümü sekonder ve minör polen grubu içerdiği için multifloral bal olarak tespit edilmiştir. Fabaceae 2 örnekte, Scrophulariaceae 5 örnekte, *Helianthus annuus* 1 örnekte, *Zea mays* 1 örnekte dominant polen grubu olarak belirlenmiştir. Sekonder polen grubunda ise Amaranthaceae, Brassicaceae, Fabaceae, Poaceae, Rosaceae, Scrophulariaceae, *Centaurea*, *Cistus*, *Eucalyptus* and *Linaria* taksonları oluşturmuştur. Araştırılan bal örneklerinde 55 bitki taksonuna ait polenlerden 21'i familya, 30'u cins, 1'i tribus, 3'ü ise tür düzeyinde tespit edilmiştir. Toplam polen sayısı 10 gram balda 332 ile 42496 arasında değişiklik göstermiştir. TPS-10 değerine göre, araştırılan bal örneklerinden 3'ü normal, diğerleri zayıf bulunmuştur. Araştırılan ballarda; *Zea mays*, *Cistus*, Poaceae, Scrophulariaceae ve Amaranthaceae taksonlarının polen kaynağı, *Helianthus annuus* and Brassicaceae taksonlarının nektar kaynağı, Fabaceae, Rosaceae*, Eucalyptus* ve *Centaurea* taksonlarının nektar ve polen kaynağı olduğu belirlenmiştir.

Anahtar kelimeler: Melissopalinoloji, TPS-10, Polen Analiz, Güney Anadolu Bölgesi, Türkiye

ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE

GENİŞLETİLMİŞ ÖZET

Amaç: Balarıları, nektar ve polen toplamak amacıyla bulundukları bölgedeki çiçekleri ziyaret ederler. Arıların polen kaynağını ise doğal flora oluşturmaktadır. Floradaki polen kaynağı olan bitki türlerinin çeşitliliği ve çiçeklenme sezonlarının uzunluğu değişiklik göstermektedir (Baydar ve Gürel, 1998). Bala kalite veren etkenlerden biri de içerdiği polen olup, balın hangi yöreye ait olduğunun tespit edilmesinde fayda sağlamaktadır. Balda yapılan polen analizleri, balların isimlendirilmesi ve menşeinin belirlenmesinde buna bağlı olarak da pazarlanmasında oldukça önem kazanmıştır. Bu çalışma ile İç Anadolu bölgesinden Ereğli, Karapınar (Konya), Ayrancı (Karaman) ve Ulukışla (Niğde) ilçelerinin farklı lokalitelerindeki 19 bal üreticisinden alınan örneklerin palinolojik yönden incelenerek, o yörelerde üretilen ballara ait nektar ve polen kaynağı olan bitkilerin tespiti amaçlanmıştır.

Gereç ve Yöntem: Bal örnekleri 2015 yılının Kasım ayında Ereğli, Karaman, Karapınar ve Ulukışla bölgelerindeki üreticilerden temin edilmiştir. Polen analizleri için preparatlar, Uluslararası Arı Araştırma Birliğinin tavsiye ettiği (Louveaux ve ark. 1970) ve Doğan ve Sorkun (2002)'un geliştirdiği yönteme göre yapılmıştır. Polen preparatlarının hazırlanması amacıyla; homojen hale getirilmiş stok baldan steril tüplere alınan 10 gram bal, 20 mL distile su ilave edilerek su banyosunda $45C^0$ de bekletilerek, balın su içinde çözünmesi sağlanmıştır. Örnekler, 3500 devirde 45 dakika santrifüj edildikten sonra tüplerin dibinde oluşan polen çökeltisi, bir miktar bazik fuksinli gliserin jelatin ile bulaştırılarak daimi preparat hazırlanmıştır. Hazırlanan preparatlarda polenlerin hangi bitki taksonlarına ait oldukları belirlenmiş ve polenlerin sayımları yapılarak yüzde oranları hesaplanmıştır. Araştırılan bal örnekleri buna göre; Eser (< %3), Minör (%3-15), Sekonder (%16-44) ve Dominant (>% 45) olmak üzere 4 grupta incelenmiştir.10 gram balda Toplam Polen Sayısının belirlenmesi için her bir bal örneği bulunan tüplere, sayısı bilinen *Lycopodium* spor tableti ilave edilmiştir. TPS'na göre polenler, I- (< 20 000), II - (20 000-100 000), III- (100 000-500 000), IV- (500 000-1 000 000), V-(>1 000 000) olmak üzere 5 kategoride sınıflandırılmıştır (Jose ve ark. 1989).

Bulgular: Analiz sonuçlarına göre 12 ve 13 nolu örneklerde Fabaceae (Baklagiller), 7,9,17 ve 18 numaralı örneklerde Scrophulariaceae, 15 numaralı örnekte *Helianthus annuus* ve 5 numaralı örnekte *Zea mays* polenleri dominant bulunmuştur. Sekonder polen grubunda ise Amaranthaceae, Brassicaceae, Fabaceae, Poaceae, Rosaceae, Scrophulariaceae, *Centaurea*, *Cistus*, *Eucalyptus* and *Linaria* taksonları tespit edilmiştir. Bitki takson çeşidi minör ve eser grupta oldukça fazla iken dominant ve sekonder gruba doğru azalma göstermektedir. Toplam polen sayısı 17 numaralı örnekte en fazla iken 10 numaralı örnekte en az tespit edilmiştir. TPS-10'a göre 3,13 ve 17 numaralı örnekler kategori 2'de (normal polenli ballar), diğer örneklerin tümü kategori 1'de (zayıf polenli ballar) sınıflandırılmıştır.

Sonuç: Bala nektar kaynağı oluşturan bitki taksonları dominant ve sekonder gruptaki polenlerdir. Bu çalışmadaki araştırma sonuçları 2015 yılı için Ereğli, Karapınar (Konya), Ayrancı (Karaman) ve Ulukışla (Niğde) ilçelerinin farklı lokalitelerinden alınan bal örneklerinde *Zea mays*, *Cistus*, Poaceae, Scrophulariaceae ve Amaranthaceae'nin polen kaynağı, *Helianthus annuus* ve Brassicaceae'nin nektar kaynağı, Fabaceae, Rosaceae, *Eucalyptus*, *Centaurea* taksonlarının ise hem polen hem de nektar kaynağı oluşturduğunu, ancak polen miktarı açısından zayıf olduğunu ortaya koymuştur. Araştırlan ballarda en yaygın bitki polenleri Asteraceae, Brassicaceae, *Centaurea*, *Cistus*, *Echium*, Fabaceae, Lamiaceae, *Plantago*, Poaceae, Rosaceae, *Salix*, *Sarcopoterium* ve Scrophulariaceae taksonlarına ait bulunmuştur. İncelenen örneklerin 19'u da, sekonder ve minör grupta bitki taksonlarına ait polenler içerdiği için multifloral özellikte bulunmuştur.

INTRODUCTION

Honeybees visit various flowers for collecting nectar and pollen. The pollen source of the bees varies depending on plant species in the foraging areas. Also the pollen source of the flora is based on the lenght of flowering season and on the variety of plant species (Baydar and Gürel 1998). Therefore it is necessary to determine the diversity of flora that is important for beekeeping. Melissopalynological analysis is an effective method to identify the floristic origin of honey. It plays a role in determining the nectar plants visited by foraging bees and also it helps to classify honey. Additionally, pollen analysis of honey informs us

about its labeling and provenance for honey consumers; for example, when the source and quality of honey is obvious, it can be marketed more easily.

The first pollen analysis of honey was carried out by Pfister in 1845 (Kaya et al., 2005). The earliest melissopalynological study in Turkey, was performed by Sorkun and İnceoğlu between 1976 and 1981 in the Central Anatolian region. In the following years, many researchers worked on this subject both in Turkey and in other countries (Lieux 1972; Moar 1985; Sorkun et al. 1989; Çakır 1990; Gemici 1991; Andrada et al. 1998; Valencia et al. 2000; Silici 2004; Atanassova et al. 2004, 2012; Yurtsever 2004; Kaya et al. 2005; Erdoğan et al. 2006, 2009; Taşkın and İnce 2009; Sabo et al. 2011; Demir 2012; Song et al. 2012; Puusepp and Koff 2014, Çelemli et al. 2018).

The cities of Konya, Karaman and Niğde, where honey specimens are collected, are located in the southeastern region of the Central Anatolia. This localitity is in the transition zone between Irano-Turanian and the Mediterranean phytogeographical regions. Ünal and Sağlam (2009) investigated flora in the region between Ayrancı Dam, Karakükürtlü Mountain, Alahan, and Karaman regions. This area has a lower semi-arid, very cold, Mediterranean climate, according to Emberger (Akman, 1990).

The dominant plant taxa is forest vegetation consisting of *Amygdalus orientalis*, *Quercus pubescens*, *Juniperus excelsa*. The dominant species of steppe vegetations, consists of *Gundelia tournefortii*, *Genista aucheri*, *Astragalus microcephalus*, *Astragalus gummifer*, *Astragalus angustifolius* subsp. *angustifolius* var. *angustifolius*, *Acantholimon ulicinum* subsp. *ulicinum*, *Thymus sipyleus* subsp. *sipyleus* var. *sipyleus*, *Genista involucrata*. The families of Asteraceae, Fabaceae, Lamiaceae, Brassicacae and Caryophyllaceae have the most species in this area, respectively. Karaömerlioğlu and Düzenli (2008) studied the flora of Niğde, Konya and Karaman regions. Their results showed that the families of Fabaceae, Asteraceae, Lamiaceae and Poaceae had the widespread plant taxa similar to findings of Ünal and Sağlam (2009).

It is known that pollen analyses in honey produced in the Central Anatolian region are limited (Sorkun and İnceoğlu, 1984; Kaplan and İnceoğlu 2002; Bağcı and Tunç, 2006). The purpose of this study is to identify the plant species in the research areas that honey bees prefer for nectar and pollen. Furthermore, it is a contribution to another melissopalynological survey of honey samples in Central Anatolia region.

MATERIALS AND METHODS

Honey samples

Honey samples (500 g) to be investigated were collected from honey producers with different localities in Ayrancı (Karaman), Ereğli, Karapınar (Konya) and Ulukışla (Niğde) in November 2015 (Fig. 1).

Preparation of pollen slides from honey samples

For pollen analysis, the pollen preparations were prepared as recommended by the International Bee Research Assosiation (Louveaux et al.1970) and modified by Sorkun and Doğan (2002). Accordingly, ten grams of each honey was dissolved in 20 mL of distilled water in the sterile test tube. The solution was centrifuged for 45 min. at 3500-4000 rpm. The supernatant solution was poured and small quantities of each pellet at the bottom of the tubes were mounted with basic fuchsin added glycerine gelatin on permanent glass slides.

For microscopic analysis of the pollen taxa of honey samples, two slides were prepared from each sample. The counting and identification of pollen grains in honey samples were carried out by a Nikon Eclipse E 100 microscope and microphotographs were taken under a Leica DM750 in Department of Biology at Sinop University.

Pollen microphotographs belonging to examined honey samples are given in Fig. 2 and Fig. 3. For identification of pollen types, pollen reference collection, palynological literatures and atleses were used (Erdtman 1954; Kapp et al. 2000; Aytuğ, 1971; Lewis et al. 1983; Faegri and Iversen 1989; Moore et al. 1991; Gemici 1991; Pehlivan, 1995; Sorkun, 2008; Song et al., 2012).

The types of pollen grains were classified into four groups according to percentages: I- Rare group (< 3%), II- Minor group (3%-15%), III- Secondary group (16% -44%), and IV- Dominant group (> 45%).

The total number of pollen (TNP in 10 g honey), was used for distinguishing between artificial and

natural honey. For the quantitative analysis of honey samples, the preparation was the same as the method described above. 20 mL of distilled water and tablets containing a known number of *Lycopodium* spores that were available from Department of Geology, Lund University, Sweden was added to ten grams of honey, which was homogenized by mixing it thoroughly with a sterile glass rod. After the tablet dissolved in the water, the tube was centrifuged for 30 min. at 3500-4000 rpm, then the supernatant was poured off. 0.1 mL 50%

of glycerine was added to the residue in the tube. 0.01 mL of this mixture was taken for preparations. Based on the TPN-10 value, the pollen grains were classified into 5 categories; Category I (< 20,000 pollen grains per 10 g honey), Category II (20,000-100,000 pollen grains per 10 g honey), Category III (100,000 – 500,000 pollen grains per 10 g honey), Category IV (500,000 – 1,000,000 pollen grains per 10 g honey), and Category V (>1 000 000 pollen grains per 10 g honey) (Jose et al. 1989).

Figure 1. The map is showing the collecting area in examined honey samples

RESULTS

In total, 55 plant taxa were identified from 19 honey samples, including 48 melliferous (e.g. Apiaceae, Brassicaceae, *Centaurea*, *Linaria*, Lamiaceae, Rosaceae) and 7 non-melliferous (Amaranthaceae, *Betula*, *Fraxinus*, *Pinus, Plantago*, Poaceae, *Zea mays*) species. Of these taxa, 21 were classified as a family, 1 was classified as a tribe, 30 were classified as a genera and 3 were classified on the species level.

In the Ereğli district, the two most dominant pollen groups consist of *Zea mays* in sample 5 and the

family of Scrophulariacae in samples 7 and 9. There were no dominant pollen groups in samples 1 - 4, 6,8 and 10. The taxa of Fabaceae (samples 1, 4, 8), Scrophulariaceae (samples 1, 4, 8, 10), *Linaria* (samples 4, 7, 8, 10), Poaceae (samples 2 and 3), Amaranthaceae (sample 3) and Brassicaceae (sample 6) were identified as secondary pollen groups. A secondary pollen group was not found in samples 5 and 9 (Table 1).

In sample 11, which was collected from Karapınar (Konya) region, the family of Rosaceae was determined as the secondary pollen group.

Dominant pollen group was not observed in this sample.

Seven samples were collected from the Karaman region. The families of Fabaceae (samples 12 and 13), Scrophulariaceae (samples 17 and 18) and *Helianthus annuus* (Sample 15) were the dominant pollen groups. *Eucalyptus* (Sample 13), Fabaceae (Sample 14, 16, 19), *Centaurea* (Sample 15) and Scrophulariaceae (14, 16) were the secondary pollen groups in this region. Dominant pollen group was not seen in sample 14 and the secondary pollen group was not in sample 18.

In the Ulukışla region, there was not any dominant pollen group. The genus of *Cistus* and the family Fabaceae were determined as the secondary pollen groups.

Asteraceae, Brassicaceae, *Centaurea*, *Cistus*, *Echium*, Fabaceae, Lamiaceae, *Plantago*, Poaceae, Rosaceae, *Salix*, *Sarcopoterium* and Scrophulariaceae were the most common pollens belonging to plant taxa in honey samples (Table 1 and 2).

TNP-10 values range from 332 to 42496. Investigated 19 honey samples were multifloral honey. Multifloral honey is defined as containing secondary and minor groups of pollen taxa while unifloral honey is defined as not containing secondary and minor pollen groups. While the highest number of TPN-10 was in sample 17, the lowest was in sample 10. (Table 1). While samples 3, 13 and 17 was classified in Category II based on TNP-10, other examined samples were in classified in Category I.
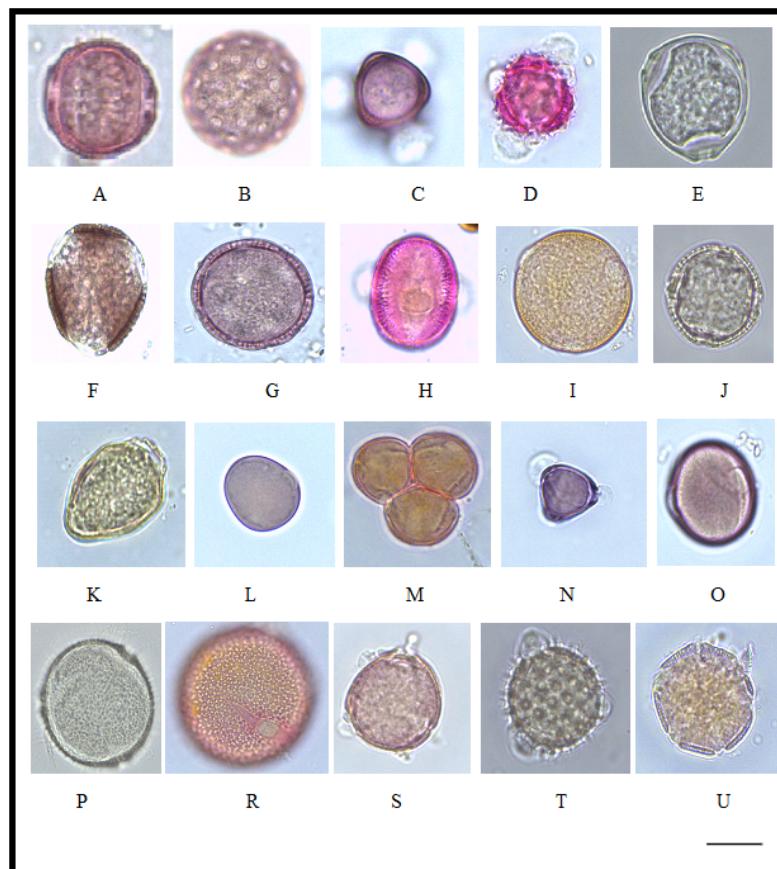
Figure 2. A-*Ailanthus* (X1000) B-Amaranthaceae (X1000) C-Apiaceae (X1000) D-Asteraceae (X1000) E-*Betula* (X1000) F-Brassicaceae (X1000) G-Caryophyllaceae (X1000) H-*Centaurea* (X1000) I-*Cistus* (X1000) J-*Citrus* (X1000) K-Cyperaceae (X1000) L-*Echium* (X1000) M- *Erica* (X1000) N- *Eucalyptus* (X1000) O- Fabaceae (X1000) P-*Fumana* (X1000) R-Geraniaceae (X1000) S-*Hedera helix* (X1000) T-*Helianthus annuus* (X1000) U-Lamiaceae (X1000) Scale bar: 20 µm.
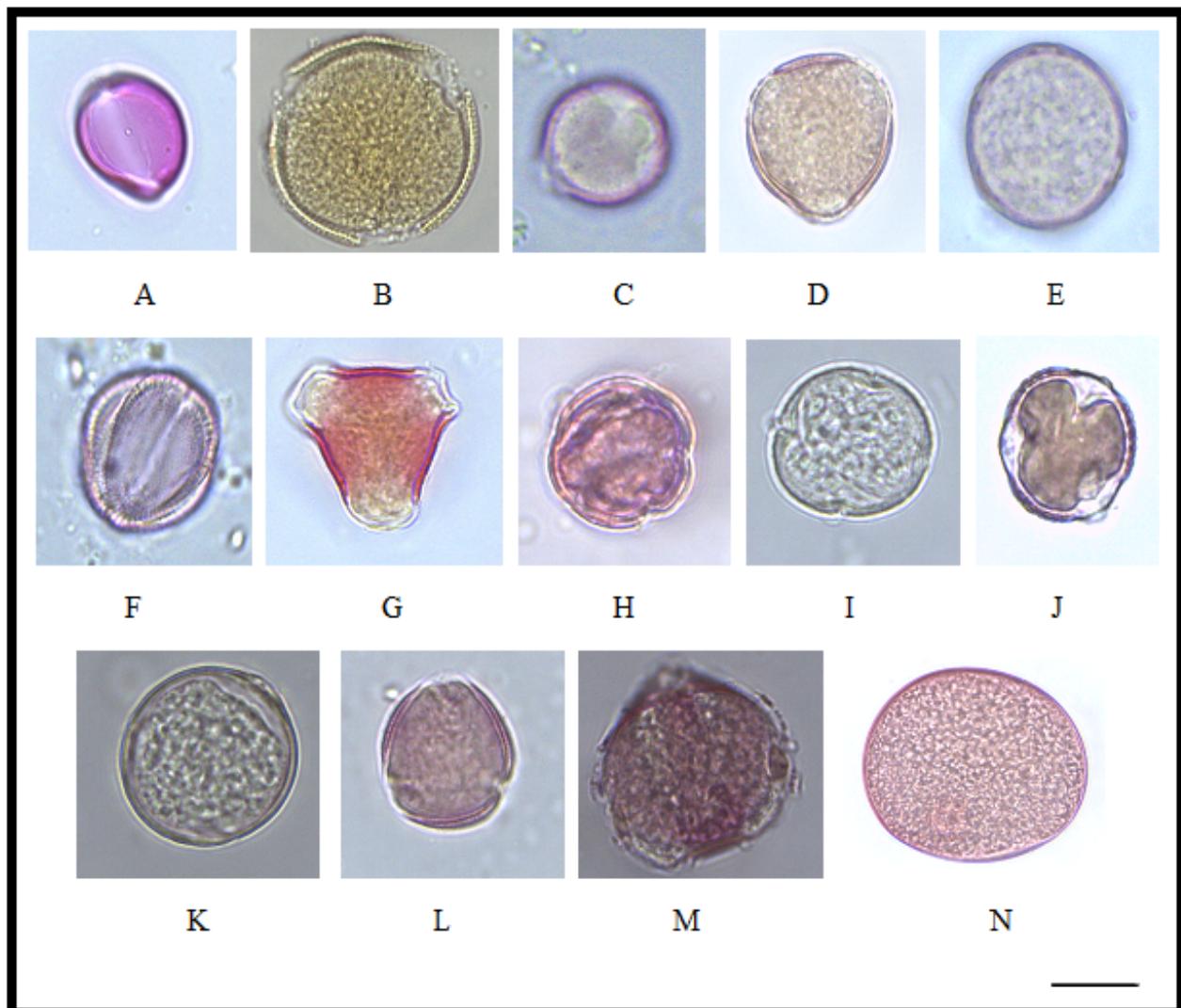
Figure 3. A- Liliaceae (X1000) B- *Linum* (X1000) C- *Linaria* (X1000) D- *Papaver* (X1000) E- *Plantago* (X1000) F- *Primula* (X1000) G- Rosaceae (X1000) H- Rubiaceae (X1000) I- *Rumex* (X1000) J- *Salix* (X1000) K- *Sarcopoterium* (X1000) L- Scrophulariaceae (X1000) M- *Veronica* (X1000) N- *Zea mays* (X1000) Scale bar: 20 μm.

Table 1. Pollen types identified, based on their spectra and TNP-10 values from the honey samples.

Samples	Locality	Pollen Spectra	TNP-10
1	Ereğli- Aziziye	* ----	
		** Fabaceae, Scrophulariaceae	3234
		*** Asteraceae, Myrtaceae, Ranunculaceae, Rosaceae, *Salix*	
		**** ----	
2	Ereğli-Bulgurluk	* ----	
	500m	** Poaceae	5889
		*** Amaranthaceae, Asteraceae, Brassicaceae, *Cistus*, Fabaceae, *Plantago*, Rosaceae, *Salix*, Scrophulariaceae	
		**** ----	
3	Ereğli-Bulgurluk	* ----	
	1000m	** Amaranthaceae, Poaceae,	29882
		***_Plantago_, Rosaceae, *Salix*, Scrophulariaceae, *Zea mays*	
		**** Apiaceae, Asteraceae, Brassicaceae, Cyperaceae, Echium, Fabaceae, Lamiaceae, Unidentifiable	
4	Ereğli-Dedeköy	* ----	
		** Fabaceae, *Linaria*, Scrophulariaceae	1087
		*** *Echium*, *Pinus*, Poaceae, *Sarcopoterium*	
		**** ----	
5	Ereğli- Headquarters	* *Zea mays*	
		** ----	17878
		***Apiaceae, *Centaurea*, *Cistus*, *Helianthus annuus*, *Plantago*	
		**** Amaranthaceae, *Malva*, *Sarcopoterium*, Poaceae, Rosaceae	
6	Ereğli- Namık Kemal	* ----	
	neighborhood	**Brassicaceae	8585
		*** Asteraceae, *Betula*,*Echium*, *Euphorbia*, Rosaceae	
		**** Apiaceae, *Centaurea*, *Erica*, *Hedera helix*, *Linaria*, Malvaceae, *Mathiola*, Poaceae, *Salix*, Scrophulariaceae, *Zea mays*	
7	Ereğli-Tumlu	* Scrophulariaceae	
		** *Linaria*	12932
		*** Fabaceae, Rosaceae	
		**** *Ailanthus*, Asteraceae, *Centaurea*, *Cistus*, *Echium*, Lamiaceae, Rubiaceae, *Salix*, *Veronica*, Unidentifiable	
8	Ereğli-Ulumeşe village	* ----	
		** Fabaceae, *Linaria*	16253
		*** Brassicaceae, Lamiaceae, *Plantago*, Rosaceae, Scrophulariaceae	
		**** Amaranthaceae, *Cistus*, *Citrus*, Caryophyllaceae, Cichorieae, Dipsacaceae, *Echium*, Geraniaceae, Liliaceae, *Papaver*, Poaceae, *Salix*, *Sarcopoterium*, Unidentifiable	
9	Ereğli	* Scrophulariaceae	
	Yellice village-1700m	** ----	2618
		*** *Cistus*	
		**** Amaranthaceae, Asteraceae, *Centaurea*, *Erica*, Geraniaceae, *Hedera helix*, Fabaceae, Lamiaceae, Liliaceae, *Linum*, *Plantago*, *Salix*, *Xanthium*, Veronica	
10	Ereğli	* ----	
	Yellice village-1100m	** *Linaria*, Scrophulariaceae	332
		*** *Cistus*, Fabaceae, Rosaceae	
		**** *Echium*, Lamiaceae, *Plantago*, Polygonaceae, Poaceae, *Sarcopoterium*, *Veronica*	

(* Dominant pollen, ** secondary pollen, *** minor pollen, ****rare pollen, TPN-total number of pollen in 10g of honey)

Table 1. Continued

11	Konya-Karapınar	* ----	
	Beyören	** Rosaceae	5978
		*** Asteraceae, *Centaurea*, *Cistus*, *Hedera helix*, Fabaceae Lamiaceae, Poaceae, *Sarcopoterium*, Scrophulariaceae,	
		**** ----	
12	Karaman-Ayrancı 2800m	* Fabaceae	
		** ----	3177
		*** Brassicaceae, Lamiaceae, *Pelargonium*, Scrophulariaceae, Rosaceae	
		**** ----	
13	Karaman-Ayrancı,	* Fabaceae	
	Berendi, 700m	** *Eucalyptus*	25405
		*** Scrophulariaceae	
		**** Amaranthaceae, Apiaceae, Asteraceae, Brassicaceae, Boraginaceae, Caryophyllaceae, *Centaurea*, *Cistus*, *Citrus*, Cyperaceae, *Echium*, *Erica*, Geraniaceae,Lamiaceae, *Linaria*, *Morus*, *Poaceae, Plantago*, Polygonaceae, *Primulaceae*, Ranunculaceae, *Rosaceae, Salix, Smilax, Quercus*, *Zea mays*	
14	Karaman-Ayrancı,	* ----	
	Berendi, 1000m	** Fabaceae, Scrophulariaceae	2805
		*** Boraginaceae, *Cistus*, *Echium*, Geraniaceae, *Plantago*, Poaceae, Rosaceae, Rubiaceae, *Veronica*	
		**** Asteraceae, Lamiaceae, *Salix*, *Zea mays*	
15	Karaman-Ayrancı Berendi	* *Helianthus annuus*	
	1400m	** *Centaurea*	8682
		*** ----	
		**** Amaranthacea, Asteraceae, Apiaceae, Boraginacea, Brassicaceae, Cichorieae, *Cistus*, Cyperaceae, *Euphorbia*, Fabaceae, *Geranium*, Lamiaceae, Liliaceae, *Linaria*, *Mathiola*, *Plantago*, Poaceae, *Primula*, Rubiaceae, *Sarcopoterium*, *Solanum*, Scrophulariaceae, *Veronica*	
16	Karaman-Ayrancı,	* ----	
	Kıraman village	** Fabaceae, Scrophulariaceae	3997
		*** Lamiaceae, Rosaceae, *Salix*	
		**** Asteraceae, Brassicaceae, Caryophyllaceae, *Centaurea*, *Cistus*, *Fumana*, Geraniaceae, *Hedera helix*, Poaceae, Primulaceae, Ranunculaceae, Rubiaceae, *Salix*, *Sarcopoterium*, Unidentifiable	
17	Karaman- Ayrancı	* Scrophulariaceae	
	Kozlu plateau	** ----	42496
		*** *Cistus*, Fabaceae, Rosaceae, Rubiaceae	
		**** Asteraceae, Apiaceae, *Artemisia*, Boraginaceae, Brassicaceae, Caryophyllaceae,Dipsacaceae, *Eucalyptus*, *Juglans*, Lamiaceae, Liliaceae, *Linaria*, *Linum*,Poaceae, *Salix*, *Sarcopoterium*, *Veronica*	
18	Karaman-Ayrancı	* Scrophulariaceae	
	Üçharman	** ----	5462
		*** Fabaceae	
		**** Asteraceae, *Centaurea*, *Cistus*, *Convolvulus*, *Echium*, Lamiaceae, Primulaceae, *Ranunculus*, Rubiaceae, *Solanum*, Unidentifiable	
19	Ulukışla-Kılan	* ----	
		** *Cistus*, Fabaceae	13814
		*** Amaranthaceae, *Echium*, *Eucalyptus*, *Linaria*, Scrophulariacea	
		**** Apiaceae, Brassicaceae, Boraginaceae, *Campanula*, Cyperaceae, *Fraxinus*, *Linaria*, Myrtaceae, Lamiaceae, Poaceae, *Plantago*, Rosaceae, *Quercus*, *Salix*	

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Table 2. The percentage of pollen grains of plant taxa examined in 19 honey samples

Localities					Ereğli					
Samples /Taxa	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10
Ailanthus							0,63			
Amaranthaceae		10,81	32,9		1,54			1,41	0,22	
Artemisia										
Apiaceae			2,61		3,07	1,96				
Asteraceae	3,33	10,81	0,65			10,78	0,63		1,51	
Betula						3,92				
Brassicaceae		8,11	0,65			42,16		10,58		
Boraginaceae										
Campanula										
Caryophyllaceae								0,53		
Centaurea	8,33				11,54	1,96	2,19		0,22	
Cichorieae								0,71		
Cistus		5,41			6,15		1,25	1,59	5,41	3,69
Citrus								0,35		
Convolvulus										
Cyperaceae			2,61							
Dipsacaceae								2,82		
Echium			1,95	3,39		3,92	0,63	0,35		2,95
Erica						1,96			0,22	
Eucalyptus										
Euphorbia						5,88				
Fabaceae	31,67	5,41	1,3	37,29			3,13	22,4	2,92	14,76
Fraxinus										
Fumana								1,23		
Geraniaceae								1,41	0,22	
Hedera helix						1,96			0,22	
Helianthus annuus					8,46					
Juglans										
Lamiaceae			1,3				0,63	4,23	2,38	2,21
Linaria				16,95		1,96	28,84	28,57		21,77
Linum									0,22	
Liliaceae								2,12	0,22	
Malvaceae					1,54	1,96				
Mathiola						1,96				
Morus										
Myrtacaeae	3,33									
Papaver								1,06		
Pelargonium										
Pinus				3,39						
Plantago		5,41	10,75		3,07	1,96		4,23	0,22	0,74
Primulaceae										
Poaceae		21,62	23,79	3,39	2,31	1,96		1,41		0,74
Polygonaceae										0,74
Quercus										
Ranunculaceae	3,33									
Rosaceae	3,33	10,81	3,91		1,54	8,82	5,64	5,64	1,4	6,27
Rubiaceae							0,63			
Salix	10	10,81	3,26			1,96	2,51	0,35	0,22	6,27
Sarcopoterium				3,39	1,54			1,06	2,92	1,84
Scrophulariaceae	36,67	10,81	4,56	32,2	1,54	1,96	52,03	7,23	80,84	36,53
Smilax										
Solanum										
Veronica							0,63		0,22	1,48
Xanthium									0,43	
Zea mays			7,82		57,69	2,94				
Unidentifiable			1,95				0,63	0,7		
Total taxa	8	10	15	7	12	18	14	22	18	13
Pollen Sum	30	18,5	153,5	29,5	65	51	159,5	283,5	462	135,5

Table 2. Continued

Localities	Karapınar				Karaman				Ulukışla
Samples /Taxa	Sample 11	Sample 12	Sample 13	Sample 14	Sample 15	Sample 16	Sample 17	Sample 18	Sample 19
Ailanthus									
Amaranthaceae			0,88			0,42			3,9
Artemisia							0,79		
Apiaceae			3,02			0,1	2,78		1,73
Asteraceae	4,44		0,39	1,64	0,55	0,73	0,6	0,58	
Betula									
Brassicaceae		3,27	1,17		2,22	0,21	0,4		2,6
Boraginaceae			0,29	3,28		0,16	0,4		0,87
Campanula									0,87
Caryophyllaceae			0,29		0,55		0,79		
Centaurea	4,44		0,29		1,66	31,88		0,58	
Cichorieae						0,21			
Cistus	13,33		0,68	5,74	2,77	2,15	4,17	1,74	26,41
Citrus			0,88						
Convolvulus								0,58	
Cyperaceae			0,19			0,1			1,73
Dipsacaceae							1,19		
Echium			1,27	5,74				0,58	3,46
Erica			0,68						
Eucalyptus			17,92				0,4		11,26
Euphorbia						0,21			
Fabaceae	6,66	73,8	55,11	36,07	44,32	1	3,97	8,72	27,71
Fraxinus					0,55				0,87
Fumana					0,83				
Geraniaceae			0,19	3,28	1,11	0,21			
Hedera helix	4,44				0,55				
Helianthus annuus						53,75			
Juglans							0,4		
Lamiaceae	4,44	3,27	0,78	2,46	8,86	1	1,39	1,16	0,87
Linaria			2,53			0,52	2,38		4,33
Linum							0,4		
Liliaceae						1,05	0,4		
Malvaceae									
Mathiola						0,1			
Morus			0,19						
Myrtacaeae									1,3
Papaver									
Pelargonium		3,27							
Pinus									
Plantago			0,58	3,28		0,47			1,3
Primulaceae			0,19		1,66	1,26		1,16	
Poaceae	4,44		0,19	3,28	0,55	1,68	0,79		2,6
Polygonaceae			0,58						
Quercus			0,58						0,87
Ranunculaceae			0,19		1,66			0,58	
Rosaceae	17,77	3,28	0,68	5,74	4,16		3,37		2,6
Rubiaceae				3,28	2,77	0,16	8,53	0,58	
Salix	13,33		0,29	1,64	4,99		0,6		0,87
Sarcopoterium	8,88				0,55	0,21	1,59		
Scrophulariaceae	13,33	13,11	9,44	19,67	19,11	1,89	64,29	81,98	3,9
Smilax			0,19						
Solanum						0,1		0,58	
Veronica	4,44			3,28		0,42	0,4		
Xanthium									
Zea mays			0,29	1,64					
Unidentifiable					0,55			1,16	
Total taxa	12	6	29	15	20	25	22	13	20
Pollen Sum	22,5	30,5	513,5	61	180,5	953,5	252	172	115,5

DISCUSSION

Of the 19 honey samples investigated, pollen grains of 55 plant taxa were identified. The number of pollen grains were highest in samples 13 and 16 from Karaman regions, while the lowest was in samples 1, 4 and 12 from the Ereğli and Karaman regions respectively (Table 1).

Among the samples studied the total amount of pollen was the lowest in sample 2 while the total amount of pollen was the highest in sample 16 (Table 2). The pollen variety of plant taxa declined from the rare group to dominant group (Table 1).

Many researchers indicated that pollen grains in the dominant and secondary groups contribute to the formation of honey as they come from a nectar source (Doğan and Sorkun 2001; Kaya et al. 2005). The results of this study demonstrated that there was not a dominant group in all 11 honey samples (1 - 4, 6, 8, 10, 11, 14, 16, 19). Pollen grains of *Zea mays* (Poaceae) in sample 5 (Ereğli), the family of Scrophulariaceae in samples 7 and 9 (Ereğli), 17, 18 (Karaman), Fabaceae in samples 12, 13 (Karaman) and *Helianthus annuus* in sample 15 (Karaman) were the dominant groups. The secondary group of pollen was not seen in samples 5, 9 (Ereğli), 12, 17, and 18 (Karaman).

Pollen grains of secondary group consist of the family of Scrophulariaceae in samples 1 and 10 (Ereğli), 14 and 16 (Karaman); Poaceae in samples 2 and 3 (Ereğli); Amaranthaceae in sample 3 (Ereğli); Brassicaceae in sample 6 (Ereğli); *Linaria* in samples 7, 8 and 10 (Ereğli); Rosaceae in sample 11 (Konya); *Eucalyptus* in sample 13 (Karaman); *Centaurea* in sample 15 (Karaman) and *Cistus* in sample 19 (Ulukışla).

Sorkun et al. (1999) explained that plant taxa belonging to the families of Asteraceae, Fabaceae, Fagaceae, Myrtaceae, Malvaceae, Brassicaceae, Scrophulariaceae, Lamiaceae and Oleaceae are the main source of Turkish flower honey. In earlier studies, pollen analysis of 94 honey samples from Central Anatolian regions were studied by Sorkun and İnceoğlu (1984). They found that the pollen taxa of *Astragalus*, *Rubus*, *Lapsana communis*, *Brassica oleracea*, *Teucrium orientale*, *Peganum harmala*, *Consolida raveyi*, *Hedysarum*, *Centaurea triumfettii*, *Heliotropium suaveolens* were dominant.

Another study related to Konya region was conducted by Kaplan and İnceoğlu (2002). They described 63 pollen types in 24 honey samples from the Konya region. According to their results, *Trifolium*, *Achillea*, *Euphorbia*, *Marrubium*, *Helianthus annuus*, *Vicia*, *Lotus*, *Centaurea*, *Medicago* were the source of nectar, while *Papaver*, *Linum*, *Cistus*, *Quercus* and *Fraxinus* were the source of pollen in the investigated honey samples. According to their results, *Helianthus annuus* and plant taxa of Fabaceae e.g. *Medicago*, *Trifolium* were dominant pollen groups and Brassicaceae was a secondary pollen group. In the pollen analysis performed in the Mediterranean region of Turkey, pollen grains of plants belonging to the families Apiaceae, Asteraceae, Fabaceae and Rosaceae were found as widespread by Silici and Gökçeoğlu (2007).

Taşkın and İnce (2009) analysed pollens in 20 honey samples from Burdur region. Their results exhibited that the taxa of Apiaceae, *Pimpinella anisum*, *Anthriscus*, *Cardamine*, Compositae, *Centaurea*, Ericaceae and *Dianthus* were in dominant groups while the taxa of Brassicaceae, Fabaceae, *Crepis*, *Xeranthemum* and *Trifolium* were in secondary groups. Pollen grains belonging to the taxa of Fabaceae in honey samples were identified most frequent in the different region from Adapazarı, Komati (Çamlıhemşin), Giresun and Kars as it is in this study (Erdoğan et al. 2006; Demir 2012; Temizer et al. 2016; Çelemli et al. 2018).

The families of Asteraceae, Rosaceae, Poaceae, Brassicaceae, Lamiaceae and the genera of *Centaurea*, *Salix* and *Cistus* were generally common in minor and rare groups of pollen of plant taxa in honey samples (Table 1 and 2). The results of this study agree with their results. Bağcı and Tunç (2006) presented pollen grains belonging to 65 plant taxa in 21 honey samples from the Konya and Karaman provinces. Their results showed that the pollen of *Achillea*, *Astragalus*, *Onobrychis*, and *Trifolium* were dominant.

Pollen analysis of the honey samples revealed that the pollen grains in minor and rare groups contained various plant taxa. Lieux (1979) demonstrated that most of the taxa in the minor and trace groups were randomly mixed in the honey samples. The rare groups of pollen was recorded in samples 13 and 15 from the Karaman region. But five samples (1, 2, 4 11, 12) had no pollen from the

rare group. The minor group was not found only in one sample from the Karaman (15) region (Table 2). These results from the pollen analysis in honey samples are supported by the floristic composition of Niğde, Konya and Karaman regions (Karaömerlioğlu and Düzenli 2008; Ünal and Sağlam 2009).

TNP-10 values ranged from 332 to 42496. In regards to TNP-10 values, pollen grains were classified into Category I as 84,2% (332-17878), and Category II as 15,8% (25405-42496) (Table 1). Whereas the TPN values that were calculated between 400 and 12.400 in the 7 honey samples that were thought to be artificial, the 16 honey samples collected from different regions of Turkey by Başoğlu et al. (1996) was between 14.800 - 37.800. According to the study conducted by Kaplan and İnceoğlu (2002), 15 honey samples were considered to be poor, 7 samples were cnosidered to be normal, and 2 samples were considered to be very rich, in terms of pollen amount.

Bağcı and Tunç (2006) demonstrated that 11 samples were considered to be poor, 6 were considered to be normal, 11 samples were considered to be rich and 3 samples were considered to be very rich in terms of pollen in investigated honey samples. When compared to our results, the quantities of pollen were considered to be poor in 16 honey samples and this was similar to previous findings and 3 samples were considered to be normal. Similar to the results of our study, Temizer et al. (2016) classified 4 honey samples collected from the Giresun region and based on TPN - 10 value, 2 samples were classified in Group I (< 20000) while the other 2 samples were classified in Group 2 (20000-100000).

The findings of this study exhibited that the taxa of *Zea mays*, *Cistus*, Poaceae, Scrophulariaceae and Amaranthaceae can be considered as pollen sources, *Helianthus annuus* and Brassicaceae as nectar sources, and Fabaceae, Rosaceae, *Eucalyptus*, *Centaurea* as nectar and pollen sources that were visited by honeybees in the investigated area.

CONCLUSION

The findings of this study demonstrated that pollen grains of the family of Fabaceae, Rosaceae, the genera of *Eucalyptus* and *Centaurea* were in nectar and pollen sources for honey production, but 84.2% of the surveyed honey samples had a poor amount of pollen in 10 grams of honey that were sampled at different locations in the year of 2015. In this case, the following probabilities can be put forward: honeybees may not have collected pollen from certain plants due to unsuitable climatic conditions such as drought and excessive rainfall. The pollen content of honey may have been removed by filtration or if bees were fed with sugar syrup then this would dilute the amount of pollen in the sampled honey.

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