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# Comparison of honeybee behaviour in blooming fruit plantations

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**Abstract:** Field observations were made on the flower visiting behaviour of honeybee foragers in commercial fruit plantations of apricot, Japanese plums, sour cherry, apple and pear. The number of inspected cultivars was 18. The intensity of flower visiting by honey bees was markedly different when data of different fruit species are compared. Most intense bee activity was registered on the Japanese plums, somewhat less on apricots, the intensity diminished significantly with apples and pears. Our data presented on the honeybee visitation of Japanese plums can be regarded as new finding because no information has been available so far on the relative attractiveness of this fruit species compared to European fruit tree species. Japanese plums were somewhat more attractive to honeybees than apricot and much more attractive than sour cherry, apple and pear. The behaviour of honeybees as visiting the blooming trees displayed specific differences according to the fruit species (apricot, sour cherry, pear), which coincide largely with earlier results. It is notable that the flower visiting behaviour of honeybees on Japanese plums has been found to be fairly similar to the same on European plums.

***Key words:*** honeybee, intensity of bee visitation, flower visiting behaviour, commercial fruit plantations, apricot, Japanese plum, sour cherry, apple, pear

## Introduction

Experts of bee science as well as commercial fruit growers consider the role of honey bees in pollinating the large scale fruit plantations as indispensable (*Free* 1970, 1993, *Benedek et al.* 1974, *McGregor* 1976, *Benedek* 1996). The effectiveness of honeybee pollination depends largely on the size of the honeybee population (that can be regulated by the density of bee colonies per area) but also on the flower visiting behaviour of bees, i.e. how they perform the visit of open flowers. On the flowers of fruit trees the honeybee foragers can be pollen gatherers, collecting deliberately pollen only, regular nectar gatherers approaching the nectaries from the top of the flower, mixed behaviour bees gathering deliberately nectar and sweeping time by time the pollen grains sticking on their body hairs to their pollen basket too, as well as side worker nectar gatherers landing on petals and avoiding any contact with anthers and stigmata (*Free* 1970, 1993, *Benedek et al.* 1974, *McGregor* 1976, *Benedek* 1996).

The ratio of honeybees representing the four types of behaviour depends first of all on the demand for pollen or nectar of the bee colony are partly on the pollen and nectar production of the fruit trees in question. The most efficient pollinators among honeybees visiting fruit tree flowers are the pollen gatherers and somewhat less efficient ones are the nectar anthers, nevertheless mixed behaviour honeybees are also efficient (*Free,* 1970), on the other hand, side working nectar gatherers are definitely inefficient pollinators. Their frequency depends mainly on the structure of the flowers (*Free* 1970, *Benedek* 1996, 2003). The bees are able to reach the nectaries from the side only in the case when the stamens of the flowers are stiffly erected, leaving a gap between the stamens and the corolla.

The behaviour of honeybees has been subject of studies and comparisons in the past decades regarding to different fruit species (*Free* 1970, 1993, *Benedek et al.* 1974, *McGregor* 1976, *Benedek* 1993) and fruit tree cultivars cultivars (*Benedek* 2003). Most observations were implemented on single fruit species or in a number of varieties of the same fruit species in cultivar collections and only few investigations were concentrated on commercial plantings. In order to check our observations on a larger scale, we started studies in 2008 and mainly 2009 in commercial orchards, where honeybees are regularly used for pollination.

## Material and method

### *The sites of observations*

Three plantings have been selected for investigations in 2008 and in 2009. All the three plantations served commercial fruit growing, two of then were commercial fruit farms (Nagykutas, Nagykanizsa) and the third was the commercial plantation of a fruit research station (Újfehértó).

At Nagykutas, the Alma 2000 Gyümölcstermelő Kft. (Ltd) was the host where apple is the most important commercial fruit but they also grow a variety of other fruit species, too. Here the observations regarding the behaviour of honeybees were concentrated to fruiting apricots (cv: Ivana) and Japanese plums (cv: Black Amber) in the period of April 7–15. 2009.

At Újfehértó the research observation were made at the area of the Research and Extension Station of Fruit Growing. They manage commercial plantations with different fruit species and several varieties. Observations were performed at a fruiting sour cherry plantation with three cultivars (Újfehértói fürtös, Oblacsinska, Csengődi), in the period of April 15–16, 2009. Furthermore, observations were also made between April 24–27, 2009 in a fruiting apple plantation with two varieties (Rewena, Topaz).

At Nagykanizsa, our investigation were made at the area of the Gyümölcskert Co were in 2008 and 2009. Flower visiting behaviour of honeybees was inspected at two fruiting pear plantations. In 2008 bee behaviour was studied at eight pear cultivars were studied (Bonne Louise d'Avraches, Bosc kobak, Clapp's Favourite, Conference, Hardenpont, Early Bosc kobak [Alexander], Olivier des Serres, Decane d'hiver, Williams) at the "Zalasárszeg" plantation between April 9-18, and seven cultivars were inspected (Bonne Louise d'Avranches, Bosc kobak, Clapp's Favourite, Conference, Olivier des Serres, Packham's Triumph, Williams) at the "Feketesár" orchard in the period of April 4–14. In the next year work was conducted partly at the "Feketesár" orchard and at the "Bánfa" plantation. Observation at the "Feketesár" orchard were made in the period of April 14–15 and the bee behaviour was observed on two varieties (Bosc kobak, Williams) only. At the "Bánfa" plantation investigations were extended to 3 pear varieties (Bosc kobak, Abate Fétel, Williams) in the period of April 14–17.

### *The flower visiting behaviour of honeybees*

The observation of bees has been based on the four well known types of flower visiting honeybees that are regarded to be important in the pollinating efficiency f bee in flowering fruit plantations (see: *Free* 1970, *Benedek el al.* 1974, Benedek 1996).

1. *Pollen gatherers*: They are recognised by their approach to the flowers from top. hey sweep the pollen by their forelegs into the pollen baskets on their hind tibias. They do not push their head and tong into the nectary and spend shorter time on a single flower than the nectar gatherers, therefore their work is regarded to be the most efficient as pollinators.

2. *Nectar gatherers*: They approach the flowers similarly from the top as the former ones but they deliberately push their tongue between anthers and stigma toward the nectar accumulating in the lower part of the flowers and they do not carry pollen load in their pollen baskets because they do not gather pollen. The empty baskets are clearly distinguished by their dark, glossy colour. Their efficacy is inferior to that of the pollen gatherers because they spend longer time on a single flower and carry less pollen grain on their body.

3. *Mixed behaviour*: Those are the nectar gatherers that carry also pollen load in their pollen baskets. Arriving from at the top of the flower they push their head and tong towards the nectary, i.e. towards the base of the flower, where the nectar is accumulating. They brush the pollen grains sticking on their body hairs time by time to their pollen baskets, but do not collect pollen deliberately. Their efficacy in pollination is regarded to be nearly equal of the pollen gatherers.

4. *Side workers*: Their alternative designation is "nectar robbers". These are nectar gatherer honeybees that do not land on the top of the flower but they land on the petals and push their tong towards the nectary from the "side", without touching the stigma and the anthers. This kind of behaviour depends on the structure of flowers because it appears on those cultivars only where the stamens of the flowers are stiffly erected, leaving a gap between the stamens and the corolla. Therefore their do not contribute in pollinating the flowers.

### *Observations*

For each fruit species we selected 2–3 days during their main blooming period, when the weather was prosperous, sunny and the movement of bees was lively. Only transitory clouds and a gentle breeze might occur. In most cases, two trees were observed at each cultivar inspected (except the "Feketesár" orchard Nagykanizsa where 6 trees were involved in 2008). On the northern and southern side of the trees, branches with 50 open flowers were chosen (that is two times 50 flowers per tree) and the flower visiting behaviour of honeybees were inspected on them at least on two different days with favourable weather to bee activity. Observation were made for 10 minutes on each selected branch with 50 flowers at two time intervals, late morning (between 10–12 a.m.) and early afternoon (between 13–15 p.m.) at each day of observations. The number of honeybees visiting the selected branches during the 10 minutes periods and the type of their flower visiting behaviour were registered carefully. Altogether, we made as much as 12–32 observations (for 10 minutes period each) at each inspected fruit tree cultivar. This amount f observation gave 120–320 minutes time of observations per cultivar.

Corresponding to earlier studies (see in *Benedek* 2003) no decisive differences could be found in the flower visiting behaviour of bee at different cultivars of individual fruit species. Accordingly, instead of evaluating the results of observation to individual varieties we concentrated to differences in bee behaviour at the fruit species. On this

basis, we compared the per cent ratio of the behaviour classes of honeybees on the flowers of the fruit species inspected. This way the results of some 12–32 periods of observations were taken into account to individual fruit species.

## Results and discussion

The accumulated time spent for observing the behaviour of honey bees as they visited the flowers was 5280 minutes in total (i.e. as much as 88 hours net). During this time we have detected as much as 1091 flower visiting honeybees on the flowering branches selected for observations. As each observation was made on branches representing 50 flowers, the average number of flower visits by honeybees per one minute was 0.208 per 50 flowers per one minute. If daily 8 hours are considered as periods of working activity of honeybees, the daily incident of honeybee visits per one flower was 1.984 in days with weather conditions favouring to bee activity.

The intensity of flower visiting by honey bees was markedly different when data of different fruit species are compared (*Table 1*). In the plantings in question, most intense visiting activity was registered on the Japanese plums, which means 0.558 visits per minute per 50 flowers. Somewhat less intense activity was observed on apricots (0.4). Compared with apples, the intensity diminished (0.275), on pears (0.130–0.266, as a mean 0.183) and on sour cherries (0.158) the visiting diminished to its half or even third rate (*Table 1*). The data coincide with our earlier observations referring to the fruit species indicating the relative preference of honey bees (cf. *Benedek et al.,* 1974).

Three of the fruit species observed was represented by several varieties – 3 sour cherries, 2 apples, 11 pears – but between the varieties, we could not prove significant differences. In sour cherries (*Benedek et. al.,* 1990, 1996) and pears (*Benedek, Ruff & Nyéki,* 1997), the results are conformable to earlier experiences, but in apples, earlier data proved marked differences between varieties (*Benedek & Nyéki,* 1994, 1996, *Benedek et al., 1*989). The present data showing no essential differences between the two apple cultivars in question may explained by the high similarity of the two varieties as well as the low number of visiting bees (88 altogether).

On the other hand, the flower visiting behaviour of honeybees proved to be largely different at the flowers of different fruit species (*Table 1*).

In apricots, the pollen gatherers prevailed at a rate of 2/3 of the visits (*Table 1*). Mixed behaviour, nectar gatherer and side working each appeared at a frequency of some 1/10. Those data are coincident with earlier observations with apricots, which are rather variable (cf. *Benedek, Nyéki & Szabó,* 1991, 1994).

The observations made on Japanese plums (*Table 1*) are considered to be novelties in the literature. Most of the honeybees (40%) were pollen gatherers and less as half as many (16%) displayed mixed behaviour. Those two behaviour classes are the most efficient ones in pollination,

***Table 1*** – Intensity of honeybee visitation and the flower visiting behaviour of honeybees in flowering commercial plantations of different fruit tree species

| **Experiment** | | | | **Total number of honeybees observed on a branch with 50 open flowers** | **Number of honeybee visits per one minute on 50 open flowers** | **Flower visiting honey bees following different types of behaviour during visiting flowers %** | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Fruit species** | **Experimental site, the number of cultivars observed and the total number (n) of 10 minutes' observation periods** | **Period of observations** | **Total net time spent for observation (minutes)** | | | **pollen-gatherers** | **mixed behaviour (nectar gathers with pollen loads)** | **nectar gathers (with no pollen load)** | **side worker nectar gatherers** |
| Apricot | Nagykutas (1 cvs, n= 12) | 2009.04.07-09. | 120 | 48 | 0.400 | 67.4 | 9.4 | 11.6 | 11.6 |
| Japanese plum | Nagykutas (1 cvs, n=12) | 2009.04.08-10. | 120 | 67 | 0.558 | 40.2 | 16.4 | 37.3 | 6.1 |
| Sour cherry | Ujfehértó (3 cvs, n=58) | 2009.04.15-16. | 580 | 92 | 0.158 | 22.8 | 34.0 | 37.0 | 2.2 |
| Apple | Ujfehértó (2 cvs, n=32) | 2009.04.24-27. | 320 | 88 | 0.275 | 18.2 | 22.3 | 52.7 | 6.8 |
| Pear | Nagykanizsa: Zalasárszeg (8 cvs, n=128) | 2008.04.09-18. | 1280 | 167 | 0.130 | 93.4 | 0 | 6.6 | 0 |
| | Nagykanizsa: Feketesár (7 cvs, n=112) | 2008.04.04-14. | 1120 | 298 | 0.266 | 96.6 | 0 | 2.4 | 0 |
| | Nagykanizsa: Feketesár (2 cvs, n=116) | 2009.04.14-15. | 1160 | 272 | 0.234 | 96.0 | 0 | 4.0 | 0 |
| | Nagykanizsa: Bánfa (3 cvs, n=58) | 2009.04.14-17. | 580 | 59 | 0.102 | 76.3 | 0 | 23.7 | 0 |

thus their collective ratio (56% of the flower visiting honeybee foragers) is very promising for Japanese plum production. Nectar gatherers were nearly as frequent as pollen gatherers (37%), but the side worker nectar robbers appeared in a low number only (6%).

In apples pollen gatherers and mixed behaviour honeybees made up 40% of the flower visiting honeybee population together, half of the bees were nectar gatherers (53%) and the ratio of side workers was some 7% only (*Table 1*). These data are conformable to earlier experiences (*Benedek et al.,* 1989, *Benedek & Nyéki,* 1994, 1996), although the pollen gatherers were somewhat more frequent than general, but their ratio together with the mixed behaviour bees attained as much as 74%, as usual. Nectar gathers were somewhat less frequent than usual (26%), but this figure does not contravene earlier results because rather high variability of nectar gatherers is typical at several apple cultivars having been studied before (Benedek & Nyéki, 1996).

In the case of pears, the patter of flower visiting behaviour of honeybee foragers showed closely similar tendencies in all the four series of our observations (*Table 1*). Most of the honeybees were pollen gatherers, 93–96% or more, and in a single case only was less, some 76% only (*Table 1*). Besides pollen gathers nothing else than nectar gathers appeared, their ratio was between 2.4–23.7%. The predominance of pollen gatherers on pears has been known for a long time (*Free & Smith,* 1961), which diverges significantly from the rest of European fruit species (cf. *Benedek & Nyéki, 1*994). The high rate of pollen gatherers and the low rate of nectar gatherers have been proved with our earlier survey when bee behaviour was checked on a number of different pear cultivars (*Benedek, Ruff & Nyéki,* 1997). In our earlier studies the presence of side workers was though observed, but their appearance at pear flower was rather low in all instances and it was not a rule but it was almost exceptional (*Benedek, Ruff & Nyéki,* 1997). Presently, we did not find side workers at all on pears. In our present study we did not find notable differences in honeybee behaviour on 11 pear cultivars inspected and this finding was in a good accordance with earlier results (*Benedek, Ruff & Nyéki,* 1997).

## Conclusions

The intensity of honey bee visits on blooming fruit trees can vary considerably according to fruit tree species and cultivars as usually experienced and this reflects the differing attractive effect of fruit species to honeybee foragers. Experiences from the present study corroborate this statement.

Our data presented on the honeybee visitation of Japanese plums can be regarded as new finding because no information has been available so far on the relative attractiveness of this fruit species compared to European fruit tree species. Compared with some other fruit tree species we found Japanese plums being somewhat more attractive to honeybees than apricot and much more attractive than sour cherry, apple and pear. On Japanese plums most honeybees (40%) were pollen gatherers, less than half as many (16%) displayed mixed behaviour and more than one third of the honeybee foragers were nectar gatherers (37%) and the rest was side working nectar robbers (6%). Observed honeybee behaviour on the Japanese plums are fairly similar to our earlier results on European plums (*Szabó, Nyéki & Benedek,* 1989, *Benedek, Szabó & Nyéki,* 1994, Benedek & Nyéki, 1994), where in spite some differences between cultivars, the average figures for the species were largely similar to the present data, namely 56% of the flower visiting honeybees were pollen gatherers, 18% were mixed behaviour bees, 26% of them were nectar gatherers and no more than 6% of the bees were side working nectar robbers.

The behaviour of honey bees as visiting the blooming trees displayed specific differences according to the fruit species (apricot, sour cherry, pear), which coincide largely with earlier results (*Benedek, Ruff & Nyéki,* 1997). In apples, where significant differences were found between cultivars in earlier studies (*Benedek & Nyéki,* 1994, 1996, *Benedek et al.,* 1989), the presently observed two cultivars has shown similar picture as the flower visiting behaviour of honeybee foragers in concerned.

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