V. ECOLOGICAL AND SUSTAINABLE AGRICULTURE

POLLEN GIVING PLANTS VISITED BY THE HONEY BEE (*APIS MELLIFERA* L.)

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Abstract: The analysis of the honey plants in the area of apiculture is very important about the development, reproduction and productivity of bee colonies. The knowledge of the floral specialization of *Apis mellifera* L. is main point for good beekeeping practices. The bees have visited 46 species of honey plants from 41 genera and 22 families. The honey bees prefer to collect pollen from 2 to 5-6 plant species during every single month. Bees mainly collect pollen from two or three plants every month. The agricultural species *Brassica napus* as well as the meadow flora – *Centaurea solstitialis* and *Centaurea cyanus* are the most visited honey plants during their flowering. Bees prefer to collect pollen from 16 plants out of 46 visited taxons. Not all plants in the area serve as a source of pollen for the bees. The greatest amount of collected pollen comes from *Brassica napus* – 3798.69 g. The visited cultivated honey taxons are around 22 % but about 56.5 % of the total amount collected pollen. Around 78 % of the visited plants are common natural as well as about 43.5 % of the total amount collected pollen.

Key words: honey bee, honey plants, pollen, pollen traps, melissopalynologia, specialization

INTRODUCTION

Plants provide pollen rich of protein and play major role for the development, reproduction and productivity of the honey bee [1-3]. The knowledge of the honey plants is of great importance for planning and organize the beekeeping activities in accordance with the seasonal dynamics of the honey resources in a given region [4]. Research clearly shows the variability in the behavior of honey bees in the selection of flora, which in turn is determined by the disturbed natural balance in nature as a result of human influence (afforestation, felling, monoculture, mechanization, early mowing of a number of crops, pesticide use, etc.); seasons, and even the ratio of plant species flowering in a certain period and the genetic potential of honey bee colonies and their needs [5, 6].

In a research on urban condition, over 40 % of the collected pollen comes/ originates from native flora [7]. The cultivated agricultural lands could be improved as a source of nectar and pollen for bees, by maintaining the biodiversity of plants in field margins and uncultivated areas [8, 9]. The grass mixes of blossoming plants for attracting pollinators may be composed of the following plant species: white mustard, phacelia, coriander, alfalfa, wild oats, crimson, Egyptian and white clover [10].

Every honey bee colony in the apiary has its favourite plants, from which it mainly collects pollen [11]. The purple colour in the grass mix is provided by Phacelia and mostly attracts honey bees [12]. Not all plants in the same area serve as a source of pollen for bees [13]. The results of other researchers have established that the bulk of a colony's pollen usually comes from a relatively small number of plant species [14-18].

The purpose of the study was to investigate the visited pollen giving plants by the honey bee (*Apis mellifera* L.) and to determine the most visited.

MATERIALS AND METHODS

Pollen traps were placed in five bee hives and the pollen was harvested every 2 days from April until September 2014 in the area of Belozem (42.201860, 25.049330), Bulgaria. The pollen loads from each hive were analysed carefully. Four hundred and fifty samples of bee-collected pollen were separated with pincette over white sheets, according to colour, shape and texture.

The plant species of each pollen sample was identified through microscopic examination of the grains and weighed on an analytical scale. Melissopalynological analysis was carried out using methodology [19]. Each identified pollen sample was placed on a slide with a drop of isoglucose and added fuchsin. The slides were then dried at a temperature not exceeding 40°C and fixed with Entelan™ (Entelan Microscopy, Karlsruhe, Germany). To identify the pollen, the database of the laboratory of Apiculture-Sericulture of the Agricultural school of Aristotle University in Thessaloniki, Greece, and a personally created database of the plants from the study area have been used for reference.

The data for the climatic characteristics of Belozem area for 2014 was taken from the National Institute of Meteorology and Hydrology.

RESULTS AND DISCUSSION

The analysis give that, the bees have visited 46 species of honey plants from 41 genera and 22 families. Floral analyses of the collected pollen indicate that, the honey bees preferred to collect

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pollen from 2 to 5-6 plants during each month, while the rest of the flora is less preferable (Tables 1-6). Studies carried out by other researches shows that bees collect pollen primarily from 5-6 species of plants when there are more than 41 flowering species [20, 21]. Importantly, bees mainly collect pollen from two or three plant species every month.

It is made a list of the most visited plant species during the year (Fig. 1). The use of pollen traps gives precise results about visited and pollen-giving plants [22, 23]. As a result of the research, it can be concluded that bees prefer to collect pollen from 16 honey plants out of 46 visited taxa.

Table 1. Amount collected and identified pollen (g) in April 2014

	Amount collected and identified pollen of each bee colony (g)					Total amount of the collected and identified pollen from the bees (g)
Bee colony (№) →	№1	№2	№3	№4	№5	
Plant species						
<i>Brassica napus</i>	495.58	376.72	660.32	300.20	882.60	2715.42
<i>Salix</i> sp.	52.65	52.05	23.87	33.53	59.44	221.54
<i>Pyrus malus</i>	54.57	9.82	15.87	9.47	46.24	135.97
<i>Prunus cerasifera</i>	32.53	23.2	18.46	10.98	30.33	115.50
<i>Brassica nigra</i>	20.31	37.17	16.89	15.73	8.59	98.69
<i>Juglans regia</i>	14.01	0.50	0.27	1.48	0.19	16.45
<i>Morus nigra</i>	2.39	0.67	2.14	7.15	2.72	15.07
<i>Cornus sanguinea</i>	6.25	2.63	0.8	2.68	1.85	14.21
<i>Persica vulgaris</i>	3.19	1.36	2.68	2.70	1.14	11.07
<i>Taraxacum officinale</i>	1.91	0.36	1.21	1.35	1.29	6.12
<i>Lamium purpureum</i>	0.22	0.79	2.65	0.72	0.24	4.62
<i>Veronica longifolia</i>	0.37	0.07	0.31	-	-	0.75

Table 2. Amount collected and identified pollen (g) in May 2014

	Amount collected and identified pollen of each bee colony (g)					Total amount of the collected and identified pollen from the bees (g)
Bee colony (№) →	№1	№2	№3	№4	№5	
Plant species						
<i>Brassica napus</i>	188.57	88.09	418.21	68.91	221.56	985.34
<i>Papaver rhoeas</i>	68.24	21.93	80.50	67.26	262.73	500.66
<i>Centaurea cyanus</i>	111.21	45.67	106.55	26.45	2.83	292.71
<i>Amorpha fruticosa</i>	6.99	18.45	18.41	19.24	17.77	80.86
<i>Trifolium dalmaticum</i>	5.59	14.12	11.40	11.70	6.80	49.61
<i>Vicia</i> sp.	9.22	4.83	9.80	5.32	13.87	43.04
<i>Robinia pseudoacacia</i>	4.08	8.90	3.50	1.14	3.97	21.59
<i>Trifolium repens</i>	0.39	1.22	7.26	0.04	0.05	8.96
<i>Brassica nigra</i>	0.51	1.45	1.18	0.19	0.49	3.82
<i>Convolvulus arvensis</i>	0.29	1.60	0.95	0.18	0.44	3.46
<i>Pyrus malus</i>	0.12	1.49	0.40	0.57	0.34	2.92
<i>Salix</i> sp.	0.25	0.06	0.73	0.05	0.24	1.33
<i>Plantago</i> sp.	0.28	0.14	0.31	-	0.40	1.13
<i>Ranunculus</i> sp.	0.17	0.06	0.26	0.26	0.26	1.01

Table 3. Amount collected and identified pollen (g) in June 2014

	Amount collected and identified pollen of each bee colony (g)					Total amount of the collected and identified pollen from the bees (g)
Bee colony (№) →	№1	№2	№3	№4	№5	
Plant species						
<i>Centaurea cyanus</i>	93.94	66.93	203.58	51.35	32.90	448.70
<i>Papaver rhoeas</i>	35.45	1.89	54.73	19.21	82.95	194.23
<i>Trifolium dalmaticum</i>	33.68	20.25	26.35	13.95	18.20	112.43
<i>Vicia</i> sp.	9.71	8.30	15.34	6.79	5.76	45.90
<i>Helianthus annuus</i>	7.32	9.18	3.28	12.50	5.98	38.26
<i>Brassica napus</i>	4.53	10.2	15.10	0.39	0.83	31.05
<i>Cirsium</i> sp.	13.59	1.55	7.60	1.45	5.17	29.36
<i>Plantago</i> sp.	8.00	10.59	4.12	0.50	2.88	26.09
<i>Melilotus officinalis</i>	1.15	3.52	1.67	0.56	1.85	8.75
<i>Amorfa fruticosa</i>	0.09	2.49	2.26	0.24	0.59	5.67
<i>Carduus</i> sp.	0.18	1.17	0.43	0.14	0.33	2.25
<i>Coriandrium sativum</i>	0.94	0.61	-	-	0.35	1.90
<i>Trifolium repens</i>	1.46	0.08	0.27	0.07	-	1.88
<i>Tilia</i> sp.	0.10	0.16	0.10	0.18	0.64	1.18
<i>Crepis</i> sp.	0.07	0.10	0.42	-	0.08	0.67
<i>Cucumis melo</i>	0.47	-	-	-	-	0.47
<i>Verbascum</i> sp.	0.24	0.04	-	-	-	0.28
<i>Convolvulus arvensis</i>	0.09	-	0.14	-	-	0.23
<i>Zea mays</i>	-	-	-	0.13	-	0.13

Table 4. Amount collected and identified pollen (g) in July 2014

	Amount collected and identified pollen of each bee colony (g)					Total amount of the collected and identified pollen from the bees (g)
Bee colony (№) →	№1	№2	№3	№4	№5	
Plant species						
<i>Centaurea solstitialis</i>	52.77	24.85	77.5	107.91	59.23	322.26
<i>Helianthus annuus</i>	5.24	6.55	5.77	14.72	26.33	58.61
<i>Plantago</i> sp.	10.19	8.37	7.40	9.66	19.21	54.83
<i>Trifolium dalmaticum</i>	6.85	3.74	10.51	6.48	4.33	31.91
<i>Cirsium</i> sp.	1.03	2.38	11.70	3.38	4.62	23.11
<i>Brassica napus</i>	2.03	5.58	9.53	2.55	3.23	22.92
<i>Convolvulus arvensis</i>	2.61	0.55	0.23	8.84	5.34	17.57
<i>Citrullus lanatus</i>	0.05	0.48	1.74	14.10	-	16.37
<i>Centaurea cyanus</i>	1.72	1.16	3.55	0.07	0.13	6.63
<i>Echinops ritro</i>	1.41	0.14	0.33	1.41	0.37	3.66
<i>Zea mays</i>	0.52	0.38	0.06	1.80	0.74	3.50
<i>Vicia</i> sp.	0.08	0.79	0.06	0.74	1.28	2.95

<i>Cichorium intybus</i>	-	0.03	0.10	1.83	0.67	2.63
<i>Carduus</i> sp.	0.12	0.19	0.45	0.78	0.33	1.87
<i>Verbascum</i> sp.	0.83	0.12	0.22	0.35	0.14	1.66
<i>Melilotus officinalis</i>	-	0.30	0.26	0.67	-	1.23
<i>Crepis</i> sp.	0.04	0.54	0.05	0.26	0.10	0.99
<i>Portulaca grandiflora</i>	0.62	0.06	-	0.19	-	0.87
<i>Centaurea</i> sp.	-	-	0.16	0.13	0.29	0.58
<i>Centaurea calcitrapa</i>	0.04	0.02	-	0.44	0.06	0.56
<i>Papaver rhoeas</i>	0.25	0.12	0.16	-	-	0.53
<i>Cucumis melo</i>	0.06	0.10	0.02	0.15	0.03	0.36
<i>Eryngium campestre</i>	-	-	-	-	0.27	0.27

Table 5. Amount collected and identified pollent (g) in August 2014

	Amount collected and identified pollen of each bee colony (g)					Total amount of the collected and identified pollen from the bees (g)
Bee colony (№) →	№1	№2	№3	№4	№5	
Plant species						
<i>Centaurea solstitialis</i>	41.60	4.62	20.76	39.73	25.44	132.15
<i>Cirsium</i> sp.	1.19	2.87	0.04	26.19	17.82	48.11
<i>Ehinops ritro</i>	0.48	1.83	0.15	6.72	15.98	25.16
<i>Carduus</i> sp.	1.13	1.22	2.84	0.48	3.75	9.42
<i>Centaurea calcitrapa</i>	2.08	0.22	0.10	2.05	2.10	6.55
<i>Chenopodium</i> sp.	2.14	0.09	0.12	0.62	2.59	5.56
<i>Plantago</i> sp.	2.23	0.61	0.61	0.09	1.38	4.92
<i>Portulaca grandiflora</i>	0.55	0.56	-	1.36	0.25	2.72
<i>Dipsacus</i> sp.	0.13	0.21	0.21	0.23	1.29	2.07
<i>Brassica napus</i>	0.52	-	0.08	0.75	0.36	1.71
<i>Atriplex patula</i>	-	0.17	0.35	0.53	0.22	1.27
<i>Chondrilla juncea</i>	0.48	0.28	0.12	0.18	0.21	1.27
<i>Centaurea</i> sp.	0.06	0.14	0.42	0.06	0.07	0.75
<i>Vicia</i> sp.	0.27	0.07	0.06	-	0.20	0.60
<i>Cichorium intybus</i>	0.19	0.12	0.06	0.05	-	0.42
<i>Convolvulus arvensis</i>	-	-	0.32	0.09	-	0.41
<i>Trifolium dalmaticum</i>	0.07	0.11	0.05	-	0.14	0.37
<i>Melilotus officinalis</i>	0.05	-	-	0.15	0.06	0.26
<i>Cucumis melo</i>	-	0.02	0.11	0.02	0.03	0.18
<i>Eryngium campestre</i>	-	-	-	-	0.17	0.17
<i>Centaurea cyanus</i>	-	-	0.14	-	-	0.14
<i>Lythrum salicaria</i>	0.05	-	0.06	0.03	-	0.14
<i>Zea mays</i>	0.04	-	-	-	-	0.04

Table 6. Amount collected and identified pollen (g) in September 2014

	Amount collected and identified pollen of each bee colony (g)					Total amount of the collected and identified pollen from the bees (g)
Bee colony (№) →	№1	№2	№3	№4	№5	
Plant species						
<i>Brassica napus</i>	1.76	2.25	-	35.88	2.36	42.25
<i>Dipsacus</i> sp.	3.77	-	-	0.60	11.96	16.33
<i>Chondrilla juncea</i>	0.33	0.02	3.20	2.91	0.34	6.80
<i>Cirsium</i> sp.	0.67	3.01	0.08	1.39	1.46	6.61
<i>Zea mays</i>	-	0.93	0.48	5.12	-	6.53
<i>Carduus</i> sp.	0.69		3.84	0.07	0.47	5.07
<i>Chenopodium</i> sp.	0.16	0.12	2.24	0.47	0.26	3.25
<i>Centaurea calcitrapa</i>	0.31	0.20	0.85	0.88	0.77	3.01
<i>Cucumis sativus</i>	0.09	0.06	0.10	1.01	0.63	1.89
<i>Centaurea solstitialis</i>	0.69	-	0.45	0.29	0.03	1.46
<i>Portulaca grandiflora</i>	-	0.10	0.04	1.07	0.13	1.34
<i>Ehinops ritro</i>	0.08	0.18	0.03	0.52	0.34	1.15
<i>Centaurea</i> sp.	0.45	-	0.10	0.07	-	0.62
<i>Cichorium intybus</i>	-	-	0.25	0.12	0.15	0.52
<i>Verbascum</i> sp.	0.07	-	0.19	-	0.19	0.45
<i>Convolvulus arvensis</i>	0.07	-	0.22	0.06	-	0.35
<i>Plantago</i> sp.	-	-	0.19	-	0.05	0.24
<i>Atriplex patula</i>	-	-		0.20	-	0.20

The result coincides with previous research on urban environment in the village of Saedinenie (Bulgaria), found the same distribution [24]. In the village of Topchii (Bulgaria) was established that 85% of the visited taxons were natural and 15% were cultivated [9]. The highest number of honey species is represented by the family *Asteraceae* (12 species) followed by *Fabaceae* (6 species). Other researchers also establish the family *Asteraceae* as the one with the highest number of visited taxons [7-9, 24]. The native trees, weed and meadow flora 78 % of the visited taxons provide a great diversity of pollen with different nutritive value, needed for the normal development of the bee colonies. This shows the need for the existence and preservation of uncultivated plants as a source of food for bees [7].

The agricultural species *Brassica napus* (Fig. 1/ Tables 1, 2, 6) and the meadow flora *Centaurea cyanus* (Fig. 1/ Table 3). and *Centaurea solstitialis* (Fig. 1/ Table 4, 5) are the most visited honey plants during their main flowering. The taxonomic

structure of vascular honey plants in the survey area includes 133 species, which means that not all plants in the area are visited and used as a source of pollen by bees [25].

The total amount of collected pollen by the colonies is 7219.61g. The greatest amount of collected pollen comes from *Brassica napus* - 3798.69 g, followed by: *Centaurea cyanus* - 748.18 g, *Papaver rhoeas* - 695.42 g, *Centaurea solstitialis* - 455.87 g, *Salix* sp. - 222.87 g, *Trifolium dalmaticum* - 194.32 g, *Pyrus malus* - 138.89 g, *Prunus cerasifera* - 115.5 g, *Cirsium* sp. - 107.19 g, *Brassica nigra* - 102.51 g, *Helianthus annuus* - 96.87 g, *Vicia* sp. - 92.49 g, *Amorfa fruticosa* - 86.53 g, *Plantago* sp. - 86.08 g, *Ehinops ritro* - 29.97 g (Tables 1-6). The visited cultivated honey taxons are around 22%, but about 56.5% (4081.82 g) of the total amount collected pollen. Around 78% of the visited flora is common natural as well as about 43.5% (3137.79 g) of the total amount collected pollen. The amount of pollen that the bees

collect depends on the population of the certain plants that bees visit. We have to take into account the differences in the discoveries of bees-scouts, when searching for new crops, flower type, the number of flowers, bees' direct access pass, the distance to the hives, ecological factors and etc. When flowering introduced agricultural plants, bees collect most of them pollen, depend on the climate condition [21].

According to the data in Fig. 1 can be observe the underlying dynamics of the visited flora. This may be due to the climate dynamics which varies every year, the ecological factors- rains, temperature and humidity. The annual dynamics of

the above-mentioned factors can be observed in Fig. 2. The dynamic rainfall leads to increasing the moisture content of the soil and as a result it influences the flowering of plants. They were rainfalls through all apicultural season, and especially during summer (Fig. 2). The phenology of honey flora flowering is directly dependent on the climatic characteristics of the geographical area [26, 27]. The urban environment in the area of the experimental study, the anthropogenic factor, the cultivation of different agricultural crops which occupy a large area in the urban environment, also play a major role in pollen preferences of bees.

Fig. 1. Amount collected and identified pollen (g) in 2014

Fig. 2. Climatic characteristics of Belozem area for 2014

CONCLUSIONS

The bees have visited 46 species of honey plants from 41 genera and 22 families. The honey bees preferred to collect pollen from 2 to 5-6 plants species during each month. The bees mainly collect pollen from two or three plant species every month. The agricultural species *Brassica napus* as well as the meadow flora- *Centaurea solstitialis* and *Centaurea cyanus* are the most visited honey plants during their flowering. The bees prefer to collect pollen from 16 honey plants out of 46 visited taxons. Not all plants in the area serve as a source of pollen for the bees. The greatest amount of collected pollen comes from *Brassica napus* - 3798.69 g. Around 78% of the visited honey plants are common natural and about 43.5% of the total amount collected pollen, while the visited cultivated honey taxons are around 22% and about 56.5% of the total amount collected pollen. The highest number of visited honey species is represented by the family Asteraceae followed by Fabaceae. The ecological factors can favor or hamper the development of different plant species. The cultivation of different agricultural crops which occupy large areas, also plays a major role in the pollen preferences of bees.

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