

Foraging Behaviour of *Apis Spp.* on Apple Flowers in a Subtropical Environment

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Abstract: Observations on foraging behaviour, time spent per flower and number of flowers visited per minute by the two species of honey bee viz. *Apis cerana* and *A. mellifera* were made and a significant and nonlinear relationship was found. The number of flowers visited by each bee was also examined and it was found that *A. cerana* visited higher number of flowers than that of *A. mellifera*. Similarly the exotic *A. mellifera* carried heavier pollen loads than the native bee *A. cerana*. The foraging activity of *A. cerana* was observed at a peak between 1100 to 1300 hrs and then a steady decline was recorded which abruptly decreased between 1700 to 1800 hrs. However, in the case of *A. mellifera*, the increase was steady and reached its peak between 1300 to 1500 hrs. [New York Science Journal 2010;3(3):71-76]. (ISSN: 1554-0200).

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1. Introduction

Foraging behavior is one of the important characteristic of any insect. Bees can also be classified as generalists or specialists depending on their foraging habits. Bees that gather nectar and pollen from a wide variety of flowers are **generalists**. Bumble bees and honey bees are good examples of generalists. Bees that depend on a single plant or a small number of plants for pollen and nectar are categorized as **specialists**. The criterion used to select candidate pollinator species undoubtedly vary from crop to crop, but some general rules apply. In principle, promising pollinator species should show a preference for foraging on flowers of the target crop (Torchio, 1976; Maeta, 1978; Marquez *et al.*, 1994).

Pollination of apples is more complicated as compared to other fruits by the fact that five stigmas have to be pollinated separately (as the transmitting tissue of each style is separate; Pratt, 1988), otherwise misshapen fruits result (Free, 1993). It is estimated that bees accomplish more than 80 percent of the total pollination by the insects. Honeybees are the main pollinators responsible for over 98% of visits to flowers of apple. They are among the most important pollinating insects found within orchards and modern agricultural systems (Williams, 1994; Morse and Calderone, 2000; Sharma *et al.*, 2004). Foraging rate is one of the important factors to compare pollination efficiency of different bee species. More is the foraging frequency more is the pollination efficiency (Singh *et al.* 2006). Bees are the most important pollinators, so understanding the scale at which they

forage has important ecological implications and conservation applications (Greenleaf *et al.* 2007).

The honeybee, *A. mellifera* is flower constant, which means that on any foraging trip, it focuses on only one kind of flower. Pollen is transferred only between flowers of the same species and this is one of the features that make honey bees so popular for commercial pollination of crops. On the down side, some scientists have expressed concern that honey bees are too efficient in their collection of nectar and pollen, leaving none in a given local flower source for the foraging of other pollinators (Buchmann and Nabhan, 1996; Hubbell, 1997).

Consequent overcrowding stresses, however, strongly debilitate the bee populations concerned; nectar and pollen may not suffice to nourish all bees introduced, which thus compete for the resources available, or the bees may experience increased larval mortality (Robinson *et al.*, 1989; Kevan *et al.*, 1995; Strickler, 1996, 1997). In India foraging behavior of *Apis* spp. has been recorded by different workers on different crops in different localities (Gupta *et al.*, 1984; Verma and Dutta, 1986; Kapoor and Dhaliwal, 1989; Negi and Joshi, 2006). This study has been carried out in one of the most apple producing areas of Uttarakhand state of India.

2. Materials and Methods

The study was carried out during April-June, 2009, which is the peak season of flowering of apple, in one of the apple orchard (situated in Cheepa) in district Nainital of Kumaon Himalayas situated in

Uttarakhand state of India. Village Cheepa is situated at N 29°26'07.4" and E 079°36'22.8" and is at an altitude of 2150 m. It has apple and peach orchards. The study site is under the Ramgarh block of Mukteshwar area, which is well known for its fruit orchards and fruit production. This study was carried out by placing two colonies each of Indian hive bee *A. cerana* and European bee *A. mellifera*. All the bee colonies had almost equal number of frames in brood chamber with similar strength and almost equal amount of brood. The experiment was started when about 15-20% flowering had taken place, so that bees do not forage outside the orchard on the other floral resources. The observations were made for the different foraging parameter continuously for a period of 7 days.

Foraging Time

Foraging time of both the species was assessed in terms of timings of commencement and cessation of flight activity and was observed by noting the time when first bee started its flight in the morning and the last bee ceased its flight in the evening.

Foraging Speed and Rate

Time spent per flower and number of flowers visited per minutes were taken as the indicators of foraging speed and rate respectively (Free, 1993). Time spent by a worker bee of *A. cerana* and *A. mellifera* on apple flower and number of flowers visited per minute were recorded with the help of stop watch with an accuracy of ± 1 . These observations were taken during 6.00 – 7.00; 11.00-12.00 and 1700 – 1800 hrs every day and continued for a period of 7 days by calculating the mean of ten sub samples each.

Flight Activity Pattern

It was measured in terms of number of bees leaving the hive per minute. These observations were made at regular interval of one hour from 7.00 in the morning to 1800 hrs in the evening. The peak foraging hours were calculated for both the species under observations in terms of maximum number of foragers leaving the hive at a particular hour (Southwood, 1978).

Preference of Tree Heights by the Bees

The branches of apple tree bearing about more than 300 flowers each were marked at a height of 2, 4 and above 4 meters and these heights were designated as lower, middle and top heights respectively and the number of honey bees at each height was counted for a period of 10 minutes at 6.00

– 7.00; 11.00-12.00 and 1700 – 1800 hrs every day and continued for a period of 7 days.

Pollen Carrying Capacity

It was calculated in terms of pollen load carried by a worker bee of both the species during different hours of observations (900, 1200 hrs). To examine the pollen carrying capacity of the bee, individuals were collected whilst foraging, stored in pre weighted small viols coated with ethyl acetate and carried to lab, where they were first weighed along with the bottle (Total net weight) and then the pollen load was removed from the legs of bee. The pollen load detached was weighed in an electronic weighing machine to an accuracy of 0.001 mg. To confirm the results, the weight of the pollen load was also calculated by deducting the weight of the bee and bottle from the total net weight. A mean of ten individual samples each was calculated for the same. Data was recorded from 900 h to 1800 h at time of opening of flowers.

3. Results and Discussions

A. cerana proved to be the most frequent pollinator having average population of 1.24 individuals per plant per 30 sec and *A. mellifera* remained the second most frequent visitor 0.52 individuals per plant per 30 sec.

Results showed that *A. cerana* started its activity earlier (1030 h) and attained its peak at 1200 h. However, *A. mellifera* started at later (1130 h) and got its peak activity at 1400 h (Table 01), which was the end point of *A. cerana* peak activity. There was no fluctuation in temperature and relative humidity around the flowering period. Weather also remained clear in all the dates of data record.

Foraging Time (Time Spent on Apple Bloom)

It was observed that the foraging time of *A. cerana* was significantly higher than *A. mellifera*. *A. cerana* commenced its foraging activity earlier in the morning (mean time 6.09 hrs) than *A. mellifera* (mean time 6.17 hrs.). Similarly in the evening *A. cerana* ceased its flight activity (mean time 18.56 hrs) later than *A. mellifera* (mean time 18.38 hrs). The flight activity of *A. cerana* lasted for 12.47 ± 0.5 hrs while in *A. mellifera* it lasted for 12.11 ± 0.7 hrs.

Flight Activity Patterns

It was monitored for the foraging activity of both the bee species at regular intervals between 0700 hrs to 1800 hrs. As the flowers opened in the morning, peak visitation by bees took place in late morning hours (1030 h to 1230 h). Flight activity pattern of both the species has been presented in **Table 1 and Fig. 1**. A steady increase in the flight

activity of *A. cerana* was observed between 700 hrs to 1000 hrs. The peak in foraging activity was observed at between 1100 to 1300 hrs and then a steady decline was recorded which abruptly decreased between 1700 to 1800 hrs. Similarly, in case of *A. mellifera*, the increase was steady and reached its peak between 1300 to 1500 hrs. and then there was steady decrease. It was observed that *A. cerana* reached its peak activity much before the *A. mellifera*. Thus *A. cerana* showed higher activity than *A. mellifera*.

Apis mellifera exhibited more efficient foraging behavior, whereas *A. cerana* proved to be the most abundant pollinator. Most of the pollinator activity took place in late hours of the morning (1000 – 1230 h) and in afternoon (1530 h–1730 h) when the temperature of the site was quite high and the weather was warm and pleasant.

Foraging Speed and Rate

Our observations (**Table 2**) on time spent per flower and number of flowers visited per minute revealed that at 9.00 hrs *A. cerana* spent 5.11 ± 0.9 seconds per apple flower and visited 10.71 ± 0.7 flowers per minute. *A. mellifera* spent 7.43 ± 0.8 seconds per flower and visited 8.44 ± 0.2 flowers. *A. cerana* visited higher number of flowers than that of *A. mellifera*.

Pollen Carrying Capacity

It was calculated in terms of pollen load carried by a worker bee of both the species during different hours of observations (900, 1200 hrs). At 900hrs the mean weight of pollen pellet carried by *A. cerana* was 8.33 ± 0.41 mg, whereas it was 10.11 ± 0.29 mg for *A. mellifera*. Similarly at 12 00 hrs *A. cerana* carried pollen pellets of 9.16 ± 0.31 mg and *A. mellifera* carried pallet of 11.19 ± 0.11 mg. *A. mellifera* carried heavier pollen loads than *A. cerana*.

Height Preference by the Bees

Population count of bees on marked branches of apple trees at different heights showed that *A. cerana* was more abundant on middle (50.2%) (at a height of about 4 m) than lower (31.7%) and top (19.1%) heights of trees. Similarly, *A. mellifera* again preferred middle heights (51.6%) followed by top (25.8%) and lower (23.6%).

Effects of Weather on Flight Activities

The effect of various climatic conditions was also examined during the study period. Climatic conditions strongly affect the foraging activity of pollinating insects.

Temperature

Little or no flight activity occurs at or below 10°C (50 F). On clear and sunny days some flight was seen at temperatures of 12-15°C (53.6 - 59 F). Flight begins in earnest at 16°C (60.8 F) and the numbers of bees taking foraging trips increases as the temperature continues to rise. Above 20°C (68 F) it tends to reach a relatively constant high level. At low temperatures (below 20-22°C), wind, rain and low light intensity reduce the flight activity of bees. At low temperatures fewer bees are observed and most bees forage nearby to the hives (out to a distance of 50 meters). The wind speed should be less than 15 mph.

Rainfall

Flight activity ceases during rain. Both *A. cerana* and *A. mellifera* prefer to be in their hives during rain and in periods of inclement weather may fly between showers for short distances of up to 100 meters.

Humidity

Relative humidity has less effect on the flight activities of *Apis* species. However, combination of temperature and humidity is most important in the ripening of the anthers of the flowers and the availability of pollen to visiting insects. Therefore low temperatures and high humidity have the double effect of reducing bee activity and slowing the release of pollen.

Light

The flight activity of both the species is reduced during periods of heavy cloud cover. When the cloud cover is seven-tenths or more, bees begin to lose interest in foraging. These weather factors are important for most of the fruit trees. Cool, dull, showery conditions are unfavorable for the foraging trip.

Table 1. Foraging Activity of Bee Species *A. cerana* and *A. mellifera* During Different Hours of the Day.

Bee species	Time in hours											
	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800
<i>A. Cerana</i>	26.83 ±1.33	34.33 ± 2.56	44.19 ± 2.43	67.77 ± 1.98	88.61 ± 2.47	92.21 ±1.11	91.11 ±2.16	88.12 ± 2.01	61.44 ± 1.39	50.13 ± 2.31	33.31 ±1.01	16.64 ±1.11
<i>A. mellifera</i>	18.22 ±1.13	22.34 ± 1.36	38.11 ± 2.13	59.78 ± 1.66	73.00 ± 2.07	79.67 ±1.11	82.98 ±2.11	88.46 ± 2.11	86.33 ± 1.09	71.66 ± 1.42	36.73 ±1.51	11.12 ±1.22

Figure 1: Graphical Representation of Foraging Activity of Bee Species *A. cerana* And *A. mellifera* During Different Hours of the Day.

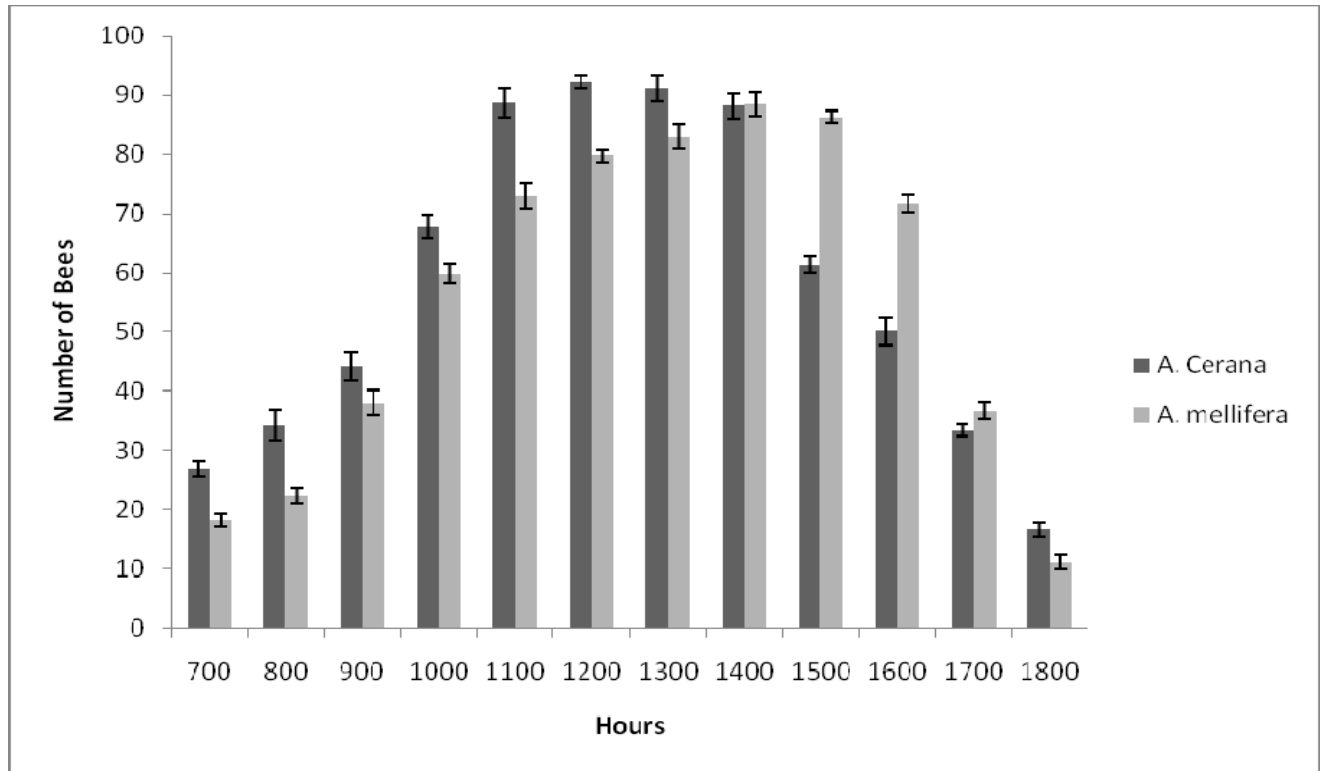


Table 2. Commencement, Cessation and Duration of Foraging Activity of *A. cerana* and *A. mellifera*.

Bee species	Commencement	Cessation	Duration (hrs)	Speed and rate
<i>A. cerana</i>	6.06-6.11	18.53-19.07	12.47	5.11 ±0.9 10.71± 0.7
<i>A. Mellifera</i>	6.12-6-20	18.24- 18.52	12.12	7.43±0.8 8.44 ± 0.2

The present study indicates that *A. cerana* is much more efficient pollinator for the sub tropical region than the *A. mellifera*. There have been earlier reports on the time spent by *A. mellifera* on apple flowers. Rymahesvskii (1956) has reported that this species spends more than 30 seconds on the flowers of apple; Verma and Dutta (1986) reported this time as 6.65. Singh (1979) reported maximum number of *A. cerana* (5.66) at 1400 hrs on strawberry flowers. The time spent by any bee on any flower depends on many factors including size of flower and nectar present in the flower. Verma and Dutta (1986) reported that *A. mellifera* visits 3.33 flowers of apple per minute. In the present study maximum foraging rate of *Apis* species was observed between 1200 – 1300 hrs, the same observations have also been reported by many workers (Dhaliwal and Bhalla, 1980; Raj and Rana, 1994; Anon, 1999; Singh *et al.*, 2006).

In the present study it was observed that *A. mellifera* carries 11.19 ± 0.11 mg of pollen load at 1200 hrs, which is the highest in both the species, whereas Verma and Dutta (1986) have reported this as 12.22 mg in apple, Rana (1989) has reported this as 15.50 mg in plum and Negi and Joshi (2006) has reported this weight as 11.20 mg in *Brassica juncea*. The behavior of an efficient apple pollinator should be such that the insect contacts the stigma of the flower in many of its visits and carries enough germinable pollen grains of compatible cultivars on its body.

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