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Foraging behaviour of honeybees on crimson bottlebrush, *Callistemon Lanciolatus* flowers

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Abstract
Foraging behavior of honeybees on crimson bottlebrush, *Callistemon* was studied 16 *Callistemon* bogs in Chalisgaon during February, 2019 to April, 2022. Honey bee species i.e. *Apis dorsata, Apis mellifera* and *Apis florea* were observed as they foraged on *Callistemon* flowers and their activities were assessed. Variation in foraging behaviour of honey bees was noted. Foraging activity took place during morning (6:30 am to 12:30 pm hours) time only and reached a peak at 8:30 am. Maximum average abundance (11.52 bees/m²/min) of *A. florea* workers was observed on bottle brush flowers at 8:30 am followed by *A. dorsata* (6.12 bees/m²/min) and *A. mellifera* (3.18 bees/m²/min). The bees preferentially foraged first for pollen and then after for nectar in the flowers of bottlebrush. It was also noted that pollen foragers spent less time per flower and visited more flowers per minute when bees collected both pollen and nectar from the same plant. *A. dorsata* spent 9.42± 3.6 sec/flower and visits 7.93±3.2 flowers/min was the highest average than other bee species.

Keywords: *Callistemon lanceolatus*, honey bees, *A. dorsata, A. mellifera, A. florea*, pollination, foraging behavior

Introduction

In India, bottlebrush is widely cultivated ornamental plant cultivated in gardens, avenues and on road sides [1]. Bottlebrush plants are the member of the genus *Callistemon* and belong to the family Myrtaceae. Plants are all woody shrubs which range from 0.5 m to 4 m tall. The inflorescence of bottlebrushes form in spring and summer and are made up of a number of individual flowers. Flowers are a good source of nectar and pollen and are alluring to nectar-feeding birds and insects [2].

C. citrinus is one of the species of bottlebrush has flowers throughout the year and many pollinators visit the flowers for pollen and nectar collection [3]. *C. lanceolatus* mainly bloomed during April-May while a little number of flowering observed during year [1, 4]. Flowers consists of around 25 to 40% nectar concentration with main ingredient in the form of sugar composition [1].

Insect pollination is the effective, vital and safe service ensuring sustainability of the ecosystem. Along with birds, many popular insect acts as a good pollinators are the bees, wasps, butterflies, moths, flies, bugs and beetles. The main *Apis* species i.e. giant rock bee (*Apis dorsata*), the Indian hivebee (*Apis cerana indica*) and the little bee (*Apis florea*) are the native honeybee species commonly found and distributed at different ecological regions of India. European bee *Apis mellifera*, is highly popularized in India for crop pollination [5, 6]. All the bees influencing both crops and bee hive productivity. This bottlebrush which provides subsistence forages and serves an important purpose of sustaining bee colonies at critical time of floral scarcity.

Before this study, inadequate literature is available on the relationships between the honey bee and *Callistemon* plant in India [1, 2, 4]. The objective of this study was to investigate comparative analysis of the foraging behavior of honeybee species in selected area of Chalisgaon region. It may helpful to improve pollination efficiency during dearth period. At certain extent this study maintain the population of natural bees as conserve bottlebrush in gardens and roadways.

Material and methods

The study was carried out on 16 *Callistemon* bogs located in Chalisgaon region, North Maharashtra in India during the month of February, 2019 to April, 2022. Visiting honey bee species i.e. *Apis dorsata*, *Apis mellifera* and *Apis florea* were observed as they foraged on inflorescence of *Callistemon lanceolatus*. During flowering days, the activities of all *Apis* species were noted every ten minutes at different time intervals. Different parameters of foraging behavior were compare between honeybee species i.e. abundance of foragers on flowers per minute, duration of individual flower visits (using stopwatch), time spent by bees on flower and time spent by bees in between flowers.

The collected raw data was then analyzed statistically by using correlation coefficient (r) for the evaluation of the association between two variables, students t-test for the comparison of mean of two samples.

Observations

The flowering period of the bottle brush, *Callistemon lanceolatus* occurred during 27th February to 10th April (Total 43 days). During flowering seasons, around 21 different insects and 5 birds were noted on *Callistemon* inflorescence. Among the insects, all noted species of honeybees were most dominant flower visitors during the flowering season all year. They typically foraged of nectar by crawling around the base of the flowers. It was also observed that honeybees often brushed anthers and stigmas while visiting the inflorescences.

The foraging preference of different worker bees of *A. mellifera*, *A. dorsata* and *A. florea* differed significantly at different times of the day and flowering periods. It was observed that *A. mellifera* visits 103 (1.28%), *A. dorsata* visits 2001 (24.84%) and *A. florea* visits 5950 (73.88%), showed that *A. florea* was the more frequently observed bee species than other two bee species. All the species were

active on flowers during day time with variable in numbers showing two peaks of visits, the highest between 7:30 h and 8:30 h and the lowest between 14:30 h and 15:30 h (table 1). Throughout flowering period, the forager visit of all the species were highest during early morning hours (6:30-9:30 am), then dropped in the noon while somewhat rises in the evening hours (4:30-5:30 pm) (Table 1). It was observed that overall the foraging hours during flowering period, the foraging activity higher in 8:30-9:30 am while lower in afternoon hour (2:30-3:30 pm). During the morning hours (8:30-9:30 am), the density of foragers per flower of *A. florea* (12.52 ± 5.1) was more as compare to *A. dorsata* (7.93 ± 3.2) and *A. mellifera* (4.36 ± 2.2) (Table 2). Time spend on a flower by worker bees of *Apis florea* was highest 17.26 ± 6.7 sec/flower than *A. dorsata* (9.42 ± 3.6 sec) and *A. mellifera* (12.13 ± 5.6 sec) (Table 3).

Table 1: Daily visiting time period of honeybees on callistemon

Species name	Time period						Total
	Time	0630-730	0830-930	1030-1130	1230-0130	0230-0330	0430-0530	
Apis dorsata	No. of Visits	330	705	327	243	144	252	2001
	%age	16.49	35.23	16.34	12.14	7.20	12.59	100
Apis florea	No. of Visits	1248	1523	893	563	752	971	5950
	%age	15.83	26.99	22.12	13.33	9.98	11.75	100
Apis mellifera	No. of Visits	17	35	22	12	9	8	103
	%age	16.50	33.98	21.36	11.65	8.74	7.77	100

Table 2: Foraging rate of honeybees on callistemon (foragers/flower)

Species name	Time period (Foragers/per flower)					
	0630-730	0830-930	1030-1130	1230-0130	0230-0330	0430-0530
Apis dorsata	3.5 ± 1.7	7.93 ± 3.2	5.25 ± 2.4	3.85 ± 1.2	1.83 ± 0.8	1.35 ± 0.6
Apis florea	8.2 ± 2.3	12.52 ± 5.1	8.51 ± 3.8	7.15 ± 2.8	5.13 ± 2.1	7.85 ± 3.4
Apis mellifera	0.8 ± 0.6	4.36 ± 2.2	2.65 ± 1.7	1.15 ± 0.8	0.63 ± 0.6	1.12 ± 0.9

Table 3: Duration of visit of honeybees on callistemon (seconds/flower)

Species name	Time period (Seconds/flower)					
	0630-730	0830-930	1030-1130	1230-0130	0230-0330	0430-0530
Apis dorsata	8.17 ± 2.3	9.42 ± 3.6	8.96 ± 2.7	7.71 ± 2.2	6.92 ± 2.8	6.08 ± 3.4
Apis florea	11.24 ± 4.7	17.26 ± 6.7	12.91 ± 5.9	10.08 ± 3.2	7.29 ± 2.6	11.18 ± 5.4
Apis mellifera	8.76 ± 2.7	12.13 ± 5.6	10.09 ± 4.8	8.98 ± 3.6	5.14 ± 1.9	7.23 ± 4.1

Discussion

As per results obtained from these studies indicated that *A. florea* had highest foraging frequency than to *A. dorsata* and *A. mellifera*. Among the bee species, *A. florea* activity remained high throughout the day, constituting 73.60% of the foraging visits showed that it was most dominant species than other two bee species. Earlier workers also noticed that *A. florea* was leading bee species in different foraged crops [6, 7, 8].

Earlier comparative studies showed that different bee species were a dominant species observed in selected crop plants as *Apis mellifera* [1, 9, 10, 11], *Apis dorsata* [2, 4]. The dominancy of a bee species was depends on many factors including number of colonies present in the selected area, efficiency of worker bees, size of flower and nectar present in the flower.

All the bee species were active on flowers during day time with variable in numbers showing two peaks of visits, the highest between 7:30 h and 8:30 h and the lowest between 14:30 h and 15:30 h. During morning hours, the peak of selected bee species foraging activity was high, which may correlates to the ample availability of nectar and pollen on *Callistemon* flowers and suitable foraging temperature. According to Panda *et al*. (1993) [12], *A. dorsata* and *A. c. indica* were relatively more active in the morning hours while *A. florea* was active in the afternoon. Waheb and Ebadah (2011) [13] reported that the foraging activity of *A. mellifera* in nigella crop was highest during 12:00 to 2:00 pm. The earlier studies showed that the foraging activity was highest during afternoon than the morning period [2, 5, 14].

The density of foragers per flower of *Callistemon* by worker bees of *A. florea* was highest (12.52 ± 5.1) as compare to *A. dorsata* and *A. mellifera*. The highest time spent on a flower was maintained by *A. florea* workers observed at 08:30 to 09:30 am (17.26±6.7 s/flower). The density and time spend by *A. florea* was higher than other bees which may associated with the size of the bees, high concentration of nectar and pollen of bottlebrush during morning hours. It was noted that, density of *A. dorsata* per flowers was highest on bottlebrush during early flowering period [4, 6]. Overall, the foraging behavior of a particular honeybee species is determined by many factors as flower morphology, concentration and flavor of nectar, quality of pollen as well as environmental factors mainly temperature, light intensity, humidity and solar radiation [5].

Conclusion

This study revealed that, bottlebrush, *Callistemon lanceolatus* pollinated by honeybee species are the most dominant insects among other pollinators. All the bee species whose foraging rate is high during early morning hours than evening hours. The comparative analysis of the foraging behavior of honeybee species showed that the *A. florea* was most dominant species as compare to *A. dorsata* and *A. mellifera*. Many factors influence the foraging activity of bee species as number of colonies located in selected area, efficiency of foragers, flowering period, temperature etc. A decrease in flowering intensity was influenced by a decrease in honeybee density. This study may helpful to improve pollination efficiency during dearth

period. In addition to this, conservation of bottlebrush is necessary to maintain the bee colonies.

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