

Original Research Article

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## Comparative Foraging Behaviour of *A. florea* and *A. cerana* during Different Weather Conditions

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### ABSTRACT

#### Keywords

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To study the comparative foraging behaviour of *A. cerana* and *A. florea* bright sunny day and cloudy day an experiment was conducted in the apiary of foraging activity of little bee, during June, 2007 at Regional Research Station, University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bangalore, which is located at an altitude of 930M, latitude and longitude of 12<sup>o</sup>58 N & 77<sup>o</sup>31 E respectively. The results of comparison study showed that *A. cerana* recorded significantly more number of nectar gatherers over *A. florea* in both bright sunny and cloudy day. *A. cerana* started foraging early in morning when compared to *A. florea* in both bright sunny and cloudy day. Number of outgoing bees in *A. cerana* and *A. florea* recorded higher in bright sunny compared to cloudy day.

### Introduction

Bees are insects of the order Hymenoptera which feed on pollen and nectar. They constitute a group of about 20 000 species throughout the world, known taxonomically as the Superfamily Apoidea. Honeybees of the genus *Apis* belong to the family Apidae, a sub-group of this superfamily. Although the question of how many honeybee species exist is still debated among taxonomists, at least four species are commonly recognized: the dwarf, or midget, bee *Apis florea*, the giant, or rock, bee *Apis dorsata*, the oriental (Indian, Chinese, Japanese, etc.) bee *Apis cerana*, and the common (European, African, etc.) honeybee *Apis mellifera* (Pongthep, 1990).

In social bees, adequate colony nutrition requires a supply of both pollen and nectar (Michener, 2000). Pollen is a source of protein, nectar is a source of carbohydrates and together they provide all the food necessary for larval growth and metamorphosis and for adult function and development (Winston, 1987). While bees collect nectar and pollen, they provide one of the most important ecological services pollination. On a single foraging trip, foragers tend to collect either pollen or nectar (not both) from a single species of plant, continuing to collect pollen or nectar from that plant throughout the day (Bakker, 1999 and Corlett, 2011). The successful survival of honey bee colony depends on the foraging

efficiency of worker bees and hence, the number of bees going out for foraging per unit time is an indicator of colony activity. The availability of sufficient flora within the foraging range and the prevailing environmental factors could affect foraging activity through energy needs of bees for flight activity (Abrol, 2005).

All the daily activities and foraging patterns of honeybees are under the control and/or changed with weather conditions (Hossam et al 2012; Contreras et al 2013). Insects accordingly can alter their food preferences depending on environmental conditions (Tripath, 2011; Contreras *et al.*, 2013).

To predict whether a given honey bee species is worth using as a pollinator in a given climate, it is useful to know the foraging behavior of local honeybees and their response to the climatic factors. Moreover, there is limited information that pertaining the impact of climatic factors on the foraging patterns of local honeybees. Besides, their foraging behavior was not studied hence, study was undertaken at Regional Research Station, University of Agricultural Sciences, Gandhi KrishiVignana Kendra, Bangalore, to study the comparative foraging behaviour of *A.cerana* and *A. florea* bright sunny day and cloudy day an experiment was conducted in the apiary of foraging activity of little bee, during June, 2007.

### **Materials and Methods**

Foraging activity of little bee, *A. florea* was studied in comparison with *A. cerana* during different weather conditions during June, 2007 at Regional Research Station, University of Agricultural Sciences, Gandhi KrishiVignana Kendra, Bangalore, which is located at an altitude of 930M, latitude and longitude of 12<sup>o</sup>58 N & 77<sup>o</sup>31 E respectively. The foraging activity in terms of the number

of foragers leaving the nest, the number of foragers returning to the nest with pollen load (pollen foragers) and without pollen load (nectar foragers) were recorded for a period of 5 minutes at 60 minutes interval from 0600 – 1800 hr. These observations were recorded during bright sunny days and cloudy days to know the difference in time of initiation, termination and peak period of foraging activity at different weather conditions. The scoring for foragers that returned with pollen loads was unambiguous, but for bees that lacked pollen loads the nature of their trip was unclear. For bees that returned to the hive without pollen, could not be discriminated between an unsuccessful trip, a successful nectar collection or a successful water collection, and thus the bees were classified as simply pollen or non-pollen foragers.

### **Foraging activity of *A. florea* and *A. cerana* during bright sunny day**

The data collected on foraging activity of *A. florea* and *A. cerana* i.e. number of out going bees, pollen foragers and non-pollen foragers at different hours of the day during bright sunny day is presented in Table 1.

### **Outgoing bees**

During bright sunny day the foragers of *A. florea* were found going out at 0800 hr (7.6 bees/5 min.) and continued up to 1700 hr (0.33 bees/5 min.) and was at its peak during 1000 hr (75.00 bees/5 min.) and 1100hr (85.33 bees/5 min.). The activity was maximum between 0900 and 1500 hr. The foraging activity of *A. cerana* began at 0700hr (31.66 bees/5 min.) and was maximum between 1000 to 1100hr (76.33 -78.33 bees/5 min.) gradually decreased at 1500hr (24.33 bees/5 min.) and reached the lowest (9 bees/5 min.) at 1800hr. Maximum activity was observed between 0800 and 1700 hr.

## Incoming bees

### Pollen foraging activity

The incoming of the pollen foragers of *A. florea* began at 0800hr (17 bees/5 min.) increased gradually and reached maximum at 1400hr (49 bees/5 min.) followed by (46.67 bees/5 min.) at 1300hr, finally ceased at 1700 hr (0.33 bees/5 min.). Pollen foraging was very active between 0800 and 1600 hr. The incoming of pollen foraging bees in *A. cerana* began at 0700hr (12.33 bees/5 min.) and reached maximum at 1100 hr (49.33 bees/5 min.) then onwards this activity showed a declining trend and reached the lowest (5.66 bees/5 min.) at 1800hr. Pollen foraging activity was good between 0700 and 1700 hr.

### Non-pollen foraging activity

The incoming of non-pollen foragers of *A. florea* were observed at 0800hr (9.00 bees/5 min.), the maximum number of non-pollen foragers were observed at 1200hr (42.33 bees/5 min.) followed by 1400hr(40 bees/5 min.) and reached the lowest at 1700 hr (1 bees/5 min.). Active non-pollen foraging was observed between 0900 and 1600 hr. The non-pollen foragers of *A. cerana* began to return around 0700hr (16.33 bees/5 min.) the maximum number of non-pollen foragers were observed at 1100 hr (90 bees/5 min.) and reached the lowest (20.33 bees/5 min.) at 1800hr. Non-pollen foragers was very active between 0700 and 1800 hr with a peak at 1000 and 1100 hr.

### Foraging activity of *A. florea* and *A. cerana* during cloudy day

The data collected on foraging activity of *A. florea* and *A. cerana* i.e. number of out going bees, pollen foragers and non-pollen foragers at different hours of the day during cloudy day is presented in Table 2.

## Outgoing bees

The foraging activity of *A. florea* began at 0800hr (2 bees/5 min.) and continued up to 1600hr. The maximum number of outgoing foragers was observed between 1000 and 1500hr (78.0- 61.67 bees/5 min.) with a peak between 1100 and 1200 hr. by 1600 hr numbers drastically reduced and reach the lowest (2.33 bees/5 min.). During cloudy day *A. cerana* foragers found going out at 0700 hr (18.33 bees/5 min.) continued up to 1800 hr (8.33 bees/5 min.) and reached the peak at 1100 hr (46.00 bees/5 min.).

## Incoming bees

### Pollen foraging activity

The incoming of *A. florea* pollen foragers began at 0800 hr (0.66 bees/5 min.) and continued up to 1700hr (0.33 bees/5 min.). Maximum number of pollen foragers were observed (21.67 bees/5 min. - 21.33 bees/5 min.) between 1000 and 1400 hr. The incoming of pollen foraging bees in *A. cerana* began at 0800 hr (12.33 bees/5 min.) and reach the maximum at 1100 hr (41.33 bees/5 min.) then onwards the activity showed a declining trend and reach the lowest at 1800 hr (9.67 bees/5 min.).

### Non-pollen foraging activity

The non-pollen foraging bees in *A. florea* began returning around 0800 hr (0.33 bees/5 min.) and continued up to 1700 hr the maximum number of non-pollen foragers were observed at 1400 hr (40.33 bees/5 min.) gradually decreased and reached the lowest (1.33 bees/5 min.) at 1600 hr. The returning of non-pollen foragers in *A. cerana* began around 0700 hr (15 bees/5 min.) and reached the maximum at 1100 hr (65.33 bees/5 min.) gradually reduced and reached the lowest at 1800 hr (14.00 bees/5 min.).

**Table.1** Comparative foraging behaviour of *A. florea* and *A. cerana* during bright sunny day

Time(hr)	<i>A. florea</i>			<i>A. cerana</i>		
	Outgoing bees*	Pollen foragers*	Non-pollen foragers*	Outgoing bees*	Pollen foragers*	Non-pollen foragers*
0600	0.00 (0.70) <sup>c</sup>	0.00 (0.70) <sup>a</sup>	0.00 (0.70) <sup>b</sup>	0.00 (0.70) <sup>c</sup>	0.00 (0.70) <sup>a</sup>	0.00 (0.70) <sup>a</sup>
0700	0.00 (0.70) <sup>c</sup>	0.00 (0.70) <sup>a</sup>	0.00 (0.70) <sup>b</sup>	31.66 (5.67) <sup>b</sup>	12.33 (3.55) <sup>ac</sup>	16.33 (4.08) <sup>cd</sup>
0800	7.66 (2.84) <sup>b</sup>	17.00 (4.17) <sup>ab</sup>	9.00 (3.11) <sup>c</sup>	56.00 (7.51) <sup>ab</sup>	26.33 (5.17) <sup>ca</sup>	35.33 (5.96) <sup>bc</sup>
0900	47.66 (6.93) <sup>ab</sup>	22.66 (4.80) <sup>ac</sup>	26.00 (5.14) <sup>ab</sup>	63.33 (7.98) <sup>ac</sup>	44.66 (6.70) <sup>bc</sup>	58.00 (7.60) <sup>be</sup>
1000	75.00 (8.68) <sup>ac</sup>	29.66 (5.46) <sup>bc</sup>	40.66 (6.41) <sup>ac</sup>	76.33 (8.76) <sup>bc</sup>	47.33 (6.89) <sup>cb</sup>	71.66 (8.39) <sup>ac</sup>
1100	83.33 (9.14) <sup>bc</sup>	37.00 (6.11) <sup>ef</sup>	38.33 (6.21) <sup>ef</sup>	78.33 (8.86) <sup>bc</sup>	49.33 (6.93) <sup>cb</sup>	90.00 (9.51) <sup>ef</sup>
1200	57.33 (7.60) <sup>ca</sup>	42.67 (6.56) <sup>f</sup>	42.33 (6.53) <sup>ca</sup>	74.67 (8.66) <sup>bc</sup>	33.67 (5.84) <sup>ef</sup>	58.00 (7.64) <sup>be</sup>
1300	61.33 (7.86) <sup>ef</sup>	46.67 (6.86) <sup>ca</sup>	28.66 (5.35) <sup>da</sup>	46.67 (6.86) <sup>ef</sup>	25.33 (5.08) <sup>f</sup>	41.33 (6.43) <sup>ac</sup>
1400	71.66 (8.47) <sup>d</sup>	49.00 (7.03) <sup>af</sup>	40.00 (6.30) <sup>ac</sup>	41.33 (6.45) <sup>dc</sup>	26.00 (5.14) <sup>f</sup>	53.67 (7.35) <sup>ca</sup>
1500	32.33 (5.72) <sup>be</sup>	34.00 (5.86) <sup>d</sup>	24.00 (4.94) <sup>af</sup>	32.00 (5.69) <sup>b</sup>	13.67 (3.73) <sup>ae</sup>	53.00 (7.30) <sup>ca</sup>
1600	7.00 (2.68) <sup>b</sup>	21.67 (4.70) <sup>dc</sup>	13.00 (3.71) <sup>d</sup>	30.33 (5.54) <sup>be</sup>	11.33 (3.43) <sup>ab</sup>	61.00 (7.84) <sup>d</sup>
1700	0.33 (0.87) <sup>f</sup>	0.33 (0.87) <sup>be</sup>	1.00 (1.18) <sup>dc</sup>	24.33 (4.97) <sup>af</sup>	10.66 (3.29) <sup>ab</sup>	30.66 (5.53) <sup>de</sup>
1800	0.00 (0.70) <sup>c</sup>	0.00 (0.70) <sup>a</sup>	0.00 (0.70) <sup>b</sup>	9.00 (3.07) <sup>f</sup>	5.66 (2.40) <sup>f</sup>	20.33 (4.56) <sup>ab</sup>
<b>Mean</b>	<b>36.97(4.99)</b>	<b>25.02(4.47)</b>	<b>21.11(3.95)</b>	<b>47.00(6.67)</b>	<b>25.52(4.85)</b>	<b>49.11(6.85)</b>
<b>S.Em ±</b>	<b>2.53(0.18)</b>	<b>1.89(0.16)</b>	<b>3.45(0.28)</b>	<b>2.72(0.18)</b>	<b>4.08(0.34)</b>	<b>4.49(0.29)</b>
<b>CD at 5%</b>	<b>7.44(0.55)</b>	<b>5.55(0.49)</b>	<b>10.14(0.83)</b>	<b>8.00(0.55)</b>	<b>11.99(1.02)</b>	<b>13.17(0.87)</b>

\* = Mean no. of bees /5min, Figures in the parenthesis are  $\sqrt{X + 1}$  transformed values

Means followed by same alphabet in a column do not differ significantly by DMRT at 5 per cent level

**Table.2** Comparative foraging behavior of *A. florea* and *A. cerana* during cloudy day

Time (hr)	<i>A. florea</i>			<i>A. cerana</i>		
	Outgoing bees*	Pollen foragers*	Non-pollen foragers*	Outgoing bees*	Pollen foragers*	Non-pollen foragers*
0600	0.00 (0.70) <sup>a</sup>	0.00 (0.70) <sup>b</sup>	0.00 (0.70) <sup>a</sup>	0.00 (0.70) <sup>c</sup>	0.00 (0.70) <sup>a</sup>	0.00 (0.70) <sup>a</sup>
0700	0.00 (0.70) <sup>a</sup>	0.00 (0.70) <sup>b</sup>	0.00 (0.70) <sup>a</sup>	18.33 (4.31) <sup>ab</sup>	12.33 (3.55) <sup>c</sup>	15.00 (3.92) <sup>ab</sup>
0800	2.00(1.46) <sup>c</sup>	0.66 (1.05) <sup>a</sup>	0.33 (0.87) <sup>ac</sup>	28.33 (5.36) <sup>ac</sup>	21.67 (4.69) <sup>e</sup>	33.00 (5.77) <sup>ac</sup>
0900	11.33 (3.36) <sup>ab</sup>	9.33 (3.10) <sup>ac</sup>	7.00 (2.70) <sup>ab</sup>	33.67 (5.84) <sup>ba</sup>	36.33 (6.06) <sup>d</sup>	52.00 (7.22) <sup>bc</sup>
1000	51.67 (7.11) <sup>ac</sup>	17.33 (4.21) <sup>ab</sup>	26.33 (5.07) <sup>bc</sup>	38.33 (6.22) <sup>bc</sup>	37.66 (6.15) <sup>d</sup>	56.67 (7.52) <sup>be</sup>
1100	78.00 (8.46) <sup>bc</sup>	18.66 (4.37) <sup>ab</sup>	28.33 (5.33) <sup>bc</sup>	46.00 (6.81) <sup>d</sup>	41.33 (6.39) <sup>f</sup>	65.33 (8.01) <sup>ef</sup>
1200	61.67 ( 5.98) <sup>d</sup>	20.67 (4.56) <sup>bc</sup>	28.66 (5.32) <sup>bc</sup>	34.33 (5.90) <sup>ba</sup>	28.66 (5.29) <sup>ab</sup>	45.33 ( 6.74) <sup>fe</sup>
1300	47.33 (6.79) <sup>dc</sup>	21.67 (4.69) <sup>bc</sup>	29.67 (5.37) <sup>bc</sup>	27.00 (5.24) <sup>ac</sup>	24.33 (4.93) <sup>ac</sup>	38.33 ( 6.21) <sup>c</sup>
1400	36.33 7.84) <sup>ef</sup>	21.33 (4.66) <sup>bc</sup>	40.33 (6.30) <sup>ef</sup>	23.00 (4.84) <sup>ef</sup>	17.33 (4.13) <sup>bc</sup>	40.00 (6.30) <sup>d</sup>
1500	21.00 (4.52) <sup>f</sup>	12.33 (3.57) <sup>d</sup>	22.00 (4.72) <sup>f</sup>	17.00 (4.17) <sup>f</sup>	15.00 (3.93) <sup>ef</sup>	36.33 ( 6.05) <sup>dc</sup>
1600	2.33 (1.56) <sup>c</sup>	4.33 (2.15) <sup>dc</sup>	16.33 (4.08) <sup>ca</sup>	22.33 (4.77) <sup>ef</sup>	16.67 (4.12) <sup>de</sup>	32.33 ( 5.70) <sup>cf</sup>
1700	0.00 (0. 70) <sup>a</sup>	0.33 (0.70) <sup>a</sup>	1.33 (1.26) <sup>d</sup>	15.33 (3.96) <sup>b</sup>	18.66 (4.32) <sup>ca</sup>	23.33 (4.85) <sup>ca</sup>
1800	0. 00(0.70) <sup>a</sup>	0.00 (0.70) <sup>b</sup>	0.00 (0.70) <sup>a</sup>	8.33 (2.96) <sup>af</sup>	9.67 (3.15) <sup>cf</sup>	14.00 (3.74) <sup>ab</sup>
<b>Mean</b>	<b>26.00(4.10)</b>	<b>10.52(2.88)</b>	<b>16.69(3.54)</b>	<b>26.00(5.03)</b>	<b>23.03(4.72)</b>	<b>37.63(6.00)</b>
<b>S.Em ±</b>	<b>9.34(0.68)</b>	<b>1.22(0.17)</b>	<b>9.29(0.42)</b>	<b>1.56(0.16)</b>	<b>3.33(0.33)</b>	<b>3.88(0.27)</b>
<b>CD at 5%</b>	<b>27.40(2.01)</b>	<b>3.57(0.51)</b>	<b>12.60(1.25)</b>	<b>4.59(0.48)</b>	<b>9.77(0.97)</b>	<b>11.39(0.79)</b>

\* = Mean no. of bees /5min, Figures in the parenthesis are  $\sqrt{X + 1}$  transformed values  
 Means followed by same alphabet in a column do not differ significantly by DMRT at 5 per cent level

Correlation study revealed that the foraging activity was positively correlated with higher temperature and sunshine and negatively correlated with low temperature and sunshine. The present results are in confirmation with Mann and Singh, (1981) who reported that foraging activity of all the three species was much lower on cloudy days. Most foragers flew between 0900 and 1300 hr and only a few up to 1700 hr for *A. mellifera* and *A. dorsata*, peak activity was at about 1100 hr. The flight activity of *A.c. indica* F. started early in the morning (mean time, 0503 hours) and ended very late in the evening (mean time, 1932 hours) during the summer (Mattu and Verma, 1985). Similar results were also reported by other investigators for this species from South India (Cherian *et al.*, 1947; Subbareddi *et al.*, 1980). Jadhav (1982) observed that *A. florea* and *A. dorsata* foraged up to 1700 and 1630 hr respectively. Choi and Kim (1988) observed foraging by honey bees began at about 0800 hr and ended at about 1800 hr, it was at its maximum between 1200 and 1300 hr. Panda *et al.*, (1993) studied the foraging behaviour of *A. ceranaindica*, *A. dorsata* and *A. florea*. *A. dorsata* and *A. c. indica* were relatively more active in the morning hours while *A. florea* was active in the afternoon. Mattu and Verma, 1985 reported that the foraging activity of *A.c. indica* was greater in summer and autumn than in the rainy and winter seasons. This may be due to the favourable weather in the summer and autumn which results in the maximum honey flow conditions due to the availability of a large number of bee plants. In the summer and autumn, greater flight activity may also be due to higher population of bees in the hives. In the rainy season, because of continuous monsoon and foggy weather, the percentage of bees leaving the hive was low, whereas, in the winter, foraging activity may be at its lowest due to scarcity of bee flora and low ambient temperature. Palanichamy *et al.*, (1995) observed that the little bee *A.*

*florea* was more active at about 1000 h and less at about 1600h. The foraging activity of all the three species was much lower on cloudy days. Most foragers flew between 0900 and 1300 h and only a few up to 1700 h. (Mann and Singh, 1981).

In conclusion a better understanding of the relationship between bees and the weather could potentially help farmers identify and match suitable bee species to their crops, given latitude, flowering season and local climate (Clarke and Robert, 2018). The results of comparison study showed that the number of outgoing bees and non-pollen foragers were more in *A.cerana* compared to *A. florea* in both bright sunny and cloudy day. However, *A.cerana* and *A. florea* were on par with each other with respect to number of pollen gatherers in both bright sunny and cloudy day. The data on non-pollen collector indicates that, the non-pollen foragers were always more than the pollen foragers during both bright sunny and cloudy day in in both *A.cerana* and *A. florea*.

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