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Arshad Shaikh
M.Sc. Scholar, Department of Agricultural Entomology, College of Agriculture, Dapoli, Maharashtra, India

Santosh Wankhede
Scientist (Entomology), Regional Coconut Research Station, Bhatye, Ratnagiri, Maharashtra, India

Sameer Kale
Assistant Professor, Department of Agricultural Entomology, DBSKKV, Dapoli, Ratnagiri, Maharashtra, India

Arfa Ainarkar
M.Sc. Scholar, Department of Floriculture and Landscape Architecture, College of Horticulture, Dapoli, Maharashtra, India

Sayali Mali
M.Sc. Scholar, Department of Agricultural Entomology, College of Agriculture, Dapoli, Maharashtra, India

Corresponding Author:
Arshad Shaikh
M.Sc. Scholar, Department of Agricultural Entomology, College of Agriculture, Dapoli, Maharashtra, India

Nesting structure and biology of stingless bee, *Tetragonula* nr. *pagdeni* in Konkan region of Maharashtra

Arshad Shaikh, Santosh Wankhede, Sameer Kale, Arfa Ainarkar and Sayali Mali

Abstract
The Nesting structure of stingless bee indicated that the average brood cell height was recorded 1.93±0.08 mm and width of 2.13±0.05 mm. The queen cell was larger than the worker cells. Soft cerumen was used to make the pollen and honey pots. The mean height and breadth of oval-shaped pollen pots were 5.69±0.56 mm and 4.50±0.21 mm, respectively. Entrance tube length and width were recorded 1.63 mm and 0.93 mm respectively. However internal cavity length and height were found 10.6 cm and 34.6 cm, respectively. The honey pots were oval, dark brown and slightly bigger than the pollen pots. The mean height and breadth of honey pots were 6.75±0.4 mm and 5.52±0.3 mm, respectively. It requires 38.2±1.48 days to complete the biology of stingless bee *Tetragonula* nr. *pagdeni* from egg laying by the queen to the emergence of the adult from brood cells. Development of larvae from eggs required 6 to 7 days. With continued growth in age, the length and width expanded. the larval period lasted between 14 and 16 days with a mean of 15.1±0.74 days. The pupal stage lasted 18.7±0.82 days before the adult stage appeared. Exarate type pupa is found and it is creamy white in colour. From egg to adult, the complete growth process took 38.20 days. The mean length and width of the egg was noticed 0.83±0.03 mm and 0.33±0.03 mm, respectively. The larvae were creamy white, apodous and C-shaped. The 1-day old larva was measured 1.06±0.05 mm in length and 0.25±0.01mm in width.

Keywords: Nesting structure, biology, stingless bee, *Tetragonula* nr. *pagdeni*

Introduction
Apiculture is the practice of raising honey bees for honey production and as pollinators for various crops. Despite the fact that honey bees produce excellent honey, there is always the risk for untrained bee keeper about honey bee attack when growing them (Shaikh *et al*. 2022) [9]. However, there are some honey bees that do not bite and are referred as stingless bees. It is tiniest honey-producing bees found in electric pipe, plumbing pipe, live and dead tree trunk, crevices in window, door, wall etc. (Wankhede *et al*. 2022) [11]. The sting of these bees is usually reduced. Stingless bees are highly eusocial, with various specialized characteristics such as large permanent colonies, extreme caste differentiation, inability of queens to form solitary nests, complex nest architecture, communication systems, large food storage and highly effective thermoregulation. However, because of their limited range in the tropics, the biology of stingless bees has received significantly less attention than that of other honey bees (Sakagami 1982) [4]. The practice of keeping stingless bee is known as meliponiculture, become popular due to good quality of honey and propolis produced by stingless bee. The meliponiculture has grown in response to scientific research that showed enormous benefits of honey and propolis, not only in medical sectors but the products become ingrained in many socio-cultural norms of several societies, serving as food, medicine, ritualistic component and commercial commodity (Puteri *et al*. 2022) [2]. Stingless bees are taxonomically different from Apis bees. A thorough understanding of reproductive biology of stingless bees is essential for proper colony multiplication and development of husbandry techniques (Prabhu, 2008) [1]. However, the interest of keeping stingless bees is increasing because keeping the stingless bees are more profitable (Trianto and Purwanto, 2020) [10]. Hence, present work was carried out to identify the species of stingless bees in Konkan region and generate more information on the nesting structure and biology of the stingless bee.

Material and Methods

An experiment was conducted near Biocontrol unit of Department of Agricultural Entomology, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. The colonies of stingless bees are harvested from its natural habitat (Wankhede *et al*. 2022) [11] and specimens of bees were sent to NBAIR for species Identification. Thus, male bees with correctly associated female bees were sent to Dr. Shashidhar Viraktamath, Emeritus Scientist, NBAIR, and it is revealed that the species found in Konkan region is identified as Teragounla nr. pagdeni that means they are similar to Tetragonula pagdeni (Schwarz 1939) [8]. The biology and nesting structure of stingless worker and its nesting structure was studied. Observations were taken from egg to adult emergence. It includes the duration of the egg, larval and pupal period.

Egg period: The egg period was determined by observing the changes in uncapped cells from oviposition to egg hatching. For this purpose, the brood cell was marked with ink and brood cells were uncapped and dissected every day at the rate of 10 cells per day and was observed till the egg hatched. Length, width, diameter, shape and colour were observed under the Dino-lite digital microscope with definite magnification. Larval period: The larval period was determined by again dissecting the marked brood cells at intervals and also by observing the exhaustion of brood food and the changes in colour of brood cells from brown to creamish white, which gives a transparent look and indicates the completion of the larval period (Roopa, 2002) [13]. Length, width, diameter, shape and colour were observed under the Dino-lite digital microscope with definite magnification. Pupal period: The pupal period was determined similarly, from the spinning of the cocoon by the matured larva till adult emergence. Exarate type pupa is found and it is creamy white in colour. Total development period: The period from egg laying to the emergence of adult was recorded, calculated the total development period and thus average total developmental period was recorded.

Results and Discussion

Nesting structure of stingless bee

The nesting structure build by stingless bees were presented in table 1. It is revealed that brood chambers of stingless bee, *Tetragonula* nr. *pagdeni* were built on pillars supported with resinous material at the bottom of the hive in clusters or like bunches of grapes and also were oval in shape and resembled jowar grains. Each brood cell had two to three external connections that connected it to the cell next to it. The newly created brood cells were dark brown, which later turned lighter in colour as pupal cells were creamy white in colour. Once an adult bee emerged from the brood chamber, the brood cell was destroyed and removed from the colony. This ensures that each brood cell is only ever used once by these bees. The size of brood cells was less than that of feeding pots. The data regarding nesting biology of stingless bee indicated that the average brood cell height was recorded 1.93±0.08 mm and width of 2.13±0.05 mm. The queen cell was larger than the worker cells. Soft cerumen was used to make the pollen and honey pots. The mean height and breadth of oval-shaped pollen pots were 5.69±0.56 mm and 4.50±0.21 mm, respectively. The pollen pots were closed after being properly filled with pollen particles. Only a few pots that were meant to store arriving pollen were formed open. The stored pollen had a sour taste and was a little wet. The honey pots were oval, dark brown and slightly bigger than the pollen pots. The mean height and breadth of honey pots were 6.75±0.4 mm and 5.52±0.3 mm, respectively. Similar to pollen pots, honey pots were also sealed once the honey was fully mature. The eggs of stingless bee, *Tetragonula* nr. *pagdeni* are whitish, translucent and cylindrical in shape, with a broader end at one side. The egg is laid in the centre of a provisioned brood cell. The position of a freshly laid egg can be vertical or horizontal inside the brood cell. The mean length and width of the egg was noticed 0.83±0.03 mm and 0.33±0.03 mm, respectively. The larvae were creamy white, apodous and C-shaped. The 1-day old larvae was measured 1.06±0.05 mm in length and 0.25±0.01 mm in width. The width of larvae was found to decrease due to the expansion of eggs and a change in their shape. The length and width increased with further development in the age. The results are in agreement with Rakhee (2000) [3] who observed that the average dimensions of worker brood cells were 0.22 mm in diameter and 0.33 mm in height. The length and width of the entrance tube measured was 20 mm in length, 18 mm in width and the total length of the tube including the accessed tube that connected with the nest measured 70 mm. Similar results were reported by Sangma (2022) [7]. The size of queen cells was larger than that of worker cells. In their early stages, brood cells were dark brown in colour. The pollen and honey cells often have an oval shape. Brood chambers were larger than the storage pots.

Biology of stingless bee

The biology of stingless bees at the egg, larval and pupal stages are presented in table 2. It is observed that, it requires 38.2±1.48 days to complete the biology from egg laying by the queen to the emergence of the adult from brood cells. Development of larvae from eggs required 6 to 7 days with an average of 6.3±0.48 days. With continued growth in age, the length and width expanded. the larval period lasted between 14 and 16 days with a mean of 15.1±0.74 days. It takes a larva 18-20 days to pupate. The pupal stage lasted 18.7±0.82 days before the adult stage appeared, hence the pupal stage typically lasted 18 to 20 days. From egg to adult, the complete growth process took 38.20 days, with an average of 6.3±0.48, 15.1±0.74 and 18.7 days during the egg, larval and pupal stages. The present study is in conformity with Salmah *et al*. (1987) [5] who revealed the mean total development time from oviposition to the emergence of adult workers of T. moorei was 46.5 days. This includes 5.5 days for egg development, 10 days for larval development and 31 days for pupal development, respectively. Similar results were reported by Wittaman *et al*. (1991) [12] who reported that T. itama takes 46.50 days from oviposition to the emergence of adult workers, with the egg, larval and pupal phases taking 4.20 days, 10.40 days and 31.90 days, respectively. Salmah *et al*. (1996) [6] again studied the incubation period of stingless bee, studies have shown that the egg, larval and pupal stages of T. itama development takes 4, 10 and 31.90 days, respectively, with a mean total period of 46.50 days. Our reports were in confirmatory with the findings of Rakhee (2000) [3] who concluded that the egg took 4.7 days to hatch. The larva in the cell acquired a horizontal posture after hatching. The 'C' shape larvae were visible in the later stages. The larva required an average of 18.6 days to pupate. The pupa takes an average of 21.8 days to mature into an adult. Thus, in Trigona iridipennis Smith, the average duration from egg to adult was 45.1 days.

Table 1: Nesting structure of stingless bee, *Tetragonula* nr. *pagdeni*

Sr. No	Parameters	Length (mm) ±S. D	Width (mm) ±S. D	Height (mm) ±S. D	Shape	Colour	Location
1	Egg	0.83±0.03	0.33±0.03	NA*	Cylindrical	Creamish White	Centre of brood cell
2	Larvae (1 day old)	1.06±0.05	0.25±0.01	NA	'C' Shape	Crystal White	Centre of brood cell
3	Brood cell	NA	2.13±0.05	1.93±0.08	Oval	Dark Brown	Corner of the hive
4	Honey pots	NA	5.52±0.3	6.75±0.4	Oval	Blackish Brown	Near to brood cells
5	Pollen pots	NA	4.50±0.21	5.69±0.56	Circular	Orange	End point of entrance tube
6	Entrance tube	1.63	0.93	-	Not Specified	Blackish	Outside of habitat cavity
7	Internal Cavity	NA	10.6 cm	34.6 cm	Round	Dark brown	Wood, iron poles, walls, wood cavity etc.

* Because of the spherical nature of brood cells, honey pots and pollen pots length could not be measured.
*NA: Not available

Table 2: Biology of stingless bee *Tetragonula* nr. *pagdeni*

Developmental period in days				
No. of broods	**Egg**	**Larva**	**Pupa**	**Total duration**
1	6	14	18	38
2	6	14	18	38
3	6	15	18	39
4	6	15	18	39
5	6	15	18	39
6	6	15	19	40
7	6	15	19	40
8	7	16	19	36
9	7	16	20	36
10	7	16	20	37
Range	6 -7	14 - 16	18 - 20	36 - 40
Mean±S.D.	6.3±0.48	15.1±0.74	18.7±0.82	38.2±1.48

Plate 1: Nesting structure of stingless bee, Tetragonula nr. pagdeni

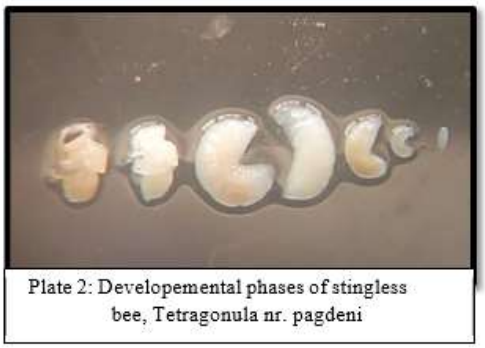

Plate 2: Developemental phases of stingless bee, Tetragonula nr. pagdeni

Plate 3: Biology of stingless bee

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