In this study, 23 honey samples collected from South-Eastern Anatolia Region of Turkey were investigated to identify their botanical sources. According to the microscopic analysis results, pollen grains identified belong to the 24 taxa of 27 plant families.

As a result of melissopalinological analysis, 21 of the honey samples are characterized as multiflora and two of them are as uniflora (Myosotis honey). As the second step of the microscopic analysis, the total pollen number of in 10 grams honey (TPN10) of the samples were calculated and it was observed that the values were vary between 1 177 and 82 005.

Key words: South-Eastern Anatolia, Honey, Melissopalinology, TPN10
GENİŞLETİLMİŞ ÖZET

Giriş: Türkiye’nin gerek iklim özellikleri gerekse bitki çeşitliliği bakımından içerdiği yedi coğrafik bölgesi de arıcılık için oldukça yüksek potansiyele sahiptir. Gençlerin ve kadınlarımızın da bu konuda istihdamına yönelik çalışmalar ve teşvikler Türkiye’nin çeşitli bölgelerinde yapılmaktadır. Türkiye için önemli bir pazar olan arıcılık sektörü özellikle Doğu Anadolu Bölgesi’nde kırsal kalkınma için önemli bir iş koludur.

Türkiye’de üretilen ballar bitkisel içerik bakımından çok çeşitlilik göstermekle birlikte, bunlar arasında üçgül balı, narenciye balı, kestane balı, ormangülü balı, yayla balı ve salgı balları sayılabilir. Çoğu yöremizde kendine has ve ön plana çıkıyor ağaç türlerine sahip olan bal üretimi mevcuttur. Ancak ülkemizde bal üretimi genelde yöre bazında yapılmaktadır, Türkiye’nin farklı bölgelerinden toplanan ballar üzerinden gerçekleştirilen melissopalinolojik analizler ile tanımlanmadan fizikokimyasal analizlerine dayalı çalışmalar yapılmaktadır. Dolayısıyla tam bir karakteriçe etme gerçekleşirilememektedir.

Gereç ve yöntem: Bu çalışmamız ile daha önce detaylı olarak çalışılmamış olan Türkiye’nin Doğu Anadolu Bölgesi’nde bulunan Şırnak ili’ne ait 23 bal örnekine melissopalinolojik analiz uygulanmıştır.

Bulgular: Örnekler nitel açıdan incelendiğinde, analiz edilen 23 bal örneğinin bitkisel kökeni olarak çoğunlukla; Asteraceae, Apiaceae, Berberidaceae, Betulaceae, Boraginaceae, Brassicaceae, Campanulaceae, Caryophyllaceae, Caprifoliaceae, Chenopodiaceae, Cistaceae, Convolvulaceae, Fabaceae, Fagaceae, Geraniaceae, Lamiaceae, Liliaceae, Malvaceae, Plantaginaceae, Poaceae, Polygonaceae, Ranunculaceae, Rosaceae, Rubiaceae, Rutaceae ve Salicaceae familyalarına ait bitki taksonları tespit edilmiştir. Dominant oranda sadece Boraginaceae familyasına ait Myosotis sp. taksonuna ait polenlere rastlanmıştır. Apiaceae, Berberidaceae, Caryophyllaceae, Fabaceae, Lotus sp., Onobrychis sp., Plantago sp., Rosaceae ve Trifolium sp. taksonlarına ise bazı örneklerde sekonder oranlarda rastlanmıştır.

Nicel analiz kısmında ise; incelenen bal örneklerinin 10 gramında bulunan toplam polen miktarları hesaplanmış ve polence zenginlik düzeyleri gözlemlenmiştir. Bu değerlerin 1 177 ila 82 005 aralığında değişiklik gösterdiği tespit edilmiştir. En düşük değer Beytüşşebap ilçesinin Yeşilöz köyünden toplanan A16 örnekinde gözlemlenirken en yüksek değer ise aynı ilçenin Toptepe Köyü’nden toplanan A22 örnekinde gözlemlenmiştir.

Sonuç: Çalışma sonucunda yöre ballarının çoğunluğunun karışık çiçek balı olduğu, yani baskın olmak üzere çok sayıda farklı bitkiden kaynaklandığı gözlemlenmiştir. Örneklerden iki tanesinin ise Myosotis sp. olarak nitelendirilmesi tespit edilmiştir. Bu iki bal ise unifloral olarak nitelendirilmiştir. Myosotis balı olarak nitelendirilen A7 balı Beytüşşebap ilçesinin Taşkın Köyü’nden toplanmıştır, A8 örneği ise aynı ilçenin Beşabilir köyünden toplanmıştır.

Bu sonuçlar, Şırnak balları ile ilgili çalışmalara ilişkin niteliktedir ve yöreden elde edilebilecek Myosotis balları ile ülke pazara yeni bir ürün girdisi sağlayabileceğini düşünlütedir.

INTRODUCTION

Honey is described as “the sweet substance produced by honeybees from the nectar of blossoms or from secretions on living plants, which the bees collect, transform and store in honey combs” (Codex Alimentarius Commission, 2001). The content and quality of honey shows varieties according to the climatic conditions, the environmental temperature, the botanical source that bees prefer to collect nectar, honey bees species, harvesting and storage conditions (Alvarez-Suarez et al. 2010). Also its colour has a wide range of spectrum, including white, amber, red, brown and almost black (Ndife et al.,2014). The taste, smell and...
color of honey changes according to the nectar of flowers collected by bees. Its flavour and texture also vary owing to the botanical source (Alvarez-Suarez et al. 2010).

The most known biological activity of honey is its antimicrobial effect. Besides antimicrobial activity, honey has been found to contain significant biological activities, especially antioxidant activity (Bogdanov et al. 2008).

Melissopalynological analysis is a type of method that investigate the pollen grains and spores in honeys to determine the source of honey. It can give information about the botanical and geographical sources of the sample (Kaya et al. 2005). Microscopical analysis of honey is based on the fact that the raw materials of honey (nectar and honeydew) have certain constituents which remain identifiable in the ripe honey. For the nectar, these constituents are generally pollen grains from the plants producing the nectar. For the honeydew, these constituents are usually fungus spores and hyphae that come from the forest trees (Lieux 1972).

From the honey types, monofloral honeys, that are originated from dominantly one plant species, are most attractive compare to the multifloral honeys. It is possible to determine their origin from the dominant pollen grains by microscopic investigation. Besides this, multifloral honeys are originating from the nectar of several plant species (Barth 2004).

Studies in Turkey identified flowering plants containing nectar through pollen analysis in honey samples were started with Quistan (1976), the first research for the pollen analysis of Turkish honey. Sorkun and Yuluğ (1984), investigated the honey samples from Erzurum, Gür (1993), investigated Elazığ honey, Kaplan (1993), Konya honey, Türker; (1993) Gümüşhane honey, Silici (1995), Antalya honey, Yilmaz (1969), İzmit honey, Kemancı (1999), Marmaris honey, Mercan et al. (2007), honey samples from İzmir, Sivas Afyon and Muğla. Also Sorkun and Doğan (1995), Can et al. (2015) were investigated the honey samples from various regions of Turkey by melissopalyonlogical analysis.

By this study we aimed to determine botanical sources of some honey samples collected from Şırnak city located in South-Eastern Region of Turkey, by melissopalyonlogical analysis.

MATERIALS AND METHODS

23 honey samples were collected from Şırnak city which is located in South-Eastern Region of Turkey in 2017.

Seven of them were collected from the village Toptepe, seven from Yeşilöz, four from Akarsu village, one sample each from Beşağıç, Boğazören and Söğütçe villages and two samples from Uludere (Figure 1, Table 1).

Figure 1. The location of Şırnak city (This map prepared with ArcGIS pro 2.2)
Table 1. The collection areas of the honey samples

|   | Latitude | Longitude | City | Location-                     | Sample Numbers |
|---|----------|-----------|------|-------------------------------|----------------|
| 1 | 37.4652000 | 42.39     | Şırnak | Beytişşebap-Toptepe Village | A1, A11, A17, A19, A20, A22, A23, |
| 2 | 37.6980194 | 43.431    | Şırnak | Beytişşebap-Yeşilööz Village | A2, A4, A9, A14, A16, A18, A21, |
| 3 | 37.6338500 | 43.27     | Şırnak | Beytişşebap -Akarsu Village  | A3, A5, A7, A15, |
| 4 | 37.4679556 | 43.24     | Şırnak | Beytişşebap -Beşağıç Village | A8 |
| 5 | 37.5280833 | 43.00     | Şırnak | Beytişşebap –Boğazören Village | A6 |
| 6 | 37.5904278 | 43.23     | Şırnak | Beytişşebap Söğütçe          | A12 |
| 7 | 37.4269333 | 42.88     | Şırnak | Uludeere                     | A10, A13 |

Melissopalynological Analysis

Preparation of honey samples for qualitative and quantitative melissopalynological analysis was performed by Louveaux et al. (1978). Stock honey sample was well stirred and 10 grams of it was weighed in a centrifuge tube. Then 20 ml distilled water was added and to melt down the honey, tube was left for 10-15 minutes in a water bath of 45°C. The mixture was centrifuged in 3500 rpm for 45 minutes. After centrifugation, the supernatant was poured and from the residual sediment slides were prepared by using glycerine gelatine with basic fuchsin. Then the slides were investigated under the microscope. The classification of Zander (1935) was used in this study to indicate pollen and associated nectar source: dominant pollen (over 45%), secondary pollen (16-45%), minor pollen (1-15%); trace pollen (less than 1%).

The total pollen number in 10 grams honey (TPN10) of all samples was calculated according to the method described by Moar (1985). The honey samples (10g) were classified according to total pollen number (TPN10) as Group I: TPN<20000; Group II: 20000<TPN<100000; Group III: 100000<TPN<500000; Group IV: 500000<TPN<1000000 and Group V: TPN>1000000 (Maurizio 1975).

RESULTS

According to the microscopic analysis results, pollen grains were identified belong to the taxa of Asteraceae, Apiaceae, Berberidaceae, Betulaceae, Boraginaceae, Brassicaceae, Campanulaceae, Caryophyllaceae, Caprifoliaceae, Chenopodiaceae, Cistaceae, Convolvulaceae, Dipsaceae, Fabaceae, Fagaceae, Geraniaceae, Lamiaceae, Liliaeae, Malvaceae, Plantaginaceae, Polygonaceae, Ranunculaceae, Rosaceae, Rubiaceae, Rutaceae, Salicaceae. The microscopic analysis results of the honey samples are given in Table 2. With regard to Zander’s classification; pollen grains belong to the Berberis sp., Onobrychis sp., Trifolium, Plantago taxa and Apiaceae, Caryophyllaceae, Fabaceae, Rosaceae families were found in secondary ratios. Besides this only pollen of Myosotis sp. was found in dominant ratio in investigated two samples with high ratios (72.77%-80.63%) owing to higher pollen producing potential of Myosotis (A7, A8) (Fig. 2,3,4).

The TPN10 values are vary between 1 177 and 82 005. According to the Moar (1985): 9 of 23 samples are included in group II, 14 of total are in group I (Table 2).
### Table 2. Microscopic analysis results of honey samples (for samples A1-11) (D> 45%, S:16-45%, M:1-15%, T<1%).

| Plant Family      | Plant taxa                        | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 |
|-------------------|-----------------------------------|----|----|----|----|----|----|----|----|----|-----|-----|
| Asteraceae        |                                   |    |    |    |    |    |    |    |    |    |     |     |
|                   | Centaurea sp.                     | M  | M  | M  |    |    |    |    |    |    |     |     |
|                   | Taraxacum sp.                    | M  | T  |    |    |    |    |    |    |    |     |     |
| Apiaceae          |                                   |    |    |    |    |    |    |    |    |    |     |     |
|                   | Daucus sp.                        | T  |    |    |    |    |    |    |    |    |     |     |
| Berberidaceae     |                                   |    |    |    |    |    |    |    |    |    |     |     |
|                   |                                   |    |    |    |    |    |    |    |    |    |     |     |
| Boraginaceae      |                                   |    |    |    |    |    |    |    |    |    |     |     |
|                   | Centrinthe sp.                   |    |    |    |    |    |    |    |    |    | M   | T   |
|                   | Helianthopium sp.               |    |    |    |    |    |    |    |    |    | T   |     |
|                   | Myosotis sp.                     |    |    |    |    |    |    |    |    |    | M   | D   |
| Brassicaceae      |                                   |    |    |    |    |    |    |    |    |    | M   | T   |
|                   | Vicia sp.                        |    |    |    |    |    |    |    |    |    | M   |     |
| Campanulaceae     |                                   |    |    |    |    |    |    |    |    |    | M   | T   |
| Caryophyllaceae   |                                   |    |    |    |    |    |    |    |    |    | M   | T   |
| Caprifoliaceae    | Scabiosa sp.                     | T  | T  |    |    |    |    |    |    |    |     |     |
| Cistaceae         |                                   |    |    |    |    |    |    |    |    |    | T   |    |
| Fabaceae          |                                   |    |    |    |    |    |    |    |    |    | S   | M   |
|                   | Astragalus sp.                   |    |    |    |    |    |    |    |    |    | M   | T   |
|                   | Trifolium sp.                    |    |    |    |    |    |    |    |    |    | M   | S   |
|                   | T. pratense                      |    |    |    |    |    |    |    |    |    |     |     |
|                   | Castanea sativa                  |    |    |    |    |    |    |    |    |    | T   |     |
| Fagaceae          |                                   |    |    |    |    |    |    |    |    |    | T   | T   |
| Geraniaceae       |                                   |    |    |    |    |    |    |    |    |    |     |     |
| Lamiaceae         |                                   |    |    |    |    |    |    |    |    |    | M   | T   |
|                   | Teucrium sp.                     |    |    |    |    |    |    |    |    |    |     | T   |
| Liliaceae         |                                   |    |    |    |    |    |    |    |    |    | M   |     |
| Malvaceae         |                                   |    |    |    |    |    |    |    |    |    | M   |     |
| Plantaginaceae    |                                   |    |    |    |    |    |    |    |    |    |     |     |
| Poaceae           |                                   |    |    |    |    |    |    |    |    |    | M   | T   |
| Polygonaceae      |                                   |    |    |    |    |    |    |    |    |    | M   | M   |
| Ranunculaceae     |                                   |    |    |    |    |    |    |    |    |    | M   | M   |
| Rosaceae          |                                   |    |    |    |    |    |    |    |    |    | M   | S   |
|                   | Sanguisorba sp.                  |    |    |    |    |    |    |    |    |    |     | M   |
### TPN 10 values

|          |   |   |   |   |   |   |   |   |   |
|----------|---|---|---|---|---|---|---|---|---|
|          | 27 | 009 | 21 | 985 | 15 | 713 | 96 | 663 | 12 | 410 | 21 | 244 | 14 | 890 | 12 | 539 | 63 | 22 | 21 | 133 | 38 | 664 |

### Plant Family

| Plant Family | Plant Taxa | A12 | A13 | A14 | A15 | A16 | A17 | A18 | A19 | A20 | A21 | A22 | A23 |
|--------------|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Rubiaceae    |            |     |     |     |     |     |     |     |     |     |     |     |     |
|              |            |     |     |     |     |     |     |     |     |     |     |     |     |
| Salicaceae   |            |     |     |     |     |     |     |     |     |     |     |     |     |
|              |            |     |     |     |     |     |     |     |     |     |     |     |     |
| TPN 10 values|            |     |     |     |     |     |     |     |     |     |     |     |     |

### Plant Taxa

| Plant Family | Plant Taxa | A12 | A13 | A14 | A15 | A16 | A17 | A18 | A19 | A20 | A21 | A22 | A23 |
|--------------|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Asteraceae   |            | M   | M   | M   | M   | M   | M   | M   | M   | M   |     |     |     |
|              | Centaurea sp. |     |     |     |     |     |     |     |     |     |     |     |     |
|              | Taraxacum sp. |     |     |     |     |     |     |     |     |     |     |     |     |
| Apiaceae     |            | M   | S   | M   | M   | M   | M   | T   | M   |     |     |     |     |
|              | Daucus sp.  |     |     |     |     |     |     |     |     |     |     |     |     |
| Berberidaceae|            | S   | M   | M   | M   | M   |     |     |     |     |     |     |     |
| Betulaceae   |            |   |     |     |     |     |     |     |     |     |     |     |     |
| Boraginaceae |            | M   | M   |     |     |     |     |     |     |     |     |     |     |
|              | Alkanna sp. |     |     |     |     |     |     |     |     |     |     |     |     |
|              | Echium sp.  | T   | T   |     |     |     |     |     |     |     |     |     |     |
|              | Cerinthe sp. | T |     |     |     |     |     |     |     |     |     |     |     |
|              | Heliotropium sp. |     |     |     |     |     |     |     |     |     |     |     | M   |
|              | Myosotis sp. |     |     |     |     |     |     |     |     |     | T   |     |     |
| Brassicaceae |            |     |     |     |     |     |     |     |     |     |     |     |     |
|              |            |     |     |     |     |     |     |     |     |     |     |     |     |
| Campanulaceae|            | M   | T   |     |     |     |     |     |     |     |     |     |     |
| Caryophyllaceae |        |   |     |     |     |     |     |     |     |     |     |     |     |
| Caprifoliaceae|            | S   | T   |     |     |     |     |     |     |     |     |     |     |
|              | Scabiosa sp. |     |     |     |     |     |     |     |     |     |     |     |     |
| Chenopodiaceae|           | M   |     |     |     |     |     |     |     |     |     |     |     |
| Cistaceae    |            |     |     |     |     |     |     |     |     |     |     |     |     |
| Convolvulaceae|           | M   |     |     |     |     |     |     |     |     |     |     |     |
| Geraniaceae  |            | M   |     |     |     |     |     |     |     |     |     |     |     |
| Dipsacaceae  |            |     |     |     |     |     |     |     |     |     |     |     |     |
| Fabaceae     |            | M   | M   | M   | M   | S   | S   | S   | S   | S   | S   | S   | S   |
|              | Astragalus sp. |     |     |     |     |     |     |     |     |     |     |     |     |
|              | Vicia sp.    |     |     |     |     |     |     |     |     |     |     |     |     |
|              | Lathyrus sp  |     |     |     |     |     |     |     |     |     |     |     |     |
|              | Lotus sp.    | M   | T   | M   | M   | S   | M   | M   | M   |     |     |     |     |
|              | Medicago sp. |     |     |     |     |     |     |     |     |     |     |     |     |
|              | Onobrychis sp.|     |     |     |     |     |     |     |     |     |     |     |     |
|              | Trifolium sp.| M   | M   | M   | M   | M   | M   | M   | M   |     |     |     |     |
|              | T. pratense  |     |     |     |     |     |     |     |     |     |     |     |     |

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### Table 1: Pollen Morphology and TPN 10 Values

| Family       | Genus     | Morphology | TPN  10 values |
|--------------|-----------|------------|----------------|
| Lamiaceae    | Teucrium sp. | M M T T M M M | 2071 3314 55833 17972 1177 5029 3945 7000 48330 61411 82005 39168 |
| Liliaceae    | Plantago sp. | T T M M M M M |               |
| Plantaginaceae | Rumex sp. | T M M M M |               |
| Poaceae      | Plantago sp. | T T M M M M |               |
| Polygonaceae | Galium sp. | T T M M M M |               |
| Ranunculaceae | Rumex sp. | T M M |               |
| Rosaceae     | Salix sp. | M M T T T |               |

#### Figure 2. Microphotograph of *Trifolium* sp. pollen grain (X400)

#### Figure 3. Microphotograph of *Berberis* sp. pollen grain (X400)
DISCUSSION

Turkey has a rich flora and suitable climatic conditions for beekeeping and producing high quality bee products. Especially the Eastern parts of Turkey exhibits a high diversity of plant species. Owing to plant species richness of the country, honeys produced in Turkey have really high quality that represent so many nectar source in it.

As a result of melissopalynological analysis, only two of the investigated of 23 honey samples were found as unifloral that is sourced dominantly from *Myosotis* nectar. The other 21 samples were evaluated as multifloral honey that are mostly sourced from nectar of *Berberis* sp., *Onobrychis* sp., *Trifolium* sp., *Plantago* sp., Apiaceae, Caryophyllaceae, Fabaceae, Rosaceae plant taxa.

According to the previous studies, it is the first investigation about botanical origin of honey which are produced in Şırnak. We observed that there is no any detailed information about botanical source of honey samples of Şırnak city. Generally the researches are about the different locations of Turkey.

There are so many researches about Turkish honey (Yılmaz and Yavuz, 1999; Küçük et al., 2007; Cengiz et al., 2018) but they are mostly based on physicochemical analysis and not comprise a specific location as we done.

Can et al. (2015) analyzed melissopalynological and physico-chemical properties of sixty-two honey samples from the regions of Aegean, Marmaraean and Black Sea of Turkey. They found 11 unifloral honeys (chestnut, heather, chaste tree, rhododendron, common eryngo, lavender, Jerusalem tea, astragalus, clover, acacia), two different honeydew honeys (lime and oak), and 7 different multifloral honeys. The samples of their study showed that physico-chemical and biological characteristics of honeys are closely related to floral sources, and dark colored honeys evaluated as oak, chesnut and heather, having high therapeutic potential.

Kaya et al., 2005 investigated the 13 floral honeys from various regions of Turkey (Kırklareli, Marmaris, Manisa, Yozgat, Çankırı, Bolu, Balıkesir, Aydın, Bartın, Elazığ, Tekirdağ, Rize ). They found one unifloral honey and 12 multifloral honeys. Pollen have been identified belonging to the 86 taxa. The dominant group of pollen grains consisted of: *Hedera helix, Gossypium, Trifolium, Sophora, Rhododendron, Castanea sativa, Peganum harmala* and *Helianthus*.

Mercan et al. (2007) investigated the honey samples from İzmir, Sivas, Muğla and found Chenopodiaceae pollen grains as dominant in İzmir, *Anthemis, Papaver, Rumex, Trigonella, Onopordum, Umbelliferae* in Sivas, *Erica, Centaurea, Chenopodiaceae, Amaranthaceae, Helianthus annus* in Ayfon, *Erica, Umbelliferae* in Muğla.

Yılmaz and Küfrevioğlu (2001) investigated honey samples from South-Eastern Anatolia but they studied chemical properties of the samples. They don’t give any information about the botanical sources of honey from this region.

Çam et al. (2010) investigated, 30 honey samples from Ankara city markets. They identified pollen grains belong to the 46 taxa. The pollen grains of Fabaceae, Aceraceae, Boraginaceae, Poaceae, Asteraceae, Apiaceae, Caryophyllaceae, Rosaceae,
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