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Nest Infrastructure and Biology of Small Carpenter Bee *Ceratina binghami* Cockerell (Hymenoptera: Apidae) in different host plants of TamilNadu, India

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A B S T R A C T

Ceratina binghami Cockerell is an efficient pollinator of cultivated and uncultivated crops. They construct the linear nest for their young ones in pruned sticks, hollow stems and dead wood. The present investigation was carried out at Agricultural College and Research Institute, Madurai, during 2018-2019. Nests (29 nos.) were collected for this study from six different host plants *viz*., Crotons, *Codiaeum* sp., Yellow bell, *Tecoma* sp., Peacock flower, *Caesalpinia pulcherrima*, Copper pod tree, *Peltophorum pterocarpum* and Rose. The nests were linear and partitioned with chewed straw. Among these, the most preferred host was *Peltophorum pterocarpum*. Diameter of the nest entrance, length and width of the nests were recorded as 0.36±0.06 cm, 11.59± 4.35 cm and 0.36±0.06 cm, respectively. Duration of each and every stage of immatures was recorded. Younger ones were located at the nest entrance and the older progeny was placed in the inner side of the nest. Some brood cells were empty between the cells and adult were found at the nest entrance, to guard the immatures from predators and parasitoides.

Introduction

Small Carpenter bees *Ceratina binghami* Cockerell belong to the family Apidae and subfamily Xylocopinae, tribe Ceratinini, twenty three subgenera come under the genus *Ceratina*, found in all the continents but rarely distributed in Australia, usually small, shiny metallic green in colour and body without hairs (Michener, 2007).It is a dominant pollinator both cultivated crops and wild plants *viz.,* Ridge gourd, Brinjal, Rapeseed, Carrot, Niger, Safflower, Mustard, linseed, Ocimum, Marigold, Yellow cosmos, Antirrhinum, *Tephrosia* sp., *Vernonia cinerea* and *Alyssum*sp. (Batra, 1967; Navatha and Sreedevi, 2015). It has instinct behaviour to construct simple linear nest inside pithy, hollow and pruned branches up to 20cm depth with numerous brood cells (Kaliaperumal, 2019 and Michener, 2007). The female adult forage pollen and nectar make it into pollen mass and placed in each cell, eggs were laid on this pollen mass and it served as food for their young ones (Udayakumar and Shivalinghaswamy, 2019), each cell was capped with chewed straw along the length of linear nest chamber. Females remain in the nest entrance until the progeny emerge and it exhibited great parental care by guarding their brood cell from natural enemies, through blocking their nest entrance with abdomen (Rehan *et al.,* 2009).

Intensive agricultural land use and alter, habitat fragmentation and other anthropogenic activities found to alter the bee diversity, which show direct negative impact on the life history of the bees, although life history traits might be used to predict the bee species responses to the environmental disturbances (Williams *et al.,* 2010). To conserve the bees, there is a need to understand the bioecology and nesting behaviour. The present investigation was completely focused on the nest infrastructure and biology of *C.binghami*.

Materials and Methods

Nesting behaviour and study on biology was carried out at Agricultural College and Research Institute, Madurai, during November 2018- December 2019.Regular visits were made to locate the nests and twenty nine nests were sampled from different locations of the campus covering six different host plants *viz*., Crotons, *Codiaeum* sp., Yellow bell, *Tecoma* sp., Peacock flower, *Caesalpinia pulcherrima*, *Nerium oleander*, Copper pod tree, *Peltophorum pterocarpum* and *Rosa* sp., from different locations. The nests were located by visual observation, frequent visits of the adult to the dried exposed pithy stems, pruned stick with the linear depth of hole. A bit of cotton was used to close the nest entrance to avoid the escape of adult and care was taken to bring the nest to laboratory for further detailed study. Nests were dissected with sharp knife lengthwise to prevent the injury to immature stages, rubber bands were used to join the split, the elements of nest infrastructure were recorded *viz*., length of the nest, width of the nest, inner diameter of the nest and brood cell length. Each immature stage was observed on daily basis, to assess the duration of each developmental stage up to adulthood.

Results and Discussion

The present investigation revealed that *C.binghami* preferred six different hosts for the construction of the nests *viz*., Croton, Yellow bell, Copper pod tree, Peacock flower, Nerium and Rose (Fig.1). Ali *et al.,* (2016) documented *C. smaragdula* preferred pruned stalks of Ravenna grass for nesting. Udayakumar and Shivalingaswamy, 2019 reported *C.binghami* constructed linear nest in *Caesalpinia pulcherrima,* they also noticed in the other hosts *Adhathoda zeylanica* and *Adenanthera pavonina.* While, *C. mikmaqi*, *C. dupla* constructed unbranched nest in

fullerstease land *C. calcarata*in raspberry (Vickruck, 2011).Depending upon availability of the host *Ceratina* sp. prefers different hosts for their nesting site, which is dried pithy, soft wooded pruned sticks and hollow stems.

The nest had only one entrance, linearly arranged with numerous brood cells along the length of the nest with equal partitions made by chewed straw. An average length of the nest was 11.59± 4.35 cm with nest entrance diameter of 0.36±0.06 cm(Table 1).While, *C. hieroglyphica* constructed unbranched nest in cashew pruned sticks with nest entrance diameter of3.2±0.22mm and total length up to 20 cm deep (Kaliaperumal, 2019).A series of brood cells were observed with older cell at inner side of the nest and younger cell near the nest entrance. The present results were accordance with the findings of Batra, 2012, who reported *C. propinqua* and *C.* (*Pithitis*) *smaragdula*, constructed nest in pithy stems with older brood cell always be at down portion of the nest and the upper cell had direct contact with the mother without capping the brood cell. Number of cells per nest ranged between one to three. There was an empty space in between the cells in the host Croton, Yogi & Khan, 2014 also reported this kind of behaviour in other species *viz*., *C. propinqua* Cameron.

Adult females collected the pollen and nectar and made into a pollen ball, which is yellowish brown in colour, placed in each brood cell and laid egg on the ball. The egg was spindle in shape, it took four days for hatching (Fig. 2 a). Early instar appeared whitish in colour, very small in size one fifth to the pollen mass and voraciously feeding on it(Fig. 2 b). Pre defecating larvae (Fig. 2 b, c, d, e) required 8 days with an average 4±2.70 days (N= 29) and post defecating larvae lasted 4 days with an average 3.5±1.29, respectively. Pupal duration was recorded based on eye pigmentation, white colour eyed, light brown colour eyed and thick brown eyed stage of pupa lasted for one to three days each, and dark black colour eyed pupa required one to three days (Fig. 2 g, h, i, j). Total pupal development took three to nine days(Table 2).The present findings are similar with the findings of Udayakumar and Shivalingaswamy, 2019, they studied the biology of *C.binghami* based on morphology, the duration taken to complete the pupa was 10±2.07 days. Pupa head placed upright direction towards the nest entrance. Present findings were similar with the findings of Yogi and Khan, 2014, who reported that *C. simillima* pupa head towards the nest entrance, while *C. propinqua* pupa head oriented towards down position to the nest.

Table.1 Nest infrastructure of *Ceratina binghami* Cockerell

Particulars	Mean ±SD	Range
Nest entrance diameter (cm)	0.36±0.06 (N=29)	0.2-0.4
Length of the nest (cm)	11.59± 4.35(N=29)	7- 21.5
Width of the nest (cm)	0.36±0.06 (N=29)	0.2-0.4
Number of cells per nest	2±1	1-3
Length of the cell (cm)	1.45±0.57	0.8-2.5
Number of adults during nest collect	5±1	1-6
Total number of immatures per nest	2±0.86	1-3

Table.2 Duration of immature stages of *Ceratina binghami* under laboratory conditions (N=29)

Life stages	Mean ±SD (Days)	Range
Egg	4.0 (N=1)	4
Larva		
Pre defecating larvae	4± 2.70 (N=4)	2-8
Post defecating larvae	3.5±1.29(N=5)	2-5
Total larval period	3.77±1.85	
Pupa		
White eyed pupa	2±0.70 (N=6)	1-3
Pale brown eyed pupa	2±0.63 (N=6)	1-3
Thick brown eyed pupa	2.75±1.28 (N=8)	1-3
Dark black eyed pupa	2±0.70 (N=5)	1-3
Total pupal days	2.28±0.95	3-9 days
Adult	3 ±0.89	

Fig.1 *C. binghami* Cockerell adult constructing nest in six different hosts

i. Croton, *Codiaeum* sp.,

ii. Nerium

iii. Rose

iv. Yellow bell, *Tecoma* sp.,

v. Copper pod tree *Peltophorum pterocarpum*

Adult required 3 ±0.89 for completion of the stage from thick brown eyed pupa to adult (Fig. 2 k, l, m),
29-32 days was required to complete the developmental period of *C.binghami*.

Fig.2 Biology of *C.binghami* Cockerell with different developmental stages

a- Egg

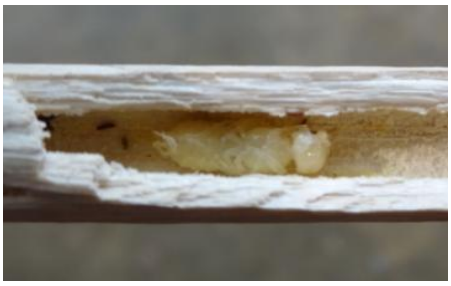
b-1st day larvae

c. 2nd day larvae

d - Pre-defecating larvae

e - Pre-defecating larvae with a bit of pollen mass

f- Post-defecating larvae



g. White eyed pupae

h. Light brown colour eyed pupa

i. Brown colour eyed pupa

J. Dark black colour eyed pupa

k. Complete body black in colour

l. Changed to light green in colour

m. Metallic green in colour Adult

The present study concluded that *Ceratina binghami* preferred pithy stems of six different hosts *viz*., Crotons, Yellow bell, Peacock flower, *Nerium* sp., Copper pod tree and Rose. The present findings may help to understand the nest preference, nest infrastructure, which could be used to develop the artificial nest to conserve the bees. This information may also be useful for providing the artificial nest site for conserving the native bees and to increase the pollination.

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