Flower constancy of honeybees (*Apis mellifera L.*) to blooming pear plantations

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Summary: Studies were made on the composition of pollen loads of honeybees captured at the flowers of blooming pear trees in pear plantations. Also the foraging behaviour of honeybees was observed. Overwhelming majority of honeybees visiting the flowers of 13 pear cultivars in 1996 were pollen gatherers (95.6 per cent). Proportion of pure nectar gatherers was as low as some 3.7 per cent and no more than 0.7 per cent performed mixed behaviour. The analysis of pollen loads of bees collected at pear flowers in blooming pear plantations showed that fidelity was as high as 89–90 per cent towards pear, higher than for another fruit species in other studies. Even those plant species that are regarded to be strong competitors of blooming fruit trees in the literature *(Taraxacum officinale, Stellaria media, Lamium purpureum)* were scarcely represented in the loads. Accordingly, honeybees can be much more important and more effective pollinating agents of pear cultivars than generally believed.

Introduction

Most cultivated varieties of pear are self-sterile and need cross pollination to set a good crop. The pollen vectors are recruited of flower visiting insects. Pear, however, does not have any specialised flower visitors (c.f. *Free,* 1970, 1993, *Benedek et al.*, 1974, *McGregor,* 1976, *Benedek,* 1996) and thus its flowers are frequented by polylectic and widely oligolectic pollinators. Accordingly, their behaviour and fidelity towards pear is greatly important from the point of view of its pollination and also of commercial fruit set. In forest clearings solitary wild pear tree are visited by several type of flower visiting insects but wild bees are the most frequent visitors of them. In large commercial pear plantations, however, the proportion of honeybees is usually overwhelming in flower visiting insect populations (*Free,* 1970, 1996, *McGregor,* 1974, *Benedek,* 1996).

It is well known that bees tend to be constant on specific flower species during their foraging trips (*Free,* 1963). For this reason flower constancy is greatly important from the point of view of insect pollination of flowers (*Free,* 1970, 1993). In the case of honeybees, however, constancy is largely different at the level of the individual forager bee and at the level of the colony, respectively. Individual foragers visit much more limited number of pollen and nectar sources than all the field bees of the colony together (*Free,* 1970, 1993). Thus flower constancy of honeybee foragers is an important factor in pear production.

Previous studies on the flower constancy of honeybee foragers were based on the composition of pollen loads of individuals collected at the hive entrance when they were returning back from their foraging trips (*Betts,* 1920, *Percival,* 1947, *Maurizio,* 1953, *Free,* 1963 and others). This kind of study provides a very good picture on the general pattern of flower constancy of all foragers of the honeybee colony. Individual foragers, however, can be and usually are constant at different plant species, simultaneously. Pollinating efficiency of honeybees visiting a specific crop does not depend on the fact that they come together from different bee colonies. Therefore, the approach mentioned does not give a reliable information on the relative constancy of bees visiting a specific plant species. For this reason we made attempts to explore the fidelity of honeybees towards pear when visiting the flowers of blooming pear trees in

commercial plantations independent of the fact whether they came from different bee colonies at the neighbourhood.

Material and methods

Studies were made partly at a commercial pear plantation at Pomáz (Central Hungary) in 1993 and 1994. The plantation was 11 ha large and was consisted of several cultivars of 20–25 years old trees. There were a number of apiaries in the settlements nearby, the foraging field bees of which frequented the plantation fairly well but no bee colonies were moved into the orchard for supplementary pollination. At this site pollen gatherer honeybees were collected on the flowers of blooming pear trees.

More detailed studies were made in 1996 at a cultivar collection of pear at Keszthely (South-western Hungary). This plantation was 1.5 ha large. Pollen gatherers were collected on the flowers of pear trees like at the other site in previous years. Additionally, foraging behaviour of honeybees was observed, too, at two trees of 13 cultivars each late morning and the afternoon for ten minutes several times during the blooming period on two branches per tree containing some 50 opening flowers each. Counting on foraging behaviour were made parallel at cultivars involved on each day of observation.

Pollen grains of crop studied and also the pollen of other flowering plants found inside or in the close vicinity of the experimental plantations were collected in each time and all was used to make a pollen collection for identification purposes.

Pollen loads of honeybee foragers were moved in the laboratory and their composition was identified under the microscope. Five to ten different sections (views) of each pollen load (sample) were observed with the microscope and the number of pollen grains in each section was counted per pollen species present. Overlap between individual sections (views) was carefully avoided for all sample. This procedure is virtually identical with the method of *Benedek* (1976) as well as with the method of *Westrich* and *Schmidt* (1986) for studying pollen gathering constancy of wild bees visiting different plant species. Some 460 honeybee foragers were captured with pollen loads at the flowers of blooming pear trees and all the loads were analysed as above.

Results

1. ***Foraging behaviour of bees on pear flowers:*** Most honeybees at the plantation observed in 1996 (at Keszthely) were pollen gatherers scrabbling deliberately for pollen only (96.5%) and only small fraction of them were pure nectar gatherers (3.7%) while the mean ratio of foragers with mixed behaviour was negligible (0.7%). However, some slight differences could be found between the cultivars inspected (*Table 1*). No matter of question that the overwhelming majority of honeybee foragers were pollen gatherers even on the cultivar level, but the ratio of nectar gatherers was a bit more variable. There were two cultivars, *Mercedes* and *Conference* at which the nectar gatherers were more frequent than 10 per cent of the foraging honeybees (15.2 and 12.5, resp.). At other cultivars no nectar gatherers were found or their proportion was not more than a few per cent. Mixed behaviour was rather a rare phenomenon. It was missing at most of the cultivars and it was not more than only a few per cent or it was close to be negligible at those cultivars, too, at which this type of behaviour has been observed at all (*Table 1*).

Table 1 Foraging behaviour of honeybees at the flowers of pear cultivars (Keszthely, 1996)

Cultivar	Proportion of behaviour classes (per cent)		
	pollen gatherers	nectar gatherers	mixed behaviour
Abbé Fétel	96.7	3.3	0
Bartlett	100	0	0
Beurré Diel	97.1	0	2.9
Clapps Favourite	95.7	3.8	0.5
Conference	87.5	12.5	0
Lentier doktor	97.8	2.2	0
Magyar Kobak	100	0	0
Mercedes	84.8	15.2	0
Miklós	95.6	0	4.4
Olivier de Serres	93.7	6.3	0
Passe Crassane	97.6	1.2	1.2
Pringall	96.1	4.0	0
Red Clapp	100	0	0
Mean	95.6	3.7	0.7

2. ***Composition of pollen loads of honeybee foragers captured when visiting pear flowers:*** Pollen preference of honeybees towards pear can be recognised in the composition of pollen loads (*Table 2*). Fairly high proportion of the loads were free of any contaminating pollen species and a good deal or the great majority of the mixed loads contained only less then two per cent of other pollen species than pear. Considering the ratio of the pure loads and those ones together that contained only minor (>2%) contamination the percentages are very high for all of the cases studied. Namely, these values are around 90 per cent (88.9, 89.8 and 90.5%, respectively) that shows a high rate of fidelity (*Table 3*). The distribution of the larger amounts of contamination also contributes to this picture because smaller contamination are always more frequent than the higher ones. It can be observed that great amount of contamination (more than 10 or 20%) were very rare and appeared only at one of the cases analysed.

Table 2 Composition of pollen loads of honeybee foragers visiting flowering per trees

Site	Sampling date	No. of loads analysed	Distribution of pollen loads (per cent) the based on proportion of pollen grains other than pear				
			0	2	2.1–10	10.1–20	20.1–30
Pomáz	30.04.93	126	77.8	11.1	11.1	0	0
Pomáz	20.04.94	216	80.5	9.3	10.2	0	0
Keszthely	29.04.96	124	64.7	25.8	4.8	1.6	3.1

Table 3 Fidelity of honeybees to pear flowers in blooming pear plantations

Site and year	Proportion of pure and less contaminated loads*	Rate of fidelity
Pomáz, 1993	77.8+11.1	= 88.9 %
Pomáz, 1994	80.5+ 9.3	= 89.8 %
Keszthely, 1996	64.7+25.8	= 90.5 %

*Pure loads plus mixed ones that contained less than 2% contamination

3. ***Composition of mixed loads:*** Contamination of mixed loads is also to be considered (*Table 4*). It can be seen that the average contamination of mixed loads was rather low at about two and a half per cent (*Table 4*), however, the amplitude of the extremes were much wider. It varied from close to nil up to 6 to 9 or even up to 30 per cent. The low mean contamination, therefore, was resulted in of the high frequency of very low contamination as seen in *Table 2*.
Major contaminating pollen species were more or less different at the cases investigated (*Table 5*). Two observations were made at the same site (Pomáz) in two consecutive years and here the major contamination originated from a common cruciferous weed plant, *Capsella bursa-pastoris*, which is in flower from early spring to late autumn. At the third case (at Keszthely) the profile of the contamination was different as the effect of the local weed flora. For this reason a labiate flower, *Lamium purpureum* was the major source of contamination and also *Stellaria media* of *Cariophyllaceae* was important. Other weed species, on the other hand, were much less represented in the mixed loads.
Finally the frequency of contaminating pollen species has to be taken into account (*Table 5*). Major contaminating pollen species were usually present more frequently in mixed loads than others but this was not always the case. The figures were fairly proportional at two cases (at Pomáz) but not exactly so at the third one (at Keszthely). Here dandelion (*Taraxacum officinale*), a composit weed species was very poorly represented by its amounts (*Table 4*), however, the occurrence of that was rather frequent (*Table* 5) almost as frequent (7.2%) as of the labiate weed *Lamium purpureum* (9.7) that represented as much as more than the half of the total contamination (43).

Table 5 Contaminating pollen species in mixed loads of honeybees visiting flowers of blooming pear trees

Site	Sampling date	Contamination of mixed loads (per cent)		Proportion of contaminating pollen species in the contaminated loads altogether
		mean	extremes	
Pomáz	30–04.93	2.4±1.6	0.5–8.6	20% Capsella bursa-pastoris 14% Prunus spinosa 55% Unidentified
Pomáz	16.04.94	2.3±1.3	0.5–5.7	21% Capsella bursa-pastoris 13% Prunus spinosa 17% Lamium purpureum 49% Unidentified
Keszthely	29.04.96	2.3±1.2	0.001–30	54% Lamium purpureum 25% Stellaria media 5% Veronica polita 1.5% Capsella bursa-pastoris 0.5% Senecio vulgaris 0.1% Taraxacum officinale 14% Unidentified

Discussion and conclusions

High proportion of pollen gatherer honeybees found at blooming pear trees is in a good accordance with the earlier statements in the literature, since most authors have reported that honeybees prefer gathering pollen on pear (*Vansell,* 1942, *Stephen,* 1958, *Free & Smith*, 1961, *Free,* 1963, *Choi & Kim,* 1988). However, the proportion of pollen gatherers can show a variation across the day (*Vansell,* 1942, *Free & Smith,* 1961) and their behaviour may be variable between cultivars, too (*Choi & Kim,* 1988). Recent results show that even in the case of a very high overpopulation, most honeybees can be pollen gatherers. That was typical at Keszthely in 1996 where at the commencement of blooming 18 strong colonies were placed in a pear plantation not larger than 1.5 ha. We also found slight differences in the behaviour

Table 4 Frequency of contaminating pollen species in pollen loads of honeybees visiting the flowers of pear trees in bloom

Site and date	Contaminatingpollen species	Per cent ratio of contaminated loads in the proportion of all loads analysed	Number of loads containing contamination of				
			individual grains only	2	2.1–10	10.1–20	20.1–30
Pomáz 30.04.93	Capsella bursa-pastoris	8.4	0	6	5	0	0
	Prunus spinosa	4.6	0	5	1	0	0
	Unidentified	9.2	0	5	7	0	0
Pomáz 20.04.94	Capsella bursa-pastoris	6.0	0	9	4	0	0
	Lamium purpureum	3.2	0	5	2	0	0
	Prunus spinosa	2.8	0	2	4	0	0
	Unidentified	7.4	0	6	10	0	0
Keszthely 29.04.96	Lamium purpureum	9.7	0	8	0	2	2
	Taraxacum officinale	7.2	9	0	0	0	0
	Stellaria media	5.6	0	5	0	0	2
	Capsella bursa-pastoris	3.2	0	4	0	0	0
	Veronica polita	1.6	0	0	2	0	0
	Senecio vulgaris	1.6	0	2	0	0	0
	Unidentified	6.4	0	6	2	0	0

of honeybee foragers between cultivars but these differences were not so large as indicated in earlier studies (*Choi & Kim*,1988).

Our findings on the composition of pollen loads of honeybee foragers captured at pear flowers corroborate to earlier statements because they prove the high preference towards pear as a pollen source. In this respect, it is important to say that a very small amount of contaminating pollen can be the result of accidental mistakes (*Linsley*, 1958) and also of temporary searching for another food source with no real final satisfaction to bees (*Free*, 1970, 1993) or of accidental pollen exchange between honeybees cleaning themselves side by side in the hives (c.f. *Free*, 1970, 1993). For this reason this small amount of contamination can be omitted (*Free*, 1970) even up to some two per cent (*Linsley*, 1958). Taking these considerations into account, flower constancy of honeybees seems to be fairly high at blooming pear trees, higher than at some other temperate zone fruit trees, at apple, sour cherry and apricot (*Benedek & Nagy*, 1995).

Dandelion (*Taraxacum officinale*) is regarded to be a major competitor against blooming fruit trees (c.f. *Free*, 1970, 1993). However, recent results show clearly that this general belief is not usually true for pear. Namely, at the site of the third experiment there was a high density of this plant in bloom but, surprisingly, its bee visitation was very poor during the intensive blooming of pear (*Benedek, Béres & Nyéki*, 1998) and also the pollen loads of forager bees captured at pear flowers contained individual pollen grains only of this weed species being present at the orchard in bloom in a rather high density.

High fidelity of honeybee foragers towards pear flowers is of great practical importance in pear growing because honeybees can be much more important and more effective pollinating agents of pear than generally believed. Pollen gatherers usually approach the flowers form the top and so no one pollen gatherer can be ineffective side-worker forager like at apple (*Free*, 1970, 1993, *Benedek & Nyéki*, 1996). This is very important because there is a large gap between anthers and petals in the flowers of several pear cultivars, too, and that structure encourages honeybees to land here and for this reason foragers can lean in a short time to be side worker nectar gatherers.

Fidelity of honeybee foragers towards pear flowers seems to be so strong that it also indicates a strong preference of honeybee gatherers for pear pollen even in the presence of competitor weed species in bloom. This can decrease even the competing effect of dandelion (*Taraxacum officinale*) and *Stellaria media* that are known to be of very strong effect to honeybee visits against flowering fruit trees (c.f. *Free*, 1970, 1993).

The high fidelity of honeybees to pear flowers has not been influenced even by the great overpopulation of the Keszthely experimental pear orchard with honeybees (18 strong colonies moved to a small, 1.5 ha large pear plantation). Though, very intense bee visitation here was expected to encourage foragers to explore and exploit other sufficient pollen and nectar sources abundant in the vicinty, the opposite has happened (at least with pollen gatherers, since their proportion was overvhelming). This picture, however, is not an exceptional case with pear. Also *Free & Smith* (1961) observed that in bee colonies moved to pear orchards 47 to 91 per cent of pollen grains carried into the hive had come from pear. Thus, though as a source of nectar pear is not very attractive to honeybees, it is very attractive to them as a pollen source even when there are a great number of foragers present gathering large amount of pollen in a short time. Since, pollen presentation of the pear plantations has not found to be notably decreasing during the day at our experimental orchards, pollen production of pear trees seems to be abundant enough to attract a great number of honeybees and provide enough pollen to them visiting the pear trees in bloom.

For this reason it is worth to take this advantage and move honeybee colonies to pear orchards for supplementary pollination because they probably would not be influenced very much by the competing effect of the blooming weed flora (present study), of blooming fruit trees (*Benedek & Nagy*, 1995, present study) or of other crops blooming simultaneously, except winter rape (e.g. *Benedek & Nagy*, 1995) or of other related cruciferous crops (*Free*, 1970). This is an exceptionally favourable condition that is not typical to other temperate zone fruit trees at all (c.f. *Free*, 1970, 1993, *McGregor*, 1976, *Benedek*, 1996). For this reason it should be exploited by pear growers much better in the future than it has been made so far.

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