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Foraging strategies of honeybees in pollinating apple flowers and its variation with altitude in Kullu hills of western Himalaya, India

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Abstract
Foraging strategies of honeybees in terms of foraging time, flight activity patterns, foraging speed and rate, duration of a foraging trip etc., were studied by placing two colonies each of Indian hive bee *Apis cerana* and Europian bee *Apis mellifera* in apple orchards located at Bhalogi (1400 m), Baskhola (1580 m) and Dhamadhar (1810 m) areas of Kullu hills of Western Himalaya. The results revealed that *A. cerana* foraged for significantly longer time and visited more flowers per minute than *A. mellifera*, however, *A. mellifera* took greater time for completing a single forging trip and spent significantly more time per flower than *A. cerana*. Peak foraging activity for *A. cerana* occurred at 1000 to 1300 hours and it was between 1200 to 1500 hours for *A. mellifera.* By placing both the species of honeybees in the same orchard, the duration of peak activity can be prolong and better pollination obtained. Interspecific comparison between *A. cerana* and *A. mellifera* showed no significant differences with regard to top as well as side workers. These two species of honeybees preferred middle than top and lower branches of apple trees. Present results suggest that altitudinal variation affect the timings of commencement and cessation of foraging activity, duration of foraging activity, number of flowers visited per minute and duration of foraging trip however, it did not affect the peak hours of foraging for *A. cerana* and *A. mellifera.*

Keywords: Foraging strategies, Honeybees, Apple crop, Altitudinal variation, Kullu hills.

1. Introduction
Pollinating insects especially honeybees help in the process of reproduction of many plants by mediating pollens from flower to flower. They can play an important role in modern agriculture and horticulture because of following reasons: the reduction of natural pollinator population by agrochemicals, the increase of greenhouse effect that natural pollinating insects cannot commute, unexpected abnormal weather conditions, and extensive public interest in sustainable agriculture. Moreover, artificial pollination results in deterioration of fruit quality in terms of a decrease in fruit size and uneven fruit shape [1, 2].

Honeybees have long been recognized as important pollinators of apple crop because of their potential for long working hours, presence of pollen baskets, floral fidelity, micromanipulation of flowers, maintainability of high population and adaptability to different climatic conditions. Further, honeybees can be domesticated, marketed and transported from place to place. Therefore, income from agriculture by the use of honeybees in crop pollination is many times higher than their value as honey and beeswax producers [3-5]. In the absence of honeybee pollination, the important factors that lack in the complex of agronomical practices in apple cultivation were the total cross-pollination and fertilization of flowers which can lead to the flower as well as fruit drop in Golden Delicious and Red Gold cultivars, but pollination by honeybees can enhance fruit setting and improve quality of fruit set in apple crop [2, 6-9]. The vital role which honeybees play in the pollination of large number of cultivated crops is often underestimated in developing countries.

Many investigators have studied the pollination ecology of horticultural crops in relation to *pis. mellifera* L. pollination in Europe, North America, South America and Australia [10-13]. However, a little is known about the role of Indian hive bee, *Apis cerana* F. in pollinating fruit crops especially temperate fruit crops [14-19]. Therefore, present investigation was conducted in order to know the foraging strategies of honeybees in pollinating apple flowers and its variation with altitude in Kullu hills of Western Himalaya.

2. Materials and methods

2.1 Comparative foraging behaviour of honeybees on apple bloom

Foraging studies were conducted on Indian hivebee *Apis cerana* F. and European bee *Apis mellifera* L., by placing two colonies of each species in experimental apple orchards located at Bhalogi (1400 m), Baskhola (1580 m) and Dhamadhar (1810 m) areas of Kullu hills during the months of March-April, 2015. All the bee colonies had almost equal number of frames in brood chamber, were of similar strength and had almost equal amounts of brood and pollen stores. Both the species showed no signs of disease and their hive entrances were also opened in the same direction. The colonies were brought to the orchards, when about 15 to 20 percent of flowering had already taken place, so that they did not forage outside the orchard on other floral resources. Bee colonies were kept in the orchards till the end of flowering.

Following parameters pertaining to foraging behaviour of *A. cerana* and *A. mellifera* were studied: Foraging time, flight activity patterns, foraging speed and rate, duration of foraging trip, top versus side workers and bees' preferences to different heights of apple tree.

2.2 Effect of altitudinal variation on foraging behaviour of honeybees

Effect of altitudinal variations on the foraging behaviour of *A. cerana* and *A. mellifera* was analyzed for different foraging traits. Various parameters studied were: commencement of foraging, cessation of foraging, duration of foraging activity, peak foraging hours, duration of a foraging trip, time spent per bee per flower, number of flowers visited per minute and number of honeybees visiting different heights of apple tree.

2.3 Statistical analysis of data

Data was analysed statistically by using Standard error about mean, Coefficient of variation and t-test so as to test the significance of results.

3. Results and discussion

Studies on foraging strategies of two honeybee species i.e. Indian hive bee, *Apis cerana* and European bee, *Apis mellifera* in pollinating apple flowers and its variation with altitude have been summarized as follows:

3.1 Foraging time

A. cerana (Mean time, 0614, 0620 and 0627 hours respectively) commenced its foraging activity significantly ($P<0.01$) earlier in the morning than *A. mellifera* (Mean time, 0625, 0635 and 0645 hours respectively) in all the three apple orchards studies i.e. Bhalogi, Baskhola and Dhamadhar respectively. However, the evening, *A. cerana* (mean time 1922, 1858 and 1839 hours respectively) ceased its flight activity significantly ($P<0.01$) earlier than *A. mellifera* (mean time, 1930, 1860 and 1852 hours respectively) in all the above orchards. Thus flight activity lasted for 13.08±0.49, 12.38±0.32 and 12.12±0.61 hours in *A. cerana* and 13.05±0.78, 12.25±0.21 and 12.07±0.18 hours in *A. mellifera* at Bhalogi, Baskhola and Dhamadhar orchards respectively (Table 1). Above results thus suggest that *A. cerana* foraged for significantly longer time on apple bloom than *A. mellifera*. Similar results were also reported by [20] and [21] for apple, plum, almond and peach crops in Himachal Pradesh.

3.2 Flight activity patterns

Indian hive bee and European bee were monitored for their foraging activity at regular hourly intervals in three different experimental apple orchards. At Bhalogi, flight activity of *A. cerana* showed an increase from 0700 (5.12%) hours in morning to 0900 (9.65%) hours and then it peaked from 1000 (15.12%) to 1200 (18.41%) hours. From 1600 (7.64%) to 1800 (3.14%) hours, it showed a decrease in foraging activity. Peak of foraging activity was achieved between 1000 (15.12%) to 1200 (18.41%) hours. On the other hand Exotic bee, *A. mellifera*, showed an increase in its foraging activity from 0700 (5.22%) to 1100 (12.60%) hours and then it peaked from 1200 (15.55%) to 1400 (17.80%) hours and then decreased abruptly from 1700 (5.80%) to 1800 (3.12%) hours (Tables 1, 2).

In another apple orchard located at Baskhola, flight activity of *A. cerana* showed a continuous increase from 0700 (4.18%) to 0900 (9.21%) hours and then it peaked between 1100 (15.32%) to 1300 (17.55%) hours. Afterwards, it showed a regular decrease from 1500 (7.49%) to 1800 (4.69%) hours. However, in case of *A. mellifera*, flight activity increased continuously from 0700 (3.07%) upto 1100 (10.59%) hours and peaked from 1300 (13.91%) to 1500 (14.48%) hours. From 1700 (4.13%) hours onwards, a regular decline was observed up to 1800 (4.02%) hours (Tables 1, 3). At Dhamadhar orchard, flight activity of *A. cerana* showed an increase from 0700 (3.10%) to 1000 (10.92%) hours and then peak was achieved between 1200 (18.38%) to 1300 (20.70%) hours. From 1600 (9.29%) hours onwards, it decreased upto 1800 (4.16%) hours. However, in case of *A. mellifera*, foragers showed a regular increase from 0700 (3.02%) to 1000 (7.39%) hours and peaked from 1300 (14.14%) to 1500 (13.37%) hours. Then it showed continuous decrease from 1700 (7.65%) to 1800 (3.23%) hours (Tables 1, 4). Thus present results showed that peak hours of foraging activity for *A. cerana* were between 1000 to 1300 hours, whereas, *A. mellifera* showed maximum foraging activity between 1200 to 1500 hours. Present results further suggest that *A. cerana* reached its peak activity before *A. mellifera* in all the three experimental apple orchards. Similar results were also reported by [22] for apple crop in Himachal Himalaya. However, **[21]** found that *A. mellifera* reached its peak activity before *A. cerana* on almond crop, whereas, peak foraging activity of *A. cerana* and *A. mellifera* was almost at same time on peach crop.

3.3 Duration of a foraging trip

Foraging data on apple bloom showed that *A. cerana* spent on an average 10.16±0.51, 12.05±0.65 and 13.45±0.72 minutes for a single foraging trip, whereas, this duration was 11.60±0.40, 14.25±0.39 and 15.50±0.78 minutes for *A. mellifera* at Bhalogi, Baskhola and Dhamadhar orchards respectively. These results showed significant ($P<0.05$) differences between *A. cerana* and *A. mellifera* regarding this parameter in all the three experimental apple orchards. Thus *A. mellifera* took significantly ($P<0.05$) greater time for completing a single forging trip as compared to *A. cerana* (Table 1).

3.4 Foraging speed and rate

In the apple orchard at Bhalogi, foraging data on time spent per flower and number of flowers visited per minute revealed that, *A. cerana* spent 6.25±0.41 seconds per apple flower and visited 9.66±0.9 flowers per minute. Whereas, *A. mellifera* spent 8.10±0.23 second per flower and visited 6.80±0.15 flowers per minute. Thus, *A. cerana* visited significantly (P<0.01) more number of flowers and spent significantly (P<0.05) less time per flower than *A. mellifera* (Table 1).

In Baskhola, *A. cerana* spent 6.71±0.34 seconds per flower and visited 8.65±0.11 flowers per minute, whereas, *A. mellifera* spent 9.27±0.10 seconds per flower and visited 6.26±0.13 flowers per minute. Thus, *A. cerana* visited significantly (P<0.05) more flowers and spent significantly (P<.0.01) less time per flower than *A. mellifera* (Table 1).

In apple orchard at Dhamadhar, *A. cerana* spent 7.55±0.08 seconds per flower and visited 8.08±0.20 flowers per minute, whereas, *A. mellifera* spent 10.33±0.41 seconds per minute and visited 5.62±0.13 flowers per minute. Thus, *A. cerana* spent significantly (P<0.01) less time per apple flower and visited significantly (P<0.01) more number of flowers per minute (Table 1). Present results suggest that *A. cerana* visited significantly (P<0.01) more flowers per minute and spent significantly (P<0.01) less time per flower than *A. mellifera* in all the three experimental orchards. These results are in conformity with the findings of [23] who also observed similar trend on apple flowers in Kullu valley of Himachal Pradesh.

3.5 Top versus side workers

There were fluctuations in the percentage of top and side worker bees of *A. cerana* and *A. mellifera* on apple bloom. Top workers of both *A. cerana* (39.66, 40.00 and 43.00%) and *A. mellifera* (41.33, 43.00 and 47.33%) differ from side workers of these species for *A. cerana* (59.33, 52.66 and 59.66%) and for *A. mellifera* (55.33, 51.00 and 55.33%) respectively at three different orchards (Table 1). Interspecific comparison between *A. cerana* and *A. mellifera* with regards to top as well as side workers showed no significant (P>0.05) differences. These results support the earlier observations of [24] on apple flowers in Jammu and Kashmir.

3.6 Bees' preferences to different heights

Bees' preference to different heights of apple was investigated in terms of their population count at top (above 4 meters), middle (between 2 to 4 meters) and lower (below 2 meters) heights of trees. In Bhalogi orchard, population counts made on marked branches of apple trees showed that *A. cerana* was more abundant on middle (48.20%) than top (28.04%) and lower (30.64%) heights of trees. Similarly, *A. mellifera* population was significantly more at middle (44.51%) than lower (28.82%) and top (23.51%) branches of apple trees (Table 5).

In Baskhola orchard, the percentage of *A. cerana* on middle branches of apple tree was 46.58%, whereas, for *A. mellifera* it was 45.18%. Number of bees on top branches was 20.16% for *A. cerana* and 17.63% for *A. mellifera*. On the lower branches, the percentage was 22.32 and 20.48 for *A. cerana* and *A. mellifera* respectively. In Dhamadhar orchard, percentage population count for *A. cerana* was 50.14% on the middle, 16.42% on the top and 17.72% on the lower branches, whereas, *A. mellifera* showed percentage population count of 47.61% on the middle, 16.83% on the lower and 14.31% on the top branches of apple trees (Table 5).

Thus *A. cerana* and *A. mellifera* did not differ with regards to their preference to different heights of apple trees and both the species preferred middle than lower and top branches. Recently, [22] found middle heights to be more attractive for honeybees than lower and upper heights of apple, plum and kiwi crops respectively. However, [21] found top branches of peach and middle and top heights of almond to be more attractive for *A. cerana* and *A. mellifera*.

4. Effect of altitudinal variations on the foraging behaviour of honeybees

Effect of altitudinal variations on different foraging traits like commencement of foraging, cessation of foraging, duration of foraging activity, peak foraging hours, duration of foraging trip, time spent per bee per flower, number of flowers visited per minute and number of honeybees at different heights of tree revealed the following results:

Statistical analysis of foraging data on *Apis cerana* and *Apis mellifera* at three different altitudes i.e. Bhalogi (1400 m), Baskhola (1580 m) and Dhamadhar (1810 m) revealed that altitudinal variations affect the timing of commencement and cessation of foraging activity of both *A. cerana* and *A.mellifera*. For example, *A. cerana* commenced its activity at 0614 hours at Bhalogi, whereas, at Dhamadhar the timing of commencement was delayed (0627 hours). Similarly, in *A. mellifera*, foraging commenced at 0625 hours, at Bhalogi but it started later at Dhamadhar (0645 hours) orchards. Timing of cessation of foraging activity was delayed at lower than higher elevations in case of both *A. cerana* and *A. mellifera*. For example, foraging activity of *A. cerana* ceased at 1922 hours in Bhalogi and 1839 hours in Dhamadhar. Similarily, in case of *A. mellifera*, foraging activity ceased earlier at Dhamadhar (1852 hours) than Bhalogi (1930 hours). Present studies therefore suggest that altitudinal variations also affect the duration of foraging activity of honeybees (Table 1).

Altitudinal variations did not considerably affect the peak hours of foraging activity i.e. peak hours of foraging activity of *A. cerana* were at 1000 to 1200 hours, 1100 to 1300 hours and 1200 to 1300 hours at Bhalogi, Baskhola and Dhamadhar orchards respectively. Similarly, in *A. mellifera*, foraging activity was between 1200 to 1400 hours at Bhalogi, and 1300 to 1500 hours at Baskhola and 1300 to 1500 hours at Dhamadhar. Thus, peak hours of activity of *A. cerana* and *A. mellifera* were almost in same range in all the three altitudes (Table 1).

Foraging data on duration of a foraging trip of *A. cerana* and *A. mellifera* showed that this parameter was affected by altitudinal variations because at Bhalogi (10.16 minutes), duration of foraging trip of *A. cerana* was significantly (P< 0.01) less than that of the highest elevation i.e. Dhamadhar (13.45 minutes). Similarly, *A. mellifera* took significantly (P<0.01) more time to complete a foraging trip at Dhamadhar (15.50 minutes) than Bhalogi (11.60 minutes) (Table 1).

Data on foraging rate and speed showed that *A. cerana* visited significantly (P<0.05, 0.01) more number of flowers per minute at Bhalogi (9.66) than Dhamadhar (8.08). Similarly, number of flowers visited by *A. mellifera* were significantly

more (P<0.01) at Bhalogi (6.80) than Dhamadhar (5.62). Moreover, significant differences were observed with regards to time spent per flower by *A. cerana* and *A. mellifera* at different altitudes. Thus, altitudinal variations affect foraging speed and foraging rate of *A. cerana* and *A. mellifera* (Table 1).

Present results suggest that altitudinal variation affect the timings of commencement and cessation of foraging activity, duration of foraging activity, duration of a foraging trip, number of flowers visited per minute and time spent per flower. However, it did not affect the peak hours of foraging by *A. cerana* and *A. mellifera* (Table 1). Earlier, [20] reported that the duration of a foraging trip in both the species of honeybees increased with the increase in altitude of the place and this duration was significantly longer at 24.00 and 18.75 m than at 13.50 m in Jubbal area of Shimla hills. At higher altitudes, both the species may make less trips per day than at lower altitudes.

These differences in the foraging behaviour of *A. cerana* and *A. mellifera* at different altitudes may be attributed to the variations in light intensity, sun rise and sun set, temperature, wind and humidity. [25, 26] also reported that the environmental temperature and sun light have positive relation on bee activity. The optimum temperature for foraging flight of honeybees has been reported to be 32 to 35ºC [27, 28] found a highly significant correlation between temperature and flight activity. According to him, there is a significant positive correlation of foraging activity with relative humidity and wind speed.

Similarly, [29] observed little effect on flight activity of *A. mellifera* on apple bloom upto 3 mph wind speed with a decrease in activity thereafter at 6 mph and above [30] also observed differences in the meantime of initiation (0500 to 1030 hours) and cessation (1330 hours to the end of the day) of pollen gathering activity of *A. cerana* during different seasons in Delhi.

Table 1: Comparative foraging strategies of *A. cerana* and *A. mellifera* in pollinating apple flower at three different altitudes

	PARAMETERS	BHALOGI (1400m)		BASKHOLA (1580m)		DHAMADHAR (1810m)	
		A. cerana	***A. mellifera***	***A. cerana***	***A. mellifera***	***A. cerana***	***A. mellifera***
		X±S.E.	**X±S.E.**	**X±S.E.**	**X±S.E.**	**X±S.E.**	**X±S.E.**
A)	Commencement of foraging (Time of day)	0614±0.82	0625±1.01	0620±0.71	0635±0.12	0627±0.79	0645±1.11
B)	Cessation of foraging (Time of day)	1922±1.20	1930±0.65	1858±0.34	1860±0.26	1839±0.81	1852±0.64
C)	Duration of foraging activity (hours)	13.08±0.49	13.05±0.78	12.38±0.32	12.25±0.21	12.12±0.61	12.07±0.18
D)	Peak foraging hours (time of day)	1000-1200	1200-1400	1100-1300	1300-1500	1200-1300	1300-1500
E)	Duration of a foraging trip (Minute)	10.16±0.51	11.60±0.40	12.05±0.65	14.25±0.39	13.45±0.72	15.50±0.78
F)	Time spent/bee/flower (Sec)	6.25±0.41	8.10±0.23	6.71±0.34	9.27±0.10	7.55±0.08	10.33±0.41
G)	No. of flowers visited/bee/minute	9.66±0.9	6.80±0.15	8.65±0.11	6.26±0.13	8.08±0.20	5.62±0.13
H)	No. of honey bees at different heights						
	(a) Above 4 meters (Top)	8.52±0.09	8.04±0.17	7.05±0.03	6.84±0.10	5.26±0.19	4.82±0.13
	(b) Between 2-4 meters (Middle)	18.20±0.04	16.82±0.1	15.64±.17	14.14±0.12	11.61±0.17	10.31±0.20
	(c) Below 2 meters (Lower)	10.72±0.20	9.50±0.08	8.44±0.19	7.16±0.11	6.56±0.07	5.75±0.18
(I)	Percentage of top workers (TW)	39.66	41.33	40.00	43.00	43.00	47.33
(J)	Percentage of side workers (SW)	59.33	55.33	52.66	51.00	59.66	55.33

A: For timings of commencement: Bhalogi> Baskhola> Dhamadhar for *A. cerana* and *A. mellifera*
B: For cessations: Dhamadhar > Baskhola > Bhalogi for *A. cerana* and *A. mellifera*
C: Duration of foraging activity: Bhalogi> Baskhola > Dhamadhar for *A. cerana* and *A. mellifera* (P < 0.01)
D: Peak foraging hours: Bhalogi> Baskhola > Dhamadhar
E: Duration of foraging trip: Dhamadhar > Baskhola > Bhalogi for *A. cerana* and *A. mellifera* (P < 0.05)
F: Time spent/flower: Dhamadhar > Baskhola> Bhalogi for *A. cerana* and *A. mellifera* (P < 0.01)
G: No. of flowers visited/minute: Bhalogi> Baskhola> Dhamadhar for *A. cerana* and *A. mellifera* (P < 0.05)
H: For *A. cerana* and *A. mellifera*, b > c > a (P < 0.05, 0.01)
I, J: Top workers and side workers: SW > TW for both *A. cerana and A. mellifera*

Table 2: Foraging activity of *A. cerana* and *A. mellifera* on apple bloom at different hours of the day at Bhalogi orchard.

		Time in Hours											
		0700	**0800**	**0900**	**1000**	**1100**	**1200**	**1300**	**1400**	**1500**	**1600**	**1700**	**1800**
A. cerana	X	29.30	18.50	79.00	101.00	117.48	124.40	92.22	81.20	72.30	62.68	47.41	34.23
	± S.E.	1.09	2.20	1.81	2.14	3.20	1.63	2.51	1.88	1.42	1.12	1.23	1.80
	%age	(5.12)*	(6.84)	(9.65)	(15.12)	(20.62)	(18.41)	(17.12)	(13.34)	(10.02)	(7.64)	(5.43)	(3.14)
A. mellifera	X	35.22	39.42	44.20	70.63	89.40	120.20	142.80	129.80	109.41	72.22	55.62	33.83
	± S.E.	1.25	1.18	1.09	2.25	1.81	1.42	3.21	1.15	1.62	1.15	1.88	1.35
	%age	(5.22)*	(6.81)	(8.14)	(10.32)	(12.60)	(15.55)	(16.24)	(17.80)	(12.02)	(8.56)	(5.80)	(3.12)

Peak activity : 1000-1200 hours in *Apis cerana*
1200-1400 hours in *Apis mellifera*
X = Mean
S. E. = Standard error about the mean
* = Figure in parenthesis indicates percentag

Table 3: Foraging activity of *A. cerana* and *A. mellifera* on apple bloom at different hours of the day at Baskhola orchard.

		Time in Hours											
		0700	**0800**	**0900**	**1000**	**1100**	**1200**	**1300**	**1400**	**1500**	**1600**	**1700**	**1800**
A. cerana	X	27.2	36.55	49.00	86.33	140.33	138.24	127.44	95.67	75.00	64.00	54.02	40.66
	± S.E.	1.69	3.43	2.71	3.32	4.11	1.88	5.64	3.71	6.51	3.24	2.09	2.26
	%age	(4.18)*	(6.09)	(9.21)	(1.81)	(15.32)	(18.64)	(17.55)	(10.54)	(7.49)	(6.33)	(5.72)	(4.69)
A. mellifera	X	22.13	31.25	40.45	54.66	79.00	83.02	107.64	114.05	113.34	89.56	69.00	41.63
	± S.E.	3.81	1.63	2.42	4.51	2.21	6.61	5.78	4.49	1.53	1.17	2.28	3.34
	%age	(3.07)*	(5.51)	(7.62)	(8.79)	(10.59)	(11.42)	(13.91)	(15.78)	(14.48)	(12.21)	(4.31)	(4.02)

Peak activity: 1100-1300 hours in *Apis cerana*
1300-1500 hours in *Apis mellifera*

Table 4: Foraging activity of *A. cerana* and *A. mellifera* on apple bloom at different hours of the day at Dhamadhar orchard.

		Time in Hours											
		0700	**0800**	**0900**	**1000**	**1100**	**1200**	**1300**	**1400**	**1500**	**1600**	**1700**	**1800**
A. cerana	X	29.23	41.29	52.67	83.32	97.56	181.42	196.12	97.00	80.20	70.00	43.74	28.06
	± S.E.	5.02	2.81	4.62	3.13	1.25	6.49	3.37	5.78	2.18	4.49	1.82	5.19
	%age	(3.10)*	(6.28)	(8.62)	(10.92)	(16.49)	(18.38)	(20.70)	(15.80)	(12.18)	(9.29)	(6.57)	(4.16)
A. mellifera	X	21.15	39.02	43.00	55.02	66.21	78.52	101.78	118.12	103.35	64.25	38.42	30.52
	± S.E.	1.89	6.54	3.57	5.92	2.80	2.71	6.59	2.67	3.27	7.19	1.93	3.25
	%age	(3.02)*	(4.13)	(5.26)	(7.39)	(11.86)	(12.20)	(14.14)	(15.09)	(13.37)	(11.87)	(7.65)	(3.23)

Peak activity: 1200-1300 hours in *Apis cerana*
1300-1500 hours in *Apis mellifera*

Table 5: Number of worker bees of *A. cerana* and *A. mellifera* (500 flowers/10minutes) visiting different heights of apple tree

			A. cerana	***A. mellifera***
			X ± S.E.	**X ± S.E.**
BHALOGI	A	Above 4.0 metres (Top)	8.54±0.21 (28.04)*	8.04±0.11 (23.51)
	B	Between 2.0 and 4.0 metres (Middle)	18.21±0.42 (48.20)	16.82±0.56 (44.51)
	C	2.0 metres (Lower)	10.72±0.09 (30.64)	9.50±0.70 (28.82)
BASKHOLA	A	Above 4.0 metres (Top)	7.02±0.81 (20.16)	6.84±0.63 (17.63)
	B	Between 2.0 and 4.0 metres (Middle)	15.64±0.30 (46.58)	14.44±0.08 (45.18)
	C	2.0 metres (Lower)	8.44±0.04 (22.32)	7.16±0.73 (20.48)
DHAMADHAR	A	Above 4.0 metres (Top)	5.56±0.41 (16.42)	4.82±0.16 (14.31)
	B	Between 2.0 and 4.0 metres (Middle)	11.61±0.07 (50.14)	10.31±0.02 (47.61)
	C	2.0 metres (Lower)	6.56±0.18 (17.72)	5.75±0.23 (16.83)

*Figure in parenthesis indicate percent population, At Bhalogi, Baskhola and Dhamadhar B > C > A for *A. cerana* and *A. mellifera*, On Top and Lower *A. cerana* > *A. mellifera* ($P < 0.05$).

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