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# FORAGING BEHAVIOR OF HONEYBEES ON APPLE CROP AND ITS VARIATION WITH ALTITUDE IN SHIMLA HILLS OF WESTERN HIMALAYA, INDIA

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**ABSTRACT**
Foraging studies in terms of foraging time, flight activity patterns, foraging speed and rate, duration of a foraging trip, pollen carrying capacity etc., were conducted on Indian hive bee *A. cerana* and European bee *A. mellifera*, by placing two colonies of each species in apple orchards located at Shilaroo (2409 m), Matiana (2514 m) and Narkanda (2648 m) of Shimla hills of Western Himalaya. The results pointed that *A. cerana* foraged for significantly longer time, reached its peak activity, visited more flowers per minute and took greater time for completing a single forging trip on apple bloom than *A. mellifera*. However, *A. mellifera* carried significantly heavier pollen loads, greater number of pollen grains and carried significantly more unifloral pollen loads as compared to *A. cerana* in all the three experimental orchards. Moreover, interspecific comparison between *A. cerana* and *A. mellifera* with regards to top as well as side workers showed no significant differences. In addition, both *A. cerana* and *A. mellifera*, showed pronounced floral constancy. These two species of honeybees preferred middle branches than top and lower branches of apple trees. Present results suggested that altitudinal variation affect the timings of commencement and cessation of foraging activity, duration of foraging activity, duration of foraging trip and number of flowers visited per minute. However, it did not affect the peak hours of foraging, time spent per flower and weight of pollen loads carried by *A. cerana* and *A. mellifera.*

**KEY WORDS:** Foraging Behavior, Honeybees, Apple Crop, Altitudinal Variation, Shimla Hills.

## INTRODUCTION

Many insect species help in the process of reproduction of plants through mediating pollens from flower to flower. Pollinating insects play important roles in modern agriculture for the 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. In particular, artificial pollination results in deterioration of fruit quality, such as a decrease of the fruit size and uneven fruit shape (Yun, 2005).

Honeybees derive their food in the form of pollen and nectar, which are the raw materials of beekeeping industry. Therefore, a honey bee colony has different sets of worker bees that are responsible for collecting pollen, nectar and sometimes both of these (Singh, 1962; Free, 1993). Pollen is practically the sole source of proteins, lipids, minerals and vitamins, whereas, nectar is reward offered to bees in return for their indispensable services in crop pollination. Nectar is composed almost entirely of sugars and water, but proportion of these ingredients varies widely. This collection of pollen and nectar from flowering plants by bees is known as 'foraging behaviour' (Michener, 1974; Gary, 1992). Bees and beekeeping provide free ecosystem services in the form of crop pollination, thereby helping in conservation of forest and grassland ecosystems, therefore, it is becoming an important component of present day strategies for sustainable development and organic farming programmes (Mattu, 2009).

## MATERIALS AND METHODS

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## RESULTS AND DISCUSSION

Studies on foraging behaviour of honeybees i.e. *Apis cerana* and *A. mellifera* in terms of foraging time, flight activity patterns, foraging speed and rate, duration of a foraging trip, pollen carrying capacity etc., have been summarized as follows:

**i) Foraging Time**

Indian hive bee, *A. cerana* (mean time, 0609, 0616 and 0626 hours respectively) commenced its foraging activity significantly (P<0.01) earlier in the morning than European bee, *A. mellifera* (mean time, 0616, 0621 and 0640 hours respectively) in all the three apple orchards i.e. Shilaroo, Matiana and Narkanda respectively. In the evening, *A. cerana* (mean time 1915, 1852 and 1845 hours respectively) ceased its flight activity significantly (P<0.01) later than *A. mellifera* (mean time, 1896, 1838 and 1815 hours respectively) in all the above orchards. Thus flight activity lasted for 13.00±0.70, 12.36±0.01 and 12.21±0.02 hours in *A. cerana* and 12.45±0.01, 12.16±0.01 and 11.30±0.01 hours in *A. mellifera* at Shilaroo, Matiana and Narkanda orchard respectively (Table 1). Above results thus suggest that *A. cerana* foraged for significantly longer time on apple bloom than *A. mellifera*.

**ii) Flight Activity Patterns**

Indian and European hive bees were monitored for their foraging activity at regular hourly intervals in different apple orchards. At Shilaroo, flight activity of *A. cerana* showed an increase from 0700 (4.23%) hours in morning to 1000 (10.15%) hours and then it peaked from 1100 (13.54%) to 1300 (13.36%) hours. From 1400 (10.73%) hours to 1700 (2.73%) it showed decrease in foraging activity. Peak of foraging activity was achieved between 1100 (13.54%) to 1300 (13.36) hours. Exotic bee, *A. mellifera* on the other hand, showed an increase in its foraging activity from 0700 (2.58%) to 1200 (11.91%) hours and then it peaked from 1300 (13.86) to 1500 (14.28%) hours and then decreased abruptly from 1600 (11.33%) to 1800 (1.07%) hours (Table 1).

In the apple orchard at Matiana, flight activity of *A. cerana* showed a continuous increase from 0700 (2.5%) to 0900 (10.58%) hours and then it peaked between 1000 (16.62%) to 1100 (16.82%) hours. Afterwards, it showed a regular decrease from 1200 (12.57%) to 1800 (1.93%) hours. In case of *A. mellifera*, flight activity increased continuously from 0700 (3.06%) hours upto 1100 (10.33%) hours, remained almost constant from 1200 (14.43%) to 1400 (14.46%) hours. From 1500 (10.63%) onwards, a regular decline was observed upto 1800 (2.29%) hours (Table 1). At Narkanda, flight activity of *A. cerana* showed an increase from 0700 (11.05%) to 1000 (14.40%) hours and then peak was achieved between 1100 (17.64%) to 1200 (18.10%) hours. From 1300 (14.47%) hours onwards, it decreased upto 1800 (6.52%) hours. In case of *A. mellifera*, foragers showed a regular increase from 0700 (4.83%) to 1100 (10.56%) hours and peaked from 1200 (13.08%) to 1300 (13.29%) hours. Then it showed continuous decrease from 1400 (12.63%) to 1800 (3.46%) hours (Table 1). Thus present results indicate 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 1600 hours. In addition, present results suggest that *A. cerana* reached its peak activity before *A. mellifera* in all the three apple orchards.

**iii) Foraging Speed and Rate**

In the apple orchard at Shilaroo, foraging data on time spent per flower and number of flowers visited per minute revealed that at 0900 hours, *A. cerana* spent 5.28±0.12 seconds per apple flower and visited 10.60±0.15 flowers per minute. Whereas, *A. mellifera* spent 7.62±0.87 second per flower and visited 9.25±0.13 flowers per minute. Similarly at 1200 hours, time spent per flower and number of flowers visited per minute was 6.87±0.10 seconds and 9.06±0.24 flowers for *Apis cerana* and 9.97±0.14 seconds and 9.30±0.14 flowers for *Apis mellifera* respectively. At 1500 hours, *A. cerana* spent 5.73±0.13 seconds per apple flower and visited 10.53±0.30 flowers per minute. Whereas, *A. mellifera* spent 7.09±0.17 seconds and visited 9.47±0.11 flowers per minute. Thus during all the three hours, *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 Matiana, at 0900 hours, *A. cerana* spent 6.00±0.16 seconds per flower and visited 10.36±0.12 flowers per minute, whereas, *A. mellifera* spent 7.94±0.21 seconds per flower and visited 8.60±0.17 flowers per minute. At 1200 hours, time spent per flower by *A. cerana* and *A. mellifera* was 8.07±0.14 and 7.86±0.17 seconds and they visited 9.73±0.13 and 8.15±0.10 flowers per minute respectively. At 1500 hours, *A. cerana* spent on an average 6.23±0.24 seconds per flower and visited 9.67±0.14 flowers per minute, whereas, *A. mellifera* spent 7.97±0.25 seconds and visited 7.82±0.13 flowers per minute. Thus during all the three hours of the day, *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 Narkanda, at 0900 hours, *A. cerana* spent 6.22±0.21 seconds per flower and visited 8.85±0.14 flowers per minute, whereas, *A. mellifera* spent 6.37±0.17 seconds per minute and visited 7.86±0.09 flowers per minute. Similarly, at 1200 hours, the time spent and number of flowers visited for *A. cerana* was 6.32±0.14 sec and 8.52±0.14 flowers and for *A. mellifera* it was 6.91±0.17 seconds and 6.71±0.16 flowers per minute respectively. At 1500 hours, *A. cerana* spent on an average 6.60±0.22 seconds per flower and visited 9.00±0.13 flowers per minute, whereas, *A. mellifera* spent 7.29±0.14 sec. and visited 6.20±0.15 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*.

**TABLE 1:** Comparative foraging behaviour of *A. cerana* and *A. mellifera* on apple flower at three different altitudes

| | PARAMETERS | SHILAROO (2409 m) | | MATIANA (2514 m) | | NARKANDA (2648 m) | |
|---|---|---|---|---|---|---|---|
| | | *A. cerana* X ± S.E. | *A. mellifera* X ± S.E. | *A. cerana* X ± S.E. | *A. mellifera* X ± S.E. | *A. cerana* X ± S.E. | *A. mellifera* X ± S.E. |
| A) | Commencement of foraging (Time of day) | 0609 ± 1.33 | 0616 ± 1.10 | 0616 ± 1.04 | 0621 ± 0.84 | 0626 ± 0.95 | 0640 ± 1.08 |
| B) | Cessation of foraging (Time of day) | 1915 ± 0.51 | 1896 ± 6.26 | 1852 ± 1.65 | 1838 ± 1.27 | 1845 ± 0.90 | 1815 ± 0.84 |
| C) | Duration of foraging activity (hours) | 1300 ± 0.70 | 12.45 ± 0.01 | 12.36 ± 0.03 | 12.16 ± 0.01 | 12.21 ± 0.02 | 11.30 ± 0.01 |
| D) | Peak foraging hours (time of day) | 1100 - 1300 | 1300 - 1600 | 1000 - 1100 | 1200 - 1400 | 1100 - 1200 | 1200 - 1400 |
| E) | Duration of a foraging trip (Minute) | 12.15 ± 1.17 | 10.65 ± 0.88 | 14.57 ± 0.87 | 12.21 ± 0.79 | 16.13 ± 1.17 | 14.20 ± 0.55 |
| F) | Time spent/bee/flower (Sec) | 5.96 ± 0.12 | 8.23 ± 0.39 | 6.77 ± 0.18 | 7.92 ± 0.21 | 6.38 ± 0.19 | 6.86 ± 0.16 |
| G) | No. of flowers visited/bee/minute | 10.67 ± 0.19 | 9.34 ± 0.13 | 9.92 ± 0.13 | 8.19 ± 0.13 | 8.79 ± 0.14 | 6.92 ± 0.13 |
| H) | Weight of pollen load (mg) | 8.97 ± 0.42 | 11.36 ± 0.40 | 9.08 ± 0.42 | 11.12 ± 0.35 | 9.47 ± 0.65 | 11.04 ± 0.86 |
| I) | Percentage of multifloral loads (MF) | 15.00 | 17.00 | 6.00 | 10.33 | 12.33 | 12.83 |
| J) | Percentage of unifloral loads (UF) | 85.00 | 83.00 | 94.00 | 89.77 | 87.33 | 87.17 |
| K) | No. of honey bees at different heights | | | | | | |
| | (a) Above 4 metres (Top) | 6.64 ± 0.14 | 4.34 ± 0.09 | 5.11 ± 0.23 | 5.17 ± 0.14 | 4.37 ± 0.14 | 4.80 ± 0.11 |
| | (b) Between 2-4 metres (Middle) | 12.71 ± 0.13 | 9.13 ± 0.15 | 11.15 ± 0.07 | 10.80 ± 0.11 | 9.97 ± 0.10 | 9.88 ± 0.10 |
| | (c) Below 2 metres (Lower) | 5.49 ± 0.13 | 3.79 ± 0.07 | 4.83 ± 0.06 | 3.42 ± 0.23 | 4.09 ± 0.15 | 2.66 ± 0.11 |
| L) | No. of grains per pollen load | 67723 ± 105.41 | 77836 ± 108.8 | 67830 ± 8396 | 69458 ± 87.43 | 66118 ± 92.74 | 71073 ± 124.03 |
| M) | Percentage of top workers (TW) | 41.67 | 38.67 | 42.67 | 46.67 | 47.33 | 45.00 |
| N) | Percentage of side workers (SW) | 58.33 | 61.33 | 57.33 | 55.33 | 52.67 | 55.00 |

A For timings of commencement: Shilaroo>Matiana>Narkanda for *A. cerana* and *A. mellifera*
B For cessations: Narkanda>Matiana>Shilaroo for *A. cerana* and *A. mellifera*
C Duration of foraging activity: Shilaroo>Matiana>Narkanda ($P<0.01$)
D Peak foraging hours: Matiana>Shilaroo>Narkanda
E Duration of foraging trip: Narkanda>Matiana>Shilaroo ($P<0.05$)
F Time spent/flower: Shilaroo>Matiana>Narkanda for *A. mellifera* ($P<0.01$)
G No. of flowers visited/minute: Shilaroo>Matiana>Narkanda for *A. cerana* ($P<0.05$)
H Weight of pollen load: Shilaroo>Matiana>Narkanda for *A. cerana* ($P<0.01$)
I, J For *A. cerana* and *A. mellifera*, UF>MF ($P<0.01$)
K For *A. cerana* and *A. mellifera*, b>a>c ($P<0.05$, 0.01)
L No. of grains per pollen load: Shilaroo>Matiana>Narkanda ($P<0.01$).
Top workers and side workers: SW> TW for both *A. cerana* and *A. mellifera*.

**iv) Duration of Foraging Trip**

Foraging data on apple bloom showed that *A. cerana* spent on an average 10.65±0.88, 12.21±0.79 and 14.20±0.55 minutes for a single foraging trip, whereas, this duration was 12.15±1.17, 14.57±0.87 and 16.13±1.17 minutes for *A. mellifera*, at Shilaroo, Matiana and Narkanda orchards respectively. These results showed significant ($P<0.05$) differences between *A. cerana* and *A. mellifera* regarding this parameter in all the three apple orchards. Thus *A. cerana* took significantly ($P<0.05$) greater time for completing a single forging trip as compared to *A. mellifera* (Table 1).

**v) Pollen Carrying Capacity**

Pollen carrying capacity was expressed in terms of pollen load carried by a worker bee of *A. cerana* and *A. mellifera* at 0900, 1200 and 1500 hours of the day in a particular orchard. In Shilaroo orchard, at 0900 hours, mean weight of pollen pellet carried by *A. cerana* was 8.62±0.61 mg, whereas, it was 11.26±0.47 mg for *A. mellifera*. At 1200 hours, *A. cerana* and *A. mellifera* carried pollen pellets weighing 9.27±0.31 and 11.46±0.31 mg respectively. At 1500 hours, average pollen load carried by a forager of *A. cerana* was 9.02±0.34 mg, whereas, it was 11.39±0.43 mg for *A. mellifera* (Table 1). Thus *A. mellifera* carried significantly ($P<0.01$) heavier pollen loads than *A. cerana* during different hours of the day.

In Matiana orchard, at 0900 hours, pollen load carried by *A. cerana* was 9.37±0.52 mg, whereas, it was 11.27±0.49 mg for *A. mellifera*. At 1200 hours, the mean weight of pollen loads carried by *A. cerana* and *A. mellifera* was 9.09±0.46 and 11.21±0.30 mg respectively. At 1500 hours, *A. cerana* carried on an average pollen weighing 8.79±0.28 mg, whereas, this weighed 10.89±0.27 mg for *A. mellifera*. These results showed that *A. mellifera* carried significantly ($P<0.01$) heavier pollen loads than *A. cerana* during different hours of the day (Table 1).

In Narkanda orchard, mean weight of pollen pellets carried by *A. cerana* at 0900 hours was 9.96±0.73 mg, whereas, it was 11.58±0.98 mg for *A. mellifera*. At 1200 hours, *A. cerana* and *A. mellifera* carried pollen pellets weighing 9.56±0.66 and 11.09±0.75 mg respectively. At 1500 hours, average pollen load carried by a forager of *A. cerana* was 8.88±0.55 mg whereas it was 10.44±0.85 mg for *A. mellifera*. Thus weight of pollen loads carried per bee differ significantly ($P<0.01$) between *A. cerana* and *A. mellifera* at different hours of the day (Table 1). Above results suggest that in case of apple, *A. mellifera* carried significantly ($P<0.01$) heavier pollen loads than *A. cerana* in all the three experimental orchards.

**vi) 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* (41.67, 42.67 and 47.33%) and *A. mellifera* (38.67, 55.33 and 45.0%) differ from side workers of these species (58.33, 53.33 and 52.67%) for *A. cerana* and 61.33, 44.67 and 55.0% for *A. mellifera*) respectively at three orchards. The average hourly ratio of top workers to side workers was 1:1.16, 1:1.36 and 1:1.35 for *A. cerana* at 0900, 1200 and 1500 hours of the day, whereas, the ratio of top workers and side worker for *A. mellifera* was 1:1.25, 1:1.36 and 1:1.45 respectively (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.

**vii) Floral Constancy**

Floral constancy of honey bees was worked out by analyzing pollen loads of *A. cerana* and *A. mellifera* on apple bloom at different hours of the day. In apple orchard at Shilaroo, at 0900 hours, *A. cerana* carried 86% pollen grains from apple and 14% from other floral resources present around the orchard, whereas, *A. mellifera* carried 82% pollen grains from apple and 18% from other pollen resources. At 1200 hours, *A. cerana* and *A. mellifera* carried 88% and 84% apple pollen and 12% and 16% pollen grains from other plants resources respectively. Similarly at 1500 hours, *A. cerana* had 81% apple pollen and 19% pollen from other floral resources and these percentages were 83% and 17% respectively for *A. mellifera* (Table 1).

In apple orchard at Matiana, at 0900 hours, *A. cerana* carried 96% pollen grains from apple and 04% from other floral resources present around the orchard, whereas, *A. mellifera* carried 90% pollen from apple and 10% from other pollen resources. At 1200 hours, *A. cerana* and *A. mellifera* carried 95% and 90% apple pollen and 15% and 10% pollen grains from other floral resources respectively. Similarly, at 1500 hours, *A. cerana* returned to hive with 91% apple pollen and 9% pollen from other floral resources and these percentages were 89% and 11% respectively for *A. mellifera* (Table 1).

In Narkanda orchard, at 0900 hours, *A. cerana* carried 88% pollen grains from apple and 12% from other floral resources present around the orchard, whereas, in case of *A. mellifera*, pollen foragers returned to hive with 87% apple pollen and 13% pollens from other honey plants. At 1200 hours, both *A. cerana* and *A. mellifera* carried 89% apple pollen and 11% from other floral resources in equal percentage. Similarly, at 1500 hours, *A. cerana* foragers returned to hive with 86% apple pollen and 14% pollen from other honey plants, whereas, these percentages were 84% and 16% respectively for *A. mellifera* (Table 1). Thus both *A. cerana* and *A. mellifera* carried significantly ($P<0.01$) more unifloral pollen loads than multifloral pollen loads from apple crop, thereby showing pronounced floral constancy.

**viii) Number of Pollen Grains in Pollen Load**

In apple orchard at Shilaroo, the number of pollen grains carried by *A. cerana* and *A. mellifera* pollen foragers at 0900 hours were 70287±98.22 and 81532±114.42 respectively. Similarly, at 1200 hours, *A. cerana* carried 68377±78.69 pollen grains, whereas, *A. mellifera* picked up 72462±93.34 pollen grains. At 1500 hours, *A. cerana* and *A. mellifera* carried 64505±139.33 and 79515±97.64 pollen grains respectively. In Matiana orchard, at 0900 hours, the number of pollen grains carried by *A. cerana* and *A. mellifera* were 69463±55.51 and 70402±68.89 respectively. At 1200 hour and 1500 hours, *A. cerana* had 68489±104.15 and 65537±92.22 and *A. mellifera* had 69482±100.12 and 68500±93.28 pollen grains respectively (Table 1).

In apple orchard at Narkanda, the number of pollen grains carried at 0900, 1200 and 1500 hours by *A. cerana* were

67479±79.12, 66555±109.55 and 64320±89.54 pollen grains whereas, *A. mellifera* carried 71682±188.05, 70181±107.91 and 71356±76.12 pollen grains respectively. Thus *A. mellifera* carried significantly (P<0.01) more pollen grains than *A. cerana* in all the experimental orchards (Table 1).

Above results suggested that *A. mellifera* carried significantly (P<0.01) greater number of pollen grains than *A. cerana*.

**ix) Bees' Preferences to Different Heights**

Bees' preference to different heights of apple was investigated in terms of their population count at top (above 4 metres), middle between (between 2 to 4 metres) and lower (below 2 metres) heights of trees. In Shilaroo orchard, population counts made on marked branches of apple trees showed that *A. cerana* was more abundant on middle (51.17%) than top (26.73%) and lower (30.66%) heights of trees. Similarly, *A. mellifera* population was significantly more at middle (52.90%) than top (25.14%) and lower (21.96%) branches of apple trees (Table 1).

In Matiana orchard, the percentage of *A. cerana* at middle branches of apple tree was 52.99%, whereas, for *A. mellifera* it was 55.70%. The number of bees in top branches was 24.29% for *A. cerana* and 26.66% for *A. mellifera*. In the lower branches the percentage was 22.96 and 17.64 for *A. cerana* and *A. mellifera* respectively. In Narkanda orchard, percentage population count for *A. cerana* was 54.10% on the middle, 23.71% on the top and 22.19% on the lower branches, whereas, *A. mellifera* showed percentage population count of 56.98% on the middle, 27.68% on the top and 15.34% on the lower branches of apple trees (Table 1).

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 branches than top and lower branches.

**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, weight of pollen load, percentage of unifloral and multifloral pollen loads and number of honeybees at different heights of tree revealed following results:

Statistical analysis of foraging data on *A. cerana* and *A. mellifera* at three different altitudes i.e. Shilaroo (2409 m), Matiana (2514 m) and Narkanda (2648 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 0609 hours at Shilaroo, whereas, at Narkanda the timing of commencement was delayed (0626 hours). Similarly, in *A. mellifera,* foraging commenced at 0616 hours, at Shilaroo but it started later at Narkanda (0640 hours) orchards. Timing of cessation of foraging activity were also delayed at higher than lower elevations in case of both *A. cerana* and *A. mellifera.* For example, foraging activity of *A. cerana* ceased at 1915 hours in Shilaroo and 1845 hours in Narkanda. Similarily, in case of *A. mellifera,* foraging activity ceased earlier at Narkanda (1815 hours) than Shilaroo (1896 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 1100 to 1300 hours, 1000 to 1100 hours and 1100 to 1200 hours at Shilaroo, Narkanda and Matiana orchards respectively. Similarly, in *A. mellifera,* foraging activity was between 1300 to 1600 hours at Shilaroo, and 1200 to 1400 hours at both at Matiana and Narkanda. 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 foraging trip of *A. cerana* and *A. mellifera* showed that this parameter was affected by altitudinal variations because at Shilaroo (12.15 minutes), duration of foraging trip of *A. cerana* was significantly (P< 0.01) less than that of the highest elevation i.e. Narkanda (16.13 minutes). Similarly, *A. mellifera* took significantly (P<0.01) more time to complete a foraging trip at Narkanda (14.20 minutes) than Shilaroo (10.65 minutes).

Data on foraging rate and speed showed that *A. cerana* visited significantly (P<0.05, 0.01) more number of flowers per minute at Shilaroo (10.67) than Narkanda (8.79). Similarly, number of flowers visited by *A. mellifera* were significantly more (P<0.01) at Shilaroo (9.34) than Narkanda (6.92). Moreover, no significant differences were observed with regards to time spent per flower by *A. cerana* and *A. mellifera* at different altitudes. Thus, altitudinal variation affect number of flowers visited per minute by *A. cerana* and *A. mellifera* but not the time spent per flower.

Foraging data showed no significant differences in weight of pollen loads carried by *A. cerana* and *A. mellifera* at all the three altitudes. Further, both the species of honeybees i.e. *A. cerana* and *A. mellifera* preferred unifloral to multifloral pollen loads at all the elevations. *A. cerana* and *A. mellifera* preferred to forage on middle than top and lower heights of apple trees at all the altitudes.

Present results suggest that altitudinal variation affect the timings of commencement and cessation of foraging activity, duration of foraging activity, duration of foraging trip and number of flowers visited per minute. However, it did not affect the peak hours of foraging, time spent per flower and weight of pollen loads carried by *A. cerana* and *A. mellifera.* Both the species of honeybees preferred unifloral pollen loads and tried to forage maximum on the middle heights of apple tree (Table 1).

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