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Foraging behavior of *Apis cerana indica* Fab. (Apidae Hymenoptera) on Cucumber

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Abstract

The present study entitled "Foraging behavior of Indian bee, *Apis cerana indica* Fab. on cucumber". Studies on Indian bee abundance, pollen and nectar foraging period, time spent, on *Cucumis sativus* flowers and number of flowers visited by Indian bee at different hours. The result revealed that highest activity of *Apis cerana indica* 2.57 bees/ m²/5 min at 0800 h. The peak pollen collection activity of Indian bee was observed in the morning hours from 0800 to 1000h of the day. The peak activity of nectar collection of Indian bee was observed in the morning from 1000- 1200h of the day. The nectar collection activity ceased at 1400h. The mean maximum time spent by Indian bee was 46.75secs/flower at 0800-1000h. The Time spent between 0800h and 1000h shows significantly higher for bee foraging than the other timing intervals. The mean number of flowers visited by *A. c. indica* population was maximum at 0800-1000h (5.0 flowers / minute). The number of flowers visitation was minimum at 1200-1400h (2.2 flowers / minute). There is no visitation of *A. c. indica* population at 1400-1600 and 1600-1800h, indicating that significantly higher number of flower visitation occurs during 0800-1000h than the other timing intervals.

Keywords: *Apis cerana indica*, cucumber, foraging behavior, pollination, India

1. Introduction

Cucumber is one of the important groups of vegetable crops extensively cultivated in India. It occupies fourth place among the different vegetable crops in terms of acreage and production after tomato, brinjal and onion. In India, cucumber is grown in an area of 44,000 ha with an annual production of 6.85 lakh tones of tender fruits. Tamil Nadu ranks first among the states cultivating cucumber having an area of 1060 ha with an annual production of 24,320 metric tons [15]. Although, the cultivation of cucumber is increasingly popular in the state in view of good returns, the overall productivity of the crop is rather low due to various factors. The economic success of cucumber depends upon higher yield with good quality fruits. One of the most important factors which influence the yield and quality of cucumber crop is successful pollination. Due to the presence of male and female flowers separately on the same plant, the flowers are not self-pollinated [36]. Pollination is thought to be one of the key factors responsible for low productivity of many cross-pollinated crops [2, 3, 4, 27].

Cucumber being highly cross pollinated crop, it is well suited to pollination by insects. Pollen grains of cucumber being sticky and large in size, needs an agent to be transfer to the pistillate flowers for fruit set. Cross pollination in cucumber is aided by numerous insect pollinators. Honey bees are particularly the most reliable pollinating agents of cucumber crop [1, 2, 8, 11, 19, 18, 30], as they are capable of carrying the sticky pollen for efficient transfer to the pistillate flowers aiding for proper fruit set [13, 28] and realizing potential yield. Cucurbit crops like bitter gourd, ash gourd and cucumber with attractive yellow coloured flowers lured the bees in large number and offered nectar for the bees [33, 32]. Achievement of desired pollination lies in the systematic planning and efficient use of honey bees to increase the yield as well as improving qualitative and quantitative parameters of the crop. Prior extensive research were carried out and found that the yield increment to the tune of 100 to 150 per cent in various cucurbitaceous crops through effective management of pollinators [18, 8, 5]. Since there is no adequate documentation regarding the foraging behaviour of Indian bee on cucumber in Sothern region of Tamil Nadu, the present study entitled "Foraging behaviour of *Apis cerana indica* Fab. on cucumber" was undertaken to create awareness among farmers.

2. Materials and Methods

The field experiments were conducted at the farmland of the Horticultural college and research institute for women [HC & RI (W)], Tiruchirapalli, Tamil Nadu.

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The cucumber crop was raised under open field condition. The foraging activity of *Apis cerana indica* was recorded at the time of full bloom of cucumber. The observations were recorded for Indian bee visiting the cucumber field during the flowering period at 0600, 0800, 1200, 1400, 1600 and 1800 hrs for five minutes in each square meter area from five spots selected at random. The bees were collected by sweep method using cone type insect collection net and peak visiting hours

was recorded by counting them on flowers per m² for five minutes on respective plants. The Indian bees were observed for pollen and nectar collection at two hour intervals throughout the day between 0600 to 1800 hrs during flowering period and expressed as mean number of bee visits per minutes. The data pertaining to relative abundance, foraging speed, number of flowers visited were statistically analyzed using AGRSS software and as per the protocol [38].

Table 1: Abundance of *Apis cerana indica* on *C. sativus* flowers at different hours

Time (hours)	Mean number of pollinators visit /flower / 5 min.				Mean
	Week 1	Week 2	Week 3	Week 4	
0600-0800	2.86 (1.83)	2.56 (1.75)	2.46 (1.72)	2.4 (1.70)	2.57 (1.75)a
0800-1000	2.3 (1.67)	2.85 (1.83)	1.87 (1.54)	1.68 (1.48)	2.18 (1.64)a
1000-1200	1.4 (1.38)	1.29 (1.34)	1.37 (1.37)	1.26 (1.33)	1.33 (1.35)b
1200-1400	0.72 (1.10)	0.6 (1.05)	0.62 (1.06)	0.56 (1.03)	0.63 (1.06)c
1400-1600	0.02 (0.72)	0.05 (0.74)	0.02 (0.72)	0.06 (0.75)	0.04 (0.73)d
1600-1800	0.70 (0.70)	0.00 (0.70)	0.00 (0.70)	0.00 (0.70)	0.00 (0.71)d
Mean	1.22 (1.31)	1.23 (1.31)	1.06 (1.25)	0.99 (1.22)	-

The values are mean of four replications; Figures in parenthesis are square root ($\sqrt{x+0.5}$) transformed values; CD (P = 0.05)

Sed	CD (P=0.05)	CD (P=0.01)
0.05	0.10	0.14

Table 2: Pollen and nectar foraging period of bee pollinators on *C. sativus* flowers

Foraging activity	Foraging activity time (hours)/flower/5 min.		
	Initiation	Peak	Cessation
Pollen	0600	0800-1000	1400-1600
Nectar	0600	1000-1200	1400-1600

Table 3: Time spent by *A. c. indica* on *C. sativus* flowers at different hours

Time (hours)	Mean time spent (sec) / flower/5min.				Mean
	Week 1	Week 2	Week 3	Week 4	
0600-0800	28 (5.34)	29 (5.43)	35 (5.96)	34 (5.87)	31.5 (5.66)b
0800-1000	47 (6.89)	48 (6.96)	47 (6.89)	45 (6.75)	46.75 (6.87)a
1000-1200	23 (4.85)	24 (4.95)	26 (5.15)	23 (4.85)	24.00 (4.95)c
1200-1400	16 (4.06)	14 (3.81)	17 (4.18)	13 (3.67)	15.00 (3.94)d
1400-1600	06 (2.55)	04 (2.12)	12 (3.54)	06 (2.55)	07.00 (2.94)e
1600-1800	0 (0.71)	0 (0.71)	0 (0.17)	0 (0.71)	00.00 (0.71)f
Mean	20 (4.53)	19.83 (4.51)	22.83 (4.83)	20.17 (4.55)	-

The values are mean of four observations; Figures in parenthesis are square root ($\sqrt{x+0.5}$) transformed values; CD (P = 0.05)

Sed	CD (P=0.05)	CD (P=0.01)
0.18	0.39	0.54

Table 4: Number of flowers visited by *A.c. indica* on *C. sativus* at different hours

Time (hours)	Mean number of flowers visited/ min				Mean
	Week 1	Week 2	Week 3	Week 4	
0600-0800	2.86 (1.83)	3.2 (1.92)	2.65 (1.77)	2.35 (1.69)	2.8 (1.81)c
0800-1000	5.68 (2.49)	4.9 (2.32)	4.9 (2.32)	4.4 (2.21)	5.0 (2.34)a
1000-1200	4 (2.12)	4.25 (2.18)	4.12 (2.15)	4.12 (2.15)	4.1 (2.15)b
1200-1400	2.21 (1.65)	2.42 (1.71)	1.95 (1.57)	2.02 (1.59)	2.2 (1.63)d
1400-1600	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.0 (0.71) e
1600-1800	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.0 (0.71)e
Mean	2.5 (1.72)	2.46 (1.72)	2.27 (1.66)	2.15 (1.63)	-

The values are mean of four observations; Figures in parenthesis are square root ($\sqrt{x+0.5}$) transformed values; CD (P = 0.05)

Sed	CD (P=0.05)	CD (P=0.01)
0.04	0.09	0.13

3. Results and Discussion

3.1. Indian bee abundance

The foraging activity of *A. cerana indica* was recorded throughout the day which started from morning 0600h and

continued up to 1800h as well as throughout the flowering period (Table 1). The peak activity of *A. cerana indica* was noticed at 0800h with a mean of 2.57 bees/m²/5 min, which was followed by a next peak at 1000h with 2.18 bees/m²/5

min. Lowest bee activity was observed at 1400 and 1600h of the day with 0.63 and 0.04 bees/m²/5 min, respectively. The present findings are in line with the previous reports of Mohan Rao and Suryanarayana (1990) [20] who reported the peak activity of *A. cerana* at 09.00h of the day in Watermelon. Similarly, Morris (1968) [21] on niger; Kumar (2002) [18] on onion also reported the maximum activity at 1200h. Similar observations were made by Panda *et al.* (1993) [26] with maximum bee visitation from 11.00 to 12.00h during the flowering period of niger and oilseed rape crops respectively. Previously, Dicks *et al.* (2002) [7], Quijas *et al.* (2012) [29] and Rivera-Hutinel *et al.* (2012) [31], Panchabhavi and Devaiah (1977) [25], Ortiz-Sanchoz (1993) [23] and Oz *et al.* (2009) [24] on sunflower, Cervancia and Bergonia (1990) [6], Ambrose *et al.* (1995) [4], Kumar (2002) [18] and Gahlawat *et al.* (2002) [9] on cucumber, and Kumar (2003) [17] on sunflower have also documented on compartmentalization of plant-insect flower visitors web for diversified crop plants with similar results.

3.2. Pollen foraging period

The data on the Indian bee started collecting the pollen from 0600h of the day (Table 2). The peak pollen collection activity of Indian bee was observed in the morning hours from 08.00 to 1000h of the day. The pollen foraging activity ceased at 1200h during the period of observation. The present findings are in agreement with Hurd (1966) [14] on the genus *Cucurbita*, Stephen (1970) [38] on cucurbits; Grewal and Sidhu (1983) [12] on cucurbits, Suranarayana *et al.* (1992) [39] on diversified crop plants, Vaish *et al.* (1978) [40], Wilson and Collison (1988) [43], Wilson (1989) [42], Ganapathy *et al.* (1997) [10] and Vaishampayan and Sinha (2000) [41] on sunflower, Stanghellini (2002) [37] on watermelon, Nidagundi (2004) [22] on bitter gourd, and Jauker *et al.* (2012) [16] on oilseed rape crops.

3.3. Nectar foraging period

Nectar foraging activity of the Indian bee pollinators on cucumber flowers are presented in Table 2. The Indian bee started collecting nectar from 0600h of the day. The peak activity of nectar collection of Indian bee was observed in the morning from 1000- 1200h of the day. The nectar collection activity ceased at 1400h. The present findings are in line with the report of Mohan Rao and Suryanarayana (1990) [20] who reported the peak activity of *A. cerana* at 0900 h of the day in Watermelon. Nidagundi (2004) [22] also reported the maximum nectar foraging activity at 1000 h of the day in the respective crops.

3.4. Foraging time

The mean maximum time spent by *A. cerana indica* population was 46.75 secs/flower at 0800-1000 hours. The mean time spent was minimum at 1400-1600 hours (7secs/flower). There was no visitation of the *A. cerana indica* population at 1600- 1800 hours. Thus, the peak time spent on flower visitation by *A. cerana indica* is observed to be at 0800-1000h. The present findings are in line with the previous records of Seyman *et al.* (1969) [35], Mohan Rao and Suryanarayana (1990) [20] who reported that *A. cerana* spent maximum time between 0800 and 0900h of the day in Watermelon. These findings were in close proximity with the finding of Kumar (2002) [18] who stated that the average time a bee spent on a flower of cucumber was 11.4 seconds per flower visit, corresponding to a foraging rate of 5.3 flowers per minute. Sattigi *et al.* (1996) reported on the foraging

behavior of *A. cerana* with similar observations.

3.5. Number of flowers visited

The data on number of flowers visited by *A. c. indica* on cucumber flowers at different hours of the day are presented in Table 4. The mean number of flowers visited by *A. c. indica* population was maximum at 0800-1000h (5.0 flowers / minute). The number of flowers visitation was minimum at 1200-1400h (2.2 flowers / minute). There is no visitation of *A. c. indica* population at 1400-1600 and 1600-1800h, indicating that significantly higher number of flower visitation occurs during 0800-1000h than the other timing intervals. Similar observations with maximum time spent between 0800-1000h have been reported by Mohan Rao and Suryanarayana (1990) [20] in Watermelon ecosystem.

4. Conclusion

From the results of the present investigations, it is evident that Indian bee pollination was one of the major insect pollinators on Cucumber. It requires bees as additional biological inputs for successful pollination and fruit set. Bee pollination in cucumber played a vital role with increased yield of fruit. Hence, it is strongly recommended that bee hives must be maintained in cucumber fields to provide pollination of bee visitation to increase the yield.

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