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DIVERSITY OF INSECT FORAGERS ON INDIAN JUJUBE *ZIZIPHUS MAURITIANA*

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ABSTRACT

A total of 12 insect foragers were recorded in *Ziziphus mauritiana* of which *Apis cerana indica* F. was the dominant one (50.66%) followed by *Vespa magnifica* (10.30%), *A. mellifera* (6.42%), *Musca domestica* (4.70%), *Calliphora* sp. (4.48%), *Eristalinus* sp. (4.27%), *Monomorium indicum* (3.94%), *Athyma perius* (3.50%), *Polistes hebraeus* (3.49%), *Pelopidas* sp. (3.45%), *Pieris rapae* (2.33%) and *Coccinella septempunctata* (2.24%). The forager abundance was maximum in the forenoon (0900-1000 hr). Foraging behaviour of *A. cerana* revealed that 0900-1000 hr was the peak period of its visit and activities.

Key words: *Ziziphus mauritiana*, diversity, foragers, *Apis cerana*, foraging behaviour, pollination, abundance, foraging rate, speed, pollen load, visits.

Pollination is an important ecological process which sustains both floral and faunal diversity. Honey bees are the most effective pollinators of entomophilus crops accounting for a large proportion of total global pollination service. The common European honey bee is credited with nearly all the pollination in nature and agriculture (Parker et al., 1987). These bees are critically important for crop pollination and contribute 80% of insect pollination (Robinson et al., 1989). Honey bees harvest pollen and nectar from the flowers and help in pollination process (Dalio, 2015; Kumar and Sharma, 2016). Indian jujube, a member of Rhamanaceae family is a cross pollinated crop, grown in 50,000 ha with an estimated production of 513 thousand mt (2017-18). Insect foragers play an important role in cross pollinated crops and contribute in the increase of production and productivity (Islam and Deka, 2009). The foragers recorded in jujube flowers are honey bees, house flies and lady bird beetles but only the honey bees effect cross pollination yielding viable seed (Ackerman, 1961). Jujube flowers are pollinated by various insects such as honey bees, flies, wasps, ants and butterflies (Devi et al. 1989). Indian bee *A. cerana indica* F. is an economically important, domesticated honey bee species in southern part of India (I'anson Price and Gruter, 2015). Considering the importance of *A. cerana* in Indian jujube, the present study was conducted to determine the insect forager complex and foraging behaviour of honey bee.

MATERIALS AND METHODS

The experiment was conducted in the Experimental farm, Department of Horticulture, Assam Agricultural University, Jorhat during 2017-18 and 2018-19 from mid-September to November. A jujube plantation of variety "Thailand Apple" measuring 500 m^2 was selected, and floral biology, particularly floral taxonomy was studied during peak flowering. The insect foragers were collected at hourly intervals from 0800 to 1600 hr by sweep method in a randomly selected 1 m^2 area. These observations were made at three days interval during the flowering period. The foraging activity of *A. cerana* was also recorded at hourly interval from 0800 to 1600 hr, in randomly selected four branches/ plant in four directions. Ten observations at two days interval were made during the peak flowering period and mean value was calculated, as per the methodology given by Dhara and Tandon (1993). In this method canopy of jujube was divided into four different directions such as East, West, North and South. Observations on number of *A. cerana* were observed from 0800 to 1600 hr during peak blooming period. The foraging speed of *A. cerana* was recorded by a stop watch on randomly selected four shoots/ plant. The foraging rate was determined by the methodology of Islam and Deka (2009). The number of flowers visited by bees/ trip was recorded in randomly selected branches from 0800 to 1600 hr at hourly intervals. The pollen loads carried by ten adult bees were removed with the help of a camel hair brush and collected on a paper and weighed in an electronic weighing balance. The size of the pollen grains was measured by ocular micrometer. A randomised block design was used for all the abovementioned experiments. The obtained data were

statistically analysed using ANOVA, with significance determined with F value (p= 0.05)

RESULTS AND DISCUSSION

The flowers of jujube were small, yellowish-green, 6-8 mm in dia, complete, hermaphrodite, protandrous and hypogynous; with stamens pentandrous of 2 mm and carpel 2 mm in size; and inflorescence is condensed axillary cyme and the number of flowers/ inflorescence range from 12-16. Some cultivars attain anthesis early in the morning, others do so later in the day. Pareek (1983) reported that anthesis occurred between 7.30 to 8.30 am in cultivars Seb, Jogiya, Ponda, Aliganj and Illaichi, while in cultivars Gola and Mundia it was between 12.00 noon to 1.00 pm. The pollen grains measure 26.90± 0.46 µm. Pradeep and Jambhale (2000) and Tel-Zur and Schneider (2009) also recorded similar size of pollen grains in jujube. A total of 12 species were recorded as foragers of which *A. cerana* (50.66%) was the maximum followed by *Vespa magnifica* (10.30%), *A. mellifera* (6.42%), *Musca domestica* (4.70%), *Calliphora* sp. (4.48%), *Eristalinus* sp. (4.27%), *Monomorium indicum* (3.94%), *Athyma perius* (3.50%), *Polistes hebraeus* (3.49%), *Pelopidas* sp. (3.45%), *Pieris rapae* (2.33%) and *Coccinella septempunctata* (2.24%) (Table 1). Devi et al. (1989) observed 20 species of insect foragers with *A. cerana* being the dominant (52-95%). Srivastava et al. (2017) also observed *A. cerana* (65%) as the dominant one among the 20 species recorded on litchi. The peak period of the visitors like *A. cerana* and *A. mellifera* was found to be 0900-1000 hr and other visitors viz*., P. hebraeus*, *V. magnifica, Calliphora* sp. and *M. domestica* was 1100-1200 hr. Similar peak period of visit by bee was observed by Devi et al. (1989) on jujube, Hussain (2011) on guava and Deuri et al. (2018) on mango.

The abundance of bee at 0900-1000 hr was 10.05± 0.62 while it was 3.18± 0.37 at 1500-1600 hr of the day (Table 2). Verma and Partap (1995) and Joshi (2000) made similar observations on initiation, cessation and

Table 1. Insect forager complex on jujube flowers (2017 & 2018)

S. No.	Species	Order	N&P	Peak period of visit (hr)	Abundance (%)
1.	*Apis cerana*	Hymenoptera	P+N	0900-1000	50.66
2.	*Vespa magnifica*	Hymenoptera	N	1100-1200	10.30
3.	*Apis mellifera*	Hymenoptera	P+N	0900-1000	6.42
4.	*Musca domestica*	Diptera	N	1100-1200	4.70
5.	*Calliphora* sp.	Diptera	N	1100-1200	4.48
6.	*Eristalinus* sp.	Diptera	N	1000-1100	4.27
7.	*Monomorium indicum*	Hymenoptera	N	1000-1100	3.94
8.	*Athyma perius*	Lepidoptera	N	1000-1100	3.50
9.	Polistes hebraeus	Hymenoptera	N	1100-1200	3.49
10.	*Pelopidas* sp.	Lepidoptera	N	1000-1100	3.45
11.	*Pieris rapae*	Lepidoptera	N	1000-1100	2.33
12.	*Coccinella septempunctata*	Coleoptera	P+N	1000-1100	2.24

P-pollen; N-nectar

Table 2. Foraging behaviour of *Apis cerana* on jujube (2017 and 2018)

Time of observation (hr)	Abundance of *A. cerana*/ sq. m/ min (± SD)	Foraging rate (± SD)	Foraging speed (sec) (± SD)	No. of flowers visited by *A. cerana*/ trip (± SD)	Pollen load/ trip (mg) (± SD)
0800-0900	6.27± 0.43	19.00± 1.20	4.52± 0.94	234.20± 3.50	3.87± 0.43
0900-1000	10.05± 0.62	21.85± 1.31	6.60± 0.44	265.45± 2.46	5.20± 0.54
1000-1100	8.95± 0.74	19.40± 1.10	5.59± 0.66	256.70± 4.97	5.05± 0.55
1100-1200	8.15± 0.64	16.70± 1.10	5.18± 0.62	235.35± 2.68	3.74± 0.44
1200-1300	5.59± 0.40	9.70± 1.45	4.50± 0.57	171.50± 4.28	3.57± 0.50
1300-1400	3.53± 0.52	3.70± 0.99	2.74± 0.45	133.45± 3.24	2.52± 0.54
1400-1500	3.95± 0.31	6.40± 1.06	3.64± 0.63	181.70± 4.06	3.18± 0.58
1500-1600	3.18± 0.37	5.30± 0.57	3.09± 0.45	143.85± 3.43	2.24± 0.33
Mean	6.04± 0.50	12.76± 0.44	4.48± 0.59	202.77± 3.58	3.67± 0.49
S.Ed±	0.18	0.47	0.20	1.34	0.20
CD (p=0.05)	0.36	0.94	0.40	2.69	0.40

duration of *A. cerana* foraging activity on *Brassica juncea*. Islam and Deka (2009) recorded similar results on cucumber. Observations on foraging speed and rate revealed that at 0900-1000 hr, *A. cerana* spent 6.60± 0.44 sec/ flower and visited 21.85± 1.31 flowers/ min (Table 2). These results corroborate with those of Gogoi et al. (2007) on Assam lemon and Deuri et al. (2018) on mango. Maximum honey bee activity was recorded in the forenoon as it provides more floral rewards in terms of pollen and nectar. During mid-day due to high temperature and exhaustion of nectar in flower, there was a smaller number of visits. The number of flowers visited/ trip and the pollen load carried revealed that at 0900-1000 hr, *A. cerana* visited 265.45± 2.46 flowers with a pollen load of 5.20± 0.54 mg (Table 2). Abrol (2000) observed visit of 248 to 275 flowers/ trip by *A. cerana* on guava flowers. These results derive support from those of Bhagawati et al. (2016) on sesamum and Deuri et al. (2018) on mango. The pollen loads on bees foraging are related to the size of the pollinator (Free and Williams, 1972). Thus, the present study has revealed the existence of wide and rich diversity of foragers on jujube with 12 insect species belonging to 9 families of 4 orders. The hymenopterans were the major flower visitors. Honey bees foraged jujube flowers for both pollen and nectar.

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