Honeybee (*Apis mellifera L.*) visitation at the flowers of quince cultivars (*Cydonia oblonga Mill.*)

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Summary: Studies were made on the bee visitation of 6 quince cultivars and on the foraging behaviour of honeybees at quince flowers for 3 consecutive years. The bee visitation was highly intense because both the plantation and its surrounding was overpopulated by honeybee colonies. Some 5.5 bee visits were counted in average at 50 opening quince flowers in 10 minutes and some 9.7 flowers were visited of the 50 ones observed meanwhile. This equals some 7 bee visits per flower per day per in good weather. Bee visitation, however, was variable and it was greatly different in the three consecutive years with fairly favourable weather. Some cultivars tended to be more and others less visited by honeybees than the others but these differences were not consequent at each occasion. No consequent relationship between the weather and the bee visitation of quince trees could be recognised. It was concluded that other factors were responsible for the variable nature of the bee activity at quince. Most honeybees tended to collect pollen (51.6% in average for the 3 years) and usually much less gathered for nectar only (19.9%), and the rest of them were mixed behaviour foragers gathering for both (28.5%). There were some slight differences in the foraging behaviour of honeybees at some cultivars but these differences were not always consequent in consecutive years. Also the nectar production of flowers failed to affect the bee visitation and the foraging behaviour of honeybees definitely. For the variable nature of bee visitation and bee behaviour at quince flowers, supplementary pollination is needed to achieve as high set of fruits as high is required to a good crop at quince (at least 20–25% because the flower density is low of this fruit tree species). Since the intensity of bee visitation at the flowers is the only reliable estimate of the necessity of supplementary bee pollination further research is needed to explore the relationship between the number of honeybee visits and the consequent fruit set at quince.

Introduction

Insect pollination of quince has been scarcely studied so far. Nobody else but *Simidchiev* (1967) investigated the pollinating agents of quince in Bulgaria. He inspected the insects on blooming trees of five cultivars and established that honeybees visited quince trees in bloom abundantly and they contributed effectively to the fruit set of flowers. He found that the flowers of this fruit tree species were highly attractive to honeybees. He also studied the foraging behaviour of the honeybees on quince flowers and stated that few bees collected pollen or nectar only but most of them gathered for both. This is a fairly good information but the question arises whether the result of a single study can be generalised?

In the case of two other pomaceous fruit tree species, of apple and of pear definite differences have been demonstrated in the intensity of honey bee visitation and also in the foraging behaviour of honeybees at their cultivars and these differences have been regarded to be of great importance from the point of view of the effectiveness of bee pollination of the cvs. (*Benedek & Nyéki,* 1996, *Benedek, Ruff & Nyéki,* 1997). Thus there is one another question, whether similar differences exist in the case of quince cultivars, too? Thus we decided to study this problem.

Material and method

The study was made at a 1 ha large quince orchard consisting of 15–18 years old trees of a number of cultivars. Six cultivars were selected for observations that are widely grown at those regions first of all in Europe where quince is grown at all (*Angersi, Bereczki, Bereczki bőtermő, Champion, Konstantinápolyi, Mezőtúri).* The quince plantation belonged to the Fruit Research Station Ujfehértó (Eastern Hungary). It was surrounded by a number of another fruit tree plantations of different temperate zone fruit tree species, first of all of apple. For the late flowering time of quince nothing else but some late sour cherry cultivars were in flower (at the very end of their blooming period) at the first part of the blooming period of quince.

Accordingly, no real competition of another fruit tree species occurred. Additional bee pollination is a general practice at this experimental farm. For this reason 4–5 strong bee colonies were moved to the quince plantation prior to its flowering had begun in each year of the research. Also some 30–40 bee colonies were placed at the nearby at the sour cherry plantation mentioned that was 20 ha large. As a result of this the area was well overpopulated with honeybees.

Observations were implemented during 3 consecutive years, in 1997, 1998 and 1999. Two trees were selected for observation of each of the six cultivars inspected. One branch with some 50 flowers at the Northern and one another at the Southern side of each tree were selected for observation. Observations were carried out on 3 to 5 days of the blooming period (when the weather was favourable to bee activity). Each branch with some 50 flowers were inspected twice a day, first time late morning (10–12 h) and the second time early afternoon (13–15 h) for exactly 10 minutes of time each occasion. The number of honeybees visiting (landing on) the flowers of the branch and also the number of flowers visited by them were counted. Not all the 50 flowers were open each occasion. Accordingly, the number of opening flowers was registered too, and the data for bee visitation were corrected to 50 opening flowers each time. Also the foraging behaviour of bees was carefully observed and registered. Three behaviour classes were recognised: (1) pollen gatherers, (2) nectar gatherers and finally, (3) mixed behaviour foragers that deliberately gathered for nectar and collected pollen, too.

Weather conditions during the blooming period of quince were also observed (air temperature, rainfall and the number of sunny hours a day). The weather parameters of the 10 minutes observation periods were also registered (air temperature, wind, cloudiness).

The weather was fairly good to bee activity in all the three years of the study, however, it was more or less different in the consecutive years.

In 1997: The weather was fairly hot all along the blooming period of quince (*Table 1*). Except the first two days of the flowering the daily mean temperatures were around 20 °C and the daily maximums rose up to 30-40 °C. There was very little, practically no rain and it was bright and sunny all along the blooming period of quince.

In 1998: The weather was warm but no so hot as in the previous year (*Table 2*). Daily mean temperatures were around 10 or 20 °C and the daily maximums did not surpassed 30 °C except on three days just after the first half of the blooming period. There were three rainy days at the fist quarter of the blooming with fairly good amount of precipitation. It was fairly sunny except some few days at the middle of the blooming period.

Table 1 Weather conditions in the blooming period of quince trees in 1997 (Ujfehértó)

Date	Ambient temperature, °C		Rainfall	Number of sunny
	mean	maximum	mm	hours
May 8	15.4	23.3	7.8	1.5
May 9	12.5	19.4	0.2	6.0
May 10	15.4	22.1	0	10.5
May 11	19.7	33.0	0	12.0
May 12	21.7	33.2	0	13.0
May 13	23.6	36.1	0	12.5
May 14	24.1	37.5	0	13.0
May 15	24.7	38.3	0	12.5
May 16	24.8	39.1	0	13.0
May 17	23.2	40.3	0.8	11.5
May 18	23.8	36.3	0	11.5
May 19	22.8	32.0	0	9.5
May 20	23.6	33.6	0	9.0

Table 2 Weather conditions in the blooming period of quince trees in 1998 (Ujfehértó)

Date	Ambient temperature, °C		Rainfall	Number of sunny
	mean	maximum	mm	hours
April 27	16.6	27.2	0	8.0
April 28	16.5	27.8	0	8.0
April 29	17.9	29.1	0	8.0
April 30	17.2	25.2	0	7.0
May 1	14.7	21.2	20.0	3.5
May 2	12.1	18.8	14.2	1.0
May 3	15.1	23.9	0.6	5.0
May 4	12.8	14.8	29.4	0
May 5	9.6	14.0	4.2	3.0
May 6	13.7	21.5	0	6.5
May 7	8.3	9.3	0	8.5
May 8	19.1	31.1	0.2	8.5
May 9	20.6	34.6	0	9.0
May 10	21.6	34.4	0	12.0
May 11	23.0	34.4	0	8.5
May 12	22.6	35.6	0	9

In 1999: The weather was warm too but both the daily mean and the daily maximum temperatures remained at a bit lower level than in the previous year (*Table 3*). There were few rainy days and no more than one day produced great amount of precipitation in the first quarter and one other day at the very end of the flowering. The weather was usually sunny but there were somewhat less sunny hours at the middle of the flowering.

Table 3 Weather conditions in the blooming period of quince trees in 1999 (Ujfehértó)

Date	Ambient temperature, °C		Rainfall	Number of sunny
	mean	maximum	mm	hours
April 29	14.4	19.9	0	7
April 30	14.4	20.2	0	9
May 1	16.4	23.2	0	13
May 2	14.9	20.6	18.8	8
May 3	13.8	18.5	0	11
May 4	14.0	18.8	0.3	6
May 5	10.2	13.6	0	0
May 6	9.3	14.8	0	10
May 7	10.4	16.4	0	11
May 8	13.4	18.0	0	7
May 9	13.4	17.0	2.1	2
May 10	15.4	21.8	0	12
May 11	17.0	22.6	0.8	6
May 12	14.5	19.6	5.6	3

Results

1997: The weather was uniformly hot and sunny on all the three days of the observation (see May 12,13 and 14 in *Table 1*). Nevertheless the intensity of bee visitation was greatly different on the days in question (*Table 4*). The mean number of bee visits at 50 opening flowers was 9.0 in 10 minutes. Almost two times more bee visits were observed on 13 May compared to 12 and 14 May (*Table 4*). Also the number of flowers visited of the 50 ones on the inspected branches of the trees was fairly proportional to the number of bee visits (*Table 4*). The bees visited as much as 16.6 flowers of the 50 opening ones in average in 10 minutes of the observation period, since most of them visited more than one flower at the branch observed.

Some cultivars (*Konstantinápolyi, Bereczki, Bereczki bőtermő*) were more intensely visited than others at the most cases while two cultivars of the six (*Mezőtúri, Angersi*) were much less visited than the former. The bee visitation of one variety (*Champion*) was variable during the three consecutive days since it was intensively visited on the first, somewhat less frequented on the second and scarcely visited on the third day compared to the others cultivars (*Table 4*).

Table 4 Intensity of honeybee visitation at blooming trees of quince cultivars in 1997 (Ujfehértó)

Cultivar	Date	No. of observations (n)	Bee visits at 50 opening flowers in 10 minutes	
			Number of bees visiting the flowers	Number of flowers visited
Angersi	May 12	8	4.4 ± 2.5	10.8 ± 6.9
	May 13	8	7.6 ± 1.7	12.0 ± 3.5
	May 14	8	1.6 ± 0.6	2.1 ± 0.8
Bereczki	May 12	8	7.9 ± 2.6	12.5 ± 4.3
	May 13	8	16.9 ± 3.1	28.3 ± 6.4
	May 14	8	12.2 ± 2.7	21.1 ± 3.3
Bereczki bőtermő	May 12	8	7.3 ± 3.7	15.0 ± 7.4
	May 13	8	16.1 ± 5.0	35.6 ± 12.6
	May 14	8	9.5 ± 3.6	12.9 ± 3.9
Champion	May 12	8	8.1 ± 4.0	13.4 ± 7.3
	May 13	8	13.1 ± 3.3	23.4 ± 6.0
	May 14	8	1.9 ± 0.6	2.5 ± 0.8
Konstantinápolyi	May 12	8	10.6 ± 3.6	21.1 ± 3.6
	May 13	8	17.1 ± 6.1	39.1 ± 11.2
	May 14	8	9.3 ± 3.3	18.5 ± 6.6
Mezőtúri	May 12	8	5.5 ± 1.9	9.2 ± 3.9
	May 13	8	10.0 ± 3.5	14.9 ± 4.5
	May 14	8	3.5 ± 1.2	7.0 ± 2.9
Mean of the days	**May 12**	**48**	**7.2 ± 1.3**	**8.7 ± 3.0**
	May 13	**48**	**13.5 ± 1.4**	**25.5 ± 1.8**
	May 14	**48**	**6.3 ± 1.1**	**10.7 ± 1.5**
Average of all the cultivars inspected	**1997**	**144**	**9.0 ± 0.8**	**16.6 ± 1.6**

Foraging behaviour of honeybees was less changeable than the intensity of bee visitation on the flowers (*Table 5*). Most bees tended to gather both nectar and pollen (42.5-50.0). Pure pollen gatherers (23.7–35.7%) and pure nectar collecting bees (21.8–27.5%) were less frequent but finally the majority of the bees collected pollen (pollen gatherers plus mixed behaviour foragers: 72.5–78.2% altogether). The ratio of the behaviour classes was somewhat different on the consecutive days. We found more pollen gatherers and less nectar gatherers and mixed behaviour bees on the first day but somewhat more mixed behaviour foragers, less pollen collectors and a bit more nectar gathering bees on the second and the third day (*Table 5*) but the difference was not so much and it was not significant from the statistical point of view.

Behaviour of honeybees seemed to be somewhat different at cultivars. Some cultivars (*Mezőtúri, Konstantinápolyi, Bereczki bőtermő*) tended to attract more pollen gatherers than others but the difference was not clearly consequent during all the three days (*Table 5*). Much less pollen gatherers were seen on the flowers of one cvs (*Champion)* than on the others in all the three days (*Table 5*) and the ratio of pollen gatherers was changeable at the rest of the cvs (*Bereczki, Angersi),* being sometimes medium but high or low at other instances. Mixed behaviour bees were more frequent on the cvs *Champion* than on others.

Table 5 Foraging behaviour of honeybees at blooming trees of quince cultivars in 1997 (Ujfehértó)

Cultivar	Date	Foraging behaviour of honeybees per cent		
		Pollen gatherers	Mixed behaviour	Nectar gatherers
Angersi	May 12	30	58	12
	May 13	38	44	18
	May 14	45	36	19
Bereczki	May 12	33	27	40
	May 13	14	43	43
	May 14	19	31	50
Bereczki bőtermő	May 12	46	31	23
	May 13	18	69	13
	May 14	32	59	9
Champion	May 12	19	62	19
	May 13	10	65	25
	May 14	9	82	9
Konstantinápolyi	May 12	34	42	24
	May 13	30	47	23
	May 14	15	46	39
Mezőtúri	May 12	52	35	13
	May 13	39	32	29
	May 14	22	39	39
Mean of the days	**May 12**	**35.7 ± 4.8 n=6**	**42.5 ± 5.7 n=6**	**21.8 ± 4.0 n=6**
	May 13	**25.0 ± 5.0 n=6**	**50.0 ± 5.6 n=6**	**25.7 ± 4.1 n=6**
	May 14	**23.7 ± 5.1 n=6**	**48.8 ± 7.5 n=6**	**27.5 ± 6.7 n=6**
Average of all the cultivars inspected	**1997**	**28.0 ± 3.1 n=18**	**47.1 ± 3.7 n=18**	**24.9 ± 3.0 n=18**

Proportion of pure nectar gatherers was low or medium at all of the cultivars in the three consecutive years.

1998: Mean honeybee visitation of quince flowers was much lower (4.5 bee visits at 50 opening flowers in 10 minutes in average) than in the previous year (*Table 6*). This can be explained by the somewhat cooler weather (*Table 2*). The bee visitation was somewhat different on the days of the survey but the mean bee visitation figures were not in accordance with the tendency of the weather. For example the most intense bee visitation was detected on the 7th of May (*Table 5*) when the air temperature was the lowest (*Table 2*) . Almost as intense bee visitation was observed on one other day, too (May 3) but less than half as much bee visits were counted on other days (April 30, May 1, 6), however, the weather was fairly good to bees on all of these days (*Table 2*). These differences were reflected in the number of flowers visited at the branches, too (*Table 6*). Theses figures were the greatest on the days when the most intense bee visitation was detected. Finally the bees visited some 4.1–12.5 of the 50 flowers during the ten minutes observation periods in average on the days of observation and the mean number of flowers visited was as high an 8.3 of the 50 in average in 10 minutes of observation. This mean figure is much less than in the pervious year but, in fact, it is an extremely high value in such a short period of time as 10 minutes.

Bee visitation of one cultivar was usually higher (*Champion*) and of one other was smaller than of the rest of investigated varieties (*Mezőtúri*). The same figure of the other cultivars was variable since their relative bee visitation was greatly different on consecutive days, sometimes it was higher but in other days that was smaller than of others (*Table 6*).

Far more pollen gatherers were seen than in the previous year (*Table 7*). Their ratio was as high as 47–95% (some 76% in average) but nectar gatherers were less frequent than in the previous year (0-36%, but not more than some 17% in average). The proportion of mixed behaviour bees dropped down to a great extent (down to 0–20%, and to 7.7% in average). The ratio of the behaviour classes, however, changed from day to day and to cultivar to cultivar. The proportion of the pollen gatherers gradually decreased of some extent and the ratio of nectar gatherers and mixed behaviour bees increased on the consecutive days of the observations (*Table 7*). The overall tendency of the changes, however, was not so sharp as in the previous year.

Table 6 Intensity of honeybee visitation at blooming trees of quince cultivars in 1998 (Ujfehértó)

Cultivar	Date	No. of observations (n)	Bee visits at 50 opening flowers in 10 minutes	
			Number of bees visiting the flowers	Number of flowers visited
Angersi	May 3	8	6.0 ± 2.1	9.4 ± 3.8
	May 6	8	3.2 ± 0.6	5.8 ± 1.0
	May 7	8	7.1 ± 1.6	13.3 ± 3.4
Bereczki	May 3	8	4.2 ± 1.2	8.8 ± 3.0
	May 6	8	1.5 ± 0.4	1.5 ± 0.5
	May 7	8	6.9 ± 1.1	9.9 ± 1.7
Bereczki bőtermő	May 3	8	2.3 ± 0.9	3.9 ± 1.4
	May 6	8	1.8 ± 0.3	3.7 ± 0.8
	May 7	8	8.6 ± 1.9	13.5 ± 2.9
Champion	May 1	8	4.6 ± 1.5	9.8 ± 4.0
	May 3	8	10.5 ± 0.8	24.0 ± 6.3
	May 6	8	3.2 ± 0.6	4.9 ± 1.4
Konstanti-nápolyi	May 3	8	11.0 ± 3.0	23.1 ± 7.2
	May 6	8	2.2 ± 0.8	4.3 ± 1.8
	May 7	8	3.3 ± 0.5	5.3 ± 1.0
Mezőtúri	April 30	8	2.3 ± 0.7	4.4 ± 1.3
	May 1	8	2.0 ± 0.6	2.2 ± 0.9
	May 3	8	1.2 ± 0.4	1.8 ± 0.5
Mean of the days	**April 30**	**8**	**2.3 ± 0.7**	**4.4 ± 1.3**
	May 1	**16**	**3.3 ± 0.9**	**6.0 ± 2.3**
	May 3	**48**	**5.8 ± 0.9**	**12.5 ± 2.2**
	May 6	**40**	**2.3 ± 0.3**	**4.1 ± 0.6**
	May 7	**32**	**6.5 ± 0.8**	**10.5 ± 5.6**
Average of all the cultivars inspected	**1998**	**144**	**4.5 ± 0.4**	**8.3 ± 0.8**

Table 7 Foraging behaviour of honeybees at blooming trees of quince cultivars in 1998 (Ujfehértó)

Cultivar	Date	Foraging behaviour of honeybees per cent		
		Pollen gatherers	Mixed behaviour	Nectar gatherers
Angersi	May 3	72	5	23
	May 6	81	3	16
	May 7	62	20	18
Bereczki	May 3	47	17	36
	May 6	78	0	22
	May 7	70	14	16
Bereczki bőtermő	May 3	77	5	18
	May 6	89	6	5
	May 7	87	4	9
Champion	May 1	86	0	14
	May 3	57	15	28
	May 6	85	0	15
Konstanti-nápolyi	May 3	65	3	32
	May 6	72	20	8
	May 7	55	19	26
Mezőtúri	April 30	95	0	5
	May 1	94	0	6
	May 3	92	8	0
Mean of the days	**April 30**	**95**	**0**	**5**
		n=1	**n=1**	**n=1**
	May 1	**90.0 ± 4.0**	**0**	**3.0 ± 3.0**
		n=2	**n=2**	**n=2**
	May 3	**82.8 ± 6.43**	**6.2± 2.4**	**11.0 ± 9.79**
		n=6	**n=6**	**n=6**
	May 6	**81.0 ± 4.3**	**5.8 ± 3.7**	**13.2 ± 3.03**
		n=5	**n=5**	**n=5**
	May 7	**68.5 ± 6.9**	**14.2 ± 4.9**	**17.3 ± 5.3**
		n=4	**n=4**	**n=4**
Average of all the cultivars inspected	**1998**	**75.7 ± 3.4 n=18**	**7.7 ± 1.8 n=18**	**16.6 ±2 n=18**

More pollen gatherers were observed on the flowers of one cultivar (*Mezőtúri*) than on others and the ratio was fairly uniform on the days of the survey. The ratio of the pollen gatherers was somewhat smaller but fairly high at one other cultivar too (*Bereczki bőtermő*) and the ratio was fairly similar on the different days. These two cvs, therefore, tended to be somewhat more attractant to pollen gatherers than other varieties. Namely, the ratio was much more changeable on the days of the survey at another cultivars and the mean proportion of the pollen gatherers was lower than at the former two cvs (*Table 7*). Few nectar gatherers were seen on one cultivar because the pollen gatherers were so numerous on it (*Mezőtúri*). The ratio of the nectar gatherers on other cultivars was rather variable on the days of the survey (*Table 7*). Mixed behaviour bees were somewhat more numerous at one cultivar (*Konstantinápolyi*) than at others but the difference was not so much between cvs for the relatively small ratio of this behaviour class at all (*Table 7*).

1999: Bee visitation of quince flowers was somewhat less intense as in the previous year and not more than some one third as in the first year of the study when the weather was the warmest of the three years (in 1999 the 50 opening flowers were visited only by some 3.1 bees in 10 minutes in average). Much less bees frequented the flowers on the third day of the survey than on the previous days because that day was the coolest (*Table 3*) of the three ones when bees were observed at the flowers (*Table 8*). One cultivar was more intensely visited on all the three days of the survey than others (*Konstantinápolyi*). Some other cultivars were more intensely frequented by honeybees on some days than the rest of the cvs (*Champion, Bereczki bőtermő, Angersi*) but the bee visitation of same was smaller than of others on the other days (*Table 8*). A single cvs was less visited than others on all the three days of the observations (*Bereczki*). The number of the visited flowers showed the same picture. Most flower visits were seen at a single cultivar (*Konstantinápolyi*) and the less on one other cvs (*Bereczki*) and the figures of other cvs were variable on the days of the survey (*Table 8*). However, the weather was not so good this year the average number of flowers visited by the honeybees was as much as 4.2 flowers of 50 in 10 minutes that was a substantial intensity of bee visitation.

The foraging behaviour of honeybees was somewhat different compared to the two other years of the survey (*Table 9*) since the proportion of pollen gatherers was greater in this year than in the first year but smaller than in the second one (it varied between 27–100% with some 52% in average). Much more mixed behaviour bees were seen than in the previous year but less than two years earlier (the lowest and the highest figures were 0–60% with some 31% in average). The mean ratio of nectar gatherers, on the other hand, was less than in the first but fairly similar as in the second year of the survey (the extremes were 0–48 and the mean some 17%).

The frequency of behaviour classes varied greatly on the consecutive days. The ratio of pollen gatherers increased to its double form the first to the third day and the proportion of the pure nectar gatherers decreased sharply (*Table 8*). The proportion of the mixed behaviour bees was also changing but this was much less sharp than the ratio of the other two classes.

Table 8 Intensity of honeybee visitation at blooming trees of quince cultivars in 1999 (Ujfehértó)

Cultivar	Date	No. of observations (n)	Bee visits at 50 opening flowers in 10 minutes	
			Number of bees visiting the flowers	Number of flowers visited
Angersi	May 3	8	5.5 ± 1.4	6.4 ± 1.7
	May 4	8	4.1 ± 0.9	6.5 ± 1.6
	May 5	8	0.1 ± 0.1	0.3 ± 0.3
Bereczki	May 3	8	2.8 ± 1.1	3.9 ± 1.7
	May 4	8	1.8 ± 0.5	2.1 ± 0.8
	May 5	8	0.4 ± 0.3	0.1 ± 0.1
Bereczki bőtermő	May 3	8	4.8 ± 1.5	6.1 ± 2.0
	May 4	8	1.9 ± 0.5	2.8 ± 0.7
	May 5	8	0.9 ± 0.7	1.6 ± 1.5
Champion	May 3	8	4.6 ± 0.6	6.0 ± 1.0
	May 4	8	4.6 ± 0.9	7.9 ± 1.9
	May 5	8	0.9 ± 0.3	1.3 ± 0.4
Konstantinápolyi	May 3	8	8.0 ± 3.9	9.5 ± 4.0
	May 4	8	5.8 ± 1.3	7.8 ± 1.9
	May 5	8	1.4 ± 0.3	2.0 ± 0.5
Mezőtúri	May 3	8	3.6 ± 1.2	5.5 ± 1.8
	May 4	8	3.8 ± 1.0	5.8 ± 1.6
	May 5	8	0.6 ± 0.5	0.8 ± 0.6
Mean of the days	**May 3**	**48**	**4.9 ± 0.8**	**5.6 ± 1.0**
	May 4	**48**	**3.6 ± 0.5**	**5.5 ± 0.7**
	May 5	**48**	**0.7 ± 0.1**	**1.0 ± 0.2**
Average of all the cultivars inspected	**1999**	**144**	**3.1 ± 0.3**	**4.2 ± 0.4**

Some cultivars tended to attract somewhat more pollen gatherers (*Bereczki bőtermő, Mezőtúri*) and less mixed behaviour bees than others (*Table 9*). Another two cultivars, on the other hand, attracted less pollen collecting foragers than the average (*Konstantinápolyi, Bereczki*) but the ratio of the other behaviour classes failed to be proportional of that (*Table 9*). In fact, the proportion of the behaviour classes on the flowers of individual cultivars reflected the general tendency, because the frequency of the pollen collecting bees increased and the same of the nectar gatherers decreased (*Table 9*).

Comparison of cultivars: Intensity of bee visitation of quince flowers was greatly different in the three years of the study so the calculation of the common mean visitation figures of the three years together would be meaningless. Bee visitation, therefore, can only be compared in individual years. Some differences observed between cultivars have been mentioned above. *Konstantinápolyi* was visited more intensely than other cvs and *Bereczki bőtermő,* as well as,

Table 9 Foraging behaviour of honeybees at blooming trees of quincecultivars in 1999 (Ujfehértó)

Cultivar	Date	Foraging behaviour of honeybees per cent		
		Pollen gatherers	Mixed behaviour	Nectar gatherers
Angersi	May 3	36	36	18
	May 4	27	60	13
	May 5	100	0	0
Bereczki	May 3	32	36	32
	May 4	43	50	7
	May 5	60	40	0
Bereczki bőtermő	May 3	37	26	37
	May 4	67	13	20
	May 5	85	15	0
Champion	May 3	51	17	32
	May 4	30	50	20
	May 5	57	43	0
Konstanti-nápolyi	May 3	33	19	48
	May 4	28	39	33
	May 5	64	27	9
Mezőtúri	May 3	44	34	22
	May 4	60	23	13
	May 5	80	20	0
Mean of the days	**May 3**	**38.8 ± 2.9 n=6**	**28.7 ± 3.5 n=6**	**32.5 ± 2.2 n=6**
	May 4	**42.7 ± 7.1 n=6**	**39.4 ± 7.3 n=6**	**17.9 ± 3.7 n=6**
	May 5	**74.3 ± 6.9 n=6**	**24.2 ± 6.6 n=6**	**1.5 ± 1.5 N76**
Average of all the cultivars inspected	**1999**	**52.2 ± 5.0 n=18**	**30.8 ± 4.8 n=18**	**17.0 ± 3.5 n=18**

Table 10 Comparison of honeybee visitation at blooming trees of quince (Ujfehértó, 1997–1999)

Cultivar	Year	No. of observations (n)	Bee visits at 50 opening flowers in 10 minutes	
			Number of bees visiting the flowers	Number of flowers visited
Angersi	1997	24	4.5 ± 1.1	8.3 ± 2.6
	1998	24	5.4 ± 2.5	9.5 ± 2.8
	1999	24	3.2 ± 1.4	4.4 ± 2.1
Bereczki	1997	24	12.3 ± 1.7	20.6 ±3.0
	1998	24	4.0 ± 1.6	6.7 ± 3.0
	1999	24	1.6 ± 1.1	2.0 ± 1.5
Bereczki bőtermő	1997	24	10.9 ±2.4	21.1 ± 5.3
	1998	24	4.3 ± 1.9	7.0 ± 2.9
	1999	24	2.5 ± 1.6	3.5 ± 2.4
Champion	1997	24	7.7 ± 1.9	13.1 ± 3.5
	1998	24	6.0 ± 2.0	12.9 ± 6.8
	1999	24	3.4 ± 1.0	5.0 ± 2.0
Konstanti-nápolyi	1997	24	12.2 ± 2.2	26.2 ± 5.3
	1998	24	5.5 ± 2.5	13.9 ± 4.8
	1999	24	5.0 ± 3.2	2.2
Mezőtúri	1997	24	6.3 ± 1.3	10.3 ± 1.8
	1998	24	1.8 ± 1.2	2.8 ± 1.5
	1999	24	4.0 ± 1.5	4.0 ± 2.3
Mean of the 3 years	**1997–1999**	**432**	**5.5 ± 0.3**	**9.7 ± 0.7**

Champion were more visited than the rest of the cultivars. On the other hand, *Mezőtúri* and *Bereczki* were less visited than others in two of the three years (*Table 10*). There was a single cvs, *Angersi*, the bee visitation of that was more intense in one and definitely less frequent in one other year than of other cultivars (*Table 10*). The number of flowers visited on the branches inspected was fairly proportional with these differences (*Table 10*).

Foraging behaviour of bees was rather different on single cultivars in the consecutive years (*Table 11*). In spite of this fact *Mezőtúri* seems to be definitely much more frequented by pollen gatherers and usually less visited by nectar collecting bees than others this tendency being fairly stable for all of the three years of the study (*Table 11*). *Bereczki* and *Konstantinápolyi* were also somewhat more favoured by pollen gatherers than the rest of the cvs but this tendency was not so stable in all of the three years.

Table 11 Comparison of the foraging behaviour of honeybees at blooming trees of quince cultivars (Ujfehértó, 1997–1999)

Cultivar	Year	Foraging behaviour of honeybees per cent		
		Pollen gatherers	Mixed behaviour	Nectar gatherers
Angersi	1997	38.8 ± 4.4 n=3	46.6 ± 6.6 n=3	15.0 ± 2.5 n=3
	1998	71.7 ± 5.4 n=3	9.3 ± 5.2 n=3	19.0 ± 1.9 n=3
	1999	56.1 ± 22.9 n=3	33.6 ± 17.4 n=3	10.3 ± 4.4 n=3
Bereczki	1997	22.0 ± 5.8 n=3	33.7 ± 4.9 n=3	44.3 ± 3.0 n=3
	1998	65.1 ± 9.2 n=3	10.1 ±5.1 n=3	24.8 ± 5.9 n=73
	1999	45.0 ± 8.3 n=3	42.0 ± 4.2 n=3	13.0 ± 9.9 n=3
Bereczki bőtermő	1997	32.0 ± 8.2 n=3	53.0 ± 11.5 n=3	15.0 ± 7.2 n=3
	1998	84.6 ± 3.7 n=3	4.6 ± 0.5 n=3	10.8 ± 3.0 n=3
	1999	63.0 ± 4.1 n=3	18.0 ± 9.1 n=3	19.0 ± 10.8 n=3
Champion	1997	12.7 ± 3.2 n=3	69.7 ± 6.3 n=3	17.7 ± 4.7 n=3
	1998	76.3 ± 9.4 n=3	5.0 ± 0.5 n=3	18.7 ± 4.4 n=3
	1999	46.0 ± 8.3 n=3	36.7 ± 10.2 n=3	17.3 ± 9.5 n=3
Konstanti-nápolyi	1997	26.3 ± 5.9 n=3	45.0 ± 1.6 n=3	28.7 ± 5.2 n=3
	1998	64.0 ± 4.8 n=3	14.1 ± 5.4 n=3	21.9 ± 7.2 n=3
	1999	37.7 ± 11.5 n=3	28.3 ± 5.9 n=3	30.0 ± 11.6 n=3
Mezőtúri	1997	37.7 ± 8.8 n=3	35.3 ± 2.0 n=3	27.0 ± 7.7 n=3
	1998	93.7 ± 1.1 n=3	2.8 ± 2.7 n=3	3.5 ± 1.8 n=3
	1999	61.3 ± 10.6 n=3	27.0 ± 4.1 n=3	11.7 ± 6.5 n=3
Mean of the 3 years	**1997–1999**	**51.6 ± 3.4 n=54**	**28.5 ± 2.9 n=54**	**19.9 ± 1.8 n=54**

Discussion and conclusions

No doubt we found highly intense bee visitation on flowering quince trees and so we can contribute to the statement of *Simidchiev* (1967) that this fruit tree species can be attractive to honeybees well enough. In our case, however, the quince plantation itself and also its immediate vicinity was highly overpopulated with honeybee colonies and the weather favoured to bee activity in all of the three years of the study. Under such favourable conditions like this 50 quince flowers were visited by 5.5 bees in average in 10 minutes of observation periods and some 9.7 flowers were visited of the 50 ones meanwhile. This was resulted in as much as 7 bee visits per one flower per day when the weather favoured bee activity for at least 6 hours on day. Flowers can be receptive for 1–3 days so 4–12 bee visits can be available to cross pollinate them. This is very important because the flower density of quinces is much smaller than of most other fruit tree species and so as high set of the flowers is needed for a good crop as some 20–25% instead of some 10% as for apple and pear (*Nyéki,* 1996). It is unknown, however, how many bee visits per flower are needed at the minimum to achieve as high set as required. *Benedek* (1996) has pointed out that the required intensity of bee visitation is the only reliable estimate of the necessity of supplementary bee pollination at fruit orchards. This is especially true of quince for its relatively late blooming period among fruit tree species. Namely honeybees from the apiaries being in the neighbouring settlements can greatly contribute to the pollination of quince plantations when not so much competing plant species are in bloom. For this reason further research is necessary to explore the relationship between the number of honeybee visits per flower and the consequent fruit set at quince.

It is important to say that the bee visitation of quince flowers was found to be greatly different in different years. Interestingly, this fails to be closely related to the weather since the blooming period of quince takes place much later than the same of other temperate-zone fruit tree species and so the weather is usually favourable to bee activity

Present results indicate that most honeybees tend to gather pollen at quince flowers (51.6% in average for 3 consecutive years: *Table 11*) and usually not more than much less of them collect deliberately for nectar only (19.9% in this study for 3 years in average) and also the proportion of mixed behaviour bees seems to be much less than that of the pure pollen gatherers (28.5% for 3 years in the present study). These figures are greatly differed of the values published by *Simidchiev* (1967) who stated that the pollen collecting bees made not more than 11 and the nectar gatherers some 5 per cent of the honeybees visiting quince flowers and the vast majority of them (84%) were mixed behaviour bees. Pollen gatherers and mixed behaviour bees are carrying pollen loads all and they approach each flower landing on the stamens and the stigmas so they are similarly effective in the pollination of the flowers. Counting the ratio of these two behaviour classes together, the mean figures of *Simidchiev* (1967) and the same of as are much more similar being 95 and 80 per cent, respectively.

The mean behaviour figures, however, do not say too much themselves because the behaviour of bees can be greatly different on different days, different years and sometimes at different cultivars, too, as seen from the results of this study (*Tables 5, 7, 9*). It is important that the ratio of nectar gatherers generally seems not to be too high and pollen gatherers are usually much more numerous than in the study of *Simidchiev* (1967). This fact clearly shows and also the relatively high proportion of mixed behaviour bees corroborates to the conclusion that honeybees prefer to gather pollen at quince flowers. This is very important because the sugar concentration of quince nectar (the main attracting factor of nectar to honeybees) has been found to be relatively low compared to most of the other temperate zone fruit free species (*Benedek, Szabó & Nyéki,* 2000). Therefore the relatively low sugar concentration of quince nectar and consequently its possibly low attractiveness to nectar gatherer honeybee foragers can explain the fact that the proportion of the pure nectar gatherers seems to be low at quince flowers and the ratio of the mixed behaviour bees (collecting also nectar) is greatly changeable.

Some differences were observed in the intensively of bee visitation at cultivars. There were some varieties the flowering branches of that were usually more frequented by honeybees (*Konstantinápolyi* for example). Another cultivars, at the same time, were less visited by bees (e.g. *Mezőtúri, Bereczki*).

Benedek, Szabó & Nyéki (2000) has found some slight differences in the nectar production of quince flowers since the flowers of some cultivars often contained more nectar than of others (*Konstantinápolyi, Champion*) and other cvs can contained less (*Mezőtúri*). They have put the question whether slight differences in the nectar production of the cvs can influence the bee visitation of quince. Since the measurements on the nectar production and the counting of the bee visitation have been implemented at the same orchard in the same years this question can well replied here. The reply is that the effect of the nectar production can not be excluded. Namely *Konstantinápolyi* with more nectar in its flowers was somewhat more frequented by honeybees and *Mezőtúri* with less nectar was less visited by honeybees. This statement seemed to be supported also by the fact that *Mezőtúri* (with less nectar in its flowers) attracted more pollen gatherers than others in all the three years of the present study. However, the foraging behaviour of honeybees is not in a direct relationship with the nectar production of flowers, since also *Konstantinápolyi* (the flowers of that tended to contain more nectar that others) was also favoured somewhat more by pollen gatherers than the rest of the varieties. Based a this discussion it can be concluded that the nectar production of quince flowers has got some impact on the bee visitation of the flowers of quince cultivars but this relationship is not as stable as one could expect. However, some other small differences were

also found in the foraging behaviour of honeybees at the flowers of quince cultivars but these differences did not seem to be consequent at all instances showing that the relative attractiveness of the cvs of quince is variable to honeybees. Differences of the intensity of bee visitation, therefore, can be much more influenced by other factors than the nectar production of quince flowers, their pollen production as well as by the nectar (and pollen) supply of other plant species blooming simultaneously (probably first of all by weed species or for example by locust trees in Hungary). The possible existence of influencing factors like these is supported by the fact that the foraging behaviour of honeybees was found to be variable during consecutive years and also on consecutive days of the same years. For this reason the required high fruit set of quince (et least 20–25%) seems to need regular supplementary pollination in commercial plantations.

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