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Foraging fidelity of honeybees and abundance of insect visitors on some Horticultural crops

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Abstract

The study was carried out on the foraging behavioral aspects which are either genetically influenced or are dependent on external factors on four horticultural crops viz., cabbage, Chinese cabbage, blueberry and peach at Bee Research Station, CSK HPKV, Palampur, Himachal Pradesh, India during 2019. The significantly highest foraging rate and foraging speed of *Apis dorsata* was registered as 11.76 and 9.91 respectively on four crops altogether. *Apis cerana* was the most predominant insect visitor with maximum foraging intensity as insects/m²/minute during peak bloom on cabbage (3.47) as well as on Chinese cabbage (3.61). While *Apis dorsata* was predominant pollinator on peach (6.67 insects/m²/minute) and blueberry (3.85 insects/m²/minute). This study would be helpful to beekeepers as it is very important to understand the behavior patterns represented by bees for better management aspects.

Keywords: Honeybees, foraging, Blueberry, fidelity, behavior

1. Introduction

Pollination indices on the basis of foraging behavior, foraging speed and rate has been found as an alternate parameter to evaluate the pollination efficiency as well as extent of their contribution to ecosystem (Sharma, 1990) [18]. Diversity of insect pollinator community significantly affects the pollination of important agricultural crops. In India half of its geographical area is under cultivation and out of that about 51 million hectares is under cross-pollinated crops, mostly visited by the bees for obtaining pollen, nectar or both (Albrecht *et al.*, 2013) [3]. The stone fruit crops require only one viable pollen tube to produce a fruit and in most cases the pollen should arrive from another compatible blossom at the right time (McGregor, 1976) [13], for that the insect pollinator diversity is important to bear a satisfactory commercial yield (Potts *et al.*, 2005) [14]. Honeybees are the main crop pollinators worldwide and in the United States, and about 35% of world crop production depends on the pollinators (Klein *et al.*, 2007). Pollination is critical for the production of larger, better quality and early ripening blueberries which are mostly pollinated by bumble bees through buzz pollination as they forage in colder temperatures and remove blueberry pollens efficiently (Rao *et al.*, 2009) [17]. Chinese cabbage is another cross-pollinated crop and honeybees play an important role in the pollination in natural habitat of North Western Himalayas, as per an estimate the maximum of 4,999 bee foragers or 8.33 colonies are needed to effectively pollinate a hectare of Chinese cabbage (Crane, 1991; Sushil *et al.*, 2013; Stanley *et al.*, 2017) [5, 23, 22]. Systematic work on the importance of insect pollinators in stone fruit pollination was scanty therefore; keeping this in view the present study was conducted to study the diversity and foraging behavior of insect pollinator in Himachal Pradesh.

Materials and methods**2.1. Materials to record foraging intensity and relative abundance**

Peach, blueberry, cabbage and Chinese cabbage crops were selected for the studies. With an aid of stopwatch time related observations on foraging intensity, foraging rate and foraging speed of insect pollinators were taken. These insects were collected with insect collection net made up of mosquito netting material having hoop with diameter 30 cm. Insects were then killed using airtight glass bottles containing cotton soaked with ethyl acetate.

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2.2. Methods adopted

The field studies were conducted near Bee Research Station, CSK HPKV, Palampur during the year 2018-19 and the experimental methods used and procedures are under:

2.2.1. Foraging intensity and relative abundance of insect pollinators on crops

Foraging intensity was recorded during the entire blooming period *i.e.*, early, mid, peak and at late blooming periods as number of bees/m²/minute (Thangjam *et al.*, 2018) [25]. A total number of visiting insects/m² of randomly selected crop area were counted for one minute in three replications as per the methods given by Amin *et al.*, 2018 [1]. The numbers of different pollinators were also assessed to work out their relative abundance as per Das and Jha, (2018) [6].

$$\text{Relative abundance} = \frac{(\text{Population of a specific species visiting flowers})}{(\text{Total population of all species visiting flowers})} \times 100$$

For fruit trees, the relative abundance of insect visitors was assessed by selecting trees at random throughout orchard. The branches of trees so selected were chosen in such a manner, that they have approximately same dimensions with respect to their spread, phase of flowering, number of flowers and height above ground. For data recording, four branches from three trees were randomly selected from all possible directions and observations were made as per the method given by Anita *et al.*, (2012) [2].

2.2.2. Foraging rate and foraging speed of honeybees

To know the foraging behavior *i.e.*, foraging rate and foraging speed of honeybee species, daily observations were taken on two vegetable crops *viz.*, cabbage and Chinese cabbage and two fruit crops *viz.*, peach and blueberry during the entire blooming period. Foraging rate was recorded as number of flowers visited by honeybee per minute including flying time from one flower to another (Srivastava *et al.*, 2017 and Sharma *et al.*, 2018) [21, 20]. However, foraging speed was recorded as daily observation in terms of the time (seconds) spent by each bee species on a single flower (Free, 1993) [8] for vegetables crops whereas for fruit trees four flowers were observed and each flower was considered as one replication. The data collected was analyzed by using factorial RBD.

3. Results

3.1. Foraging intensity of different insect pollinators on cabbage (*Brassica oleracea* var. *capitata*) and Chinese cabbage (*Brassica rapa* subsp. *chinensis*)

The mean foraging intensity of *A. cerana* (3.47) was significantly higher as compared to *A. dorsata* (3.29) on cabbage (Table 1). Among other insect pollinators, the highest foraging intensity was recorded in order of Hymenoptera (1.69), Diptera (1.61) and Lepidoptera (0.29). While on Chinese cabbage, the mean foraging intensity of foragers of *A. cerana* (3.61) was significantly the highest followed by *A. dorsata* (1.28). Among other insect pollinators, the highest foraging intensity was recorded in order of Hymenoptera (2.50), Diptera (1.18), Lepidoptera (0.60) and the lowest was recorded from order Coleoptera (0.05). Kakar (1981) investigated the foraging behavior of insect pollinators and reported that *A. cerana* was the most efficient pollinator and remained in good numbers during the entire period of flowering on cabbage which is in similarity with Thakur *et al.* (2004) who also reported *A. cerana* as the most abundant pollinator and support the results. Sushil *et al.* (2013) [23]

reported that more honeybee foragers visited Chinese cabbage which is in agreement to the present results.

3.2. Foraging intensity of different insect visitors on peach (*Prunus persica*) and blueberry (*Vaccinium corymbosum*)

The foraging intensity of foragers was significantly different from one another at different blooming stages as the mean foraging intensity of foragers of *A. dorsata* (6.67) was significantly the highest followed by *A. cerana* (3.26) and the lowest was *A. mellifera* (1.37) on peach (Table 2). Among other insect pollinators, highest foraging intensity was recorded from Diptera (1.11) followed by Hymenoptera (0.44), Lepidoptera (0.06) and the lowest was Coleoptera (0.01). Mean foraging intensity of various insect pollinators at different blooming stages do vary significantly as it was the highest at peak bloom stage (2.47). As it is apparent that the foraging intensity of *A. dorsata* (3.85) was significantly the highest followed by *A. cerana* (2.07) and the lowest was *A. mellifera* (0.81) on blueberry. Among other insect pollinators, the highest foraging intensity was recorded in order Hymenoptera (0.64) followed by Diptera (0.08) which was at par with Lepidoptera (0.08). Balina *et al.* (2015) [4] reported *A. dorsata* as the most efficient pollinator on peach which supports the results of our study. Gautam and Kumar (2018) also reported *A. dorsata* as the most dominant species.

3.3. Foraging rate of *Apis* spp. on different crops at Palampur

The foraging rate of *Apis* spp. on four different crops *viz.*, *Prunus persica*, *Vaccinium corymbosum*, *Brassica rapa* subsp. *chinensis*, *Brassica oleracea* var. *capitata* at Palampur shows that among different honeybee species, the maximum mean number of flowers per minute was visited by *Apis dorsata* (11.76) followed by *Apis cerana* (11.31) whereas the least mean number of flowers/minute was visited by *Apis mellifera* (4.43) (Table 3). The foraging rate of different *Apis* spp. was significantly variable on different crops surveyed. The highest foraging rate of *A. mellifera* was recorded on peach (9.88) whereas *A. mellifera* foragers were absent on Chinese cabbage and cabbage. *A. cerana* has significantly the highest foraging rate on blueberry (14.82) (Fig. 1.). Similar trend was also seen for blueberry as *A. dorsata* (14.45) showed significantly the highest foraging rate. The present record is in similarity to the reports on foraging rate of *A. cerana* on cabbage by Radchenko (1966) [15], Verma and Partap (1994) [26] also recorded that bees visited 5-8 flowers/minute on cabbage and is almost similar to the our findings. Devkota and Thapa (2005) [7] revealed the foraging rate for *A. cerana* (12.11) and *A. mellifera* (10.89) which are in accordance to present findings.

3.4. Foraging speed of *Apis* spp. on different crops at Palampur

The foraging speed of *Apis* spp. on four different crops under study revealed that the maximum time spent on single flower was recorded from *Apis dorsata* (9.91) followed by *Apis cerana* (7.71) whereas the lowest was *Apis mellifera* (4.51) on these crops (Table 4). However, the foraging speed are statistically different on all the crops as foraging speed of *A. mellifera* was recorded the highest on blueberry (9.73). *A. cerana* showed significantly the highest foraging speed on peach (12.32) and the lowest foraging rate was recorded on blueberry (5.43). Whereas *A. dorsata* showed significantly the highest foraging speed on peach (15.25) whereas foraging speed on vegetable crops were found to be significantly lower

as compared to fruit trees (Fig. 2.). Mattu *et al.* (2012) also reported foraging speed in range of 6.25 to 7.55 for *A. cerana* whereas *A. mellifera* spent 8.10 to 10.33 seconds/flower at various crops which are in accordance with the findings. Rani

et al. (2017) [16] also reported that *A. mellifera* spent maximum time (10.30) and values were 7.61 and 5.10 seconds/flower for *A. dorsata* and *A. cerana* respectively

Table 1: Foraging intensity of pollinator insects during blooming period on Cabbage and Chinese cabbage at Palampur

Insects	Mean numbers of insects/m ² /minute											
	Cabbage					Relative Abundance (%)	Chinese cabbage					Relative Abundance (%)
	Early bloom	Mid bloom	Peak bloom	Late bloom	Mean		Early bloom	Mid bloom	Peak bloom	Late bloom	Mean	
<i>Apis mellifera</i>	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00
<i>Apis cerana</i>	3.02 (2.01)	4.48 (2.35)	4.77 (2.39)	1.62 (1.64)	3.47 (2.09)	37.51	2.83 (1.91)	5.40 (2.53)	5.76 (2.59)	0.43 (1.20)	3.61 (2.06)	38.50
<i>Apis dorsata</i>	2.90 (1.98)	3.40 (2.09)	5.86 (2.59)	0.98 (1.42)	3.29 (2.02)	30.87	1.33 (1.52)	1.52 (1.57)	2.01 (1.74)	0.26 (1.14)	1.28 (1.49)	16.89
Hymenoptera*	1.52 (1.61)	2.02 (1.72)	2.83 (1.98)	0.38 (1.19)	1.69 (1.62)	14.77	2.64 (1.89)	2.51 (1.85)	4.48 (2.28)	0.36 (1.17)	2.50 (1.80)	25.81
Lepidoptera	0.17 (1.08)	0.17 (1.09)	0.81 (1.37)	0.00 (1.00)	0.29 (1.13)	2.38	0.40 (1.19)	0.45 (1.22)	1.46 (1.60)	0.07 (1.05)	0.60 (1.26)	6.19
Diptera	1.71 (1.61)	2.02 (1.72)	2.39 (1.79)	0.31 (1.15)	1.61 (1.57)	14.47	1.02 (1.45)	1.49 (1.60)	2.05 (1.73)	0.14 (1.08)	1.18 (1.47)	12.44
Coleoptera	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00	0.00 (1.00)	0.00 (1.00)	0.21 (1.09)	0.00 (1.00)	0.05 (1.02)	0.18
Mean	1.33 (1.47)	1.73 (1.56)	2.38 (1.73)	0.47 (1.20)			1.17 (1.43)	1.62 (1.54)	2.28 (1.72)	0.18 (1.09)		

*Other than *Apis* species

Figures in parentheses are the means of $\sqrt{n+1}$ transformations

Table 2: Foraging intensity of pollinator insects during blooming period on Peach and Blueberry at Palampur

Insects	Mean numbers of insects/m ² /minute											
	Peach					Relative Abundance (%)	Blueberry					Relative Abundance (%)
	Early bloom	Mid bloom	Peak bloom	Late bloom	Mean		Early bloom	Mid bloom	Peak bloom	Late bloom	Mean	
<i>Apis mellifera</i>	0.83 (1.34)	1.76 (1.63)	2.33 (1.80)	0.55 (1.23)	1.37 (1.50)	9.57	0.45 (1.19)	1.02 (1.42)	1.45 (1.56)	0.31 (1.14)	0.81 (1.32)	9.93
<i>Apis cerana</i>	2.40 (1.84)	4.12 (2.24)	4.50 (2.33)	2.00 (1.75)	3.26 (2.04)	24.14	1.76 (1.65)	2.19 (1.77)	2.74 (1.93)	1.57 (1.62)	2.07 (1.74)	28.15
<i>Apis dorsata</i>	6.45 (2.73)	6.95 (2.80)	8.1 (3.02)	5.17 (2.47)	6.67 (2.75)	54.20	3.33 (2.04)	4.29 (2.31)	4.69 (2.40)	3.07 (2.06)	3.85 (2.20)	52.95
Hymenoptera*	0.36 (1.17)	0.55 (1.22)	0.69 (1.29)	0.17 (1.10)	0.44 (1.19)	3.12	0.29 (1.14)	0.81 (1.37)	1.19 (1.47)	0.26 (1.15)	0.64 (1.28)	7.48
Lepidoptera	0.02 (1.01)	0.07 (1.03)	0.14 (1.06)	0.00 (1.00)	0.06 (1.02)	0.31	0.02 (1.02)	0.02 (1.02)	0.26 (1.11)	0.00 (1.00)	0.08 (1.03)	0.69
Diptera	1.05 (1.43)	1.31 (1.50)	1.45 (1.55)	0.64 (1.27)	1.11 (1.43)	8.64	0.02 (1.02)	0.14 (1.07)	0.17 (1.10)	0.00 (1.00)	0.08 (1.05)	0.80
Coleoptera	0.00 (1.00)	0.00 (1.00)	0.02 (1.01)	0.00 (1.00)	0.01 (1.00)	0.02	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00
Mean	1.59 (1.50)	2.11 (1.63)	2.47 (1.72)	1.22 (1.40)			0.84 (1.29)	1.21 (1.42)	1.50 (1.51)	0.75 (1.28)		

*Other than *Apis* species

Figures in parentheses are the means of $\sqrt{n+1}$ transformations

Table 3: Foraging rate of honeybees on some fruit and vegetable crops at Palampur

Honeybee species	Number of flowers visited by honeybee/ minute				
	Fruit crops		Vegetable crops		Mean
	Peach	Blueberry	Chinese cabbage	Cabbage	
<i>Apis mellifera</i>	9.88 (3.30)	7.83 (2.98)	0.00 (1.00)	0.00 (1.00)	4.43 (2.07)
<i>Apis cerana</i>	12.55 (3.68)	14.82 (3.98)	10.23 (3.33)	7.63 (2.93)	11.31 (3.48)
<i>Apis dorsata</i>	11.65 (3.56)	14.45 (3.93)	11.58 (3.55)	9.35 (3.19)	11.76 (3.56)
Mean	11.36 (3.51)	12.37 (3.63)	7.27 (2.63)	5.66 (2.38)	

*Figures in parentheses are the means of $\sqrt{n+1}$ transformations

Table 4: Foraging speed of honeybees on some fruit and vegetable crops at Palampur

Honeybee species	Time spent by honeybee/flower (seconds)				Mean
	Fruit crops		Vegetable crops		
	Peach	Blueberry	Chinese Cabbage	Cabbage	
<i>Apis mellifera</i>	8.30 (3.22)	9.73 (3.27)	0.00 (1.00)	0.00 (1.00)	4.51 (2.12)
<i>Apis cerana</i>	12.32 (3.71)	5.43 (2.55)	6.08 (2.61)	7.00 (2.83)	7.71 (2.92)
<i>Apis dorsata</i>	15.25 (4.02)	14.25 (3.96)	4.20 (2.33)	5.93 (2.61)	9.91 (3.23)
Mean	11.96 (3.65)	9.80 (3.26)	3.43 (1.98)	4.31 (2.15)	

*Figures in parentheses are the means of $\sqrt{n+1}$ transformations

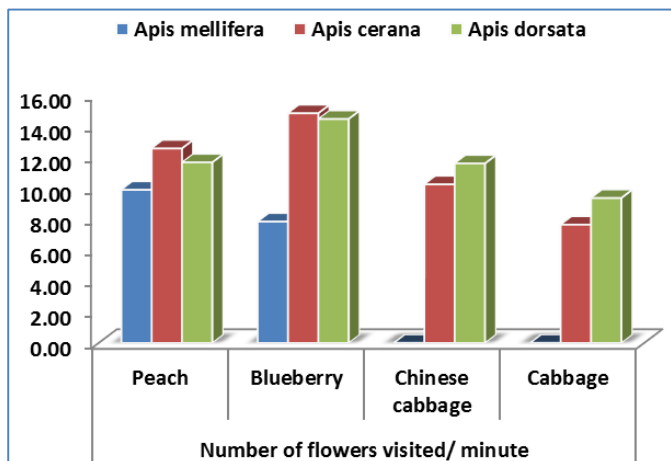


Fig 1: Number of flowers visited by honeybees on some fruit and vegetable crops

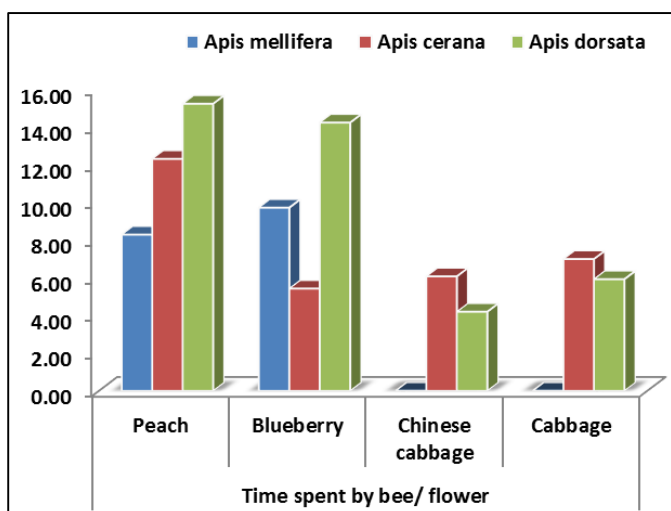


Fig 2: Time spent by honeybees in seconds on some fruit and vegetable crops

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