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Artificial Domiciliation, Foraging Behaviour and Biology of *Xylocopa fenestrata* F.

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***Abstract*:** This study demonstrated that *Xylocopa fenestrata* F. exhibited specific nesting and foraging preferences. The bees selectively utilized dry bamboo nodes for nesting, constructing linear nest patterns. The preference was shown for bamboo nodes with diameters of 1.5 cm. Xylocopa bees were active pollinators of several crops, including sunhemp, pigeonpea, sesbania and drumstick. Foraging activity varies throughout the day, with peak visitations observed in sunhemp and drumstick during the mid-afternoon and bimodal activity (morning and afternoon) on pigeonpea flowers. *X. fenestrata* was found to be the dominant pollinator on both sesbania and drumstick.

***Keywords*:** Pollinators, Foraging activity, Nesting behaviour, *Xylocopa fenestrata*

With the proliferation of monotonous agricultural landscapes that diminish biodiversity and reduce bee forage availability, research on wild and/or managed non-*Apis* bees can yield valuable insights into complementary pollinator species that could aid in food crop pollination in regions where honey bee colony maintenance is hindered or affected (Javorek et al*.,* 2002, Hoehn et al*.,* 2008, Brittain et al*.,* 2013). The ability of giant carpenter bees (*Xylocopa* Latreille 1802, Hymenoptera: Apoidea) to pollinate has drawn attention in recent years. Reports indicate the successful use of giant carpenter bees in Australia and Israel for pollinating honeydew melons and greenhouse tomatoes (Hogendoorn et al., 2000, Sadeh et al., 2007, Keasar 2010). Carpenter bees belong to the family Apidae, genus , and Xylocopa subfamily Xylocopinae (Michener 2000). These species are important pollinators of numerous crops**.** In some crops where honey bees fail to effect pollination**,** carpenter bees act as efficient alternatives. Additionally, unlike honey bees, they may forage effectively under inclement weather conditions. They contribute significantly to the pollination of fruit, vegetable, and ornamental plants, thereby enhancing crop productivity and ensuring healthy seed set. There are two types of carpenter bees: small carpenter bees (*Ceratina* spp.) and large carpenter bees (*Xylocopa* spp.), the latter characterized by robust, hairy bodies**.**

The name *Xylocopa* is derived from the Greek word *xylokopos*, meaning 'wood cutter' (Scott et al*.,* 1993). The primary characteristics of *Xylocopa* spp. include a large body size, elongated marginal cells, long prestigma, absence of stigma**,** and a robust, papillate distal portion of the wing (Kacchawa et al*.,* 2020). Nesting behaviour and biology vary among species, ranging from solitary to semi-social or primitively eusocial forms, wherein the eldest female (mother or sister) feeds both young females and males via trophallaxis (Lucia et al*.,* 2015). Large carpenter bees possess considerable potential for pollination of horticultural and agricultural crops due to their polylactic foraging habits, buzz pollination capability, year-round activity, adult hibernation, ability to forage under low-light conditions, and adaptability to artificial nesting substrates (Buchmann 2004, Keasar 2010).

Researchers worldwide have concluded that large carpenter bees are efficient pollinators of various crops**,** including eggplant, tomato, sunflower, squash, and passion fruit (Gerling et al*.,* 1989, Sihag 1993, Mardan 1995). Carpenter bees were also observed actively foraging on drumstick, sweet orange, sesbania, pigeon pea, sunhemp, and acid lime at the Agricultural Research Station, Vijayarai, and surrounding farmers' fields. However**,** information on standardizing rearing techniques for *Xylocopa* spp. and other non-*Apis* pollinators remains limited**.** Hence**,** the present study was undertaken to address this gap.

MATERIAL AND METHODS

Floral rewards (nectar or pollen) by *Xylocopa* spp. during each floral visit was observed. Observations like extending their proboscises to the base of the corolla was visually checked for nectar collection while as during pollen gathering. Surveys of pollinating insects visiting the target crop were conducted throughout the flowering season once in three days. On each sampling date, insect activity was monitored continuously from the beginning of observable pollinator foraging in the morning until activity declined in the evening. Within each day of observation, standardized counts of pollinators were made at three predetermined time points (09:00, 13:00, and 15:00) to capture temporal variation

in visitation rates. The foraging activity of *X. fenestrata* was recorded during flowering seasons of the crop during 2023-24. The foraging behavior was recorded at random spots of 1 m^2 area in a total area of 6 acres of the flowering species. The collected pollinators were preserved and were sent to ZSI, Kolkata for authentic identification.

Artificial domiciliation: For studying the nesting behaviour and standardization of rearing methodology of *X. fenestrata*, at three locations pandals were erected at ARS, Vijayarai with hollow bamboo nodes of different diameters *i.e*., 1.0-2.70 cm and the most preferred diameters of bamboo nodes were observed and length of 2.0-2.5 m were kept for nest construction in four different directions *i.e*., north, west, south and east. The data regarding nest preference was analyzed using ms excel.

The hollow bamboo nodes used for nesting were periodically monitored to observe the development of *X. fenestrata*. Nests were carefully opened to document the egg, larval, and pupal stages. The duration of each life stage (egg, larva, pupa) was recorded. After the emergence of adult bees, the nests were dissected to study their internal structure, including the number of brood cells, provision mass of the emerging bees.

RESULTS AND DISCUSSION

Foraging behaviour of *X. fenestrata*: The highest number of *X. fenestrata* visits was recorded at 3:00 pm (0.68 visits per 2 min) on sunhemp *(Crotalaria juncea*), coinciding with the highest number of flowers available (2.94 flowers per 2 min). The minimum time spent per flower was observed at 09:00 am (5.33 s) on sunhemp. Rahman and Deka (2013) reported the lowest visitation frequency during the morning hours (09:00–10:00 am). Similarly, on red gram (*Cajanus cajan*), the minimum visitation occurred at 09:00 am, while peak activity was observed at 09:00 am and 3:00 pm, with the highest number of flowers visited at 09:00 am (1.16 flowers per 2 min).

In drumstick (*Moringa oleifera*) and *Sesbania bispinosa*, *X. fenestrata* was the dominant pollinator, recording 0.73 and 0.59 visits per 2 min, respectively, and visiting a greater number of flowers (3.51 and 3.25 flowers per 2 min). The highest visitation rate of *X. fenestrata* on drumstick was observed at 3.00 pm (0.59 visits per 2 min), whereas the maximum number of flowers visited occurred at 09:00 am (3.65 flowers per 2 min) (Table 1).

Nest preference of *X. fenestrata*: *X. fenestrata* preferred bamboo as nesting material. The nests were built in an angled position in the shadow which might be due to convenience and protection from rain. The nests offered shelter for progeny and there was strong nest defence by *Xylocopa* sp. Despite a range of bamboo node diameters (1.0−2.70 cm) being provided, *X. fenestrata* showed a preference for nodes with diameters of 1.5, 1.6, and 1.7 cm for nest construction. The highest mean acceptance rate was in 1.5 cm nodes (41.75%), followed by 1.6cm with the lowest acceptance in 1.7cm nodes (22.87%). (Plate 2).

Biology: The adult female *X.fenestrata* lays eggs in nests provisioned with pollen and nectar. The developmental periods for the egg, larval, and pupal stages of *X. fenestrata* were 2, 10 and 26 days, respectively. The female scrapes the inner surface of the bamboo node and mixes the wood shavings with saliva to form individual brood cells. This masticated material is used to construct partitions, sealing each egg within its own cell. Each brood cell constructed by *X. fenestrata* females is provisioned with a mass of pollen and nectar that serves as a food source for the developing larva prior to pupation. Single egg is laid on the pollen-nectar

Table 1. Foraging activity of carpenter bees on flowers of different plant species

Time	Carpenter bee activity		
	No. of bees / 2 min	No. of flowers visited / 2 min	Time spent (sec)
On sunhemp			
9.00 AM	0.58	2.14	5.33
1.00 PM	0.58	2.49	6.03
3.00 PM	0.68	2.94	7.40
On pigeonpea			
9.00 AM	0.57	1.16	6.56
1.00 PM	0.46	0.82	3.79
3.00 PM	0.57	0.86	6.70
On sesbania			
9.00 AM	0.41	2.00	6.25
1.00 PM	0.46	2.25	6.98
3.00 PM	0.73	3.51	8.68
On drumstick			
9.00 AM	0.75	3.65	8.04
1.00 PM	0.62	2.25	6.06
3.00 PM	0.59	3.25	7.53

Table 2. Mean percentage distribution of different diameters of Bamboo nodes

Diameter of bamboo nodes	Mean percentage (%)
1.5 cm	41.75
1.6 cm	35.36
1.7 cm	22.87
CD (p=0.05)	08.74

provision. Female *X. fenestrata* typically constructs seven to eight brood cells within a single bamboo node. This process is repeated sequentially, resulting in a linear arrangement of cells within the bamboo tunnel. The total developmental period from egg to adult was approximately 38 days duration (Plate 1).

In 2023, nesting activity of *X. fenestrata* was recorded in November and December, with bamboo nodes containing eggs, larvae, and pupae, demonstrating active oviposition and brood development. In contrast, in 2024 the active breeding period shifted earlier, occurring from April to July with similar developmental stages present. This temporal shift in nesting activity across years indicates that *X. fenestrata* is multivoltine, producing multiple generations annually, and suggests that environmental or phenological factors may influence the onset and duration of breeding seasons. Developmental stages of *X. fenestrata* (Plate 1) in bamboo node at, ARS, Vijayarai at 2023-24.

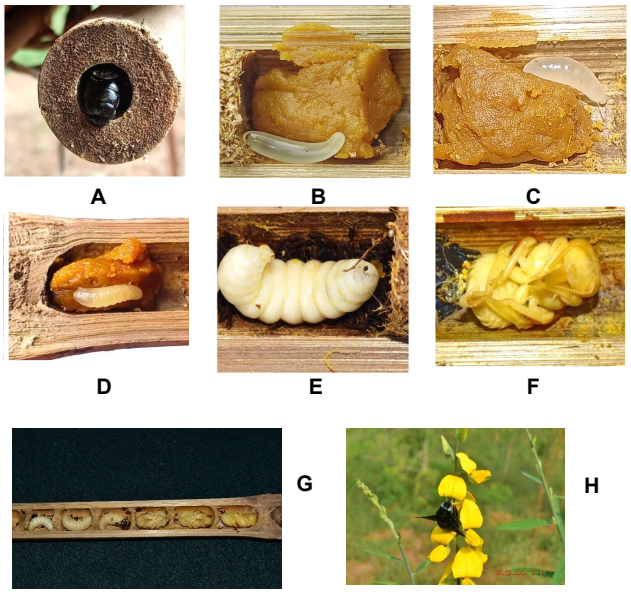

Plate 1. A: *Xylocopa fenestrata* nesting in 1.5 cm bamboo node, B: Egg laid in provisioned food (pollen+ nectar) C: Hatched egg, D: Grub, E: Pre-pupa, F: Pupa, G: Foraging of *X. fenestrata* on sunhemp, H: Different grub stages of *X. fenestrata*

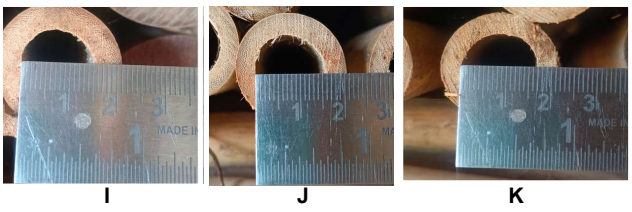

Plate 2. I: 1.5 cm diameter, J: 1.6 cm diameter, K: 1.7 cm diameter

CONCLUSION

X. fenestrata bees showed preference for dry bamboo nodes for nesting, constructing linear nest patterns. The preference was shown for bamboo nodes with diameters of 1.5 cm. Xylocopa bees were active pollinators of several crops, including sunhemp, pigeonpea, sesbania and drumstick. Foraging activity was observed in sunhemp and drumstick during the mid-afternoon and bimodal activity (morning and afternoon) on pigeonpea flowers. *X. fenestrata* was dominant pollinator on both sesbania and drumstick. For many agricultural crops, giant carpenter bees, *Xylocopa* sp. serve as highly efficient pollinators.

AUTHOR'S CONTRIBUTION

Mohan Rao K contributed to investigation, data curation, implementation, and writing/editing of the manuscript. Alekhya G assisted in literature collection, review, and editing. Kumar Naga provided supervision and validation. Sachin Suresh Suroshe was involved in conceptualization, project administration, and validation. Srinivas T contributed to review and editing. All authors have read and approved the final manuscript.

REFERENCES

Brittain C, Williams N, Kremen C and Klein AM 2013. Synergistic effects of non-Apis bees and honey bees for pollination services. *Proceedings of the Royal Society B: Biological* Sciences **280**(1754): 20122767.

Buchmann SL 2004. Aspects of Centridine biology (Centris spp.) importance for pollination, and use of *Xylocopa* spp. as greenhouse pollinators of tomatoes and other crops. *Solitary bees.* Conservation, rearing and management for pollination. ImprensaUniversitária. *Fortaleza* 203-211.

Gerling DHHWV, Velthuis HHW and Hefetz A 1989. Bionomics of the large carpenter bees of the genus *Xylocopa.*

Hoehn P, Tscharntke T, Tylianakis JM and Steffan-Dewenter I 2008. Functional group diversity of bee pollinators increases crop yield. *Proceedings of the Royal Society B: Biological Sciences* **275**(1648): 2283-2291.

Hogendoorn K, Steen Z and Schwarz MP 2000. Native Australian carpenter bees as a potential alternative to introducing bumble bees for tomato pollination in greenhouses. *Journal of Apicultural Research* **39**(1-2): 67-74.

Javorek, Steven K, Kenna E, Mackenzie, and Vander Kloet SP 2002.Comparative pollination effectiveness among bees (Hymenoptera: Apoidea) on lowbush blueberry (Ericaceae: Vaccinium angustifolium). *Annals of the Entomological Society of America* **95**(3): 345-351.

Kachhawa G, Charan SK and Nagar P 2020. The foraging activity of Carpenter bee, *Xylocopa fenestrata* on the major crops of Eastern Rajasthan, India. *Flora Fauna* **26**: 329-335.

Keasar T 2010. Large carpenter bees as agricultural pollinators. *Psyche: A Journal of Entomology* 927463.

Lucia, Mariano, Victor H, Gonzalez and Alberto HA 2015. Systematics and biology of *Xylocopa* subgenus schonnherria (Hymenoptera, Apidae) in Argentina. *ZooKeys* **543**: 129.

Mardan M 1995. Varied pollinators for Southeast Asian crops. *Pollination of Cultivated Plants in the Tropics.* Roma, FAO: 142-149.

Michener 2000. The Bees of the World. John Hopkins University Press; Baltimore, USA.

Rahman A and Deka TN 2011. Nesting and foraging behaviour of *Xylocopa fenestrata* and *Xylocopa leucothorax* on ridgegourd (*Luffa acutangula*) and cucumber (*Cucumis sativus*). *Indian Journal of Agricultural Sciences* **81**(8): 780.

Sadeh A, Shmida A and Keasar T 2007. The carpenter bee Xylocopa pubescens as an agricultural pollinator in greenhouses. *Apidologie* **38**(6): 508-517.

Scott, Peter E, Stephen L. Buchmann, and Mary Kay O'Rourke 1993. Evidence for mutualism between a flower-piercing carpenter bee and ocotillo: use of pollen and nectar by nesting bees. 234-240.

Sihag RC 1993. Behaviour and ecology of the subtropical carpenter bee, *Xylocopa fenestrata* F. Nest preferences and response to nest translocation. *Journal of Apicultural Research* **32**(2): 102-108.

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