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STUDIES ON THE RELATIONSHIP BETWEEN FLORAL FIDELITY AND QUANTITY OF POLLEN HOARDED BY HONEYBEE (*APIS MELLIFERA* L.) COLONIES

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ABSTRACT

The aim of this study was to learn the strength of floral fidelity of honeybee colonies and to find what is the relationship between this trait and the amount of collected pollen. The observations were carried out in 2003 and 2004 on 10 honeybee colonies. The pollen was gathered from pollen loads collected using a pollen trap with a 5-mm screen mesh. A scanning electron microscope was used to view pollen grains in order to determine the number of plant species visited by the bees. The mean values of floral fidelity estimated individually for each experimental colony ranged from 40.1 to 75.7% in the first year, and from 45.1 to 67.3% in the second year of the studies. Correlation between floral fidelity and the quantity of collected pollen was observed in 60% of the colonies in the first year and in 70% in the second year. Recurrence of this relationship over the period of two years was found in only 30% of the studied honeybee colonies.

Key words: floral fidelity, honeybee colonies, pollen loads, pollen yield.

INTRODUCTION

Floral fidelity, or visiting flowers of a single plant species during a foraging trip, represents one of the characteristics of the honeybees (*Apis mellifera* L.) working as pollen foragers. This term also applies to the whole colony and implies that nearly the entire harvest its foragers bring in a unit of time (e.g. a day) come from the same plant species, which is continued until its resources in the environment are consumed [4]. Forager honeybees specialise in gathering nectar and pollen from a given type of flower, thus are able to work faster and more efficiently, which should result in enhanced efficiency of the whole colony.

Foragers working in the field increase their efficiency through specialising in hoarding certain forage; about 60% of them collect nectar, 25% bring pollen, while only about 15% gather both nectar and pollen at the same time. Honeybees, however, exhibit strong ability to adapt to changing conditions and needs of the colony, which is reflected in a variable proportion between the number of nectar and pollen foragers [30].

The annual requirement of a colony for pollen ranges between about 15 and 35 kg. The quantity depends on the strength of the colony, the numbers of reared brood, as well as on pollen resources in the environment [15, 17]. Pollen is the only protein-rich provision from the outside environment that is digestible in the alimentary tract of the honeybee. It is possible to substitute pollen in the honeybee diet with mixes containing various components, e.g. soya bean protein or potato protein, supplemented with some amino-acids and probiotics [19, 20, 23]. However, despite their positive effects in the form of enhanced physical shape of worker bees, such substitutes do not fully meet the nutritional needs of the bees and, therefore, are usually applied in the seasons when pollen availability in the environment is poor [1, 12, 13, 19, 20, 21, 22, 23].

Pollen composition is very rich and offers high nutritive and biological values for both honeybees and humans, hence it is harvested by man as an apiary product. It is therefore very important that foragers bring as much pollen as possible to the hive and that we could collect as much pollen as possible from the bees, which in consequence will improve the profitability of the apiary [5, 27, 29, 30].

Pollen gathered by the bees is formed and transported to the hive as pollen loads; also in this form it is most commonly collected from the honeybees. The colour of the pollen loads the bees bring in their baskets varies, which means they have visited and gathered pollen from various plant species.
The aim of our studies was to find the degree of floral fidelity of honeybee colonies and to find out what is the effect of this trait on the pollen quantity harvested from the bees.

MATERIALS AND METHODS

The studies were carried out in July 2003 and July 2004 on 10 honeybee colonies of the Kraińska breed, Podgórska strain, kept in a stationary apiary in a town of Szydłowice (central-western Opole region, Poland). All the experimental colonies inhabited enlarged Warsaw-type hives (nesting frames 300 by 435 mm), filling “in black” from 13 to 14 combs, including 5-6 combs with sealed brood, and 2-3 combs with open brood.

The pollen was collected as pollen loads using a pollen trap with a 5-mm mesh screen. The pollen was collected throughout the day (the screens of the traps were lowered from 4.30 hours until 20.30 hours) every third day. In each year, 10 collections of pollen loads were performed, which resulted in a total of 200 samples in both years. Each pollen sample was weighed and dried at 42°C in an incubator. The pollen loads were counted in each sample, and basing on the fresh weight of each sample and the number of loads, mean pollen load weights were calculated. Thereafter, the loads were graded by shape and natural light colour using colour patterns, and so selected samples were formed. From each selected sample, 0.1 g of visually uniform loads was placed in marked test tubes and dissolved in distilled water. A few drops of the solutions were placed on a microscope slide and dried again in the incubator. After removing the pollen from the slides, its small amounts were vacuum fixed in a sputter coater Edwards-Pirani 50. Thereafter, the pollen grains were viewed using the scanning electron microscope LEO 435 VP (LEO, Zeiss+Leica). The shapes of the grains were then compared with the catalogue and tables [7, 33] in order to determine the number of plant species visited by the bees [25, 26].

The resulting data was processed statistically using Statgraphics 5.1 software package. The calculated statistics included arithmetical means, standard deviations, correlations, and estimations of significance of differences with Duncan's multiple range test.

RESULTS

The investigations have demonstrated that the forager honeybees in each colony gathered varied amounts of pollen. The mean daily yield of pollen loads from one colony was 40.70 g in 2003 and 8.55 g in 2004 (Table 1). In the first year of the studies, a strong variability was observed in the quantity of gathered pollen, since the colony no. 10 produced on average as little as 6.98 g pollen per day, while the colony no. 4 gave an average of 68.40 g pollen per day. Significantly less pollen was collected from the colonies in the second year of the observations, i.e. 2.94 g per day from colony no. 8 and 15.32 g per day from the colony no. 14 (Table 1). Considering pollen loads harvest from each colony on subsequent days of the trials, it was found that the lowest in the first year was 3.12 g per day from the colony no. 10 , while in the second year it was 0.10 g per day from the colony no. 8. The highest pollen yields per colony were 137.68 g per day (colony no. 9) and 40.21 g per day (colony no. 14) respectively in 2003 and 2004. It was found that differences between pollen hoarding yield of the colonies in both years were statistically significant ($p \leq 0.05$) or highly significant ($p \leq 0.01$) – Table 1.

The mean weights of individual pollen loads were 6.87 mg per bee in 2003 and 5.61 mg per bee in 2004 (difference highly significant, $p \leq 0.01$). In the first year the most bulky loads of 7.79 mg per bee were formed by the workers in the colony no. 10, whilst in the second year – by the foragers in the colony no. 13, 6.48 mg on average. It should be stressed that the foragers of the colony no. 13 formed the smallest loads of 5.81 mg in 2003. In 2004, the smallest pollen loads of 4.77 mg mean weight were brought by the foragers of the colony no. 15. The largest in weight pollen loads in 2003 were 15.03 mg (colony no. 8) and in 2004 – 9.21 mg (colony no 4), as shown in Table 2.

Table 1. Weight of fresh pollen loads collected from experimental colonies (g per day)

Year	Specification	Colony number										$\overline{x}$	SD
		1	2	4	8	9	10	11	13	14	15		
2003	min.	10.90	8.50	30.69	3.37	14.13	3.12	9.06	8.04	6.97	6.65	10.14	7.92
	max.	78.23	56.27	127.55	39.39	137.68	12.38	113.46	39.68	123.60	95.82	82.41	43.73
	$\overline{x}$	43.22 aA **	26.83 BbCcd **	68.40 BDEF **	19.38 aDghij **	61.70 bgGk **	6.98 ACEhGHIJK	54.35 ciHl **	25.76 FkIlm *	43.27 J	57.11 djKm **	40.70	-
	SD	30.10	18.58	35.80	15.86	45.15	3.12	35.0	11.56	43.82	39.41	-	-
2004	min.	0.18	0.75	0.01	0.10	1.08	0.64	0.82	1.88	3.83	0.99	1.03	1.13
	max.	20.70	7.65	17.17	9.12	31.88	12.16	8.68	26.16	40.21	21.89	19.56	10.84
	$\overline{x}$	7.16 **	4.14 aAb **	6.54 **	2.94 cdBCe **	14.22 acf **	4.56 fgh	8.40 d **	13.21 ABg *	15.32 bCh	9.07 e **	8.55	-
	SD	7.38	3.72	6.35	3.31	12.51	4.18	6.75	8.71	14.22	8.58	-	-

A-K Letters in pairs denote highly significant differences at P_{001} between colonies.
[a-m] Letters in pairs denote significant differences at P_{005} between colonies.
** Differences highly significant at P_{001} between years of observations.
* Differences significant at P_{005} between years of observations.

Table 2. Weight of individual pollen loads (mg per load)

Year	Specification	Colony number										$\overline{x}$	SD
		1	2	4	8	9	10	11	13	14	15		
2003	min.	6.46	6.12	6.18	5.68	5.65	6.00	5.59	5.06	5.36	5.20	5.73	0.45
	max.	7.76	7.95	7.73	15.03	8.84	9.24	7.44	6.40	7.15	6.64	8.42	2.48
	$\overline{x}$	7.22 **	6.89	6.96	7.78	7.42 *	7.79 **	6.55 **	5.81	6.37	5.88 **	6.87 **	0.71
	SD	0.51	0.68	0.58	3.58	1.24	1.17	0.70	0.61	0.72	0.55	0.70	-
2004	min.	3.60	3.03	4.74	3.33	5.68	4.19	4.45	5.70	5.11	4.09	4.54	0.84
	max.	7.89	7.57	9.21	7.00	6.90	6.53	6.14	8.24	7.58	5.61	7.27	1.06
	$\overline{x}$	5.33 **	5.78	5.56	5.34	6.18 *	5.15 **	5.24 **	6.48	6.24	4.77 **	5.61 **	0.55
	SD	1.42	1.74	3.18	1.28	0.45	0.93	0.7	1.02	1.08	0.51	0.56	-

** Differences highly significant at (P_{001}).
* Differences significant at (P_{005}).

Table 3. Number of plant species visited by forager bees

Year	Specification	Colony number										$\overline{x}$	SD
		1	2	4	8	9	10	11	13	14	15		
2003	min.	2	3	4	4	4	2	4	4	5	3	3.50	0.97
	max.	8	8	9	9	9	8	9	8	7	8	8.30	0.67
	$\overline{x}$	5.0	6.0	7.2	6.5	6.3	5.5	6.8	6.3	5.8	6.3	6.18	0.63
	SD	2.19	2.00	1.83	1.87	1.75	2.26	1.94	1.37	0.98	1.97	-	-
2004	min.	2	4	1	2	4	3	4	4	4	2	3.00	1.15
	max.	8	10	10	8	10	10	10	10	8	9	9.30	0.95
	$\overline{x}$	5.0	6.2	5.7	4.3	7.0	6.0	7.5	6.7	6.2	5.5	6.0	0.95
	SD	2.19	2.14	4.32	2.8	2.37	2.37	2.26	2.42	1.72	2.43	-	-

Table 4. Floral fidelity of pollen foragers (percentage of loads of the dominant plant species)

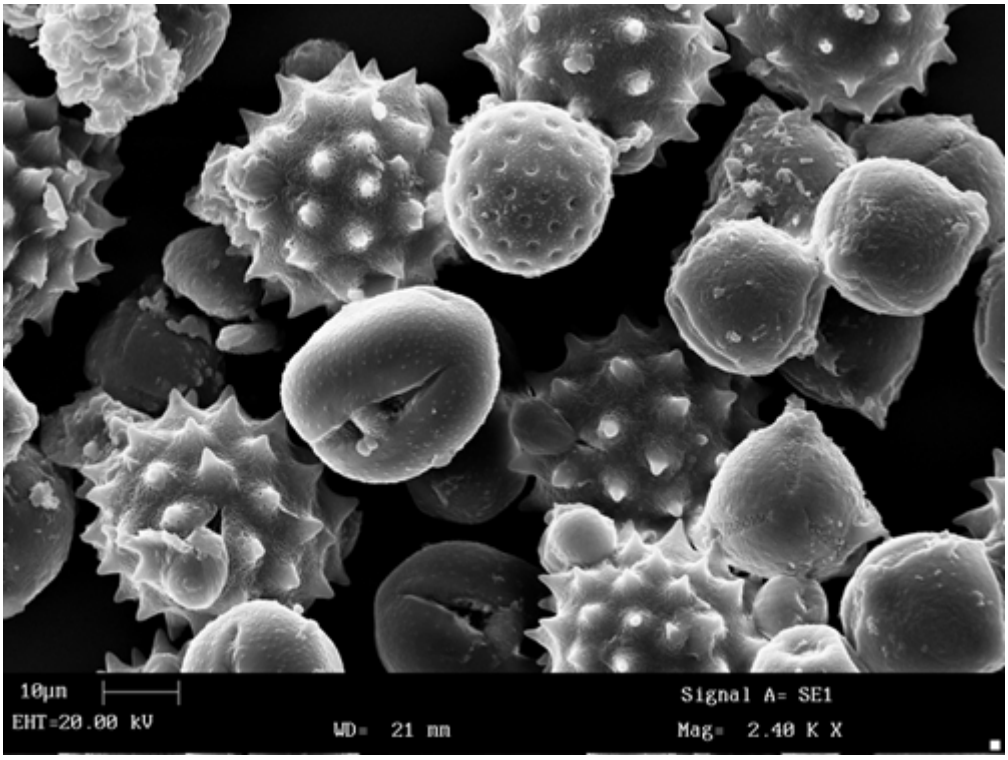
Year	Specification	Colony number										$\overline{x}$	SD
		1	2	4	8	9	10	11	13	14	15		
2003	min.	27.9	49.6	45.6	25.9	29.3	51.9	36.4	27.5	42.5	65.2	40.18	13.06
	max.	78.3	89.0	82.0	75.9	63.4	85.7	89.0	72.4	95.1	90.1	82.09	9.65
	$\overline{x}$	61.8 ^{ab}	71.8 $^{ABC\ **}$	63.5 ^{cdD}	45.6 ^{AcEFGH}	42.0 $^{aBdIJeK\ *}$	71.1 $^{EIL\ **}$	71.5 $^{FJM\ *}$	40.1 ^{bCDLMfN}	65.7 ^{Gef}	75.7 $^{HKN\ *}$	60.9	13.37
	SD	18.67	16.26	14.50	17.03	12.47	13.19	19.17	16.60	23.12	15.25	-	-
2004	min.	36.6	29.3	35.5	32.4	36.3	24.0	44.4	31.4	45.1	28.4	34.34	6.73
	max.	88.7	58.5	100.0	100.0	77.0	75.1	62.3	69.7	65.0	73.4	76.97	14.78
	$\overline{x}$	67.3 ^{Aa}	46.4 $^{A\ **}$	57.8	59.7	55.2 *	45.1 $^{a\ **}$	53.7 *	52.2	55.5	57.2 *	55.00	6.41
	SD	19.49	9.57	36.38	26.78	13.55	17.53	7.29	16.53	8.44	16.75	-	-

A-N Letters in pairs denote highly significant differences at P_{001} between colonies
$^{a-f}$ Letters in pairs denote significant differences at P_{005} between colonies
** Differences highly significant at P_{001} between years of observations
* Differences significant at P_{005} between years of observations

The number of plant species visited during a working day by the foragers from individual colonies was varied, ranging on average from 5.0 to 7.2 in the first year, and from 4.3 to 7.5 in the second year of the observations. It should be noted that during a single day the bees of the given colonies gathered pollen from 2 to 9 species of plants in July 2003 and from 1 to 10 plant species in July 2004 (Table 3). However, a single sample was nearly always dominated by the loads of pollen from the same plant species, which represented from 26 to 95% in the first year and from 24 to 100% in the second year of the studies (Table 4).

The studies have shown that floral fidelity was various depending on the colony. In the first year of the studies, the mean level of this trait for all the colonies was 60.9%, being lower in the second year, i.e. 55.0% on average. The lowest fidelity in 2003, an average of 40.1%, was exhibited by the colony no. 13 (Table 4), which produced an average of 25.76 g loads per day (Table 1). The lowest floral fidelity in 2004, mean 45.1%, was found in the colony no. 10 (Table 4), which also demonstrated a very low pollen yield, i.e. 4.56 g per day on average (Table 1). On the other hand, the highest mean level of floral fidelity, 75.7%, was found in the colony no. 15 (Table 4), which produced an average of 57.11 g of pollen loads per day (Table 1), which implies a considerably high pollen yield.
The studies allow concluding that floral fidelity is not a stable trait in forager bees, since SEM analysis of pollen from individual pollen loads demonstrated grains originating from 2 to 4 plant species (Photo 1). This in turn enable concluding that a forager bee visits a number of plant species during one forage trip.

Photo 1. SEM image of pollen from a single load; visible pollen grains of 3 plant species



The studies have also demonstrated significant ($p \leq 0.05$) or highly significant ($p \leq 0.01$) correlations between the weight of individual pollen loads hoarded by the foragers and pollen yields in 60% of the colonies in the first year and in 30% of the colonies in the second year of studies. Recurrence of this relationship over two years at a similar level was found in 20% of the colonies only (Table 5).

Table 5. Coefficients of correlation

Parameter	Year	Hive number										$\overline{X}$
		1	2	4	8	9	10	11	13	14	15	
Collected pollen weight – floral fidelity	2003	0.15	0.30	0.86**	-0.57*	0.57*	0.70**	0.78**	0.13	0.87**	0.01	0.51
	2004	0.61*	0.63*	0.42	-0.52	0.64*	0.80**	0.74**	0.79**	0.33	0.66*	0.08
Collected pollen weight – number of visited plant species	2003	-0.23	-0.28	-0.55	0.24	-0.01	-0.32	-0.50	-0.31	-0.22	0.00	- 0.39
	2004	0.79**	0.78**	0.74**	0.85**	0.90**	0.17	0.62*	0.68*	0.35	0.90**	0.86**
Collected pollen weight – weight of 1 load	2003	0.42	0.75*	-0.14	0.62*	0.79**	0.68*	0.27	0.31	0.78**	0.57*	0.53
	2004	0.14	0.65*	0.49	0.37	0.75**	0.16	0.68*	-0.29	0.38	-0.18	0.57*
Floral fidelity – weight of 1 load	2003	-0.47	-0.27	-0.60*	-0.50	-0.02	0.32	0.35	-0.44	0.73**	-0.57*	- 0.22
	2004	0.58*	0.02	0.97**	-0.52	-0.17	-0.17	0.17	0.12	-0.55	-0.02	0.69*
Floral fidelity – number of visited plant species	2003	0.17	0.72**	-0.50	-0.54	-0.02	-0.39	-0.15	0.75**	-0.01	-0.20	- 0.30
	2004	0.45	-0.11	0.15	0.86**	-0.60*	-0.33	0.32	-0.41	0.27	0.51	- 0.22
Number of visited plant species – weight of 1 load	2003	0.87**	0.07	0.04	0.61*	-0.04	-0.39	0.14	-0.07	-0.03	0.09	0.12
	2004	0.16	0.69*	0.29	0.47	0.56	0.44	0.15	-0.54	-0.25	-0.53	0.45

** Coefficient of correlation highly significant at $P_{001.}$
* Coefficient of correlation significant at$P_{005.}$

The correlations between the amount of collected pollen and number of visited vegetation species were unstable and were found only in the second year of the studies, being highly significant ($p \leq 0.01$) in 60% of the colonies and significant ($p \leq 0.05$) in another 20% (Table 5). On the other hand, the dependence between the number of floral species and the weight of individual loads was highly significant ($p \leq 0.01$) only in one colony in 2003 and significant ($p \leq 0.05$) in one colony in 2003 and another one in 2004 (Table 5).

The two-year observations have demonstrated that a majority of honeybee colonies exhibited significant ($p \leq 0.05$) or highly significant ($p \leq 0.01$) correlation between floral fidelity and the quantity of collected pollen. Such correlation was found in 60% colonies, including one colony showing negative correlation, in the first year of the studies, and in 70% colonies in the second year (all correlations positive). However, recurrence of this correlation over the period of two seasons at a similar level was found only in 30% of the studied colonies (Table 5). Therefore, it can be concluded that this relationship was highly dependent on external factors, independent from the honeybee colony.

The observations have demonstrated that the correlation between the degree of floral fidelity and the weight of individual loads may be a trait characteristic for particular colonies. Most probably, this correlation depended on current environmental conditions.

The relationship is most probably dependent on the current environmental conditions. It has been found that the foragers of the colonies exhibiting either low (e.g. colonies no. 8, 9, and 13) or high (e.g. colonies 11 and 15, Table 4) floral fidelity formed pollen loads of an average weight ranging between approx. 5.0 and 7.8 mg (Table 2). The coefficient of correlation between those parameters in both years was significant ($p \leq 0.05$) or highly significant ($p \leq 0.01$) in only 3 colonies in the first year and 2 colonies in the second year of the investigations (Table 5).

The correlation between floral fidelity and the number of visited plant species also proved unstable as a highly significant ($p \leq 0.01$) coefficient of correlation was found only in two colonies in 2003 and one in 2004, whereas a significant one ($p \leq 0.05$) – in one colony in 2004 (Table 5).

DISCUSSION

It has been recognised that an average number of collected pollen loads in Polish apiaries is approx. 3 kg per honeybee colony per season (May-June). The mean pollen yield per colony can reach about 8 kg during season only if intensive apiculture technologies are applied [27]. In the countries with a warm climate and a longer plant growing season, it is feasible to harvest up to 13 kg of this product without any special procedures [14]. Under Poland's climate and nectar-flow conditions, strong honeybee colonies, which use nectar and pollen subsequently from winter oilseed rape, field bean, and buckwheat, are able to yield as much as 20 kg of pollen loads per colony, which was observed by Bratkowski and Wilde [5].

Our studies have demonstrated that the forager bees from particular colonies gathered different quantities of pollen. In the first year, the mean pollen yield was 40.7 g per day, or slightly more than 1.2 kg pollen during the whole month of July, while in the second year only 8.6 g per day, which is approx. 0.26 kg per month (Table 1). Bearing in mind the average pollen yield per honeybee colony in Poland, i.e. about 3 kg loads per season, we can calculate daily pollen yield as about 50 g [28]. This quantity is comparable with the mean found in the first year of our observations (Table 1). Grabowski et al. [10] have reported that, using a pollen trap, they collected from 0.50 to 2.00 kg pollen loads from individual honeybee colonies during 10 days, hence their daily yield ranged between 50 to 200 g of loads. According to our studies, in 2003 more than 100 g pollen loads per day was collected each time from selected colonies, with the highest pollen yield reaching 137.7 g per day (Table 1). In 2004, the quantity of collected pollen loads did not exceed 50 g per day per colony. Hellmich et al. [11] and Grabowski and Siuda [9] stress that, besides environmental factors, the quantity of harvested pollen also depend on genetic traits of the honeybee colony, which also determine the amount of bee bread stored by the colony. Another factor shaping daily pollen yields is the period of colony growth. During its peak intensity, which is in May and June, a colony is able to hoard as much as 500 g of pollen [24]. Such quantities, as compared with our data, should be treated as impressively high (Table 1). It should also be stressed that pollen yield is also affected by the daily level of nectar flow. Polisčuk [16] observed that abundant nectar flow (increase 2-4.5 kg in weight) resulted in reduced pollen harvest, down to a few grams. On the other hand, when nectar flow increase dropped to 0.1-0.2 kg, the bees started to bring more pollen loads, as much as 190-236 g per day.

Pollen loads are collected from the colonies using all sorts of traps. With a trap, an apiarist is able to take about 30% pollen loads from the bees. The rest is usually transported by the mesh of the trap and brought into the nest. If the bees were too intensively deprived of their pollen stores through collecting too much of it, it would be negative to the development of the colony, which as a result may reduce their honey productivity by as much as 60% [8]. Bieńkowska and Pohorecka [2] have demonstrated that the quantities of collected pollen loads per honeybee colony

also depend on the mesh size in the screen of the trap. A screen with 5-mm mesh allowed the authors to collect an average pollen yield ranging between 17.2 and 24.4 g per day. These quantities were much lower than those obtained in our studies during the first year, i.e. 40.70 g per day (range 19.38-68.40 g per day). In 2004, however, we harvested much lower yields of pollen (2.94-15.32 g per day, Table 1).

The mean weight of individual pollen loads in our studies ranged between 5.06 to 15.03 mg per bee (mean 6.87 mg) in the first year and between 3.03 to 9.21 mg per bee (mean 5.61 mg) in the second year (Table 2). Free [6] reports that maximum weight of a pair of pollen loads in a forager can reach 30 mg, or one load can be 15 mg in weight. This has been confirmed by our observations by the pollen loads collected once from the colony no. 8 in the first year of the study (Table 2). Pidek [15] has demonstrated that pollen loads from individual bees differed in weight, which ranged 3.9-17.4 mg/piece after drying. Grabowski et al [10] report that the size of collected loads also depends on the strain the bees belong to and that foragers of high pollen-hoarding strains formed loads of an average weight 10.2 mg, whereas those in unselected colonies – 9.8 mg on average. In his previous studies, Roman [17] collected pollen loads of an average weight ranging from 5.68 to 7.89 mg.

We have demonstrated that the loads collected from individual colonies in both years and those from subsequent collections differed in weight (Table 2). This implies that the weather and nectar flow conditions changing during the studies influenced the weight of pollen loads brought by the bees.

Our studies have shown that the number of plant species visited during a foraging day was different in each colony and ranged between 2 and 9 species in the first year and between 1 and 10 in the second year of the studies (Table 3). However, nearly always a collection of pollen was dominated by pollen loads from one plant species, which represented from 26 to 95% in the first year and from 24 to 100% in the second year of the studies (Table 4). It should be stressed that the pollen of the dominant plant species represented a vast majority compared to the pollen of other plants [18]. Woyke [31] represents an opinion that floral fidelity is characteristic for honeybees. According to this author, bees usually visit the same plant species while foraging for nectar and pollen. Wróblewska [32], who expresses a similar opinion, has demonstrated in her experiments that the largest part of gathered and stored pollen, i.e. 98.2% of all identified plant species, came from the family *Brasicaceae*. Pollen grains of other plants usually represented a very small proportion.

Grabowski and Siuda [9] have noticed that during the field bean flowering season, low pollen-hoarding bees gathered the most pollen of this plant, which represented 88.5% of the entire stored pollen. On the other hand, the loads of foragers belonging to a high pollen-hoarding group contained only 69.0% of field bean pollen. However, Bond and Hawkins [3] have reported that during the peak field bean flowering season as many as 90% of bees may forage on this plant, while only a few foragers will seek flowering plants of other species. Grabowski and Siuda [9] have demonstrated that bees foraging on oilseed rape gathered mainly the pollen of this species; however, pollen foragers also willingly visited flowering apple trees, pear trees, and dandelions. Towards the end of oilseed rape nectar flow, the bees started to forage other available resources of pollen (mainly clover, lupine, and field bean). All this shows that honeybees specialised in one flower do not necessarily use the same nectar and pollen source, as it has been often described in the literature. Our studies have demonstrated that many loads contain pollen grains from two or more plant species, which implies that a forager visits more than one plant species during a trip.

CONCLUSIONS

1. The honeybee colonies demonstrated varied pollen yields.
2. Pollen foragers demonstrated floral fidelity at a level of 40.1 to 75.7% in the first year and 45.1 to 67.3% in the second year of the study.
3. Correlation between floral fidelity and pollen yield was found in 60% of the colonies in the first year (including negative correlation in one of the colonies) and in 70% of the colonies in the second year of the studies; recurrence of this correlation over two years was found in 30% of the colonies.
4. Correlation between pollen yield and individual pollen loads carried by the foragers was found in 60% of the colonies in the first year and 30% of the colonies in the second year; recurrence of this trait at a similar level over two years was found in 20% of the colonies.

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