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NESTING BEHAVIOUR OF THREE SPECIES OF *CERATINA* POLLINATING CASHEW

K Vanitha

Crop Protection, ICAR-Directorate of Cashew Research, Puttur 574202, Karnataka, India
Email: Vanitha.K@icar.gov.in (corresponding author): https://orcid.org/0000-0002-1081-6885

ABSTRACT

Cashew is a cross-pollinated crop requiring insects primarily bees for successful pollination. Honey bees and several native bees are important pollinators of cashew. Among the native bees, *Braunsapis* spp. and *Ceratina* spp. are commonly present in the study region. Under *Ceratina*, three species namely, *C. hieroglyphica*, *C. bingami* and *Ceratina* sp. 1 have been recorded on cashew and their nesting behaviours have been documented under the present investigation. The nests of these three bee species have been found in dried twigs/ sticks of cashew trees. Nests of all three species had smooth circular entrances, but the diameter of the entrance hole varied with species. It was just 1.0-1.5 mm for *Ceratina* sp. 1, 2.5-4.0 mm for *C. hieroglyphica*, 3.5-4.0 mm for *C. binghami*. The nest, as well as cell dimensions, varied with species. In all three species, older cells were at the bottom of nests, while young ones were towards the entrance. Each egg was laid on the pollen provided in an individual cell and sealed with powdered wood particles. Guarding at nest entrance by adult female blocking with its abdomen was commonly noticed in the nests. The number of individuals in a single nest varied between 1-14, 1-7 and 1-19 for *C. hieroglyphica*, *C. bingami* and *Ceratina* sp. 1, respectively. The trees with the pruned cut ends had more number of bee nests compared to unpruned ones. The study suggests that increasing smooth cut ends in the sticks by pruning and leaving the dried sticks in the cashew plants wherever possible can facilitate the native bees to make nests in them thereby they can be conserved.

Key words: Cashew, pollinator, nest, *Ceratina*, *Braunsapis*, pollen, bees, cross-pollination, behaviour, foraging

Cashew, *Anacardium occidentale* L. is a cross-pollinated commercial tree nut crop having sticky pollen and requires insects for pollination. Though multiple insect species visit cashew flowers, bees are important for pollination (Sundararaju, 2000). Recent surveys in cashew plantations showed that along with honey bees, several wild bees, including genera *Braunsapis*, *Ceratina*, *Pseudapis*, *Lasioglossum* etc. *Ceratina* spp. (Apidae: Hymenoptera) are common pollinators of cashew in the Puttur region of Karnataka, India (Vanitha and Raviprasad, 2016). Foraging activity of common bees on cashew flowers was documented and the peak foraging activity was noticed between 11.00 and 13.00 hrs (Vanitha and Raviprasad, 2018). Observations at cashew plantations led to the location of bee nests in the thin dried stem portions or cut ends of cashew sticks. *Braunsapis* spp. were the dominant ones among the stem nesting bees, followed by *Ceratina hieroglyphica* Smith, *Ceratina* sp. 1. and *C. binghami* Cockerell. The bees under genus *Ceratina* Latreille (Apidae: Ceratinini) are commonly known as small carpenter bees, and they can be easily separated from Halictids by its long glossa and tiny jugal lobe in the hindwings (Grissell, 2017). Although the genus *Ceratina* is taxonomically diverse in the tropics, many aspects of Neotropical species are still poorly known (Gonzalez et al., 2004). Thus, the study aimed to document the nesting behaviour of three *Ceratina* bee species pollinating cashew flowers.

MATERIALS AND METHODS

Observations for the presence of bee nests in dried twigs or stems were undertaken in the cashew plantations of ICAR- Directorate of Cashew Research, Puttur, Karnataka. The region is a hilly track between the West Coast and the Western Ghats of India, located at 12.77 ˚N and 75.22 ˚E at an average elevation of 87 metres. The vegetation cover of the study site was dominated by cashew which was grown as a monocrop, while, weed flora including *Leucas aspera*, *Mimosa* spp., *Ceasalpinia* sp., *Spermacoce* sp., *Tridax procumbens*, *Wedalia trilobata* etc and perennial trees like areca nut (*Areca catechu*), rubber (*Hevea brasiliensis*) and other forest cover surrounds the study site. The soil type is lateritic. The temperature in the area varies from 16.0 to 39.0 ˚C and relative humidity varied from 43 to 98%, with mean annual rainfall of 3970 mm.

Observations revealed that the presence of neat circular holes at the tips of dried cashew sticks or pruned cut ends indicates occupation by nests. Such

sticks were cut beyond 15-20 cm from the tip (with utmost care of not to cutting the brood), kept in cover bags and brought to the laboratory. The nests were collected upon random surveys made during 2018-2020 mostly before 10 am so that all the foraging bees would be present in the nest. The adults that escaped out of the nests during collection if any were also noted. In the laboratory, after measuring the entrance diameter and stick thickness, the individual nests were split open starting at the entrance and parallel to the stick length carefully little by little using a secateur without disturbing the cell contents and the life stages present inside were observed carefully and recorded. Along with the life stages of bees found inside, nest dimensions were also recorded. Presence of symptoms of parasitism and parasitized bee stages were also noted. A total of 50, 12 and 20 nests of *C. hieroglyphica*, *C. binghami* and *Ceratina* sp., respectively were collected during the study and observed. Measurements were made using a standard digital Caliper and scale, while images of bee stages were taken using a microscopic camera attached with stereo zoom microscope.

RESULTS AND DISCUSSION

During the survey, it was noticed that the cashew trees having pruned cut ends had more nests. Observations on the nest structure of all three bee species indicated more similarities except for variations in dimensions. Nests of all three *Ceratina* species were of narrow simple burrows without any branches (Fig. 1-3). The diameter of entrance hole as the tip was 1.0-1.5 mm for *Ceratina* sp. 1, 2.5-3.5 mm for *C. hieroglyphica* and 3.0-4.0 mm for *C. binghami* (Table 1). Bee nests were rarely seen on fresh stems i.e., undried, two nests of *C. hieroglyphica* and one nest of *C. binghami* were found in the fresh stems but at the initial nest stage. In some cases, burrows already made by some wood boring

Fig. 1. *Ceratina hieroglyphica*. From top left. Foraging bee entering into the nest, guarding bee at the nest entrance and the developing brood in split opened nest

Fig. 2. *Ceratina binghami*. From top left. Guarding bee at the nest entrance, adult bee, egg and a fully developed adult inside the cell

Fig. 3. *Ceratina* sp. 1. From top left. Egg and developing grubs and pupa, and the brood found in the split open nest

insects including ants were also occupied by these bee species. Nests of all three *Ceratina* spp. had partitions between cells. A shallow small turning chamber was present just behind the entrance in a few nests. The burrow walls appeared smooth without any particular lining. But according to Sakagami and Laroca (1971), the burrows of *C. dallatorreana* were water-proof which could be due to an invisible lining of waxy secretion.

Older cells were at the interior end of nests, while young ones were towards the entrance in all three species (Fig. 1-3). Developed adult bees have to move towards the nest entrance by moving the cell contents behind. Empty cells of developed adults were not seen in any of the examined field collected nests and the brood was arranged at its progressive development stages. According to Rau (1928), mature bees at the interior end of the nests gain freedom by a process of displacement, gradually shifting the material behind them as they make move to the entrance. In all three species, each egg was

Table 1. Nest structure of three species of *Ceratina*

Particulars	*C. hieroglyphica*		*C. binghami*		*Ceratina* sp.	
	(Mean± SD)	Range	(Mean± SD)	Range	(Mean± SD)	Range
Entrance diameter (mm)	3.1± 0.20	2.5-4.0	3.49± 0.36	3.5-4.0	1.18± 0.22	1.0-1.5
Cashew stick thickness (mm)	11.1± 5.68	5.2-21.0	7.86± 3.54	5.0-15.0	6.01± 2.06	4.0-11.0
Vestibular cell length (cm)	7.8± 3.5	4.5-14.0	8.86± 4.29	3.0-17.0	6.24± 2.83	0.8-11.5
Nest cavity depth (cm)	10.5± 4.96	5.0-20.0	11.57± 2.79	5.0-15.0	8.71± 1.91	5.5-12.0
Individual cell length (mm)	7.0± 0.57	7.0-8.0	7.71± 0.54	7.0-8.5	4.70± 0.43	4.0-5.2
Partition thickness (mm)	1.6± 0.35	1.0-2.5	2.08± 0.36	1.5-2.5	1.16± 0.29	0.9-1.5
No. of cells/ nest	6.4± 2.53	1.0-13.0	0.79± 0.89	1.0-3.0	3.44± 4.45	0.0-16.0
No. of individuals/ nest	5.5± 3.65	1.0-14.0	2.57± 1.65	1.0-6.0	6.56± 4.08	2.0-19.0
No. of adults/ nest during collection	2.5± 2.20	1.0-6.0	1.71± 1.33	1.0-5.0	3.06± 1.35	1.0-6.0

laid on the posterior upper end of the pollen provided in an individual cells and partitioned with powdered wood particles. Unlike, *C. hieroglyphica* and *Ceratina* sp. 1, the egg of *C. binghami* on pollen provision was also glued onto the nest wall at its corner (Fig. 2). *Ceratina* bees are polylectic, the pollen provisions were of semisolid to solid state, cylindrically shaped and coloured creamy or yellow or orange depending on the bee flora and arranged with its main axis along the tunnel.

Bees have occupied the cashew sticks having thickness of 4 mm to 21 mm. Vestibular cell length was 11.1± 5.68 mm, 8.86± 4.29 mm and 6.24± 2.83 mm for *C. hieroglyphica*, *C. binghami* and *Ceratina* sp. 1, respectively. Individual cell length was more for *C. binghami* (7.71± 0.54 mm) followed by *C. hieroglyphica* (7.0± 0.57 mm), while it was less for *Ceratina* sp1 (4.70± 0.43 mm). Cell partition thickness and nest cavity depth were also in the same sequence as individual cell length. Nest cavity depth was 11.57± 2.79 mm for *C. binghami*, and it was 8.71± 1.91 mm for *Ceratina* sp1 (Table 1). Nests of *C. calcarata* Robertson were 20 to 30 cm deep (Rau, 1928) and those of *C. dallatorreana* ranged from 3-19 cm deep. The absolute number of cells depends upon how deep the nest was excavated (Daly, 1966).

A maximum of 19 individuals were recorded in a single nest of *Ceratina* sp. 1, and it was 14 and 6 for *C. hieroglyphica* and *C. binghami*, respectively. Number of adults per nest ranged between 1 and 6 in most cases. Though single adult nests were found, more than one adult was seen commonly in all three species. Possible reasons for the presence of more females in a nest could be a resident female would have allowed the entry of an intruder female, or that female bees of same nest remained together after hibernation (Stark et al., 1990; Hogendoorn and Velthuis, 1993). *Xylocopa nasalis*, was between one and eight cells per nest and up to seven adults were seen in a nest (Hongjamrassilp and Warrit, 2014).

During this investigation, an empty cell was found in a nest of *Ceratina* sp. 1, but not in *C. hieroglyphica* and *C. binghami*. Empty spaces were recorded in other *Ceratina* species like *C. australensis* (Perkins) (Michener, 1962) and *C. propinqua* Cameron (Yogi and Khan, 2014). In a nest, two cells without a partition in between were also noticed in case of *Ceratina* sp. 1. The frequency of *C. hieroglyphica* stages in the nests collected during 2017 in the same study region indicated that more egg stages were present from October to March which coincided with the flowering season of cashew, while during the rainy season between July and September majority were adults (Vanitha, 2019).

Guarding at nest entrance by adult female blocking with its apical metasomal terga was commonly noticed in the nests. Two important advantages of guarding behaviour in social nesting bees are more extended foraging trips by a female while another one remains at the nest entrance and hence a higher accumulation of pollen loads and defence against conspecific or heterospecific invaders (Hogendoorn and Velthuis, 1993). The investigation recorded parasitized pupae of *C. hieroglyphica* and *Ceratina* sp. 1 to an extent of 10 and 20% respectively. The parasitoid that occurred on *C. hieroglyphica* was identified as *Neochalcis breviceps* (Hymenoptera: Chalcidoidea: Chalcididae). The parasitized nest can be easily identified by the presence of disturbed cell contents without partitions, and presence of different shaped or coloured pupa or post defecating grubs in the nest. Parasitism by chalcid

wasps had earlier been reported on *C. viridissima* by Dutt (1912). Parasitism of *Ceratina* sp. 1 by *Neochalcis* sp. was more in nests collected from mussanda plants compared to cashew. Parasitized grubs were noticed in the nests where adult bees were also present.

Based on the details of nest structure especially entrance diameter and nest depth, suitable conservation measures like designing trap nests can be taken up for these bee species. As nests of *Ceratina* bees were found more in numbers in the pruned cut ends of cashew, avoiding the destruction of dried sticks and creation of smooth cut ends would encourage these stem nesting bees to make their nests and survive.

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