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Foraging behaviour of Giant Rock honeybee, *Apis dorsata* on bottle brush, *Callistemon lanceolatus* (Myrtaceae)

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Abstract
Foraging behavior of honeybee, *Apis dorsata* on bottle brush inflorescences, *Callistemon lanceolatus* was studied in Chalisgaon, during February, 2015 to April, 2016. It was noticed that honey bee intensely and preferably foraged first for pollen and then after for nectar in the flowers of bottle brush, almost throughout the day, with a peak between 8:30 and 9:30 am. It was also noted that pollen foragers spent less time per flower and visited more flowers per minute when bees collected pollen and nectar from the same plant. *Apis dorsata* spent 9.42±3.6 sec/flower with foraging rate 7.93± 3.2 bees/flowers was the highest between 8:30 and 9:30 am during flowering period.

Keywords: *Callistemon lanceolatus*, honey bees, *Apis dorsata*, pollination, foraging behavior

1. Introduction
Pollinators play an important role in sustainability and continuity of the ecosystem and agriculture. Among the pollinators, about 80% of the commercial crops are pollinated by the insects [1]. The main group of these insect are the bees, wasps, butterflies, moths, flies and beetles. However, beside honeybees, the frequency of insect visitors is very less. The number of flowers visited by honeybees per minute was more as compared to other pollinators [2]. Prominently honeybees especially *Apis mellifera* which acts as the main pollinator insect of many cultivated crops was observed globally [3-6]. The pollinating activity of *Apis mellifera* and native honeybees has been studied in many regions of India [7-11].
In India, different *Callistemon* species are widely cultivated throughout the country as an ornamental plant due to its bright-scarlet bottle brush inflorescence [8]. *Callistemon* are commonly referred as bottle brush plants belong to the family Myrtaceae. As an ornamental plant, *C. lanceolatus* is frequently observed in the gardens. It is a woody shrub ranges from 0.5-4 m tall while the leaves are lanceolate in shape and about 7.5 cm long. The inflorescence of bottle brush bears number of individual flowers blooming in summer season. The flowers are crimson red with dark red anthers alluring to nectar-feeding birds and insects. Although *Callistemon* plant is included in the honeybee floral calendar, but there is meager information on the foraging activity of honeybees and other insects [8, 12].
The main objective of my study was to investigate the foraging behavior of *C. lanceolatus* and assessment of the apicultural value of this plant.

2. Materials and methods
The study was carried out in Chalisgaon (Latitude, $20^0$46'41'' N, Longitude $74^0$99'69" E), North Maharashtra region in India during the month of February to April, 2014 to 2016. Before study, examine the number of colonies of *A. dorsata* around the study site. Honey bee species *Apis dorsata* was observed as they foraged on *Callistemon* flowers and their activities were noted during flowering period (43 days) of *C. lanceolatus*.
The observations and data recordings were performed in clear sunny days while data of windy days was recorded separately. The numbers of bees visiting to the flowers were counted for one minute per square meter. The sampling was made at ten minutes intervals during different times of the day from 6.30 am to 5.30 am. In addition to this, daily number of foragers per flower and on 1000 flowers, the duration of individual flower visits was also observed. Data were analyzed using descriptive statistics, correlation coefficient (r) for the evaluation of the association between two variables, students t-test for the comparison of mean of two samples.

3. Results

3.1 Floral description

The flowering period of the experimental plant, bottle brush, *Callistemon lanceolatus* occurred during 27th February to 10th April (Total 43 days) in Chalisgaon region. Bottle brush produced small bisexual odorless flowers which remained opened from morning to evening. The flowers were crimson red due to red stigma, number of red stamens with brownish pollen at the tip of the filament arranged in long spikes. The petals were inconspicuous.

3.2 Foraging preference

Among the 17 insect species, honeybees were frequent visitors to *C. lanceolatus* flowers where they typically foraged of nectar by crawling around the base of the flowers. During flowering period (43 days) in the year 2015 and 2016, 4251 visits of *A. dorsata* were counted. The maximum activity of honeybee workers were observed during 08:30 to 09:30 am in morning and minimum activity during 04:30 to 05:30 pm in afternoon (table 1).

3.3 Rhythm of the visits according to the flowering stages

Visits were most numerous when the number of open flowers was highest. The correlation between the total number of flowers in full bloom and the number of *A. dorsata* visits was positive and highly significant ($r = + 0.643$; $n = 24$, $P < 0.01$).

3.4 Foraging rate per flower

During flowering period of bottle brush, the number of *A. dorsata* workers per flower varied from the morning until the evening. The mean highest foraging rate was recorded (7.93±3.2 foragers/flower) at 08:30 to 09:30 am and lowest (1.35±0.6 foragers/flower) at 04:30 to 05:30 pm (Table 2). The bees preferentially foraged first for pollen and then after for nectar in the flowers of bottle brush.

3.5 Duration of visits per flower

The workers of *A. dorsata* spend different times per flower of *Callistemon* and varied significantly from 06:30 to 05:30 pm. The time spends by the workers per flower was highest (9.42±3.6 s/flower) at 08:30 to 09:30 am while lowest (6.08±3.4 s/flower) at 04:30 to 05:30 pm (table 2).

Table 1: Daily distribution of *Apis dorsata* visited on *C. lanceolatus* inflorescences over 43 days.

	Daily schedule (Hours)						
	06:30-7:30	**08:30-9:30**	**10:30-11:30**	**12:30-01:30**	**02:30-03:30**	**04:30-05:30**	**Total**
No. of Visits	791	1432	915	512	332	269	4251
%age visits	18.61	33.69	21.52	12.04	7.81	6.33	100

Table 2: Daily distribution of *Apis dorsata* visited on *C. lanceolatus* inflorescences over 43 days.

Sr. No.	Parameters	Daily Time Period (Hours)					
		06:30-07:30	**08:30-09:30**	**10:30-11:30**	**12:30-01:30**	**02:30-03:30**	**04:30-05:30**
1	Foraging rate (foragers/flower)	3.5 ± 1.7	7.93 ± 3.2	5.25 ± 2.4	3.85 ± 1.2	1.83 ± 0.8	1.35 ± 0.6
2	Duration of visit (seconds/flower)	8.17 ± 2.3	9.42 ± 3.6	8.96 ± 2.7	7.71 ± 2.2	6.92 ± 2.8	6.08 ± 3.4

4. Discussion

The results achieved from these studies indicated that honeybee *A. dorsata* was the regular floral visitor among the insect pollinators during flowering period of *C. lanceolatus*. A positive correlation between the number of flowers and the number of visits has shown that *A. dorsata* workers were highly attracted and preferentially foraged pollen and nectar of bottle brush. The number of forager on *C. lanceolatus* flowers were recorded higher only in the morning hours than in the evening hours during the entire flowering period. The foraging rate of honeybee depends upon foraging behavior and the floral structure of the concerned plant. The foraging activity of *A. mellifera* during morning hours was maximum noted by earlier workers in certain crop plants [1, 3, 7, 12-14].

It was also examined that the foraging activity of different bee species was at peak level during the afternoon than the morning period [15-18]. The foraging activity was influenced by the pollen and nectar-sugar concentration and environmental factors. The environmental factors mainly temperature, light intensity, humidity and solar radiation were significantly altered by the foraging behavior in honeybees [19].

The highest foraging rate of *A. dorsata* workers per flowers was recorded at 08:30 to 09:30 am (9.42±3.6 s/flower) which may correlate to the high nectar and pollen attraction of bottle brush. The high density of workers per flowers depends upon the competition of bees with other pollinator insects to achieve food source, availability of plants in bloom and temperature [6].

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