https://doi.org/10.15407/animbiol22.01.036
UDC 638.1.138:178.2
Received 18.11.2019 ▪ Accepted 04.02.2020 ▪ Published online 01.05.2020

Flight activity of bee colonies at *Acer* spp. bee pollen collection

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The aim of the research was to investigate the flight activity of bee colonies during *Acer* spp. flowering, as a source of monofloral bee pollen. To achieve this goal the following tasks were set: to investigate the intensity of flight of bees during flowering of maples; to estimate the condition of bee colonies by the strength and quantity of brood after feeding with the elements of training for feed; to establish the pollen productivity of bee colonies during *Acer* spp. flowering. The common zootechnical methods of forming the analogue groups were used (control — standard maintenance; experiment — feeding with maple pollen); pollen productivity of bee colonies was evaluated by the amount of products received; the botanical origin of the bee pollen was determined by pollen analysis. It was found that the flight intensity of bees of the experimental group was higher than the control during the first accounting by an average of 38.5 %, the second by 30.0 % and the third by 19.4 %. According to the number of open and sealed broods, the experimental colonies outweighed the controls by 0.5 and 1 honeycomb at the first count and by 0.5 — at the second; by the amount of forage by 0.5 honeycomb at the first count and by 1 — at the second. The experimental colonies were found to have higher pollen productivity. The daily volume of yields in the experimental colonies ranged from 64 to 97 g with a maximum coefficient of variation of 9.6 %, and in controls — from 90 to 135 g, with a variation of 14.4 %. This suggests that the more flying bees are there in a colony, the more different work they do (collecting nectar, pollen, propolis, water), which can affect productivity over time. It has been established that stimulating feeding and training of bees have a positive effect on the increase in the pollen productivity of colonies. The average daily pollen productivity of the bee colonies of the experimental group was 104.3 g, and the control one — 79.3 g, which is less by 24 %. The weight of the raw pollen received was 2.7 kg from the experimental group and 2.1 kg from the control group, which is 22.2 % less. The difference in weight of the total collection was also caused by the larger mass of a single pollen clump out of the monofloral gathering, which outweighed the polyfloral (control group) by 28 %. Therefore, stimulating feeding of bee colonies with sugar dough with maple pollen increases their pollen productivity on harvesting monofloral bee pollen during *Acer* spp. flowering.

Key words: pollen, bee pollen, feeding, *Acer*, pollen productivity, bee training

Bee pollen is a product of plant and animal origin. The basis of its composition is a set of pollen grains (flower pollen) mainly of angiosperms, which are their male germ cells (gametophytes). Bees collect pollen, add to it the secret of salivary glands and moisten with nectar, thus forming a lump of pollen grains in a special attachment on the rear legs (basket for collecting pollen) [1].

Beekeepers began to select bee pollen by using special devices with lattices that were mounted on the entrance. For the first time such devices were invented and applied in America in 1930–1932 by practitioner beekeeper Eckhart [13]. The first pollen collectors were released in the fifties by the American company “Dadan”. The device was completely metal and heavy [6]. The principle of their work was that the bee passing through the lattice would leave a pollen lump outside. Because the openings were such that the bee could pass without the burden of pollen. This principle is still used today in all designs of modern pollen collectors. The first patent on the pollen collector lattice is owned by [1, 6].

Today, the technology for the production of bee pollen has been developed. Most of the scientific work on the development of this technology belongs to the prominent figure of Ukrainian beekeeping — Viktor Polishchuk [6]. The doctrine of the behavior of bees during the collection of forage belongs to Levchenko (1976) [5].

It is known [1, 5, 8, 7, 10, 11] that pollen productivity of colonies is influenced by many factors. They can be divided into internal and external. Internal include those related to the conditions of development and functioning of the colony — strength, number of broods, microclimate and others. Thus, [5] investigated the effect of colony strength and bee-flying intensity on the mass of the bee. According to her findings, the amount of harvested bee pollen depends on the strength of the colony and the ratio of different bees age; in April, the mass of gathered the bee pollen is lower than in May, which is explained by the lower strength of colonies.

The correlation between the morphological features of the body of the bee and bee pollen is established. The age of bees involved in pollen collecting activities also matters. After all, bees comb pollen grains from the hairs that cover exoskeleton. With age, the bee loses its hairline. In addition, in different parts of the body of the bee, the hairs have a different structure, so they accumulate pollen grains not equally [1, 14]. It has been investigated [12] that selection of bee pollen affects the number of broods and, accordingly, the development of bee colonies.

At the same time, the topic of obtaining monofloral bee pollen is not fully disclosed. Earlier, the Department of Horse Breeding and Beekeeping of NULES of Ukraine investigated the morphological features of the monofloral bee pollen from *Acer* species [9] and established the possibility of obtaining it in commodity volumes. Therefore, the studies concerning the development of technology for obtaining monofloral bee pollen, the forage conditions for its collection, the behavior of bees during collection, are relevant.

The aim of the study was to investigate the flight activity of bee colonies during the flowering of *Acer* spp. as a source of monofloral bee pollen. To achieve this goal, the following tasks were set: to investigate the intensity of bee flight during *Acer* spp. flowering; to estimate the status of bee colonies by the strength and amount of brood after feeding with training feed elements; to establish the pollen productivity of bee colonies during *Acer* spp. flowering.

Materials and Methods

The studies were conducted in February-May 2019 in the conditions of the laboratory “Holosiivskyi educational and research apiary” on bee colonies of Ukrainian breed, which were kept in multi-body hives within 10 standard honeycombs. The tasks set were solved experimentally using zootechnical (alignment and assessment of the status of bee colonies, their flight activity and pollen productivity, assessment of bee pollen on classification grounds), microscopic (pollen analysis) and statistical methods of investigation.

Zootechnical research methods consisted of comparing the data obtained from the analogous groups of bee colonies (three colonies each). The control group is classic retention, without the use of feeding. Experimental group — classic retention + protein-carbohydrate feeding with elements of training bees to smell. Other factors for the two groups were the same (nature and climate, forage). *Training of bees* was carried out by the standard technique using sugar-pollen dough with monofloral pollen of *Acer* spp. [4]. Pollen productivity of bee colonies was evaluated by the number of products obtained using common methods [4].

The selection of bee sting from bee colonies began on 01.05.19, with the beginning of flowering of maple trees (*A. platanoides*, *A. campestre*, *A. tataricum*) and finished accounting with its ending on 26.05.19. The product was selected daily and weighed in the native form. After that, it was sent to the “Sadochok” dryer for 12 hours. The obtained bee pollen from control and experimental colonies was stored separately for further evaluation.

To determine the botanical origin of bee pollen, a pollen analysis technique (methods of melissopalynology [15]) and a pollen grains classifier developed at the Department of Horses and Beekeeping of NULES of Ukraine were used [3, 4]. Assessment of bee pollen by classification characteristics was performed according to previously established data [2].

The data obtained were statistically processed.

Results and Discussion

Observations on the bee colonies of the control and experimental groups revealed rapid development as a result of the feeding used. It was found that the intensity of flight work in control and experimental colonies was different (table 1).

Table 1. Intensity of flight activity of bees (n=3)

The number of bees that returned with pollen in 5 minutes				
Groups	Accounting time	Date		
		01.05	10.05	20.05
Control	08:00	94,1±10,24	118,2±6,20	132,2±7,12
	12:00	77,3±8,17	99,1±5,15	102,3±6,22
	15:00	15,2±6,10	30,3±7,11	47,2±4,08
	Average per day	62,20	82,53	93,90
Experi-mental	08:00	128,1±7,21	140,3±8,13	134,1±8,07
	12:00	119,3±5,16	125,2±6,23	130,3±7,18
	15:00	56,2±5,09	88,1±9,19	85,1±9,14
	Average per day	101,20	117,87	116,50

For three counts, a general trend of higher flight activity in the morning was observed, falling to the second half of the day. This is probably due to the functioning and secretion of nectaries, which were filled with secretions until midday and worker switched to gathering carbohydrate forage. In general, the flight intensity of the bees of the experimental group outweighed the control throughout the collection period of the bee’s leg. Namely, during the first accounting by an average of 38.5 %, the second — by 30.0 % and the third — by 19.4 %. The decrease in the difference of the flight activity between experimental and control groups may be due to the fact that the bees of the colonies of control group began to even out in strength as a result of the accumulation of natural forages in the nests. This fact can be traced to the dynamics of the average daily flight performance of both groups (fig. 1).

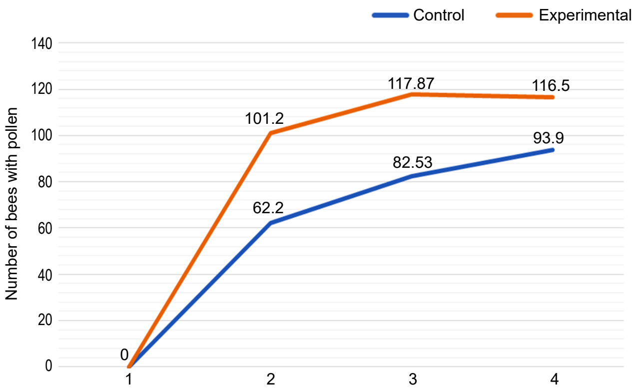

Fig. 1. Dynamics of bee flight activity during beekeeping selection

Fig. 1 shows that the average daily flight activity of the bees of the control group improved at the end of the bee collection period, which may indicate the impact of an increase in the feed base due to natural sources. At this time a large number of pollen-bearing plants began to bloom. Naturally, the bee colonies that were trained to collect pollen from maple trees were only focused on this species. And the colonies of the control group increased the number of flights by visiting different species of plants in the area of productive flight of bees.

The assumptions about the reason for the decrease in the difference between the flight performance of experimental and control groups were confirmed during the control inspection of the colonies. Thus, at the end of the bee pollen collection period, the control and experimental group colonies aligned in strength (table 2).

Table 2. Assessment of the status of bee colonies during flowering of *Acer* species

Indicator	Control			Experimental		
	1	2	3	4	5	6
for 10.05						
Strength of colonies, bee space	8	8	8	10	10	10
Open brood, combs	3	3	3	3.5	3.5	3.5
Sealed brood, combs	2	2	2	3	3	3
Fodder combs, pcs.	3	3	3	3,5	3,5	3,5
for 20.05						
Strength of colonies, bee space	10	10	10	10	10	10
Open brood, combs	3	3	3	3.5	3.5	3.5
Sealed brood, combs	3	3	3	3.5	3.5	3.5
Fodder combs, pcs.	4	4	4	3	3	3

Thus, during the second control inspection of colonies of the control group, their strength increased by 2 combs compared to the results of the first control inspection. In terms of number of broods opened and sealed, the experimental colonies outweighed the controls by 0.5 and 1 cell at the first control inspection and by 0.5 cells at the second. In terms of the number of feeds, experimental colonies outperformed the controls by 0.5 cells in the first accounting and 1 in the second.

Thus, we determined that the intensity of flight activity of bees depends on the strength of colonies and the amount of brood in the nest. This conclusion is in line with Ivanova's statements (2011) [1].

In the control colonies, where the numbers of open and sealed broods increased, there was a tendency towards the increase in flight activity. On the other hand, in experimental colonies, where the strength of colonies was the same throughout the accounting period, at the end of the flowering maple, flight activity decreased.

However, comparing the quantitative indicators of the gathered bee pollen, it has been found that the more brood there is in the colony, the more protein feed is collected by bees. The results of the bee colonies pollen productivity are presented in table 3.

Table 3. Pollen productivity of bee colonies during flowering of *Acer* species, g

Date	Control			Experimental		
	1	2	3	4	5	6
01.05	80	90	96	90	90	93
02.05	76	83	77	92	94	90
03.05	80	85	82	98	98	100
04.05	79	68	82	90	98	90
05.05	85	68	76	90	94	96
06.05	81	90	83	90	90	98
07.05	82	80	79	120	104	115
08.05	80	72	85	100	102	104
09.05	67	84	69	126	134	128
10.05	96	79	83	135	103	101
11.05	84	80	82	114	100	106
12.05	85	77	73	102	115	120
13.05	89	84	88	129	100	130
14.05	75	85	78	121	117	103
15.05	70	71	80	101	109	105
16.05	80	80	66	135	130	112
17.05	69	74	82	103	104	101
18.05	85	68	78	119	120	127
19.05	79	82	74	100	110	102
20.05	65	87	75	118	105	125
21.05	83	78	97	90	96	94
22.05	72	80	70	90	92	90
23.05	80	80	84	100	95	97
24.05	73	86	85	98	101	90
25.05	80	91	75	92	94	90
26.05	64	70	72	95	100	99
X±s	78.4± ±1.47	79.7± ±1.37	79.7± ±1.44	105.3± ±2.97	103.7± ±2.25	104.1± ±2.51
Cv, %	9.6	8.8	9.2	14.4	11.1	12.3
Lim	64→96	68→91	66→97	90→135	90→134	90→130

Note. X — the average of the sample; s — the standard error; Cv — correlation coefficient; Lim — the boundaries of the smallest and largest sample values.

Table 3 shows that the experimental colonies had higher pollen productivity, which fluctuated more in their indicators by day, as indicated by the coefficient of variation. Thus, in the experimental colonies, the daily volume of gathered bee pollen was from 64 g to 97 g with a maximum coefficient of variation of 9.6 %, and in control colonies — from 90 g to 135 g, with a variation of 14.4 %. This suggests that the more flying bees the colony has, the more different work they do (such as collecting nectar, pollen, propolis, water), which can change performance over time and cause a higher coefficient of variation.

The dynamics of averaged pollen productivity of bee colonies of control and experimental groups are shown in fig. 2.

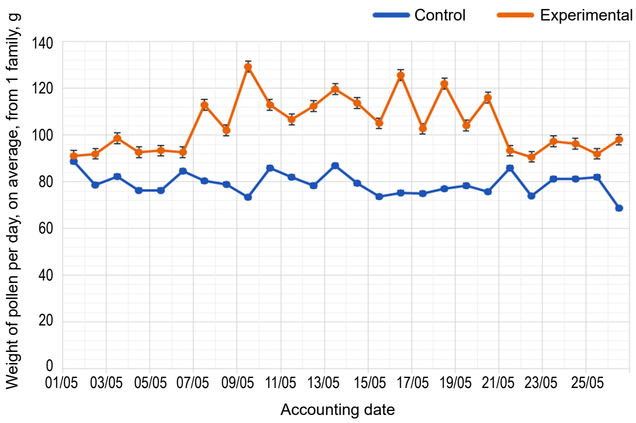

Fig. 2. Dynamics of pollen productivity of control and experimental groups during flowering of *Acer* species

As a result of the obtained data, it can be argued that the methods of increasing pollen productivity, namely carbohydrate protein feeding with odor training elements, have a positive effect on the increase of flight activity and as a consequence of the bee colonies' pollen productivity. Thus, the average daily pollen productivity of bee colonies of the experimental group was 104.3 g, and the control one — 79.3 g, which is 24 % less.

According to the results of the evaluation of bee pollen on classification grounds, the obtained product had significant differences. Thus, the mass of the collected native bee pollen during the whole accounting period was 2.7 kg from the experimental group and 2.1 kg from the control, which is less by 22.2 %. After drying of the product, the mass of the pollen decreased equally in both groups by 20 %, regardless of the species' botanical diversity. However, taking into account the average weight of one pollen lump, it differed (table 4).

Table 4 shows that the monofloral bee pollen outweighed the polyfloral obtained from the control group by an average of 28 % in terms of the weight of the pollen lump. This may be due to the fact that the total pollen collection had less formed pollen lumps or of lower weight as a species feature got into it. As well as the density of pollen lump formation and morphological structure of pollen grains.

Table 4. Classification indicators of bee pollen (n=100)

Indicator	Control	Experimental
Weight of one pollen lump, mg	9.1±1.74	12.6±0.92
Species of pollen-bearing plants	forest grass, trees, shrubs	trees of the *Acer* species
Botanical origin	forest	of *Acer* species
Season	spring	
Homogeneity	homogeneous	
Polyflora, %	polyfloral	monofloral, 90
Formation, points	2–5	5

As a result of pollen analysis, the bee pollen obtained from the control group was polyfloral, some pollen lumps had a botanical origin from forest plants, namely, grasses — anemones, garlic, nettle, wheat; bushes — barberry, white turf, trees — oak, ash, alder, maple. Because of this, within one pollen lump, it was homogeneous, that is, the pollen belonged to one type of plant. The bee pollen of the study group was homogeneous, with a monoflority of 90 %. The results of the assessment by formation showed that the pollen lumps of the bee pollen of the control group differed in the degree of formation depending on the botanical origin. In this case, the largest sizes were characterized by pollen clumps of maple and oak.

Conclusions

Flight activity of bee colonies at bee gathering is increased due to carbohydrate protein supplementation by an average of 29.3 % and dust efficiency by 24 %. Feeding bee colonies with training elements ensured the flight of bees to a specific species of plants and obtaining a 90 %. monofloral product.

Prospects for Further Research

The prospects for further research are to investigate the technological conditions for obtaining monofloral bee stalk from other plant species.

Acknowledgments

Author Leonora Adamchuk thanks the International Visegrad Fund ID #51910842 for the scholarship and research internships, during which the results and knowledge presented in this paper were obtained. The publication was prepared with the active participation of researchers involved in the International network AgroBioNet of the Institutions and researchers for realization of research, education and development program “Agrobiodiversity for improving nutrition, health and life quality” TRIVE (ITMS 26110230085).

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Льотна діяльність бджолиних сімей на зборі бджолиного обніжжя з роду *Acer* L.

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Метою було дослідження льотної діяльності бджолиних сімей під час цвітіння *Acer* L. як джерела монофлорного обніжжя. Для досягнення мети було поставлено завдання: дослідити інтенсивність льоту бджіл під час цвітіння кленів; оцінити стан бджолиних сімей за силою та кількістю розплоду після підгодівлі з елементами дресирування на корм; встановити пилкопродуктивність бджолиних сімей під час цвітіння *Acer* L. Використовували загальноприйняті зоотехнічні методи формування груп-аналогів (контроль — стандартне утримання; дослід — підгодівля пилком з клену); пилкову продуктивність бджолиних сімей оцінювали за кількістю отриманої продукції; ботанічне походження бджолиного обніжжя визначали методом пилкового аналізу. Встановили, що інтенсивність льоту бджіл дослідної групи була вищою за контрольну під час першого обліку в середньому на 38,5 %, другого — на 30,0 % і третього — на 19,4 %. За кількістю відкритого і запечатаного розплоду дослідні сім'ї переважали контрольні на 0,5 і 1 стільник при першому обліку і на 0,5 — при другому; за кількістю кормів на 0,5 стільника при першому обліку і на 1 — при другому. Встановили, що дослідні сім'ї мали вищу пилкову продуктивність. Щоденний об'єм принесеного обніжжя у дослідних сім'ях знаходився у межах від 64 г до 97 г з максимальним коефіцієнтом варіації 9,6 %, а у контрольних — від 90 г до 135 г, з варіацією 14,4 %. Це дає підставу припустити, що чим сім'я має більше льотної бджоли, тим більше різної роботи вони виконують (збір нектару, пилку, прополісу, води), що може впливати на зміну показників продуктивності за певний період. Визначили, що стимулююча підгодівля і дресирування бджіл, мають позитивний ефект на збільшення пилкопродуктивності сімей. Середньодобова пилкопродуктивність бджолиних сімей дослідної групи становила 104,3 г, а контрольної — 79,3 г, що менше на 24 %. Маса сирого зібраного обніжжя за весь період становила 2,7 кг від дослідної групи і 2,1 кг від контрольної, що на 22,2 % менше. Різниця у вазі загального збору спричинена також більшою масою окремої пилкової грудочки монофлорного збору, що переважало поліфлорне (контрольної групи) на 28 %. Отже, стимуляційна підгодівля бджолиних сімей цукровим тістом з кленовим пилком, збільшує їх пилкопродуктивність на збиранні монофлорного бджолиного обніжжя під час цвітіння *Acer* L.

Ключові слова: пилок, бджолине обніжжя, підгодівля, *Acer*, пилкопродуктивність, дресирування бджіл

Martseniuk NI, Adamchuk LO, Akulonok OI. Flight activity of bee colonies at *Acer* spp. bee pollen collection. *Biol. Tvarin*. 2020; 22(1): 36–40. DOI: 10.15407/animbiol22.01.036.