

Foraging Behavior of Honey Bees on Litchi Bloom

Matangi Mishra, Neeraj Kumar

Received 16 August 2017; Accepted 19 September 2017; Published on 14 October 2017

Abstract The observations on relative abundance of different honey bee species on litchi bloom revealed that *Apis mellifera* was dominant visitor and had maximum population (14.33 bees per minute per panicle) followed by *Apis dorsata* (11.00 bees per minute per panicle) and *Apis florea* (6.22 bees per minute per panicle) having the minimum number. The correlation coefficients of honey bee abundance with temperature was found positive and highly significant viz., (0.79**) in case of *Apis mellifera*, 0.76** in *Apis cerana* and 0.72** in *Apis florea*. The population of *Apis mellifera*, *Apis dorsata* and *Apis florea* were found negatively correlated with the relative humidity being -0.81**, -0.68* and -0.62*, respectively. Among the species, *A. dorsata* (10.52 h) foraged for maximum duration followed by *A. mellifera* (9.55 h) and minimum duration of foraging was of *Apis florea* being 7.55 h. The foraging speed was recorded highest in case of *Apis dorsata* (10.28 s) followed by *A. mellifera* (9.15s) and lowest in case of *A. florea* being 6.97 seconds.

Keywords Relative abundance, Weather parameters, Duration of foraging, Foraging rate, Foraging speed.

Introduction

The bee keeping industry is capable of enhancing production of litchi by utilizing nature's gift and that too without any suffering to nature. Foraging behavior of bee is an expression of the complex relationship between colony biology, other foragers, microclimate of the hive, the physiology of plants and other biological and environmental factors. Enhancing the amount or quality of insect pollination can lead to increase in crop value by decreasing the time to crop maturity and also by increasing its uniformity, quantity and quality. Foraging rate and foraging speed depends on foraging behavior. The performance of partially or completely self-incompatible crops can be enhanced by bee pollination.

Litchi is excellent honey plant and seems to depend on insect for cross pollination. Earlier it was observed that *Apis* spp. formed a major portion among insect visitors. The further pointed out that the insect pollination, particularly honey bees are necessary for fruit set in litchi. A relative abundance of insect visitors was recorded on litchi blooms. He observed that *Apis mellifera* L. was the dominant visitors (34.79%) amongst the *Apis* spp. followed by *Apis cerana indica* (18.2%), *Apis dorsata* (13.38%) and *Apis florea* (6.20%) accounted least. Earlier it was reported that the maximum number of bee foragers per minute per panicle was recorded in *Apis mellifera* (46.51%) followed by *Apis cerana indica* (40.28%), *Apis dorsata* (9.05%) and *Apis florea* (4.16%) in litchi. The foraging rate (the number of flowers visited by bees per minute) was maximum in *Apis mellifera* (10.74%), followed by *Apis cerana indica* (19.30%), *Apis dorsata* (2.09%) and *Apis florea* (0.96%). During

Matangi Mishra*, Neeraj Kumar
 Department of Entomology, Dr. Rajendra Prasad Central
 Agricultural University, Pusa, Samastipur 848125, Bihar,
 India
 e-mail: matangi.gaurav@gmail.com
 *Correspondence

the day the maximum number of bee foragers per minute per panicle was recorded at 15.30-16.30 h. It was found that within the temperature range of bee activity, light had a more important influence on the bee flight than slight change in temperature. Further bees spent about 7 seconds or 10 seconds per flower in collecting nectar only. Foraging rate depends on the foraging behavior of insects and floral structure of crop. It was revealed that *Apis mellifera* spent least time (5.2 seconds per flower) to collect pollen whereas, *A. c. indica* spent maximum time to collect the pollen (7.2 sec/flower). Bhatnagar and Karnataka (2010) [1] found that there was a negative correlation between the distance of litchi tree and abundance of bees. Visitation of *Apis mellifera* during morning hours was more than in evening hours.

Materials and Methods

The experiment was carried out in Litchi Orchard of University Apiary situated at DRPCA, Pusa, Samastipur, Bihar. The methodology used in the experiments are mentioned as below.

Abundance of bees

The number of honey bees visiting litchi panicle was counted in an area of 1 square meter, marked randomly on the litchi trees on which the experiment was carried out. The abundance for 1 minute was recorded

at 0700 h, 0900 h, 1100 h, 1300 h, 1500 h and 1700 h on different dates from the 10% flowering till maturity of the crop at 5-days interval. The mean population of bees were correlated with the weather parameter viz. average temperature and average relative humidity recorded at the time of observation by digital thermohygrometer to know the influence of environmental factors.

Duration of foraging

With a view to find out foraging period of *Apis mellifera* on litchi, for observations were recorded at weekly intervals on initiation time and cessation time, during which the first visits of foragers were recorded on litchi bloom as initiation time and when there were no foragers of *Apis mellifera*, it was considered as their cessation time. The duration of foraging was calculated as :

$$\text{Duration of foraging} = \text{Cessation time} - \text{Initiation time.}$$

Foraging rate

The number of flowers visited by bees per minute was recorded. It was visually observed in unit time. These observations were recorded for consecutive visits by foraging bees in a minute on 0900 h, 1200 h and 1500 h and the foraging rate was calculated for *Apis mellifera* on litchi bloom.

Table 1. Relative abundance of honey bees (No. of bees/minute/panicle) on litchi. Data is mean of four observations in three replications.

Date	Mean number of honey bees/minute/panicle				Av temperature (°C)	Av relative humidity (%)
	<i>Apis mellifera</i>	<i>Apis dorsata</i>	<i>Apis florea</i>	Mean		
15.03.2012	6.55	4.22	2.11	4.29	20.5	72.0
19.03.2012	10.33	7.89	3.22	7.14	22.6	69.0
23.03.2012	14.33	11.00	6.22	10.51	27.4	58.0
27.03.2012	12.11	9.77	4.33	8.73	24.4	67.0
31.03.2012	4.55	3.33	1.44	3.10	25.5	74.0
Mean	9.57	6.22	3.46	6.41	-	-
Factor	SEm (±)				CD (p=0.05)	
Date	0.72				2.10	
Species	0.95				2.76	
Date × Species	-				NS	

Table 2. Correlation coefficients among mean population of honey bees and weather parameters. Multiple regression equation : $Y_1 = 47.61 + 0.746^{**} (0.291) X_1 - 0.0692^{**} (-0.821) X_2$ ($R^2 = 0.79^{**}$) ; $Y_2 = 76.98 + 0.069^{**} (0.068) X_1 - 0.521^{*} (-0.628) X_2$ ($R^2 = 0.72^{*}$); $Y_3 = 65.81 + 1.29^{**} (0.708) X_1 - 0.464^{*} (-0.528) X_2$ ($R^2 = 0.71^{*}$). ** Significant at 1% probability level, * Significant at 5% probability level.

Species/Weather parameters	Temperature (X_1)	RH. (X_2)
<i>Apis mellifera</i> (Y_1)	0.79**	-0.81**
<i>Apis dorsata</i> (Y_2)	0.76**	-0.68*
<i>Apis florea</i> (Y_3)	0.72**	-0.62*

Foraging speed

It is the time spent in seconds by bees per flower. The foraging speed was recorded with the help of a stop watch. The stop watch was switched on and off as sitting and leaving the flower by the bee. It was recorded at 0900h, 1200h and 1500h. Three observations at each hour on five dates were recorded.

Results and Discussion

Relative abundance

Relative abundance of honey bees on litchi panicle during flowering were recorded on five different dates during the flowering period. The average temperature and relative humidity were also recorded. The data recorded are presented in Table 1 and Figure 1. Among the different species of honey bees, *A. mellifera* was observed as dominant visitor of litchi panicle followed by *A. dorsata* and *A. florea*. The number of honey bees per minute per panicle was found maximum on 23.03.2012 in all three species of honey bees with *A. mellifera* having 14.33 per minute per panicle and *A. florea* having 14.33 per minute per panicle having the minimum number. However, it was recorded minimum on 31.03.2012 in all the three species of honey bees with *A. mellifera* having 4.55 bees per minute per panicle to be the maximum and *A. florea* having 1.44 bees per minute per panicle to be the minimum. The abundance of honey bees was observed maximum during initiation of flowering and near maturity of crop. The abundance of honey bees was observed maximum during middle of flowering and minimum number of honey bees were observed during initiation of flowering and near maturity of crop.

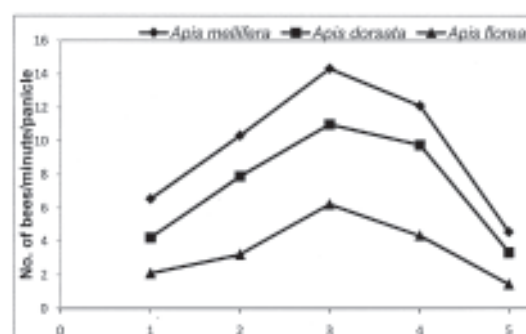


Fig. 1. Relative abundance of honey bees.

It might be due to the fact that during middle of the flowering, the flower density was high and so honey bees were getting maximum floral rewards in the middle of crop showing maximum abundance.

Earlier worker Singh et al. [2] also showed that the maximum number of bee foragers/minute/panicle was recorded at 10:30-11:30 h, followed by 11:30-12:30h, while the least number of bee foragers/minute/panicle was recorded at 15:30-16:30 h in litchi while. The peak foraging activity was recorded between 0900-1000h. Earlier it was found that the abundance and diversity of insect pollinators varied considerably between observational periods. Other studies also illustrated that the abundance of insect pollinators differed across the time of the day but increased around the midday Semida and Elbanna [3]; Andrej and Anton [4].

The correlation coefficient between abundance of bees and weather parameters were worked out and presented in Table 2. The correlation coefficient of abundance of honey bees in relation with temperature was found positive while there was a negative correlation with the relative humidity. The correlation coefficients of honey bees abundance with temperature was found positive and highly significant (0.76**) in case of *Apis mellifera* while in *Apis dorsata* it was (0.76**) and in case of *Apis florea* it was (0.72**) while it showed negative significant correlation with relative humidity being -0.81** in *Apis mellifera*, -0.68 in *Apis dorsata* and -0.62* in *Apis florea*. The R^2 value of 0.79** (*Apis mellifera*) 0.72* (*Apis dorsata*) and 0.71* (*Apis florea*). This indicates that tempera-

Table 3. Initiation and cessation time of honey bees visiting litchi panicle. Data are mean of three replications : I= Initiation time in forenoon (AM), C= Cessation time in afternoon (PM), P= Duration of foraging (hour).

Date of observation	<i>Apis mellifera</i>			<i>Apis dorsata</i>			<i>Apis florea</i>		
	I	C	P	I	C	P	I	C	P
15.03.2012	8.15	4.15	8.00	8.00	4.30	8.30	9.00	3.00	6.00
19.03.2012	8.00	4.30	8.30	7.45	5.00	9.15	8.30	3.30	7.00
23.03.2012	7.15	5.00	8.45	7.00	5.15	10.15	8.00	3.45	7.45
27.03.2012	6.30	5.30	11.00	6.00	6.00	12.00	8.00	4.00	8.00
31.03.2012	6.00	6.00	12.00	5.45	6.45	13.00	7.30	4.00	9.30
Mean			9.55			10.52			7.55

ture plays an important role in abundance of honey bees by enhancing their foraging activity, it might be due to fact that insects are poikilothermic animals.

The present finding is in conformity to the earlier reports. A positive correlation was found between honey bee population and temperature. Earlier it was also reported that bee activity was positively and significantly correlated with temperature but negatively and significantly correlated with relative humidity in all the honey bee species. Abrol and Kumar [5] observed that relative humidity did not significantly influence the field activity of honey bees.

Duration of foraging

The data recorded on initiation and cessation time of honey bees visiting litchi bloom have been presented in Table 3 indicated that all the three species started late visit during initiation of flowering in litchi and also ceased their activity earlier. The duration of foraging was minimum on 15.03.2012 being 8.00 h in *A. mellifera*, 8.30 h (*A. dorsata*) and 6.00 h (*A. florea*) while maximum duration of foraging was observed on 31.03.2012 being 13.00 h in *A. dorsata*, 12.00 h in *A. mellifera* and 9.30 h (*A. florea*). The duration of foraging of honey bees increased as the flowering progressed. Among the species, *A. dorsata* (10.50 h) foraged for maximum duration followed by *A. mellifera* (9.55 h) and minimum duration of foraging was observed in case of *A. florea* being 7.55 h.

The present finding is more or less in conformity to earlier workers findings. It was found that the foraging activity of honey bees range between 477-80 min to 522-50 minutes on different crops. It was also

found that the greater number of pollen collector of *A. dorsata* were recorded between 0900 h and 1100 h and maximum at 0900h (150.13). The maximum pollen loads carried by rock bee was 36.71 mg at 0900 h. The longer duration of foraging was observed in *Apis dorsata*.

Foraging rate of different honey bee species visiting *Litchi chinensis* bloom

The foraging rate (number of flowers visited per minute by a bee on a panicle) was recorded on litchi at 4-days interval at different hours of the day and data have been presented in Table 4. The data recorded on foraging rate (No.of flowers visited per minute) of honey bees at different hours on different date indicated the maximum foraging was exhibited by *A.florea* (14.17) followed by *A. mellifera* (11.61) and *A. dorsata* (10.41). The maximum foraging rate was observed on 31.03.12 at 1500 h in all three species being 15.00 in *A. mellifera*, 13.67 in *A. dorsata* and 16.67 in *A.florea*. The minimum foraging rate was observed on 23.03.12 at 0900 h in all the three species being 8.67 in *A. mellifera*, 7.33 in *A. dorsata* and 10.33 in *A. florea*. When honey bees were taken in account for foraging rate, on different dates, on different varieties, it indicated that the *A. florea* was swifter followed by *A. mellifera* and least by *A. dorsata*. This might be due to the fact that *A. dorsata* having heavier body size required more food that is why it spent more time on flower for collecting floral rewards resulted into lesser number of flower visit. In contrast, *A. florea* being the smallest bee required less food, spent less time and frequently visited more number of flowers. There were significant variations in foraging rate on different dates at different hours among

Table 4. Foraging rate of honey bees visiting litchi panicle.

Date of observation	Time of observation	Mean number of flowers visited/minute			Mean
		<i>A. mellifera</i>	<i>A. dorsata</i>	<i>A. florea</i>	
15.03.2012	0900h	11.33	10.33	13.67	11.77
	1200h	12.00	11.67	14.67	12.78
	1500h	13.33	12.67	16.00	14.00
	Mean	12.22	11.55	14.78	12.85
19.03.2012	0900h	10.67	9.00	12.33	10.66
	1200h	11.67	9.67	14.00	11.78
	1500h	12.33	11.67	15.67	13.22
	Mean	11.55	10.11	14.00	11.88
23.03.2012	0900h	8.67	7.33	10.33	8.77
	1200h	9.33	9.00	12.00	10.11
	1500h	10.67	9.67	14.33	11.55
	Mean	9.55	8.66	12.22	10.14
27.03.2012	0900h	9.67	8.00	11.67	9.78
	1200h	10.67	9.33	13.67	11.22
	1500h	11.00	10.33	15.33	12.22
	Mean	10.44	9.22	13.55	11.07
31.03.2012	0900h	13.67	11.67	14.33	13.22
	1200h	14.33	12.33	15.67	14.11
	1500h	15.00	13.67	16.67	15.11
	Mean	14.33	12.55	15.55	14.14
Grand mean		11.61	10.41	14.17	12.06
Factor		SEm ($\pm$)			CD ($p=0.05$)
Date		0.62			1.79
Species		0.81			2.34
Hour		0.47			1.36

the species, however, their interactions were found non-significant.

Earlier worker also reported similar findings, which showed that *A. c. indica* visited 17.5 and 25.0 flowers per minute in the morning and afternoon for nectar and *Apis mellifera* visited 25.8 and 33.6 flowers per minute during the same hour.

Earlier it was observed that highest foraging rate was recorded in case of *Apis florea* while lowest in case of *A. dorsata* on sunflower. Abrol [6] showed that the foraging rate of honey bees, *Apis mellifera*, *A. cerana*, *A. dorsata* and *A. florea* (24.7 ± 2.84 ; 23.06 ± 1.96 ; 18.60 ± 1.88 and 4.76 ± 0.80) flowers per minute, respectively on peach, pear and plum. Verma and Pratap [7] also showed that *Apis cerana* showed higher foraging rate in comparison to *Apis mellifera*.

Foraging speed of honey bees visiting litchi panicle

The foraging speed (time spent in second by a bee on a flower) was recorded on litchi panicle at different hours of day at 4-day interval. The data recorded were presented in Table 5. The observation recorded on the foraging speed (time spent is seconds/flower) on the honey bees at different hours on different dates on litchi panicle revealed that the maximum foraging speed was recorded in *A. dorsata* (10.28s) followed by *A. mellifera* (9.15s) and minimum in case of *A. florea* being 6.97 seconds. The maximum foraging speed was observed on 23.03. 2012 at 0900 h in all three species being 12.33s in *A. mellifera*, 13.67s in *A. dorsata* and 9.00s in *A. florea*. The minimum foraging rate was observed on 31.03.12 at 1500 h in all species being 5.67s in *A. mellifera*, 6.33s in *A. dorsata* and 4.67s in *A. florea*. The body weight of honey bee was an important factor for determining the foraging speed. The heavier body weight bee species spent

Table 5. Foraging speed of honey bees visiting litchi panicle.

Date of observation	Time of observation	Time spent on flowers/seconds			Mean time spent
		<i>A. mellifera</i>	<i>A. dorsata</i>	<i>A. florea</i>	
15.03.2012	0900h	10.33	11.00	7.67	9.66
	1200h	8.67	10.33	6.33	8.44
	1500h	7.33	9.00	5.67	7.33
	Mean	8.77	10.11	6.55	8.47
19.03.2012	0900h	11.33	12.00	8.67	10.66
	1200h	9.33	11.00	7.33	9.22
	1500h	8.67	10.33	6.67	8.55
	Mean	9.77	11.11	7.55	9.47
23.03.2012	0900h	12.33	13.67	9.00	11.66
	1200h	10.00	11.33	8.33	9.88
	1500h	9.33	10.67	7.33	9.11
	Mean	10.55	11.89	8.22	10.22
27.03.2012	0900h	11.33	11.67	8.33	10.44
	1200h	9.67	10.67	6.67	9.00
	1500h	8.33	9.33	6.33	7.99
	Mean	9.77	10.55	7.11	9.14
31.03.2012	0900h	8.67	9.33	6.33	8.11
	1200h	6.33	7.67	5.33	6.44
	1500h	5.67	6.33	4.67	5.55
	Mean	6.89	7.77	5.44	6.70
Grand mean		9.15	10.28	6.97	8.80
Factor		SEm ($\pm$)		CD ($p=0.05$)	
Date		.054		1.56	
Species		0.73		2.11	
Hour		0.37		1.18	
Date $\times$ Species		-		NS	
Date $\times$ Hour		-		NS	
Species $\times$ Hour		-		NS	
Date $\times$ Species $\times$ Hour		-		NS	

more time in calculating floral rewards to meet their nutritional requirement. Foraging speed of honey bees was related with their body weight and there was inverse relation was observed between foraging rate and foraging speed. Similar findings have been observed by earlier workers. Earlier it was observed that foraging speed was found to be 2.71, 3.41, 5.06 and 1.70 seconds for *A. c. indica*, *A. mellifera*, *A. dorsata* and *A. florea*, respectively in litchi. It was revealed that *A. mellifera* spent least time (5.2 sec/flower) to collect pollen while *Apis florea* spent maximum time (7.2 sec/flower). Bhatnagar and Karnatak [1] revealed that in litchi total spent per bee per forager was highest (5.83 sec) in the morning at 0900-1100 h. Nderitu et al. [8] showed that the time of the day did not significantly influence the time a bee spent on flower head. Compared with *Apis cerana*, the local

bees (*Apis mellifera*) spent more time on flower head. Verma and Pratap [7] showed that the *Apis cerana* visit to individual flower lasted from 4.3 to 6.7 seconds.

The present finding indicated that litchi in quality bee flora for honey bees. The honey bees preferred to collect nectar and pollen, from litchi and domesticated honey bee colonies can be sustained in litchi growing areas for honey production and pollination of crop.

References

1. Bhatnagar S, Karnatak AK (2010) Impact of day hours and distance of bee hives on the foraging behavior of *Apis mellifera* L. visiting litchi (*Litchi chinensis* Sonn.). Pantnagar J Res 8 : 166—169.

2. Singh B, Kumar M, Sharma AK, Yadav LP (2006) Relative abundance of insect visitors on litchi (*Litchi chinensis* Sonn.) bloom. Environ Ecol 24 : 275—277.
3. Semida F, Elbanna S (2006) Impact of introduced honey bees on native bees at St. Katherine Protectorate, South Sinai, Egypt. Int J Agric Biol 8 : 35—39.
4. Andrej S, Anton I (2006) Pollinators of *Helleborus niger* in Slovenian naturally occurring populations. Acta Agric Slovenica 87 : 205—211.
5. Abrol DP, Kumar A (2009) Foraging activity of *Apis* spp. on strawberry blossoms as influenced by pesticides. Pak Entomol 31 : 57—65.
6. Abrol DP (2010) Differential floral attractiveness as a determinant of foraging decision in honey bees. Curr Sci 99 : 1330.
7. Verma LR, Pratap U (2010) Foraging behavior of *Apis cerana* on cauliflower and cabbage and its impact on seed production. J Apicult Sci 33 : 231—236.
8. Nderitu J, Nyamasyo G, Kasina M, Oronje ML (2008) Diversity of sunflower pollination and their effect on seed yield in Makueni District, Eastern Kenya. Spanish J Agric Res 6 : 271—278.