

## POLLEN HOARDING IN THE LATE SUMMER SEASON BY HONEYBEE (*Apis mellifera* L.) COLONIES

A d a m R o m a n

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### S u m m a r y

The aim of the study was to determine the amount of pollen that bee colonies are capable of storing in the second half of the foraging season in a region that is poor in autumn and late autumn pollen resources. Another objective was to find out if there is a relationship between the size of pollen loads brought to the hive by the foragers and the amount of pollen hoarded by a bee colony. The study was conducted in the second half of July and in September, in two consecutive years (2002 and 2003) in a non-moving apiary. The amount of hoarded pollen was inferred from the number of pollen loads collected by means of pollen traps. The study showed that bee colonies operating in such an area may have a difficult time securing sufficient amounts of pollen to meet their current needs. Average amounts of pollen collected from individual colonies at that time were from 4.29 to 15.64 g/day and from 4.95 to 28.47 g/day in the first and in the second study year, respectively. Those amounts were very small compared to the actual needs of the colonies. No close relationship was found between the amount of pollen collected and the size of pollen loads, although in both survey years the largest pollen loads were brought in by the workers of colony 6 which had the lowest pollen output. The study showed that in the second half of the foraging season bee colonies may have problems securing enough pollen to meet their current needs – to sustain the development of the colony and to prepare the worker bees to the winter.

**Keywords:** bee colony, pollen loads, pollen yield, pollen traps

### INTRODUCTION

The honeybee (*Apis mellifera* L.) is the dominant pollinator of entomophilous plants under Poland's climate (Bożek 2000). The yield of seeds and fruits of more than 50 cultivated plant species is dependent upon visitation intensity by the honeybee during their blooming. The honeybee contributes to increased crop quality and yield thereby improving the rentability of crop production (Sanford 1992; Burgett et al. 1993). The honeybee is the most suitable crop pollinator since it operates in populous colonies, starts work early in the spring and the worker bees are remarkable for their species faithfulness in pollination (Bond and Hawkins 1967;

Skowronek et al. 1985; Jabłoński 1997). The high efficiency of bees as pollinators results in their vast demand for food. Average-sized bee colonies use up from 18 to more than 35 kg of pollen and ca. 90 kg of honey to satisfy their needs (Bornus et al. 1989, collective work). In order to harvest such amounts of food the bees have to visit millions of flowers in their search for it (Jabłoński 1996).

Pollen is the only protein food of full nutritional value available for the honeybee (*Apis mellifera* L.) that is brought to the nest from the outer environment. The demand of a bee colony for pollen is dependent on colony strength, number of reared brood, and the availability of pollen

in the environment. Given that 89 mg of pollen is required to feed a single bee larva and assuming the egg-laying ability of a queen in the second half of the season (second half of July and August) to be 1000 eggs per day the colony requirement to meet that sole objective is 89 g of pollen per day (Bornus 1989, collective work). It means that to sustain brood development from mid-July through August a colony requires more than 4.2 kg of pollen. Beside of that, there are also needs of adult nurse bees and of those preparing to hibernate. Pollen shortfalls in the nest make the bees reduce the number of reared brood which negatively impacts the strength of the colony as it prepares itself for winter and, consequently, affects the colony's overwintering performance.

The aim of the study was to determine, based on the amount of pollen loads harvested with pollen traps, the amount of pollen that bee colonies are capable of storing in a non-moving apiary in the late summer season (the second half of the foraging season). Another goal was to find out if there is a relationship between the size of pollen loads in foraging bees and the amount of pollen hoarded in colonies.

## MATERIAL AND METHODS

The study was conducted from July 15 till the end of August in two years: 2002 and 2003, involving 10 bee colonies (the same in both years) kept in a non-moving apiary. The beehives with experiment colonies were additionally assigned numbers from 1 to 10. The western Opole region (the place of Szydłowice) where the study was run is recognized as poor in summer and late summer bee pastures. Of cultivated plants that bloomed in that period there were only scarce stands of mustard grown as a green manure aftercrop (in the second half of August). Of wild-growing plants there was white clover, small

patches of goldenrod and some weeds growing in the meadows, at roadsides and on pieces of idle land as well as some plants flowering in house gardens.

The amount of pollen hoarded by bee colonies was inferred from the amount of pollen loads which were collected by means of entrance-mounted pollen traps with a 5.00 mm mesh perforated plate. Each time pollen was collected at the same time from 8:00 to 18:00 on every 2<sup>nd</sup> or 3<sup>rd</sup> day, regardless of the weather on a trapping day. In total, during the survey period 21 pollen load trappings were made each year to produce a total of 210 pollen samples a year (420 samples over two years). Each pollen portion was weighed accurately, all samples were dried at 42°C (in an incubator) and pollen loads were counted. The results were analyzed statistically using Statgraphics ver. 5.0 software. Arithmetic means and standard deviations were calculated. The differences were tested for significance by means of Duncan's multiple range test.

## RESULTS AND DISCUSSION

The field survey carried out with the use of pollen traps showed that the propensity of bees to visit pollen-yielding plants and the amount of hoarded pollen were an individual characteristic of each bee colony, a finding also reported by Grabowski et al. (2000). The amounts of pollen loads collected with pollen traps from bee colonies also varied extensively. However, it must be emphasized that the characteristic was clearly related to pollen-harvesting season and thus was dependent on the abundance of forage available in the environment at a given moment.

The average yield of pollen loads per colony was only 9.50 g in the first year, varying from 4.29 to 15.64 g/day among colonies (Table 1). Instead, in the second year the amounts of collected pollen were

Table 1.

Average amounts of pollen harvested from individual bee colonies in 2002 with the field survey period being broken down into 3 stages (g/day)

No. of colony	Amount of trapped pollen									Estimated pollen amount in the period
	1 – 7		8 – 13		14 – 21		Grand totals			
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	Total <sup>1)</sup>	$\bar{x}$	SD	
1	<b>14.80</b>	7.67	<b>1.26</b>	6.16	<b>1.62</b>	1.26	119.3	<b>7.95</b>	7.70	373.7
2	<b>17.34</b>	8.05	<b>0.50</b>	7.93	<b>1.47</b>	0.50	138.4	<b>9.22</b>	9.04	433.3
3	<b>11.86</b>	7.65	<b>2.80</b>	12.09	<b>7.29</b>	2.80	176.00	<b>11.73</b>	8.63	551.3
4	<b>12.44</b>	7.53	<b>1.04</b>	3.06	<b>1.94</b>	1.04	103.20	<b>6.88</b>	6.25	323.4
5	<b>19.55</b>	14.54	<b>6.68</b>	14.04	<b>8.18</b>	6.68	234.70	<b>15.64</b>	12.62	735.1
6	<b>8.45</b>	5.10	<b>0.64</b>	1.78	<b>1.28</b>	0.64	64.40	<b>4.29</b>	4.28	201.6
7	<b>24.54</b>	13.87	<b>2.07</b>	4.03	<b>2.77</b>	2.07	163.10	<b>10.87</b>	12.73	510.9
8	<b>15.08</b>	5.58	<b>0.94</b>	6.03	<b>1.89</b>	0.94	128.50	<b>8.57</b>	7.12	402.8
9	<b>14.76</b>	9.16	<b>0.90</b>	8.72	<b>1.93</b>	0.90	139.80	<b>9.32</b>	8.79	438
10	<b>18.00</b>	9.19	<b>2.62</b>	6.37	<b>3.83</b>	2.62	154.80	<b>10.32</b>	8.62	485
$\bar{x}$	<b>15.68</b>	8.86	<b>9.54</b>	7.04	<b>3.20</b>	1.97	142.20	<b>9.50</b>	8.61	446.5

<sup>1)</sup> - amounts of pollen from 21 trappings made during the field survey

Table 2.

Average amounts of pollen harvested from individual bee colonies in 2003 with the over successive periods (g/day)

No. of colony	Amount of trapped pollen									Estimated pollen amount in the period
	1 – 7		8 – 13		14 – 21		Grand totals			
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	Total <sup>1)</sup>	$\bar{x}$	SD	
1	<b>39.10</b>	13.98	<b>11.91</b>	8.46	<b>1.63</b>	1.88	358.20	<b>17.06</b>	18.73	801.8
2	<b>27.39</b>	11.00	<b>12.67</b>	7.98	<b>1.04</b>	1.07	276.10	<b>13.15</b>	13.50	618.10
3	<b>48.86</b>	20.53	<b>24.16</b>	10.17	<b>5.95</b>	4.77	534.60	<b>25.46</b>	22.47	1196.6
4	<b>25.79</b>	13.15	<b>4.59</b>	4.18	<b>2.27</b>	4.36	226.20	<b>10.77</b>	13.50	506.20
5	<b>54.61</b>	28.87	<b>30.12</b>	14.55	<b>4.25</b>	2.79	596.90	<b>28.47</b>	27.93	1338.10
6	<b>5.930</b>	1.73	<b>6.07</b>	4.24	<b>3.25</b>	2.13	103.90	<b>4.95</b>	2.97	232.70
7	<b>49.26</b>	20.58	<b>19.19</b>	8.74	<b>5.80</b>	4.70	506.40	<b>24.11</b>	22.73	1133.20
8	<b>25.76</b>	10.30	<b>13.42</b>	7.84	<b>3.92</b>	2.38	292.20	<b>13.92</b>	11.76	654.20
9	<b>33.57</b>	25.16	<b>18.05</b>	10.93	<b>2.92</b>	1.27	366.60	<b>17.46</b>	19.90	820.60
10	<b>53.33</b>	11.52	<b>15.78</b>	12.77	<b>2.14</b>	1.55	485.10	<b>23.10</b>	24.35	1085.7
$\bar{x}$	<b>36.36</b>	15.70	<b>15.60</b>	9.01	<b>3.32</b>	2.72	374.60	<b>17.85</b>	17.81	839.00

<sup>1)</sup> - amounts of pollen from 21 trappings made during the field survey

greater than that, averaging 17.84 g/day across colonies with daily outputs varying from 4.95 to 28.43 among colonies (Table 2). It must be noted that the amounts of pollen yielded by bees were significantly influenced by collecting season, the outputs decreasing considerably as the foraging season advanced. In 2002, in the first two weeks of the survey (from the 1<sup>st</sup> to the 7<sup>th</sup> collection) the yield averaged from 8.45 to 24.54 g of pollen loads per day per colony. In the next two weeks (collections from 8 to 13) the yields were from 0.50 to 6.68 g of pollen per day and in the final two weeks (collections 14 to 21) daily yields averaged from 1.28 to 8.18 g per colony (Table 2). The statistical analysis showed that in 4 colonies (1, 3, 7 and 10)

significant differences among survey years occurred (at  $P_{0.05}$ ) for the amounts of pollen harvested by the foraging bees (Table 5).

Generally it can be said that in the second half of the foraging season (second half of July and August) the amounts of pollen yielded by colonies were small in the survey area.

Given that the average pollen output in the apiaries in this country is ca. 3 kg of pollen loads per season (Wilde and Bratkowski 1997) the average output per colony can be estimated at 50 g/day (averaged over two months). This said, the results from this study are much lower when compared with those reported in the literature. Wilde and Bratkowski (1996)

Table 3.

Average weights of single pollen loads harvested in 2002 with the over successive periods (mg/piece)

Harvest period	Bee colony no.										x̄
	1	2	3	4	5	6	7	8	9	10	
1 – 7	7.72	7.77	6.58	7.26	7.47	7.78	7.64	7.32	7.82	7.41	7.48
8 – 13	7.37	7.90	6.95	7.40	6.73	7.85	7.46	7.79	7.17	7.56	7.42
14 – 21	6.41	7.71	7.46	6.49	7.01	8.03	6.61	6.37	7.02	6.86	7.00
x̄	<b>7.17</b>	<b>7.79</b>	<b>7.00</b>	<b>7.05</b>	<b>7.07</b>	<b>7.89</b>	<b>7.24</b>	<b>7.16</b>	<b>7.34</b>	<b>7.28</b>	7.31
SD	1.02	0.88	1.22	1.14	1.08	0.87	1.19	1.07	1.27	0.96	1.09

Table 4.

Average weights of single pollen loads harvested in 2003 with the over successive periods (mg/piece)

Harvest period	Bee colony no.										x̄
	1	2	3	4	5	6	7	8	9	10	
1 – 7	7.46	7.19	6.98	7.28	8.90	8.43	7.20	6.58	7.49	6.37	7.39
8 – 13	8.33	7.73	7.89	7.16	8.32	8.15	8.27	7.34	7.43	6.78	7.74
14 – 21	7.36	5.51	6.91	5.96	6.10	7.75	7.45	6.48	5.74	5.01	6.43
x̄	<b>7.75</b>	<b>6.39</b>	<b>7.11</b>	<b>6.67</b>	<b>7.25</b>	<b>8.06</b>	<b>7.64</b>	<b>6.77</b>	<b>6.61</b>	<b>5.68</b>	6.99
SD	1.39	1.33	1.08	1.23	1.67	1.07	1.12	1.07	1.23	1.05	1.24

Table 5.

Average amounts of pollen harvested from individual bee colonies in over the whole survey period (g/day)

Bee colony no.	Amount of trapped pollen					
	2002			2003		
	Total	$\bar{x}$	SD	Total	$\bar{x}$	SD
1	119.3	<b>7.95*</b>	7.70	358.2	<b>17.06*</b>	18.73
2	138.4	<b>9.22</b>	9.04	276.1	<b>13.15</b>	13.50
3	176.0	<b>11.73*</b>	8.63	534.6	<b>25.46*</b>	22.47
4	103.2	<b>6.88</b>	6.25	226.2	<b>10.77</b>	13.50
5	234.7	<b>15.64</b>	12.62	596.9	<b>28.47</b>	27.93
6	64.4	<b>4.29</b>	4.28	103.9	<b>4.95</b>	2.97
7	163.1	<b>10.87*</b>	12.73	506.4	<b>24.11*</b>	22.73
8	128.5	<b>8.57</b>	7.12	292.2	<b>13.92</b>	11.76
9	139.8	<b>9.32</b>	8.79	366.6	<b>17.46</b>	19.90
10	154.8	<b>10.32*</b>	8.62	485.1	<b>23.10 *</b>	24.35
$\bar{x}$	142.2	<b>9.50</b>	8.61	374.6	<b>17.85</b>	17.81

\* statistically significant differences between years at  $P_{0.05}$

Table 6.

Average weights of single pollen loads harvested over the whole survey period (mg/piece)

Bee colony no.	Average weights of pollen loads (mg/piece)			
	2002		2003	
	$\bar{x}$	SD	$\bar{x}$	SD
1	<b>7.17</b>	1.02	<b>7.75</b>	1.39
2	<b>7.79**</b>	0.88	<b>6.39**</b>	1.33
3	<b>7.00</b>	1.22	<b>7.11</b>	1.08
4	<b>7.05</b>	1.14	<b>6.67</b>	1.23
5	<b>7.07</b>	1.08	<b>7.25</b>	1.67
6	<b>7.89</b>	0.87	<b>8.06</b>	1.07
7	<b>7.24</b>	1.19	<b>7.64</b>	1.12
8	<b>7.16</b>	1.07	<b>6.77</b>	1.07
9	<b>7.34</b>	1.27	<b>6.61</b>	1.23
10	<b>7.28**</b>	0.96	<b>5.68**</b>	1.05
$\bar{x}$	<b>7.31</b>	1.09	<b>6.99</b>	1.24

\*\* statistically significant differences between years at  $P_{0.05}$

emphasized that in the periods of copious pollen flows – the blooming of winter rapeseed, faba bean and buckwheat – as much as 20 kg of pollen loads per colony can be obtained over the combined blooming period of those plants which would set the pollen yield at 300 g per colony's working day. However, such high yields rely on high pollen outputs of those plants and on the appropriate strength of bee colonies. As reported by Kołtowski (1966) the pollen output of faba bean may be around 5.5 mg of pollen per 10 flowers and thus the average amount of pollen gathered by bees may be ca. 500 g per 1 ha (0.5 kg). However, Veselý and Titěra (1985) in their study conducted on horse bean field found the amounts of pollen harvested over the blooming season to range from 1 to 418 g depending on colony strength and weather conditions.

Pidek (1988) reports after other authors (Falaleev 1979, Šabaršov 1980, Poliščuk 1984, Stašenko 1985, Vachonina 1987) that in the season of good pollen flows ca. 200 g of pollen can be yielded daily by a bee colony and with very copious pollen flows the yield can be up to 1.0 kg. Those yields are indeed imposing compared to the daily amounts of pollen obtained in this study (maximum of 54.61 g/day). However, as stated by Pidek (1988) too much pollen collected from bees negatively impacts the colony by weakening it which may reduce the honey output even by as much as 60%. In his study Pidek (1988) collected from 221 to 797 g of pollen from individual colonies over the period from the beginning of June to mid-July which translated to the daily yields of 4.91 to 17.71 g of pollen. It came ideally within the range of daily pollen outputs obtained in this study (4.29 – 15.64 g/day in the first year and 4.95 – 28.43 g/day in the second year). However, Pidek (1988) makes a strong point that the amounts of trapped pollen were

dependent on colony strength while emphasizing that the weather in the period was not favourable.

As reported by Warakomska (1972) in July bee colonies can gather much less pollen than they can in May. The pollen inflow per colony in July may reach an average level of 5.6 kg whereas in May it may be as high as 10 kg. Those are very large amounts when compared to the data from this study in the course of which the best colony yielded a little over 1.3 kg of pollen in the period from mid-July to the end of September (Table 2).

Bieńkowska and Pohorecka (1996) paid their attention to yet another factor affecting the amount of trapped pollen – the thickness of the plate and, first of all, the diameter of the openings in the pollen trap plates. The investigators found that the lowest amounts of pollen were trapped with pollen traps equipped with 5.00 mm mesh traps – from 17.2 to 24.4 g of pollen per day per colony. The highest amounts of pollen were trapped by using pollen traps with 4.77 mm mesh plates – from 44.7 to 63.6 g of pollen per day. However, it must be noted that the investigators (Bieńkowska and Pohorecka 1996) conducted their research in the period from the end of May to the end of June i.e. in the period of good pollen flows. It appears from the study by Bobrzecki and Wilde (1990) that the mounting of a pollen-removing insert with 5 mm mesh size allowed the removal of ca. 29% of pollen loads brought in by the foragers. It is obvious that the pollen traps used in this study (with 5.00 mesh plates) did not remove all pollen pellets. However, the percentage of actually removed pollen loads was not investigated. It can only be noted that during pollen trapping bees with pollen loads were not frequently observed to get inside the hive. Pollen was trapped on every 2<sup>nd</sup> or 3<sup>rd</sup> day so the foragers did not become used to the presence of the trap and they

were not observed to form reduced pollen loads to make an easier passage through the pollen-removing trap. Eventually, even on assuming the removal of 30% of pollen loads by the plates the average daily amounts of pollen brought in by the foragers were not imposing (up to 85 g per day in the best colony).

The study did not show a relationship between pollen load size and pollen efficiency in a colony. Indeed, the largest pollen loads (in both survey years) averaging 7.89 mg/piece in the first year and 8.06 mg/piece in the second year were brought by foragers of colony no. 6, the lowest pollen performer with an average output of 4.29 and 4.95 g of pollen per day in the first and second year, respectively. Instead, the smallest pollen loads were brought by worker bees from colonies that yielded medium-high amounts of pollen – colony no. 3 in the first year, average pollen load weight of 7.00 mg/piece (Table 3) and colony no. 10 in the second year, average pollen load weight of 5.68 mg/piece (Table 4). The foragers from colony no. 5, the highest pollen yielder, made medium-sized pollen loads – 7.07 mg/piece in the first year (Table 3) and 7.42 mg/piece in the second year (Table 4). Highly significant differences (at  $P_{0,01}$ ) between years for single pollen load size occurred in colonies no. 2 and 10 (Table 6).

In available literature data are reported that imply much higher single pollen load weights. Holm (1974) measured the pollen loads made by bees foraging on horse bean pollen and determined their weight at 21.4 mg (with a small distance from the pasture to the beehive). His comment was that they were much larger than the pollen loads gathered from other plant species. On the other hand, Skowronek (2001) reports that pollen loads brought by the bees to the hive can have a weight from 5 to 15 mg/piece or comparable to that obtained in this study. Szklanowska and Czubacki

(2000) in turn report on very small pollen loads harvested from evening primrose, their weight being from 3 to 5 mg.

Pidek (1988) reports on pollen load sizes very close to those obtained in this study. He found the pollen loads to vary in weight which, upon drying, was from 3.9 to 17.4 mg/piece. The author of this paper obtained pollen loads that averaged from 7.00 to 7.89 mg/piece in the first year and 5.68 to 8.06 mg/piece in the second year depending on colony, the average water content of pollen loads being from 12.0 to 17.4%.

The results from this study and the data from literature unequivocally indicate that the amounts of pollen which can be obtained from bees by means of pollen traps depend on forage season, to wit on the species and varieties of forage species blooming at a given moment. Therefore, in the second half of summer, in regions with poor pollen flows only small amounts of pollen were gathered, amounts that could not meet the actual current demands for pollen by the bees.

## CONCLUSIONS

The study showed that in the period from mid-July to the end of September in an area poor in summer and late summer pollen resources bee colonies are not capable of securing enough pollen from the current flows to meet their current demands including the need to sustain colony development (brood rearing) and to get the workers prepared for hibernation. They have to have pollen stores coming from an earlier period (May, June). An alternative is to seed or plant pollen-yielding species that bloom in July and August, in the vicinity of the apiaries

No close relationship was found between pollen load size and the weight of pollen harvested by the bees. Nonetheless, the largest pollen loads were formed by

foragers from the colony of the lowest pollen output. No relationships of that kind were found in other bee colonies.

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## GROMADZENIE PYŁKU KWIATOWEGO W OKRESIE PÓŻNOLETNIM PRZEZ RODZINY PSZCZOŁY MIODNEJ (*Apis mellifera* L.)

R o m a n   A .

### S t r e s z c z e n i e

Celem badań było ustalenie, jakie ilości pyłku kwiatowego są w stanie zgromadzić rodziny pszczele w drugiej połowie sezonu pożytkowego, w rejonie ubogim w pożytki letnie i późnoletnie oraz sprawdzenie czy istnieje zależność między wielkością przynoszonych do ula przez pszczoły zbieraczki obnóży, a ilością pyłku gromadzonego przez rodziny pszczele. Badania przeprowadzono w drugiej połowie lipca i sierpniu, w dwóch kolejnych latach (2002 i 2003), w pasiece stacjonarnej. O ilościach gromadzonego przez pszczoły pyłku wnioskowano na podstawie ilości obnóży pozyskiwanych przy pomocy poławiaczy pyłku. Badania wykazały, że rodziny pszczele funkcjonujące w takim rejonie mogą mieć problemy z zaopatrzeniem się w odpowiednie ilości pyłku kwiatowego na cele bieżące. Średnie ilości pyłku pozyskiwane od poszczególnych rodzin pszczelich w tym okresie wynosiły od 4,29 do 15,64 g/dzień w pierwszym i od 4,95 do 28,47 g/dzień w drugim roku badań. W porównaniu z bieżącymi pokarmowymi potrzebami rodzin pszczelich były to ilości bardzo małe. Nie wykazano ścisłych zależności między ilością pozyskiwanego pyłku kwiatowego a wielkością formowanych przez pszczoły obnóży, chociaż w obu latach badań największe obnóże przynosiły robotnice z rodziny (nr 6), od której pozyskano najmniej pyłku. Badania wykazały, że w drugiej połowie sezonu pożytkowego rodziny pszczele mogą mieć problemy z zaopatrywaniem się w pyłek na cele bieżące - rozwojowe rodziny i przygotowania robotnic do zimowli.

**Słowa kluczowe:** rodzina pszczele, obnóże pyłkowe, wydajność pyłkowa, poławiacze pyłku.