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Foraging performance of Indian honey bee *Apis cerana indica* (F.), during winter in Madurai district of Tamil Nadu, India

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Abstract

Honey bees harvest pollen and nectar from the flowers and while foraging they are exposed to broad range of weather conditions viz., temperature, rainfall, relative humidity, wind speed etc. These weather parameters have influence on the foraging activity of the Asiatic honey bee, *Apis cerana indica* (F.) Each weather parameters have marked effect on honey bee foraging activity. The present study indicated that the maximum temperature alone has positive relationship with foraging activity of bees outgoing, incoming bees with nectar and pollen ($r = 0.117$, $r = 0.188$, $r = 0.120$ respectively). Average weather parameters prevailed during the study period was as follows, air temperature minimum of 18.85 °C to maximum of 32.31 °C, relative humidity of 67.79%, rainfall of 3.75 mm and wind velocity of 4.97 kmph. During winter season 3rd, 4th and 5th standard weeks had recorded maximum foraging activity of 10.30%, 9.91% and 9.26% respectively. During 1st (47.69%) to 5th (48.61%) standard weeks the outgoing bee population outnumbered the nectar gatherers. In 6th standard week the population of nectar gatherers reached the peak (47.69%). Nectar gatherers are contributed 43% of the foraging activity and the pollen gatherers contribution was only 16%. The pollen gatherers never exceeded the nectar gatherers and outgoing bee population.

Keywords: *Apis cerana indica*; foraging activity; winter; weather parameters; temperature; seasonal variations

1. Introduction

Honey bees are micromanipulators which harvest pollen and nectar from the flowers, in turn bee helps the flowers in pollination process and both have mutualistic effect [1, 2]. Foraging activity decides the efficiency of bee survival and it directly depends on the colony population. Hence, the observation on foraging activity on the colony maintenance was observed by counting the number of workers moving out and returning to the hive with pollen and nectar for a particular period [3, 4]. Foraging activity of the worker bees is stimulated by various factors prevailing inside and outside the colony [5]. Factors present inside the colony are workers age, queen presence, strength of the colony, need of food and storage, pest and diseases etc., and factors present outside the colony are ambient weather parameters viz., temperature, rainfall, relative humidity, wind speed, sunshine hours and foraging floral availability etc., During foraging, honey bees are exposed to a broad range of ambient weather parameters which affect their efficiency in forage and alter the time of forage [6]. Each weather parameters have marked effect on honey bee foraging activity. Several reports were available for foraging activity fluctuations in *Apis mellifera* with different seasons and weather conditions and such studies were found scarce on *A. cerana* in the region of Madurai district of Tamil Nadu and hence the present work was focused on to find abiotic factors' influence on *Apis cerana indica* foraging activity in winter 2016-17.

2. Materials and Methods**2.1 Study material and location**

Insectary of the Department of Agricultural Entomology, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, India (Latitude 9°55'25.79" N; Longitude 78°05'27.00" E), was the study location where *A. cerana indica* colonies were maintained in Newton hives. Continuous floral supply for hives was assured by several agricultural, horticultural crops and natural vegetation of foot hills of Yanaimalai rock. For the

study, three strong colonies having six brood frames were selected. Each colony was considered as a replication.

2.2 Observations on foraging activity

Foraging activity of bees was determined by counting the number of worker bees moving out and returning to the hive with and without the pollen loads per five minutes by using hand tally counter and stop watch [4]. Bees returning without pollen loads were considered as nectar gatherers. To study the foraging activity variations for the period of 49th to 9th meteorological standard weeks of 2016-17, observations were recorded three times a day viz., 8.00 a.m., 12.00 noon and 4.00 p.m. for 5 minutes. The mean value of observations at three intervals was taken as the foraging activity of that particular day.

To study the diurnal patterns, weekly observations were recorded at hourly interval starting from 6.00 a.m. to 6.00 p.m. for five minutes. Bees activity percentage was calculated by using the formula as $Ft/FT*100$ where, Ft is average flight activity during a particular time interval and FT is the total flight activity as adopted by [3].

2.3 Meteorological parameters recording

The meteorological parameters viz., maximum and minimum temperature (°C), relative humidity (%), rainfall (mm) and wind speed (kmph) were recorded from the Automatic Weather Station located in the Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, India, which is located within 700 m radius from the experimental colonies. Foraging data recorded were correlated with the meteorological data of the corresponding days. Analysis of variance (ANOVA) at 5% significance was used to test the significance of mean differences.

3. Results and Discussion

The present study indicates the availability of bee flora to worker bees is fluctuating around the year in the locality of Agricultural College and Research Institute, Madurai. Besides the availability of sufficient flora within the foraging range and the prevailing environmental factors also affect foraging activity through energy needs of bees for flight activity [7].

In winter season various groups of *A. cerana indica* worker bees (nectar gatherers, pollen gatherers and outgoing bees) contributed to the total foraging activity. Nectar gatherers contributed 43% and pollen gatherers by 16% while the remaining outgoing bees apportioned by 41% (Fig. 1).

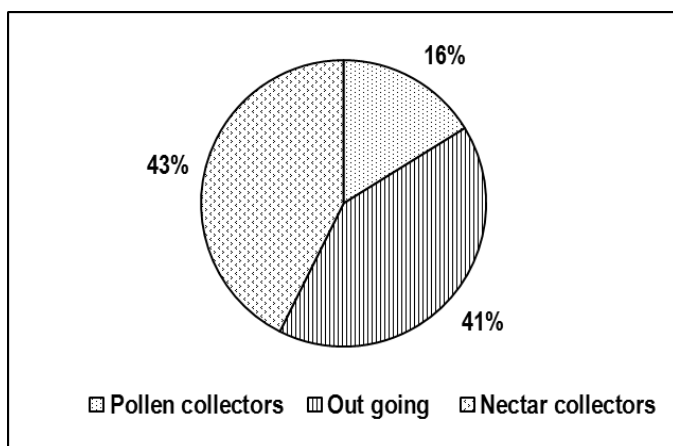


Fig 1: *A. cerana indica*, worker bees contribution in foraging activity during winter, 2016-17.

A study [3] was similar to our observation as it indicated that the percentage of nectar collecting bees was more than those collecting pollen during all the seasons of the year. Greater fluctuations were noticed in the activity of nectar gatherers as compared to others during different seasons.

Ambient environmental conditions showed varying relationship with different group of *A. cerana indica* workers. Average weather parameters prevailed during the study period were the 18.85 °C of minimum air temperature, 32.31 °C of maximum air temperature, relative humidity of 67.79%, rainfall of 3.75 mm and wind velocity of 4.97 kmph (Fig. 2). The maximum temperature had positive correlations with bees coming with pollen ($r = 0.120$), nectar ($r = 0.188$) and outgoing bees ($r = 0.117$). The minimum temperature had negative relations by correspondingly making a correlation coefficient of $r = -0.272$, $r = -0.256$ and $r = -0.222$ respectively with pollen gatherers, nectar gatherers and outgoing bees. In the present observations relative humidity, rainfall and wind speed also had negative correlations with bees coming with pollen, nectar and outgoing bees (Table 1).

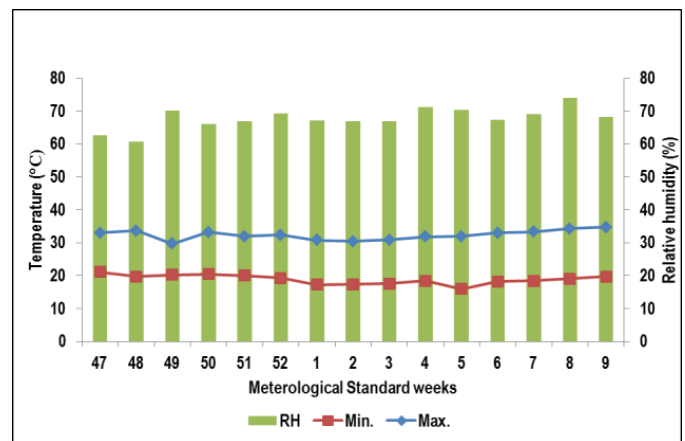


Fig 2: Meteorological parameters of standard weeks in 2016-17

Table 1: Correlation of foraging activity with climatic variables

Factors	Correlation coefficient (r)		
	No. Bees going out/five min	No. Bees coming with nectar/five min	No. Bees coming with pollen/five min
Maximum temperature (°C)	0.117*	0.188*	0.120*
Minimum temperature (°C)	-0.222*	-0.256*	-0.272*
RH (%)	-0.120*	-0.080*	-0.118*
Rainfall (mm)	-0.126*	-0.027*	-0.251*
Wind speed (kmph)	-0.173*	-0.440*	-0.190*

*Significant at 0.05%

Among several abiotic factors, temperature is found to be the most important factor affecting honey bee activities [8]. The maximum temperature had positive relations with bees coming with pollen, nectar and outgoing bees and therefore air temperature should be optimum for effective bee foraging activity. Even though honey bees are ectothermic, a populous honey bee colony can regulate the interior temperature of the hive [9]. Certain other related studies [4, 10, 11] also indicated that high temperature and low humidity had adversely affected the flight activity of honey bees. At high temperatures, the number of pollen gatherers decreased as compared with nectar and water gatherers.

In the present observations, wind speed, rainfall and relative humidity also had negative correlations with bees coming with pollen, nectar and outgoing bees (Table 1). We have also found that strong winds reduce the speed of bees and number of flights per day. Accordingly a wind stronger than 12 kmph was reported to affect honey bee foraging as they could not carry pollen load upwind at a speed > 15 kmph [4]. During our study period the wind speed was optimum (4.97 kmph) and it had not affected the foraging activity of *A. cerana* significantly. Similarly bees had not come for foraging during rainfall thus showing a strong negative correlation. Foraging activity of bee halted with rainfall and the strong wind tends to reduce the ground speed of bees which resulted in reduction in the number of flights per day [12]. Relative humidity showed less effect on the flight activities of *Apis* species [13]. Nevertheless, combination of temperature and humidity was considered to affect the availability of pollen that the factors of low temperature and high humidity might have slowed down the release of pollen. This could be attributed to a potential negative correlation as observed in our studies, which could be compared with another study [14] describing that the number of nectar collecting bees had a positive correlation with air temperature ($r=0.67$) and negative relationship with relative humidity ($r=-0.59$).

Foraging activity was maximum during 3rd, 4th and 5th standard weeks by registering 10.30%, 9.91% and 9.26% activity respectively during which the air temperature was optimal (Fig. 3). Nectar gatherers population was always high

as compared to other two categories while pollen gatherers were lower than the nectar gatherers and outgoing bees. The population of pollen gatherers neither exceeded nor met the nectar collecting population in the present study. The same pattern of foraging activity was reported in tropical climate [4]. In the pollen gatherers population slight increased activity was observed from 51st (22.30%) to 5th (20.15%) standard weeks. From 1st (47.69%) to 5th (48.61%) standard weeks the outgoing bees population outnumbered the nectar gatherers and by 6th standard week the population of nectar gatherer again reached the peak (47.69%) (Fig. 4).

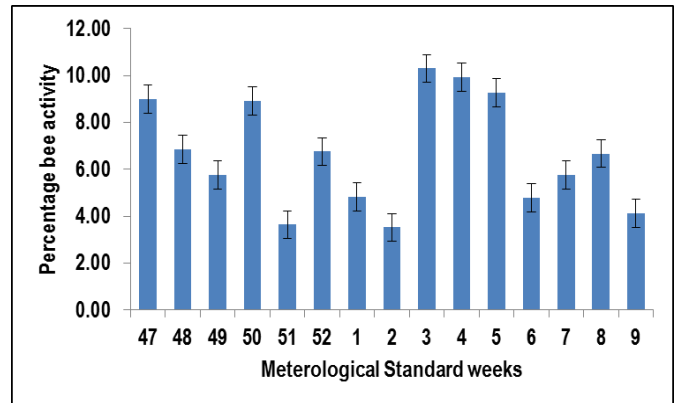


Fig 3: Total foraging activity of bees during winter 2016-17.

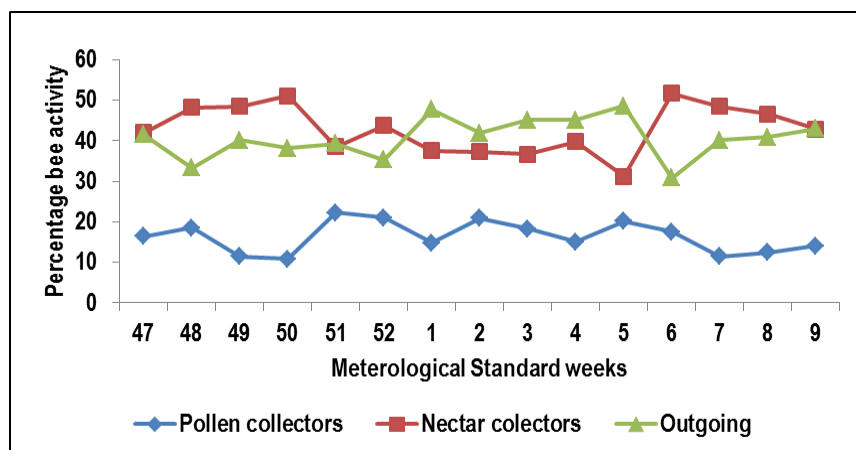


Fig 4: Activity of various foraging group of bees

4. Conclusion

From the present study, it is concluded that the foraging activity of *A. cerana indica* was maximum from 3rd to 5th standard week in the years 2016-17. The observations on foraging group of bees show a higher proportion of nectar gatherers (43%) as compared to pollen gatherers (16%) indicating the nature of the development of the colony with significant influence of weather factors, which is attributed that the *A. cerana indica* colonies could be very well exploited for honey gathering purposes in the southern district of Tamil Nadu.

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