ABSTRACT

For pollen analysis, 19 honey samples were collected from different localities in Ereğli, Karapınar, Ayranći 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, Ayranći 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 içeren 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. Araştırmalı 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 değeri göre, araştırmalı bal örneklerinden 3’ü normal, diğerleri zayıf bulunmuştur. Araştırılın 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: Melissopalynoloji, TPS-10, Polen Analiz, Güney Anadolu Bölgesi, Türkiye
ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE

GENİŞLETİLMİŞ ÖZET

Amaç: Balanları, nektar ve polen toplamak amacıyla bulundukları bögedeki çiçekleri ziyaret ederler. Arıların polen kaynağı ise doğal flora oluşturmaktadır. Floradaki polen kaynağı olan bitki türlerinin çeşitliliği ve çiçeklenme sezonlarının uzunluğu dışılık göstermektedir (Baydar ve Gürel, 1998). Bala kalite veren etkenlerinden birisi de içeriğidir polen olup, balın hangi yöreye ait olduğunu tespit etmedesinde faýda sağlamaktadır. Balanın yapılış polen analizleri, balların isimlendirilmesi ve menşeinin belirlenmesinde buna bağlı olarak da pazarlanmasında oldukça önem kazanmıştır. Bu çalışma ile İç Anadolu bölgesinde Ereğlî, Karapınar (Konya), Ayancık (Karaman) ve Ulukışla (Niğde) ilçelerinin farklı lokalitelerindeki 19 bal ürünlerinden alınan örneklerin palinolojik yönden incelenerek, o yörelerde üretilen balların isimlendirilmesine yol açan olan nektar ve polen kaynağı olan bitkilerin tespiti amaçlanmıştır.

Gereç ve Yöntem: Bal örnekleri 2015 yılının Kasım ayında Ereğlî, Karaman, Karapınar ve Ulukışla bölgelerindeki ürünlerden temin edilmştir. Polen analizleri için preparatlar, Uluslararası Arı Araştırma Birliği tavsise ettiği (Louveaux ve ark. 1970) ve Doğan ve Sorkun (2002)’in geliştirildiği yöntemde göçümsesi sağlanmıştır. Örnekle, 3500 devirde 45 dakika santrifüj edildikten sonra tüplerin dibinde oluşan polen çökeltisi, bir miktar bazik fuksinli gliserin jelatin ile bulunanın 10 gram bal, 20 mL distille su ilave edilerek su banyosunda 45 C de bekleterek, balın su içinde çözünmesi sağlanmıştır. Örnekle, 3500 devirde 45 dakika santrifüj edildikten sonra tüplerin dibinde oluşan polen çökeltisi, bir miktar bazik fuksinli gliserin jelatin ile bulunanlarda daimi preparat hazırlanmıştır. Hazırlanan preparatlarda polenlerin hangi bitki taksonlarına ait oldukları belirlenmiş ve polenlerin sayımları yapılarak örneğin en fazla olduğu belirlenmiştir. Arı ve bitki türlerinin tespit edilmistir. 4 grupta incelenmiştir. Toplam polen Sayısının belirlenmesi için her bir bal örneğin bulunan tüplerde, sayısı bilinen Lycopodium spor tablosu ilave edilmiştir. TPS’na göre polener, 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 örnek Helenium annuus’ ve 5 numaralı örnek Zea mays polenleri dominant bulunmuştur. Sekonder polen grubunda ise Amaranthaceae, Brassicaceae, Fabaceae, Poaceae, Rosaceae, Scrophulariaceae, Centaurea, Cistus, Eucalyptus and Linaria taksonlarını tespit edilmiştir. Bitki takson çeşidi minör ve eser grupta oldukça fazla iken dominant ve sekonder gruba doğru azalma göstermektedir. Toplam polen sayısı 17 numaralı örnek ne fazla iken 10 numaralı örnek 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 oluşturulan bitki taksonlarını dominant ve sekonder gruptaki polenlerdir. Bu çalışmada aşırra araştırma sonuçları 2015 yılı için Ereğlî, Karapınar (Konya), Ayancık (Karaman) ve Ulukışla (Niğde) ilçelerinin farklı lokaliteleri ile gelen bal ürünlerinde alınan örneklerde 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 oluşturduğu, ancak polen miktarı açısından zayıf olduğunu ortaya koymuştur. Araştırılan ballardan er yağın bitki polenleri Astereaceae, Brassicaceae, Centaurea, Cistus, Echium, Fabaceae, Lamiaceae, Plantago, Poaceae, Rosaceae, Salix, Sarcopoterium ve Scrophulariaceae taksonlarına ait bulunmaktadır. İncelenen örneklerin 19’u da, sekonder ve minör grupta bitki taksonlarına ait polenler içeriğini için multifloral özellikleri bulunmaktadır.

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 length 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; Çakir 1990; Gemici 1991; Andreada 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, Çelemlı 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 locality 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, Karakükürtli 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 vegetation, consists of Gundelia tournefortii, Genista aecheri, Astragalus microcephalus, Astragalus gummiifer, Astragalus angustifolius subsp. angustifolius var. angustifolius, Acantholimon uliginum subsp. uliginum, Thymus sipyleus subsp. sipyleus var. sipyleus, Genista involucrata. The families of Asteraceae, Fabaceae, Lamiaceae, Brassicaceae and Caryophyllaceae have the most species in this area, respectively. Karaömerlioğlu and Düzenni (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 Association (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 atlases were used (Erdtmann 1954; Kapp et al. 2000; Avuğ, 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 Scrophulariaceae 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 Karapinar (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, 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 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 |
|------------------|------------------|-------------------------------------------------------------------------------|--------|
| Ereğli- Aziziye  | *-  | Fabaceae, Scrophulariaceae                                                   | 3234   |
|                  | **             | ** Asteraceae, Myrtaceae, Ranunculaceae, Rosaceae, Salix                      |        |
|                  | ***            | ****                           |        |
| 2 Ereğli- Bulgurluk 500m | *-  | Peaace, Echium, Pinus, Poaceae, Sarcopoterium                                | 5889   |
|                  | **             | ** Amaranthaceae, Asteraceae, Brassicaceae, Cistus, Fabaceae, Plantago, Rosaceae, Salix, Scrophulariaceae |        |
|                  | ***            | ****                           |        |
| 3 Ereğli- Bulgurluk 1000m | *-  | Plantago, Rosaceae, Salix, Scrophulariaceae, Zea mays                       | 29882  |
|                  | **             | ** Amaranthaceae, Poaceae,                                                 |        |
|                  | ***            | Plantago, Rosaceae, Salix, Scrophulariaceae, Zea mays                       |        |
|                  | ****           | ****                           |        |
| 4 Ereğli- Dedekoy | *-              | Fabaceae, Linaria, Scrophulariaceae                                         | 1087   |
|                  | **             | ** Echium, Linaria, Scrophulariaceae                                         |        |
|                  | ***            | ****                           |        |
| 5 Ereğli- Headquarters | *   | Zea mays                                                                       | 17878  |
|                  | **             | ** Aplacaee, Centaurea, Cistus, Helianthaus annius, Plantago                 |        |
|                  | ***            | ****                           |        |
| 6 Ereğli- Namik Kernal neighborhood | *-  | Brassicaceae                                                                   | 8585   |
|                  | **             | ** Amaranthaceae, Asteraceae, Brassicaceae, Echium, Euphorbia, Rosaceae     |        |
|                  | ***            | ** Echium, Asteraceae, Cistus, Hedera helix, Linaria, Malvae,                |        |
|                  | ****           | Mathiola, Poaceae, Sarcopoterium, Scrophulariaceae, Zea mays                 |        |
| 7 Ereğli- Tumlü   | *-              | Scrophulariaceae                                                              | 12512  |
|                  | **             | ** Linaria                                                                    |        |
|                  | ***            | Fabaceae, Rosaceae                                                            |        |
|                  | ****           | Amaranthaceae, Asteraceae, Centaurea, Cistus, Echium, Lamiaceae,              |        |
|                  | **             | Sarcopoterium, Unidentifiable                                                |        |
| 8 Ereğli- Ulumeşe village | *-  | Fabaceae, Linaria                                                             | 16253  |
|                  | **             | ** Amaranthaceae, Lamiaceae, Plantago, Rosaceae, Scrophulariaceae             |        |
|                  | ***            | ****                           |        |
| 9 Ereğli         | *-              | Scrophulariaceae                                                              | 2618   |
| Yellice village- 1700m | **         | ** Echium, Asteraceae, Centaurea, Erica, Geraniaceae,                          |        |
|                  | ***            | ****                           |        |
|                  | **             | Cistus, Fabaceae, Rosaceae                                                   |        |
|                  | ***            | Amaranthaceae, Asteraceae, Centaurea, Erica, Geraniaceae, Lamiaceae, Linum,   |        |
|                  | ****           | Plantago, Sarcopoterium, Veronica                                             |        |
| 10 Ereğli        | *-              | Linaria, Scrophulariaceae                                                     | 332    |
| Yellice village- 1100m | **         | ** 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**

| No. | Location        | Terrain    | Family                        | Species                          | Area |
|-----|-----------------|------------|-------------------------------|----------------------------------|------|
| 11  | Konya-Karaşılar | Böyükren   | Rosaceae                      | Asteraceae, Centaurea, Cactus, Hedera helix, Fabaceae, Lamiaceae, Poaceae, Sarcopoterium, Scrophulariaceae | 5578 |
| 12  | Karaman-Áyano 2800m | Fabaceae     | Brassicaceae, Lamiaceae, Pelargonium, Scrophulariaceae, Rosaceae | -- | 3177 |
| 13  | Karaman-Áyano, Berendi, 700m | Fabaceae | Eucalyptus                      | Scrophulariaceae
**** Amaranthaceae, Aipaceae, Asteraceae, Brassicaceae, Boraginaeae, Caryophyllaceae, Centaurea, Cactus, Citrus, Cyperaceae, Echium, Geranium, Lamiaceae, Linaria, Matthiola, Plantago, Poaceae, Primula, Rubiaceae, Sarcopoterium, Solanum, Scrophulariaceae, Veronica | 25405 |
| 14  | Karaman-Áyano, Berendi, 1000m | Fabaceae, Scrophulariaceae | Boraginaeae, Cactus, Echium, Geranium, Plantago, Poaceae, Rosaceae, Rubiaceae, Veronica | -- | 2805 |
| 15  | Karaman-Áyano Berendi 1400m | * Helenium annuus | Centaurea | Scrophulariaceae
**** Amaranthaceae, Aipaceae, Asteraceae, Brassicaceae, Boraginaeae, Caryophyllaceae, Centaurea, Cactus, Citrus, Cyperaceae, Echium, Geranium, Lamiaceae, Linaria, Matthiola, Plantago, Poaceae, Primula, Rubiaceae, Sarcopoterium, Solanum, Scrophulariaceae, Veronica | 8682 |
| 16  | Karaman-Áyano, Karaman Village | Fabaceae, Scrophulariaceae | -- | Scrophulariaceae
**** Asteraceae, Brassicaceae, Caryophyllaceae, Centaurea, Cactus, Echium, Geranium, Lamiaecae, Linaria, Liriope, Poaceae, Primula, Ranunculaceae, Rubiaceae, Solanum, Sarcopoterium, Unidentifiable | 3997 |
| 17  | Karaman-Áyano, Kozlu plateau | Scrophulariaceae | Cactus, Fabaceae, Rosaceae, Rubiaceae | -- | 42496 |
| 18  | Karaman-Áyano, Uğularman | Scrophulariaceae | -- | Scrophulariaceae
**** Asteraceae, Centaurea, Carius, Convolvulus, Echium, Lamiaecae, Primulaeae, Ranunculaceae, Rubiaceae, Solanum, Unidentifiable | 5462 |
| 19  | Uluğkla-Kilani | Scrophulariaceae | Cactus, Fabaceae | -- | 13814 |
Table 2. The percentage of pollen grains of plant taxa examined in 19 honey samples

| Localities | Samples /Taxa | Eregli | 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 |          |        |          |          |          |          |          |          |          |          |          |          |
| Centaurea  | 8,33          | 11,54  | 1,96     | 2,19     | 0,22     |          |          |          |          |          |          |          |
| Cichoraceae|               |        |          |          |          |          |          |          |          |          |          |          |
| Citrus     | 5,41          | 6,15   | 1,25     | 1,59     | 5,41     | 3,69     |          |          |          |          |          |          |
| Citrus     |               |        |          |          |          |          |          |          |          |          |          | 0,35     |
| Convulculus|               |        |          |          |          |          |          |          |          |          |          |          |
| Cyperaceae | 2,61          |        |          |          |          |          |          |          |          |          |          |          |
| Dipsacaceae| 1,95          | 3,39   | 3,92     | 0,63     | 0,35     | 2,95     |          |          |          |          |          |          |
| Echium     | 1,96          |        |          |          |          |          |          |          |          |          |          |          |
| Erica      |               |        |          |          |          |          |          |          |          |          |          | 0,22     |
| Eucalyptus |               |        |          |          |          |          |          |          |          |          |          |          |
| Euphorbia  |               |        |          |          |          |          |          |          |          |          |          |          |
| Fabaceae   | 31,67         | 5,41   | 1,3      | 37,29    | 3,13     | 22,4     | 2,92     | 14,76    |          |          |          |          |
| Fraxinus   |               |        |          |          |          |          |          |          |          |          |          |          |
| Fumana     |               |        |          |          |          |          |          |          |          |          |          | 1,23     |
| Geraniaceae|               |        |          |          |          |          |          |          |          |          |          | 1,41     |
| Hedera helix |            |        |          |          |          |          |          |          |          |          |          | 0,22     |
| Helanthus 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  | 1,54          | 1,96   |          |          |          |          |          |          |          |          |          |          |
| Mathiola   | 1,96          |        |          |          |          |          |          |          |          |          |          |          |
| Morus      |               |        |          |          |          |          |          |          |          |          |          |          |
| Myrtaceae  | 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      | 10,81         | 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   |               |        |          |          |          |          |          |          |          |          |          | 0,64     |
| Xanthium   |               |        |          |          |          |          |          |          |          |          |          | 0,43     |
| Zea mays   | 7,82          | 57,69  | 2,94     |          |          |          |          |          |          |          |          |          |
| Unidentifiable | 1,95 |              |          |          |          |          |          |          |          |          |          | 0,63     |
| 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 | Sample 11 | Sample 12 | Sample 13 | Sample 14 | Sample 15 | Sample 16 | Sample 17 | Sample 18 | Sample 19 |
|------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Ailanthus  |           |           |           |           |           |           |           |           |           |           |
| Amaranthaceae | 0,88     | 0,42     | 0,79     |           |           |           |           |           |           |           |
| Artemisia  | 3,02     | 0,1     | 2,78     |           |           |           |           |           |           |           |
| 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 |           |           |           |           |           |
| Comanula   |           |           |           |           |           |           |           |           |           | 0,87     |
| Caryophyllum | 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   |           |           |           |           |
| Convulvulus|           |           |           |           |           | 0,58   |           |           |           |           |
| Cyperaceae | 0,19     | 0,1     |           | 1,19    |           |           |           |           |           |           |
| Dipsacaceae|           |           |           |           |           | 0,87   |           |           |           |           |
| Echium     | 1,27     | 5,74    | 0,58     | 3,46    |           |           |           |           |           |           |
| Erica      | 0,68     |           |           | 11,26   |           |           |           |           |           |           |
| Eucalyptus | 17,92    | 0,21    |           |           |           | 0,4    |           |           |           |           |
| Euphorbia  |           |           |           |           |           | 0,83   |           |           |           |           |
| 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 |           |           |           |           |           |           |           |           |           |
| Juglons    |           |           |           | 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    |           |           |           |           |           |           |
| Malvaceae  |           |           |           |           |           |           |           |           |           |           |
| Mathiola   |           |           |           | 0,1     |           |           |           |           |           |           |
| Morus      | 0,19     |           |           |           |           |           |           |           |           |           |
| Myrtaceae  |           |           |           | 1,3     |           |           |           |           |           |           |
| Papaver    |           |           |           |           |           |           |           |           |           |           |
| Pelargonium| 3,27     |           |           |           |           |           |           |           |           |           |
| Pinus      |           |           |           |           |           |           |           |           | 1,3      |           |
| 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 |           |           |           |           | 0,87   |           |           |           |           |
| Queruus    | 0,58     |           |           | 0,87    |           |           |           |           |           |           |
| Ranunculaceae | 0,19 | 1,66 |           | 0,58    |           |           |           |           |           |           |
| Rosaceae   | 17,77    | 3,28   | 0,68    | 5,74    | 4,16    | 3,37   | 0,58    |           |           |           |
| Rubiaceae  | 13,33    | 0,29   | 1,64    | 4,99    | 0,6     | 0,87   |           |           |           |           |
| Salix      | 8,88     | 0,55   | 0,21    | 1,59    |           |           |           |           |           |           |
| Sarcopoterium | 3,28 | 2,77 | 0,16 | 8,53 | 0,58 |           |           |           |           |           |
| Scrophulariaceae | 13,33 | 13,11 | 0,44 | 19,67 | 19,11 | 1,89 | 64,29 | 81,98 | 3,9 |           |
| Smilax     | 0,19     |           |           | 0,58    |           |           |           |           |           |           |
| 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 19 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 (Ulükışla).

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, Teucrum 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 Adapazari, Komati (Çamlılıhemşin), 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
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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