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# Nesting and foraging behaviour of *Xylocopa fenestrata* and *Xylocopa leucothorax* on ridgegourd (*Luffa acutangula*) and cucumber (*Cucumis sativus*)

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Carpenter bees (*Xylocopa* spp) belonging to the family Apidae are considered as solitary bees. Some of them are eusocial in nature but most do not form colony and live solitarily. They are effective pollinators of certain crops where honeybees fail to pollinate. Further, they can act as good forager in incliment weather in contrast to the honey bees. Carpenter bees are classified under the genus *Xylocopa* subfamily Xylocopinae and the family Apidae (Michener 2000). They play a major role in the pollination of fruit, vegetable and ornamental plants and thereby enhance considerable crop yield and proper seed setting. These bees are divided into two groups: the larger carpenter bees of genus *Xylocopa* and small carpenter bees of genus *Ceratina*. Larger carpenter bees are stout and hairy bodied. Males either resemble female or may be different, covered with dense pubescence. Most of these bees occur in the tropics and subtropics and less than 10% exist in temperate zone. Among the carpenter bees, *Xylocopa fenestrata* and *X. leucothorax* are the common species in north-east Himalayas.

Cucumber (*Cucumis sativus*) and ridgegourd (*Luffa acutangula*) are two important vegetable crops grown all over India. In the north east Himalayas, cucumber is grown throughout the year and ridgegourd is grown as summer vegetable crop. They are monoecious and exclusively required external agents to pollinate. Insect pollinators more particularly carpenter bees are considered as effective pollinators of these crops. However, no concrete information are available on nesting and foraging study on *Xylocopa* and hence, the present investigations were carried out with the objectives to study the nesting and foraging behaviour of *Xylocopa* spp on ridgegourd and cucumber.

To study the nesting behaviour of *X. fenestrata* and *X. leucothorax*, initially, a survey was made in and around Assam Agricultural University, Jorhat during 1994–95 and a confirmatory trial was conducted during 2003–04 to 2005–06. During the survey, a total of 65 nests of *X. fenestrata* and 60 nests of *X. leucothorax* were identified, marked and observations were recorded on nest location, position of nest, number of cells per nest, diameter of entrance hole and nesting materials, height from ground, length and breadth of cells and girth of nesting materials. Foraging behaviour of *X. fenestrata* and *X. leucothorax* on cucumber, (*Cucumis sativus*) and ridge gourd (*Luffa acutangula*) was studied in terms of the parameters, *viz.* frequency of flower visit, pollen load per trip and time taken per trip were observed. The frequency of flower visit on cucumber and ridge gourd was recorded as number of flower visit per minute at weekly interval. The foraging activity of *Xylocopa* on ridge gourd was recorded from evening 4 PM to 7 PM as the anthesis occurs in the evening and continued till next morning. In cucumber, foraging was recorded from 7 AM- 5 PM . of the day as the anthesis of cucumber flower took place in the morning. To determine the pollen load per trip on cucumber and ridge gourd, the adult females of both the species marked at thorax by using ordinary nail polish. The pollen carrying females were captured with the help of insect collecting net and pollens were removed by using fine brush from the hind legs and collected on slides. The average weight of pollen was worked out from ten samples. Time required for a foraging trip was determined by the visit of the bee to a particular flower with the difference between initiation of flower visit and final take off from the flower at weekly interval. Ten observations were recorded in each day and the average value was worked out. For foraging study, Pusa Sanjyog, an early mature and high-yielding cucumber variety was grown. Similarly, Pusa Nasdar, a high yielding fine textured ridge gourd variety was used. Seeds were sown during second week of February and fertilization and agronomic practices were rendered as per package of practices of Assam Agricultural University, Jorhat.

During the course of investigation, 65 nests of *Xylocopa*

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*fenestrata* were identified in and around Jorhat, Asom and were selected for studying the nesting behaviour. Out of 65 nests, 20 in the orchard and 45 were observed in field conditions. Most of the nests were located on bamboo top and *X. fenestrata* preferred dry bamboo top for making nests. The nest architecture of X. *fenestrata* was studied on dry bamboo top *X. fenestrata* preferred to make nest at 174.80±22.09 cm above the ground on bamboo top with the diameter of bamboo top was 2.23±0.12 cm. They made tunnels in the bamboo top and the tunnels were divided into cells by partitioning it with cell walls. The cells were arranged continuously in linear. The number of cells in a nest varied considerably. The maximum number of cells per nest was recorded to be eight and the minimum was five. *X. fenestrata* constructed cells having an average length; 1.855±0.009 cm and the breadth; 2.221±0.124 cm. The cell walls were arranged continuously in uniconcave pattern having more thickness at the periphery (0.35±0.33 cm) and less thickness at the centre (0.31±0.005 cm).Other important nest characteristics were: diameter of entrance hole, length of internode in respect to ground and girth of bamboo top; 2.53±0.12 cm were calculated and presented in Table 1. All these factors, i e distance from ground, diameter of entrance hole, length of internode and angle with respect to ground were found to be higher in case of female nest than that of male nest. The average diameter of entrance hole was 1.82±0.007 cm for male and 1.88±0.112 cm for female. The cells of the female nest were provisioned with pollen.

The nesting site of *X. leucothorax* was surveyed during 2003–04 and the materials used for the nests were observed. During investigation as many as sixty nests were traced and identified as *leucothorax* nests in and around Jorhat, Asom. Most of the nests were located in house hold conditions and nested in timber. Out of these, fifty nests of *X. leucothorax* were selected for studying the nesting behaviour. The nest architecture of *X. leucothorax* was studied on dry timber and twigs. Female *X. leucothorax* preferred to make nest at 155.50±28.416 cm above the ground on dry timber and twigs. It made tunnels in the wood and the tunnels were partitioning with cell walls in linear. The diameter of entrance hole varied of 1.66±0.096 cm for male and 1.99±0.109 cm for female. The female made several cells and the cells varied considerably with 6.3±0.48 for female. Length and breadth of the cells were 1.79±0.009 cm and 2.65±0.065 cm for female respectively. The cell walls were arranged continuously in uniconcave pattern having more thickness at the periphery

Table 1 Nesting characteristics of *X. fenestrata* and *X. leucothorax*

| Character | *X. fenestrata* | | *X. leucothorax* | |
|---|---|---|---|---|
| | Male | Female | Male | Female |
| Distance from the ground (cm) | 164.00±27.18 (50–300) | 174.801±22.09 (50–258) | 143.55±15.67 (60–210) | 155.50±28.42 (40–300) |
| Diameter of entrance hole (cm) | 1.82±0.007 (1.80–1.87) | 1.881±0.112 (1.001–2.20) | 1.66±0.096 (1.15–2.05) | 1.99±0.109 (1.45–2.50) |
| No. of cells/nest | 0.00 | 6.301±0.65 (5–8) | 0.00 | 6.30±0.48 (4–9) |
| Length of cell (cm) | 0.00 | 1.855±0.009 (1.82–1.89) | 0.00 | 1.79±0.009 (1.75–1.85) |
| Breadth of cell (cm) | 0.00 | 2.221±0.124 (1.85–2.95) | 0.00 | 2.65±0.65 (2.41–2.95) |
| Girth of bamboo top (cm) | 0.00 | 2.532±0.12 (2.3–2.9) | 0.00 | 0.00 |

Mean of 10 observations, Figure in parentheses indicate range

Table 2 Foraging behaviour of *Xylocopa fenestrata* and *X. leucothorax* on cucumber

| Observation (hr) | *X. fenestrata* | | | *X. leucothorax* | | |
|---|---|---|---|---|---|---|
| | Frequency of flower visit (min.) | Pollen load/ trip (mg) | Time spent/ flower (sec.) | Frequency of flower visit (min.) | Pollen load/ trip (mg) | Time spent/ flower (sec.) |
| 7 AM-8 AM | 4.00±0.61 | 39.00±3.45 | 25.00±3.19 | 3.00±0.30 | 39.00±4.11 | 26.00±2.94 |
| 8 AM-9 AM | 7.00±0.97 | 67.00±4.45 | 23.00±2.95 | 6.00±0.77 | 62.00±4.10 | 23.00±2.01 |
| 9 AM-10 AM | 8.00±0.99 | 68.00±3.11 | 26.00±2.45 | 6.00±0.81 | 66.00±3.12 | 26.00±3.10 |
| 10 AM-11 AM | 1100±0.96 | 65.00±2.16 | 35.00±2.01 | 10.00±0.95 | 57.00±3.99 | 35.00±2.01 |
| 11 AM-12 noon | 4.00±0.63 | 62.00±2.96 | 41.00±4.01 | 4.00±0.61 | 60.00±3.14 | 37.00±3.16 |
| 12 noon-1 PM | 5.00±0.89 | 58.00±3.57 | 28.00±1.46 | 3.00±0.32 | 55.00±2.37 | 25.00±3.22 |
| 1 PM -2 PM | 4.00±0.86 | 66.00±2.46 | 24.00±2.99 | 3.00±0.49 | 63.00±2.05 | 40.00±3.15 |
| 2 PM -3 PM | 6.00±0.88 | 65.00±2.01 | 38.00±3.65 | 4.00±0.51 | 56.00±3.32 | 26.00±2.15 |

Mean of eight observations

Table 3 Foraging behaviour of *X. fenestrata* and *X. leucothorax* on ridgegourd

| Observation (hr) | *X. fenestrata* | | | *X. leucothorax* | | |
|---|---|---|---|---|---|---|
| | Frequency of flower visit (min.) | Pollen load/ trip (mg) | Time spent/ flower (sec.) | Frequency of flower visit (min.) | Pollen load/ trip (mg) | Time spent/ flower (sec.) |
| 4 PM-5 PM | 2±0.88 | 65±2.01 | 30±3.65 | 3±0.73 | 65±1.21 | 22±2.53 |
| 5 PM-6 PM | 3±0.97 | 68±4.45 | 23±2.45 | 3±0.32 | 65±2.32 | 21±3.25 |
| 6 PM-7 PM | 2±1.05 | 61±3.95 | 35±0.01 | 2±1.52 | 60±2.32 | 30±1.32 |
| 5 AM-6 AM | 3±0.99 | 67±3.11 | 26±0.95 | 2±1.33 | 50±2.12 | 25±2.63 |
| 6 AM-7 AM | 2±0.02 | 60±2.32 | 33±0.45 | 3±1.28 | 56±3.23 | 26±3.27 |
| 7 AM-8 AM | 3±0.61 | 39±3.45 | 25±3.19 | 3±0.72 | 41±2.15 | 24±0.37 |
| 8 AM-9 AM | 3±0.39 | 21±1.35 | 20±2.23 | 3±0.39 | 30±1.32 | 20±1.37 |
| 9 AM-10 AM | 2±1.23 | 11±0.89 | 19±1.37 | 2±0.23 | 12±0.47 | 18±0.87 |

Mean of eight observations

with 0.36±0.006 cm and less thickness, i e 0.306±0.003 cm in the centre. The other important nest characters, viz nest distance from ground, diameter of entrance hole, length of internode to ground were recorded and presented in Table 1. The nest architecture in wood were found to be either branched or straight.

The investigations revealed that *X. fenestrata* and *X. leucothorax* preferred dry bamboo and dry wood as nesting materials for constructing their nests. The nests were constructed under shade in inclined position. It might be due to convenience for making nests and protection from rain. Nest architecture was found to be similar in both the species. Nests were divided into 4 to 9 cells by female *X. leucothorax* with the help of cell walls. Male and female lived in separate nests and male nests were devoid of cellular structure in contrast to female nests. Sihag (1993) in his study on behaviour and ecology of *X. fenestrata* recorded such nest preferences and nest location. Female nests were found to be functional offering shelter for progeny and there was strong nest defence by both *Xylocopa* spp. Vicidomini (1996) also observed nest defence behaviour as a part of the shelter-defence strategies by female *Xylocopa* in Southern Italy.

Foraging activity of *X. fenestrata* and *X. leucothorax* on cucumber was recorded in different hours commencing from 7 AM to 5 PM. Table 2 revealed that frequency of flower visit by both the species was maximum during 9–10 AM. with maximum pollen load of 68±3.11 mg/trip by *X. fenestrata* and 66±3.72 mg/trip by *X. leucothorax*. Time taken per trip was varied depending upon the pollen reward. Maximum time spent was between 11 AM to 12.00 noon by *X. fenestrata* and 1 PM to 2 PM hrs. by *X. leucothorax* and minimum was at 8.00 to 9.00 hrs. for both the species in cucumber. Foraging activity of *Xylocopa fenestrata* on ridge gourd was recorded for different hours from the anthesis *i.e.* 16.00 hrs to the dehiscence in the next morning upto 10 AM. The Table 3 revealed that frequency of flower visit at 5 AM-6 AM being maximum of 3.00±0.99 and minimum at 6 PM to 7 PM with 2.00±1.05/min.

The pollen load per trip was maximum between 5 PM–6 PM with 68.00±4.45 mg and the minimum was between 9 AM and10 AM being 11.00±0.89 mg. Time spent per flower was maximum at 6 PM-7 PM hrs with 35.00±0.10sec and the minimum was at 9 AM-10 AM being 19.00±1.37 sec. Similarly foraging activity of Xylocopa *leucothorax* on ridge gourd was observed for different hours from anthesis to dehiscence of flower. The maximum frequency of visit was recorded at 4 PM-5 PM with the highest pollen load of 63.00±1.21 mg/ trip in 22.00±2.53 sec. The minimum of visit was recorded at 9 AM-10 AM. with the frequency of 2.00±0.23/minute having the pollen load 12.00±0.47 mg/trip with the time span of 19±0.07 sec/flower. Kumar and Chandel (2003) reported similar type of foraging behaviour by *Xylocopa* on cucurbits in north west India.

## SUMMARY

The nesting behaviour of *X. fenestrata* and *X. leucothorax* was studied in terms of nesting site, materials and architecture. *X. fenestrata* preferred dry bamboo top for making nest, whereas *X. leucothorax* made nest in dry wood. In bamboo, the nests were constructed in a linear pattern extending only one side from the entrance hole, i e in a straight line but in wood, the nests were found to be either branched or straight. The position of nest, diameter of entrance hole, number of cells per nest and the diameter of nesting materials varied with the species and materials. The female nests of *Xylocopa* consisted of several cells whereas male nest devoid of such structure. Foraging activity of *X. fenestrata* and *X. leucothorax* on ridge gourd was observed from 5 AM to 7 PM of the day and showed that maximum number of visit at 5 AM to 6 AM of the day with pollen load 68±4.45 mg/trip for *X. fenestrata* and 65±2.32 mg/trip for *X. leucothorax*. Foraging activity on cucumber was recorded from 7 AM to 5 PM of the day with peak visit at 10 AM to 11 AM of the day having maximum pollen load 68±3.16 mg/trip and 67±3.99 mg/trip by *X. fenestrata* and *X. leucothorax*.

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