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NECTAR AND POLLEN PRODUCTIVITY OF COMMON CHICORY

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There is a need for further study of new and forgotten species of high-yielding plants for the expansion of biodiversity of the forage base of honey bees and the receipt of high-quality commercial products at bee-farms. The aim of research was to explore pollen and honey properties of common chicory (*Cichorium intybus* L.). The selection of plant samples was carried out in Kyiv, Vinnytsia, Khmelnytsky, Poltava, Sumy, Chernihiv and Kirovohrad regions of Ukraine. Standard statistic and morphometric methods, as well as mathematical formulas were used for determining the biological performance indicators. A long flowering period of common chicory was ascertained in the range from 75 to 102 days. Plant productivity indicators for honey bees were established. Biological nectar productivity was in the range from 92.55 to 190.04 g from one common chicory plant. Honey productivity was in the range from 166.59 to 301.34 kg/ha. The biological pollen productivity of one plant of common chicory was in the range from 1.785 to 3.064 g. As a result of pollen analysis of polyfloral honey obtained during the summer of 2016 the pollen grains of common chicory were found in the range from 1 to 27%. Pollen lumps of common chicory in the range from 10 to 80% of the total fee were in polyfloral bee pollen collected during the summer of 2016. The morphometric parameters of the bee pollen were ascertained: the sharping level of the pollen lump was 4 ±0.15 points, the weight of one pollen lump was 7.21 ±0.255 mg, the length of one pollen lump was 3.42 ±0.048 mm, the width of one pollen lump was 2.97 ±0.070 mm. Our further research in this direction may be conducted to determinate of the biologically active components of cichorium honey and bee pollen.

Keywords: nectar; honey; pollen productivity; *Cichorium*

Introduction

Recently, scientists devote much attention to providing of bees with high quality feed (Максимов et al., 2014; Рожков и Токар, 2014). Scientists point to the necessity to optimize forage resources for bees and improve honey-pollen resources of the area (Brovarskij et al., 2010; Боярчук 2015; Люльчак і Адамчук, 2016). For this purpose, special honey plants are used, which are grown specifically for bees, on the grounds of their high productivity, valuable medicinal or commodity qualities of the products obtained from them and prolonged use (Глухов, 1955; Brovarskij et al., 2010; Brindza et al., 2015; Grygorieva et al., 2016; Адамчук та ін., 2016; Redina et al., 2016; Адамчук і Акульонок, 2017).

However, there is a need for further search for plant species which can provide bee families with complete protein and carbohydrates. The considered value to bees has common chicory (*Cichorium intybus* L.). This is a perennial plant that has a prolonged flowering period. The study of the species

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composition of the bee pollen conducted in Ukraine showed that in the summer and late summer periods, the share of pollen of herbaceous plants rose sharply (including common chicory) and it was 91.3 and 93.7%, respectively of the total amount of bee pollen (Stashenko, 2005).

However, the duration of flowering chicory may change according to the nature-climatic conditions. So, some scientists indicate 32 days (Мельников и Еськов, 2015). Others studies of the phenology of harvesting bee pollen of *Cichorium intybus* during the year showed that it continues for 99 days (Süer and Sorkun, 2006). Chicory is a source of protein feed and nectar for bees. Its honey productivity is 100 kg/ha, and honey is light, has a bluish tint and pleasant taste (Глухов, 1955). From 1 day one flower of chicory allocates 100–250 mg of nectar, therefore this plant is recommended for use in a trophic conveyor for honey bees (Прибылова и Иванов, 2011).

The first information about using of chicory could be found in the writings of Pliny (23–79 A.D.). Avicenna (980–1037) used chicory for treating many diseases. Scientists had thoroughly studied the biochemical composition and properties of raw chicory (Deng et al., 2001; Kisiel and Zielińska, 2001; El-Lakany et al., 2004; Malarz et al., 2013; Wang et al., 2013; Aisa and Xin, 2015). They consider that the most valuable substances contained in chicory are inulin, lactucin and taraksasterol. Studies were conducted on plant cultivation, since chicory is considered highly suitable for culture introduction (Таранов, 1986). The conditions for organic production of chicory are investigated (Süer and Sorkun, 2006).

For beekeepers, this plant is valuable due to the flowering even in the cool and rainy weather, as well as the stability of stairs to frost. However, there is a need for further study of nectarous properties *Cichorium*, the definition of pollen productivity, the period of nectar production in Ukraine conditions for the possibility of using this plant as a source of feed for bees and obtaining qualitative commodity products in bee-farms. Therefore, the aim of research was to explore pollen and honey properties of common chicory.

Material and methodology

Scientific issues which set up during the research, have been solved experimentally, using the next methods of research: zootechnical (setting experiments, nectar, honey and pollen productivity), microscopical (nectarial and pollen productivity of enthomopile plants, analysis of pollen), micrometrical (morphological features of bee pollen, formation of pollen lump), statistical (biometrical data processing) and analytical (literature review, analysis and generalization of the results of research).

Thus, biological nectar productivity was determined by multiplying the average amount of sugar released by one inflorescence (mg), by the number of flowers per plant (pcs.) and the duration of flowering of the plant (days). The conventional technology of common chicory cultivation based on a wide-row sowing method with a width of rows of 45 cm and distance in the row between plants 10–12 cm. That is, 9 pcs. per 1 running meter or 27 units. per square. We derived a formula for calculating the probable honey yield of a solid mass of the plant taking into account the obtained results of nectar productivity:

$$\frac{(BN \times NP) \times 0.5}{DF} = HP$$

where: *BN* – biological nectar productivity of 1 plant, kg; *NP* – number of plants per 1 ha, pcs.; 0.5 – coefficient of conversion to the actual honey stock; *DF* – the duration of flowering, days; *HP* – honey productivity, kg/ha

Experimental samples were collected in the 2016 summer period. Equipment involved in research: scales ANG 100C, microscopes Zeiss SteREO Discovery V20 and Zeiss HBO 50/AC. Online database PalDat, ChemStation databases and personal developments served as information media. Next software resources have been used: Ascension Waves vision and other specialized software, statistical programs for micrometry, graphic editor Paint.Net 4.0.

Results and discussion

We have established the flowering period of one *Cichorium intybus* plant in Skvyra, Baryshivka and Kyiv-Sviatoshyn districts of Kyiv region; Khmilnyk, Vinnitsia region; Stara Syniava district, Khmelnytskyi region; Myrgorod district, Poltava region; Konotop and Romny districts Sumy region; Pryluky district, Chernihiv region; Gaivoron district, Kiyrovohrad region (Table 1).

Table 1 Period of flowering of common chicory (*Cichorium intybus*) in some regions of Ukraine, *n* = 50

№	District	Start of flowering season, dd.mm	End of flowering season, dd.mm	Duration, days
1.	Skvyra district, Kyiv region	20.06	10.09	82
2.	Baryshivka district, Kyiv region	20.06	12.09	84
3.	Kyiv-Sviatoshyn district, Kyiv region	20.06	10.09	82
4.	Khmilnyk, Vinnitsia region	20.06	15.09	87
5.	Stara Syniava district, Khmelnytskyi region	22.06	10.09	80
6.	Myrgorod district, Poltava region	15.06	15.09	92
7.	Konotop district, Sumy region	22.06	05.09	75
8.	Romny district, Sumy region	22.06	05.09	75
9.	Pryluky district, Chernihiv region	22.06	15.09	85
10.	Gaivoron district, Kiyrovohrad region	10.06	20.09	102

It was found out that the largest period of flowering *Cichorium intybus* was in Myrgorod (92 days) and Gaivoron (102 days) districts. Thus, in Konotop and Romny districts the period of flowering was 26% shorter compared to Gaivoron. However, throughout in the Forest-Steppe zone of Ukraine, *Cichorium intybus* has a long flowering time compared to other plant species and averaged 84 ±8 days. This gives reason to consider *Cichorium intybus* promising for use in beekeeping. In addition, this plant provides bees with carbohydrate and protein foods in the second half of the summer, which is very important for the formation of fodder stocks in the winter and the growth of generations of bees that will go to winter.

Nectar productivity of *Cichorium intybus* is determined by the amount of sugar in the nectar of flowers from one plant in g (Table 2).

Table 2 Nectar productivity of common chicory (*Cichorium intybus*), *n* = 10

№ area	Indicator				
	Total sugar content in nectar				
	M ±m, mg	δ	Cv, %	Min, mg	Max, mg
1.	1.10 ±0.026	0.084	7.569	0.951	1.150
2.	1.13 ±0.007	0.022	1.961	1.087	1.149
3.	1.05 ±0.025	0.078	7.406	0.952	1.150
4.	1.09 ±0.030	0.094	8.630	0.951	1.149
5.	1.12 ±0.021	0.067	5.941	0.956	1.150
6.	1.14 ±0.002	0.005	0.428	1.135	1.150
7.	1.03 ±0.025	0.080	7.776	0.954	1.150
8.	1.11 ±0.023	0.071	6.399	0.953	1.149
9.	1.11 ±0.018	0.056	5.104	1.003	1.149
10.	1.12 ±0.014	0.045	4.031	1.003	1.150
	Number of flowers in the inflorescence				
1.	19.4 ±0.60	1.897	9.780	16	22
2.	19.4 ±0.43	1.350	6.958	18	22
3.	19.0 ±0.54	1.700	8.946	16	22
4.	19.0 ±0.45	1.414	7.443	16	20
5.	19.2 ±0.53	1.687	8.784	16	22
6.	20.2 ±0.47	1.476	7.306	18	22
7.	19.2 ±0.61	1.932	10.063	16	22
8.	20.0 ±0.30	0.943	4.714	18	22
9.	19.4 ±0.52	1.647	8.487	16	22
10.	19.6 ±0.27	0.843	4.302	18	20
	Number of inflorescences per plant				
1.	104.6 ±7.91	23.916	23.916	65	133
2.	89.2 ±6.21	22.018	22.018	61	117
3.	74.3 ±8.93	37.989	37.989	31	115
4.	81.7 ±11.13	43.082	43.082	35	132
5.	77.3 ±8.93	36.529	36.529	33	122
6.	89.7 ±6.78	23.888	23.888	57	116
7.	62.4 ±5.99	30.333	30.333	43	94
8.	80.9 ±12.49	48.809	48.809	32	131
9.	89.0 ±8.49	30.159	30.159	53	125
10.	81.8 ±11.99	46.340	46.340	34	129

M – arithmetic mean; m – error of a measurement; δ – standard deviation; Cv – coefficient of variation; Max, Min – maximum, minimum value sample

The obtained results confirm that the index of honey productivity varies from 166.59 to 301.34 kg/ha depending on the place of germination. Significant influence on this index may be the soil, depth of groundwater, rainfall and other natural and climatic factors.

It has been established that biological pollen productivity of one *Cichorium intybus* plant was ranging 1.785 to 3.064 g. Assuming that bees gather 50% of pollen, it is possible to collect from 89.25 to 153.29 g of pollen from 100 of plants. Apart from that, it is also possible to trace the dependency between honey productivity and pollen productivity of the plant. Thus, the highest recoreded value of these variables was observed in Skvyra district, Kyiv region and the lowest – in Konotop district, Sumy region.

Pollen grains of *Cichorium intybus* were also researched in honeys of different plants origin. It has been established that in coriander honey the pollen of this plant is ranging from 1 to 5%; summer herbage honey – from 8 to 20%; buckwheat honey – from 2 to 8%; sunflower honey – from 1 to 4%; tilia honey – from 1 to 3%; late-summer herbage honey – from 18 to 27% of pollen grains. This fact proves that bees willingly use *Cichorium intybus* during all of the active season.

Calculations of the productivity of *Cichorium intybus* in various regions of the Forest-Steppe zone of Ukraine are presented in Table 3.

Table 3 Honey and pollen productivity of common chicory (*Cichorium intybus*), *n* = 10

№ of area	BNP, g	HP, kg/ha	Quantity indicator, M ±m			Averaged indicator	
			pollen in the flower, mg	number of flowers in inflorescence	number of inflorescences on the plant	pollen in inflorescence, mg	BPP, g
1.	183.04	301.34	1.51 ±0.041	19.4 ±0.60	104.6 ±7.91	29.294	3.064
2.	164.26	263.98	1.49 ±0.053	19.4 ±0.43	89.2 ±6.21	28.906	2.578
3.	121.55	200.11	1.53 ±0.052	19.0 ±0.54	74.3 ±8.93	29.070	2.159
4.	147.20	228.42	1.48 ±0.050	19.0 ±0.45	81.7 ±11.13	28.120	2.297
5.	132.98	224.40	1.50 ±0.028	19.2 ±0.53	77.3 ±8.93	28.800	2.226
6.	190.04	278.86	1.41 ±0.026	20.2 ±0.47	89.7 ±6.78	28.482	2.554
7.	92.55	166.59	1.49 ±0.043	19.2 ±0.61	62.4 ±5.99	28.608	1.785
8.	134.70	242.46	1.56 ±0.043	20.0 ±0.30	80.9 ±12.49	31.200	2.524
9.	162.90	258.73	1.46 ±0.056	19.4 ±0.52	89.0 ±8.49	28.324	2.520
10.	183.16	242.42	1.49 ±0.035	19.6 ±0.27	81.8 ±11.99	29.204	2.388

BNP – biological nectar productivity of one plant; HP – honey productivity; BPP – biological pollen productivity; M – arithmetic mean; m – error of a measurement

The appearance of the pollen of *Cichorium intybus* in the late-summer heritage honey proves the significant value of this plant in providing of carbohydrid feed for bees. It is 22.8 ±1.53%. The bee pollen from local apiaries during the flowering of *Cichorium intybus* has been analyzed. It has been established that from 63 of studied samples of bee pollen 37 contained pollen lumps formed from *C. intybus* by bees. 10 of them contained *Cichorium intybus* bee pollen ranging from 10 to 80%, the others – less than 10%.

Most of the pollen lumps of *Cichorium intybus* had a shaping level of 4 points (Table 4). Bee pollen was not an identical form, flattened sides. It was established that the weight of one pollen lump was in the range from 2.8 to 12.2 mg.

Table 4 Morphological characteristics of bee pollen lump of *Cichorium intybus*, *n* = 50

Indicator	M ±m	Cv (%)	δ	Max	Min
Weight, mg	7.21 ±0.255	25.047	1.806	12.2	2.8
Length, mm	3.42 ±0.048	7.735	0.264	4.04	2.82
Width, mm	2.97 ±0.070	12.988	0.386	3.74	2.05
Shaping level, point	4 ±0.15	20.761	0.830	5	3

M – arithmetic mean; m – error of a measurement; Cv – coefficient of variation; δ – standard deviation; Max, Min – maximum, minimum value sample.

It was found that the variation in the length of the pollen lump was weak (7.74%), in contrast to other indicators. The sharping level of pollen lump (4 points) allows us to assume the possibility of using this plant to obtain commercial bee pollen.

Conclusions

It was established a long flowering period of common chicory in the range from 75 to 102 days. Plant productivity indicators for honey bees were established: biological nectar productivity was in the range from 92.55 to 190, 04 g from one common chicory plant; honey productivity was in the range from 166.59 to 301.34 kg/ha; the biological pollen was in the range from 1,785 to 3,064 g. As a result of pollen analysis of polyfloral honey obtained during the summer of 2016 the pollen grains of common chicory were found in the range from 1 to 27%. Pollen lumps of common chicory in the range from 10 to 80% of the total fee were in polyfloral bee pollen collected during the summer of 2016. The morphometric parameters of the bee pollen were ascertained: the sharping level of the pollen lump was 4 ±0.15 points, the weight of one pollen lump was 7.21 ±0.255 mg, the length of one pollen lump was 3.42 ±0.048 mm, the width of one pollen lump was 2.97 ±0.070 mm.

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