NEST ARCHITECTURE AND NESTING SITE PREFERENCE OF *TETRAGONULA IRIDIPENNIS* SMITH IN NORTH-WESTERN PLAINS OF INDIA

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Abstract

Stingless bees constitute an important group of bee diversity providing a vital ecological service i.e. pollination. From India, nine species of stingless bees have been reported out of which *Tetragonula iridipennis* Smith is widely distributed. Studies revealed that the majority (86.67%) of these bees' nests were present in brick walls and the remaining (13.33%) were in cavities of hollow tree trunks. Most of the colonies nested at a height of 3.50 m from the ground. Most of the nests (56.67%) had entrances oriented to the east. No distinct entrance tube was observed in 26.92 per cent of the colonies. Overall average entrance tube dimensions (longer side diameter x shorter side diameter x tube length) were 11.62 x 11.73 x 14.04 mm. In all the nests, brood area was surrounded by pollen pots and a few honey pots. The mean dimensions (depth x width) of brood cells, honey pots and pollen pots were 2.79 x 2.62 mm, 5.33 x 4.52 mm and 6.93 x 5.19 mm, respectively. All of the sixty colonies whether in brick/ stone walls or in hollow tree trunks overwintered successfully. Our results can be useful for developing conservation measures for *T. iridipennis* and its augmentation for crop pollination.

Keywords: nest architecture, nesting site, stingless bee, *Tetragonula iridipennis*

INTRODUCTION

More than 503 species of stingless bees (Apidae: Meliponini) occur worldwide (Ascher & Pickering, 2017), and the majority are confined to tropical or subtropical regions (Michener, 2007). The genus *Tetragonula* Moure, 1961, is the largest group of Indo-Pacific stingless bees (Rahman et al., 2013) comprising thirty valid species worldwide (Ascher & Pickering, 2017), but Sakagami (1978) and Rasmussen (2008) described only six species belonging to three genera from India. Since then, the total number of species has been raised to nine (Rasmussen, 2013; Ascher & Pickering, 2017) with the latest recording of a new species, *Tetragonula gressitti* (Sakagami), from Arunachal Pradesh by Rathor et al. (2013). The nine species reported from India are *Lepidotrigona arcifera* (Cockerell), *Lisotrigona cacciae* (Nurse), *Lisotrigona mohandasi* Jobiraj & Narendran, *Tetragonula* aff. *laeviceps* (Smith),

Tetragonula bengalensis (Cameron), *Tetragonula gressitti* (Sakagami), *Tetragonula iridipennis* (Smith), *Tetragonula ruficornis* (Smith) and *Tetragonula fuscobalteata* Cameron.

In North-west India, only two species, namely *T. iridipennis* and *T. laeviceps* have been reported to exist in which *T. iridipennis* is widely distributed (Rahman et al., 2013). Stingless bees, like honey bees, are highly social insects living in perennial colonies. Their nests are located mostly in concealed places, and colonies may accommodate from a few dozen to more than 100 000 workers (Michener, 2007). Like other hive bees, these bees are also important because their honey offers a peculiar aroma and taste and reported to possess some medicinal value (Rao et al., 2016). In addition, stingless bees provide the vital ecological service of pollination in many crops grown under protected cultivation including strawberries (Malagodi-Braga, 2002), brinjal (Amano, 2004), sweet peppers (Cruz et

al., 2005) and cucumbers (Santos et al., 2008). This shows the immense potential of these tiny bees to be used as important and effective pollinators of many crop species (Slaa et al., 2006). Successful hiving of stingless bees is an age-old practice in India. Kani tribe members in Western Ghats, India rear this bee in bamboo stems (Ø 30-35 cm, length 80-85 cm), while the people of Naga tribes in Nagaland, India use such various structures as log wood hives (Ø 11-38 cm, length 43-128 cm) and rectangular wooden boxes (length 25-32 X width 18-26 X height 20-64 cm) as reported by Kumar et al. (2012) and Singh (2016), respectively. In Punjab, Makkar et al. (2016) characterized morphologically and molecularly the stingless bees of the region to be *T. iridipennis*. Several reports are available on various aspects of the biology and rearing of *T. iridipennis*, and the majority of them are the outcome of work conducted under tropical conditions on nesting preference (Pavithra et al., 2013), spatial distribution (Sheetal & Basavarajappa, 2009) and nest structure (Dannaraddi et al., 2009). However, there is still no report available on the biological aspects including scientific rearing under the current ecological conditions which are characterized by subtropical semi-arid climate with very hot summers and very cold winters. The present study will help in understanding how this species persists in such harsh climatic conditions, which will form a basis to develop a species-specific conservation strategy. This bee can be utilized in managed pollination programmes, which necessitate the hiving in artificial hives for easy multiplication. Therefore, the present study has been conducted to understand the nesting site preference and nest architecture of the stingless bee in North-west India for the first time.

MATERIAL AND METHODS

Study area

The study area, the Punjab Agricultural University, Ludhiana, is situated at 30°-56'N and 75°-52'E at an elevation of 247 m above mean sea level in the central plain agro-climatic zone of

the Punjab state. Most of the area is cultivated or under permanent structures. The main agricultural crops are rapeseed and mustard, cotton, maize, sunflower, linseed, sesamum and fodder crops as clover and pearl millet, and pulses as pigeon pea, chickpea and green gram. Vegetable crops grown in the area are chiefly cucurbits (cucumber, bitter gourd, squashes, sponge gourd, ridge gourd etc.), crucifers (cauliflower, cabbage, radish, turnip etc.), solanaceous crops (tomato, brinjal, capsicum and chillies) and umbelliferous (carrots and fennel). Horticultural plantations like pears, peaches, plums, guavas, gooseberries, kinnows and mangoes, and landscape plantations like mountain-ebony, golden shower, flamboyant tree, silver oak and dinner plate tree.

Climatic conditions

The mean maximum and minimum temperatures of the area fluctuate considerably during summer and winter seasons. The long term weekly mean maximum and minimum temperatures of Ludhiana were 39.7 and 5.4°C, respectively. However, on certain days, the maximum temperature reached 45°C and the minimum 0°C. The average rainfall was 400-1300 mm with approximately 80% of the rainfall received during July to September (Kaur et al., 2016).

Data collection

T. iridipennis colonies were searched in and around the PAU, Ludhiana campus between 2013 and 2015. Search operations were conducted in various localities following an all-out search method through ocular vision (Sheetal & Basavarajappa, 2009). Data on various variables as enlisted by Roubik (2006) for the study of nesting biology of stingless bees were recorded.

Nesting site

Regular surveys were done in the study area and nests of *T. iridipennis* were searched visually around human-made structures including residential buildings, educational buildings and roadsides and natural vegetation including trees and shrubs. The data was also recorded on nesting in either brick or stone walls.

Nest aggregation

Data was recorded visually on twenty-eight different sites, walls of residential buildings, accommodating 48 live colonies of stingless bees to know the aggregation of *T. iridipennis* colonies.

Height from the ground level

The height of a colony was recorded with the help of a measuring tape, but when a colony was too high to observe, black markings were recorded to locate the colony (Fig. 1). These black markings, usually present on brick walls, were associated with the presence of a colony. After that, the location was ascertained through the observation of bee movement. The height of such colonies was measured by counting the number of brick lines and multiplying it by the average height of a brick line. Observations were also taken on the occurrence of *T. iridipennis* colony with the ant or termite nests.

Fig. 1. Black markings associated with the *Tetragonula iridipennis* nests.

Nest orientation

Nest orientation was recorded using a standard compass. The direction of the opening of the entrance tube of each colony was recorded.

Entrance tube character and structure

The observations of an entrance structure's, shape, colour and material were recorded. The measurements of the entrance tube's length and orifice were also recorded. A total of

twenty-six colonies (only those which were in reach) were observed. Observations were also recorded of the number of entrances per tube and the presence of any defensive structure deployed at the entrance.

Colony defence behaviour

The number of guard bees present at the entrance gate during different time intervals of a day was also recorded and then averaged.

Nest architecture

The nest architecture of only those colonies present in the trees was studied because it was not possible to break open brick or stone wall with a nest inside. Four colonies were retrieved from the mulberry trees. The hollow stems containing *T. iridipennis* colonies were cut and opened carefully with the help of chisel and saw. Such observed aspects of nest architecture as the placement of brood and food stores, size and shape of brood and food cells, pillars size and shape were recorded. Afterwards the whole content of a nest was transferred in a mating nucleus of *Apis mellifera* Linnaeus.

Overwintering success

A layout was made depicting the placement of the colonies. Monthly observations were recorded for a year to know the overwintering success. This was ascertained only through the recording of bee activity at the entrance.

Data analysis

The collected data were compiled for various variables and wherever necessary. A general descriptive analysis was performed while the Z-test was employed to determine variations in colony characteristics and dimensions.

RESULTS

Data recorded on various aspects of nest-site preference are summarized in Tab. 1. The details are given as follows:

Nesting site

Nests were usually concealed inside the hollows of tree trunks or cracks in the cemented

Table 1.

Colony characteristics of *T. iridipennis*

Parameters	No. observed (n)	Result
Nesting site preference	60	Brick walls (86.67%) Hollow tree trunks (13.33%)
No. of colonies per nesting site	28	1 Single colony (46.43%) 2 Two colonies (32.14%) 3 Three colonies (10.72%) 4 Four colonies (7.14%) 5 More than four colonies (3.57%)
Height from the ground level	60	Modal height = 3.50m
Nest orientation	60	1 E-facing (54.67%) 2 W-facing (21.67%) 3 S-facing (15.00%) 4 N-facing (6.67%)
Entrance tube size (longer x shorter side diameter x protruding tube length)	60	Brick walls (11.62x11.73x14.04 mm) Tree trunks (17.00x 13.00x35.80 mm)

Sig. as
p=0.0008
at p=0.05

Sig. as p=0.02
at p=0.05

No. of colonies per nesting site: Pair wise (1&2, 2&3....) values are statistically at par ($p=0.05$) with each other
Nest orientation: Values of pair 1&2 are statistically different while the rest pairs (2&3 and 3&4) are at par ($p=0.05$) with each other

brick/stone walls of residential and educational buildings (Fig. 2). The nesting habits of sixty stingless bee colonies were observed in Ludhiana. Of these, eight colonies (13.33%) were found in the hollows of tree trunks. Hollow *Morus* sp. tree trunks (Fig. 3) were most preferred (07 colonies observed) while only one was observed in a *Cassia* sp. tree trunk (Fig. 4).

A statistically higher number of colonies (Z-test: $P=0.0001$), fifty-two colonies (86.67%), were observed nesting in walls, and of these ten colonies (19.23%) were observed in stone walls and the remaining (80.77%) in brick walls.

Nest aggregation

Data revealed that at the majority of sites,

Fig. 2. *Tetragonula iridipennis* colony in brick wall.

Fig. 3. *Tetragonula iridipennis* colony in mulberry tree trunk.

Fig. 4. *Tetragonula iridipennis* colony in Cassia tree trunk.

there was a single bee colony (13 sites; 46.44%), followed by two colonies per site recorded at nine different sites (32.14%). A few sites had three colonies (03 sites; 10.71%), whereas two sites had four colonies, each (7.14%). At one site, there were more than four colonies (3.57%). Significantly higher per cent aggregation (78.57%; Z-test $P=0.0008$) was recorded for combined aggregation of one and two colonies as compared to others. Hence, mostly one or two bee colonies were established per site. The minimum and maximum distances the between two nearest colonies were 12.5 cm and 900 cm, respectively.

Height from the ground level

No bee nest was observed associated with termite or ant or wasp colonies. The lowest height of the bee nest observed from the ground was 0.75 m. The modal value for this parameter was 3.50 which showed that most of the *T. iridipennis* colonies were located at 3.50 m height, though these were spotted from

0.75 m to 6.32 m in height from the ground. The average height of the colonies inhabited in natural cavities in tree trunks was 1.85 m (0.75-4.80 m), whereas colonies inhabited in walls were observed at the mean height of 3.60 m (1.20-6.32 m).

Nest orientation

Data on the orientation of the bee colonies revealed that significantly the higher number of colonies (34; 54.67%; Z-test, $P=0.02$) preferred making a nest entrance facing east followed by those who made an entrance facing west (13; 21.67%). The rest of pairs showed the values at par with each other. South-facing and north-facing entrances were favoured respectively by only 15.00 and 6.67% of colonies.

Entrance tube character and structure

Only a single distinct entrance tube per colony was observed in all the colonies but its size and shape varied among the colonies. Observations of twenty-six easily assessable colonies revealed that the colony entrance was made up of resin. Although the newly built entrance was soft and light brown in colour, it retained its shape in various seasons. The colour of the entrance tube turned darker and became rigid with the passage of time. The entrance tube orifice was somewhat circular in only a few cases, and elliptical in the majority of them. Nocturnal closure of the entrance, mentioned by Roubik (2006) as a defensive character prevalent in *Tetragonisca* sp. in which the entrance was closed at night by a network of fine thread, was not observed.

Data showed that seven colonies (26.92%) nested in brick/ stone wall structures lacked a distinct entrance tube which appeared as a rim of less than 2 mm height. The remaining colonies were noticed to have a distinct entrance tube with the average entrance tube dimensions (longer side diameter x shorter side diameter x protruding tube length) of 11.62 x 11.73 x 14.04 mm. Four colonies were observed to inhabit hollow tree trunks, and the average dimensions of the entrance tube (longer side diameter x shorter side diameter x protruding tube length)

were 17.00 x 13.00 x 35.80 mm.

Colony defence behaviour

Concealment of the nests inside tree trunk or wall cracks, nest aggregation and a sufficient height above ground may provide defence against robbers and enemies. In addition, guard bees (average 7.5 bees) were also observed at the entrance gate. No defensive biting behaviour toward the observer was observed, as the bees were timid and retreated within the entrance upon mild disturbance. However, when a colony of *T. iridipennis* was cut open, these bees showed defensive behaviour by grappling the robber *A. mellifera* bees and biting the soft tissues of other intruders.

Nest architecture of stingless colonies

The architecture of the colonies nested in hollow tree trunks (mulberry) were studied when the hollow mulberry tree trunks were carefully opened longitudinally with the help of a large-toothed saw and chisel (Fig. 5). The hollow tree trunks were found to be lined with a thin-layer of batumen. Brood cells, honey and pollen pots did not follow a set sequence inside the cavity. In one of the colonies, brood cells were recorded just behind the entrance gate, whereas in another colony, pollen pots were present next to the entrance. However, the brood area in all the colonies was surrounded largely by pollen pots and a few honey pots. Colony length varied between 17.9 and 89.0 cm corresponding to colonies IV and I, respectively (Tab. 2), while colony IV had the smallest size as there was no queen bee or brood there. Pollen pots in these colonies occupied 10.0 to 42.0 cm of cavity length, but the thickness of the rind surrounding the pollen area was 3.0-6.5 cm. Honey pots were present in a cavity of 4.4 to 47.0 cm length. The cavity diameter ranged between 3.0 and 7.2 cm and rind thickness surrounding the cavity between 3.5 and 7.5 cm. The shortest brood length in cavity was 12.5 and the longest 22.0 cm; the diameter of the latter ranged between 4.0 and 10.0 cm. The plant rind surrounding the brood area was between 6.0 and 8.0 cm thick.

The mean dimensions (length x width) of brood cells, honey pots and pollen pots all differ significantly from one another- 2.79 x 2.62 mm, 5.33 x 4.52 mm and 6.93 x 5.19 mm, respectively (Tab. 3). The lower most layer of brood cells was supported by the pillars made of soft cerumen, which measured 2.83, 0.91 and 1.46 mm in height, width and base, respectively. On these pillars, the cells were joined together with spaces in between (voids) as a free passage for the workers. The average distance between two distant cells separated by void was 1.96 mm (1.01-3.14 mm).

Over-wintering success under natural habitat

Fig. 5. Retrieving a *Tetragonula iridipennis* from mulberry tree trunk.

The sixty colonies were observed weekly for bee activity at the entrance gate during the winter season prior to the onset of autumn and spring seasons, starting in November and up to March. All the colonies, whether in brick/stone walls or in hollow tree trunks, overwintered successfully. Foraging by the colonies ceased during the second week of December and resumed during the second week of February when mustard (*Brassica juncea* and *Brassica campestris*) was in bloom. During the winter period from the end of December to the first week of February, the colonies appeared to be deserted and almost no foraging activity was recorded. However, on some sunny days in the last week of January bees were observed at the gates of some of the south-facing colonies

Table 2.

Characteristics of *Tetragonula iridipennis* colonies in hollow tree trunks of mulberry

Character	Parameter (cm)	Mean size (cm) of different parameters in different colonies				Mean /range
		Colony I	Colony II	Colony III	Colony IV	
Colony size	Cavity length	89.0	70.0	33.0	17.9	52.5±18.9
	Cavity length	20.0	42.0	10.0	13.5	21.4±8.3
Pollen pots location	Cavity diameter	3.0-7.5	6.2-7.5	7.0-7.5	3.5	3.0-7.5
	Thickness of plant rind forming cavity	3.0-5.0	3.5-4.5	5.0-6.5	4.0-4.5	3.0-6.5
Honey pots Location	Cavity length	47.0	9.2	6.0	4.4	16.7±11.8
	Cavity diameter	3.0-4.0	5.5-6.0	7.2	4.8	3.0-7.2
Brood cells location	Thickness of plant rind forming cavity	4.5-7.5	3.5-4.0	6.0-7.0	3.5-4.0	3.5-7.5
	Cavity length	22.0	12.5	19.0	---	17.8±2.8
Brood cells location	Cavity diameter	4.0-6.0	5.0-10.0	7.5	---	4.0-10.0
	Thickness of plant rind forming cavity	6.0-6.5	6.0-7.5	6.0-8.0	---	6.0-8.0

Values following ± sign are S.E. mean

exposed to sunlight. Previously, stingless bees had been thought to be generally accustomed to only a tropical climate, but their existence in the Punjab subtropical conditions with extreme summers and winters revealed that this species

adapts to extreme climatic conditions and cease foraging only in extreme winters.

Table 3.

Dimensions of different components of nest constructed by *Tetragonula iridipennis* in hollow tree trunks of mulberry

Component of nest	Number observed (n)	Mean size (mm)*	
		Length	Width
Brood cells size	10	2.79±0.06 ^a (2.57-3.16)	2.62± 0.04 ^a (2.42-2.79)
Honey pots size	10	5.33±0.09 ^b (4.97-5.89)	4.52±0.08 ^b (4.11-4.92)
Pollen pots size	13	6.93±0.40 ^c (4.73-9.73)	5.19±0.20 ^c (4.24-6.26)
Pillars	10	Height 2.83±0.24 (2.21-4.69) Girth 0.91±0.08 (0.70-1.47) Base 1.46±0.14 (0.76-2.18)	
Voids	3	1.96±0.16 (1.01-3.14)	

* values in the parenthesis are the range values
values bearing similar alphabets are statistically at par with each other
values following ± signs are S.E. mean

DISCUSSION

For social insects, the nest providing essential physical protection against environmental perturbations and enemies/robbers. In addition, nests are favourable for brood rearing as bees usually prefer stable temperature regimes which are met in a closed structure, i.e. nests through homeostasis. In the present studies carried out in Punjab's Central plain zone of, cracks/ cavities in brick walls were the most preferred place for *T. iridipennis* nesting (86.67%). In South-India, Danaraddi et al. (2009) from Dharwad and Basavarajappa (2010) from Mysore also observed cracks/cavities in brick walls to be preferred site for nest construction (70.59 and 78.79%, respectively). Pavithra et al. (2013) from Bengaluru also reported brick walls to be the preferred substrate, but it was comparatively lower (29.41%) than our results and those from earlier studies conducted in the same region.

Nesting in hollow tree trunks was lower (13.33%) than in old walls, and in line with this, low occupancy in tree cavities was observed in Mysore (Karnataka, India) (Basavarajappa, 2010). In contrast, a higher proportion of nesting in tree cavities (29.41%) was reported from Dharwad (Karnataka, India) (Dannaraddi et al. 2009); this however, may result from a small sample size (n=17) that could skew the percentage. Mulberry (*Morus* sp.) was the most preferred by *T. iridipennis* for nesting under the Punjab conditions, since nesting was recorded in *Cassia* sp. only once. However, Bhatta et al. (2019) reported *Shorea robusta* (Roth.) to be most favoured under Nepal conditions, which could be due to differences in botanical diversity prevailing at various locations. Besides this, among the various tree species in the present location, *Morus* spp. has larger natural cavities in their trunk due to which the bee might prefer. Similarly, two other species of the genus, *Tetragonula*; *Tetragonula fuscobalteata* Cameron and *Tetragonula sapiens* Cockerell were reported to prefer to nest in bamboo stems in the Philippines (Starr & Sakagami, 1987).

In our studies, no aggregation of stingless colonies was observed, i.e. there was only one

colony at a particular site (46.43%), but there was still an equal probability to find more than one colony at a particular site. Danaraddi (2007) also recorded only one colony per site in the majority of the cases (91.61%). Nest aggregations usually occur among solitary bees which burrow in the soil; however, to a certain extent under specific conditions this character is also manifested by *Apis dorsata* Fabricius and a few species of *Trigona*. Though the factors responsible for nest aggregation are still not elucidated, limitations in habitats, edaphic (in soil nesting bees) and light factors are the major ones (Michener, 1974).

The average height of colony from the ground was recorded to be 3.50 m (0.75-6.32 m); about the same average height of colony from the ground, 2.80 m (ground level - 6 m), 2.23 m and 3.0 m (maximum value) were also reported by Pavithra et al. (2013), Danaraddi et al. (2009) and Bhatta et al. (2019), respectively. Basavarajappa (2010) observed the height in the range of 0.15-7.5 m (mean 3.82 m) from India's Mysore district. However, the mean height reported by Raju (2009) was up to 1 m over the ground. Pavithra et al. (2013) reported a northward direction to be the most preferred (17%), whereas in the present studies it was the least preferred (6.67%). This could be due to the difference in weather conditions at the two locations. As stated earlier, the current location is characterized by a subtropical semi-arid type climate while the other one possesses a typical tropical type climate. Hence, to counter severe winters, this bee species may have selected this orientation to tap maximum sunshine.

The dimensions of the entrance tube of *T. iridipennis* (11.62 x 11.73 x 14.04 mm) recorded in the present studies were in between the entrance tube dimensions reported for *T. fuscobalteata* (15.0 x 09.0 x 11.0 mm) and *T. sapiens* (20.0 x 05.0 x 13.0 mm) by Starr & Sakagami (1987). Pavithra et al. (2013) reported a similar size and shape of the preferred nest opening/entrance tube size, i.e. 8.0-14.0 mm with an oval shape. Danaraddi et al. (2009) reported a mean length x width of entrance tubes of colonies in tree trunks to be 108.80 x

5.08 mm and in walled structures to be 96.55 x 3.32 mm, which were larger than those recorded in the present studies.

In our studies, the arrangement of various cells/pots was not rigid but the brood area was surrounded by pollen and honey pots which would have been provisioned purposefully in the vicinity of the developing stages to facilitate easier food availability for a bee upon emergence. Danaraddi et al. (2009) also observed that the brood cells were arranged in clusters and surrounded by pollen and honey pots. In the present study, the colony occupied a cavity length of 17.9-89.0 cm, which was comparatively larger than recorded by Danaraddi (2007) and Roopa (2002) as 4.7-32.5 and 21.0-37.5 cm, respectively. The differences might be due to the cavities of other tree species occupied by bees for nesting. Moreover, the climatic conditions in such localities may facilitate rapid growth of the colonies and result in the issuance of more swarms which resulted in smaller colonies. In the Philippines Starr & Sakagami (1987) found *T. fuscobalteata* and *T. sapiens* to have nests in a bamboo cavity with a capacity of 0.7-3.0L with interspersed honey and pollen pots. The brood cells were arranged in clusters and not surrounded by involucre similar to that recorded in the present findings. Brood cells were comparatively spherical (2.79 x 2.62 mm) and little bit larger than those reported (2.14 x 1.70 mm) by Danaraddi (2007), whereas, their placement and general appearance were alike. The void's linear dimension (1.96 mm) facilitated easy movement of *T. iridipennis* workers, whose head, thorax and abdomen width as reported by Makkar et al. (2016) were 1.605, 1.144 and 1.162 mm, respectively. The colour of pollen pots was yellowish-brown and their size was similar to that reported by Danaraddi (2007) i.e. 7.26 x 4.49 mm. The pollen loads were compactly filled in the pots. The pollen pots were erected alongside the honey pots. The honey pots were dark brown in colour and comparatively smaller than pollen pots. Comparatively larger honey pots were reported (7.73 x 5.04 mm) by Danaraddi (2007). All these conditions may have favoured *T. iridipennis* to

have perennial colonies and overwinter successfully under Punjab conditions. Thus, the data presented in this paper will form a basis for the development of strategies for easy locating and retrieving feral colonies from hollow plant stems and re-hiving them in suitable structures capable of providing all the necessary conditions. This way the artificially reared smaller movable colonies of this bee will help in their easy translocation from one place to other which is required for managed bee pollination.

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