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Coconut shell traps: easiest and economic way to attract stingless bees (*Tetragonula iridipennis*) Smith

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Abstract

The trap occupancy rate and colony development parameters of swarms of stingless bee, *Tetragonula iridipennis* in coconut shell traps was studied in the research farm of ICAR-National Bureau of Agricultural Insect Resources (NBAIR) Bengaluru, Yelahanka campus Karnataka, India. The trap occupancy rate by the stingless bees was 44.87% in a time period of 13.40 ± 4.38 days. New cells were constructed by the bees in 12.10 ± 2.13 days. The number of honey and pollen pots filled was 15.60 ± 3.92 and 6.61 ± 2.95, respectively. The brood cells were constructed 89.50 ± 6.07 days after acceptance of the shell traps with an average of 67.70 ± 20.83 brood cells per trap. The foragers preferred foraging for nectar, resin and pollen during the 15, 30 and 45 days, respectively, after acceptance of the coconut shells for nesting. Coconut shell traps are easiest and economic way of trapping the swarming population of stingless bees.

Introduction

Stingless bees *Tetragonula iridipennis* (Apidae: Hymenoptera), are eusocial, corbiculate with perennial colonies, polylectic, no/rudimentary sting, amenable for conservation and colony maintenance, forager recruitment behaviour, ability to store more food resources in hive unlike honeybees (Roubik, 1984; Leonhardt et al., 2007; Kumar et al., 2012). They construct their nests in hollows of tree trunks, stone walls, mud walls, corners of walls, crevices, termite mounds and other concealed places with proper insulation (Muthuraman & Thirugnanasambantam, 2003; Rasmussen & Camargo, 2008; Suriawanto et al., 2017). Stingless bees are reported to be efficient pollinators of many crops like sunflower, strawberry, cherry tomato, cucumber, egg plant and sweet pepper and could be viably utilised for pollination of crops grown under protected cultivations (Free, 1993; Slaa et al., 2000; Nicomedo et al., 2003; Del Sarto et al., 2005; KishanTej et al., 2017). The maintenance of colonies of stingless bees in different structures viz., mud pots, arecanut culms, bamboo culms and box hives were well studied under Indian conditions. Different hive structures viz., mango wood hive, bamboo stem hive and box hives also been studied for their efficacy (Karthick et al., 2018).

Reproduction of stingless bees occurs through swarming that starts with the location of new nesting site by the scout bees (Sommeijer et al., 2013). Swarming occurs in a gradual phase in stingless bees when few of the workers fly out to locate a new nesting site. After locating the new site, the foragers start building the nest by transporting the materials from the mother nests, actively forage for resources and build the storage pots in the new nest (Engels & Imperatriz-Fonseca,

1990). Nests found by swarming process will be of perennial nature usually founded by sterile workers and queen (Roubik, 2006). Installation of traps is reported to be a viable method to trap the swarms of different species of stingless bees like *Scaptotrigona* sp (Alvarenga, 2008), *Tetragonula angustula* (Malkowski et al., 2006) and *Plebeia nigriceps* (Witter et al., 2007). Oliveira et al. (2012) reported the trapping of 61 swarms of nine different stingless bee species in large plastic containers of 3 litre capacity coated with wax and propolis extract. Inoue et al. (1985) reported foraging of 70-80%, 10-20% and < 10% percent of three species of stingless bees for nectar, pollen and resin material, respectively, from disturbed forest areas in Sumatra, Indonesia. Dispersion of colony resources in the hive is a significant factor in the nesting biology of stingless bees (Nogueira-Neto, 1997). Unlike honeybees, the swarming behaviour in stingless bees in less explored and there is a paucity of data in the traps used for attracting the swarms. Utilisation of different trap nests for stingless bees is practised in some parts of Kerala (India). However, there are hardly any published reports on the use of empty coconut shells to attract the swarms of stingless bees and colony development parameters under Indian conditions. The present study was designed to understand the nesting characteristics of swarming foragers, colony development and foraging behaviour of stingless bees in empty coconut shells.

Materials and Methods

Study site

The present study was carried out in the experimental farm of ICAR-National Bureau of Agricultural Insect Resources (NBAIR) Bengaluru, Yelahanka campus (13.096792 N, 77.565976E) from April 2020 to March 2021. The study area comprised cultivated croplands with various annual crops like cereals and pulses, orchard blocks of mango, sapota, and cherimoya. Also, there were two patches of pollinator gardens of about 1.5acres with over 100 plant species of diverse plant families. This research campus is situated right in the heart of a rapidly growing high-tech-city and capital of the southern Indian state of Karnataka. The mean maximum and minimum temperature during the flowering period were 27.8 °C and 19 °C, respectively, with rainfall of 51.4 mm. We maintained a two years-old strong colony of *T. iridipennis* in the study site.

Preparation of Coconut shells

Used empty coconut shells (split into half) of uniform size (approximately 100-110mm of inner diameter and total height of 110-120mm) were collected from the households of Bengaluru were employed for the study. Holes if any observed in the shells were plugged using the propolis obtained from the nests of *T. iridipennis*. In the lower half of the shell, a hole (5 mm diameter) was made using hand drill and a flexible rubber tube of 2 cm length was fitted inside the hole in such a way that half of the of the tube protruded out. A thick layer of bee propolis and resin mixture was applied at the outside the protruding end of the tube to attract the swarming bees to the nest. Later the two halves of the coconut shell were joined together tightly using cellotape so that they could be separated for observation of the colony over time. We installed 25 traps in close proximity of the foragers and observed for the acceptance of these traps. The traps were tied singly and fastened using galvanized iron wire on to a stand. The nest site seeking foragers of *T. iridipennis* were observed near the study site. Observations on the number of days taken by the bees to occupy the shells was recorded. The occupancy of the shell traps by the bees was confirmed by observing the foragers entering the shell through the nest entrance. The occupied shell traps were monitored on weekly basis by gently opening the two halves of the shell trap to observe the colony establishment and construction of storage pots and brood cells. The number of days taken to construct new cells, brood cells and storage pots were recorded. The density of brood cells, density of pollen and honey pots per three fourth of cubic inch was measured after construction of the cells by the bees. The length and width of pollen and honey pots was also recorded.

After establishment of the colonies, the foraging trips of the bees was recorded for a period of five days. The number of bees entering the nest and departing bees per hour was recorded from 8.00 AM till 6.00 PM. The reward carried by the foragers to the nest viz., mud, pollen and resin was also recorded. The foraging preference of the founding bees for different resources viz., pollen, nectar and resin in the just accepted nests was recorded at 15, 30 and 45 days after the nest acceptance.

Results

Colony development parameters

The colony development parameters of stingless bees in the coconut shell trap are presented in Table 1. Out of the 25 traps of coconut shells installed, 11 traps were successfully accepted by the swarms with an average trap occupancy rate of 44.87%. The coconut shell traps were accepted by the stingless bees in a time period of 13.40 ± 4.38 days. The time taken for the construction of new cells was 12.10 ± 2.13 days. Storage pots appeared egg shaped, honey pots were dark brown in colour, pollen pots pale were yellow in colour arranged in clusters. The number of days taken to construct the storage pots was 7.50 ± 3.06 days. The number of honey and pollen pots filled was 15.60 ± 3.92 and 6.61 ± 2.95, respectively. Brood cells appeared elliptical in shape, surrounded by sheaths of bitumen with multiple layers of wax and cerumen. Newly formed broods appeared dark brown in colour and matured brood cells turned pale yellowish white in colour. The length and width of brood cells was 4.40 ± 0.52 mm and 2.90 ± 0.21 mm respectively while that of honey pots was 6.79 ± 0.35 and 6.35 ± 0.67 respectively. The brood cells

Table 1. Colony development parameters of *Tetragonula iridipennis* in shell traps.

Parameters	Mean ± SD
Number of days taken for acceptance of the shell traps	13.40 ± 4.37
Trap occupancy rate	44.87%
Number of days taken for construction of new cells after acceptance	7.50 ± 3.06
Number of days taken for initiation of filling of storage pots	29.23 ± 8.97
Number of honey pots observed after initiation of filling of storage pots	15.60 ± 3.92
Length of honey pots	6.79 ± 0.35 mm
Width of honey pots	6.35 ± 0.67 mm
Number of pollen pots observed after initiation of filling of storage pots	6.63 ± 2.95
Length of pollen pots	5.83 ± 0.91 mm
Width of pollen pots	4.04 ± 0.53 mm
Number of days taken for construction of brood cells	89.50 ± 6.07
Density of brood cells / three fourth cubic inch	67.71 ± 20.83 cells
Length of brood cell	4.42 ± 0.51 mm
Width of brood cell	2.92 ± 0.21 mm

were constructed 89.50 ± 6.07 days after acceptance of the shell traps. On an average, the bees constructed 67.70 ± 20.83 brood cells per trap.

Foraging behaviour of the bees

During the initial 15 days after acceptance of the nest by the bees, 40% of the bees foraged for nectar followed by resin foragers (34%) and pollen foragers (26%) (Fig 1). Resin foraging bees were found to be dominant (41.34%) at 30 days after acceptance of the nest followed by pollen foragers (21.82%) and nectar foragers (19.97%). At 45 days after nest acceptance, the pollen foraging bees were the highest (34.11%) followed by nectar (31.06%) and resin foragers (11.78%). Increased nectar foraging trips during the initial days of nest acceptance might be due to the requirement of sugar reserves in the storage pots for the bees engaged in initial hive maintenance work. As resin is an important hive construction material for the bees, greater abundance of resin foragers was noticed during the early nest founding days. The requirement of pollen for provisioning the broods might be the reason for increased foraging of pollen at 45 days as the brood cluster formation started 53.60 days after nest acceptance. Active foraging of the bees was recorded few days after acceptance of the coconut shells. The average number of bees entering and departing the nest to the traps were 32.81 and 26.83 per day, respectively. Around 30.60 foragers carried nectar load, 14.20 foraging bees carried pollen load, 10.80 bees carried resin load and 7.20 bees carried mud load during an active foraging day (Fig 2).

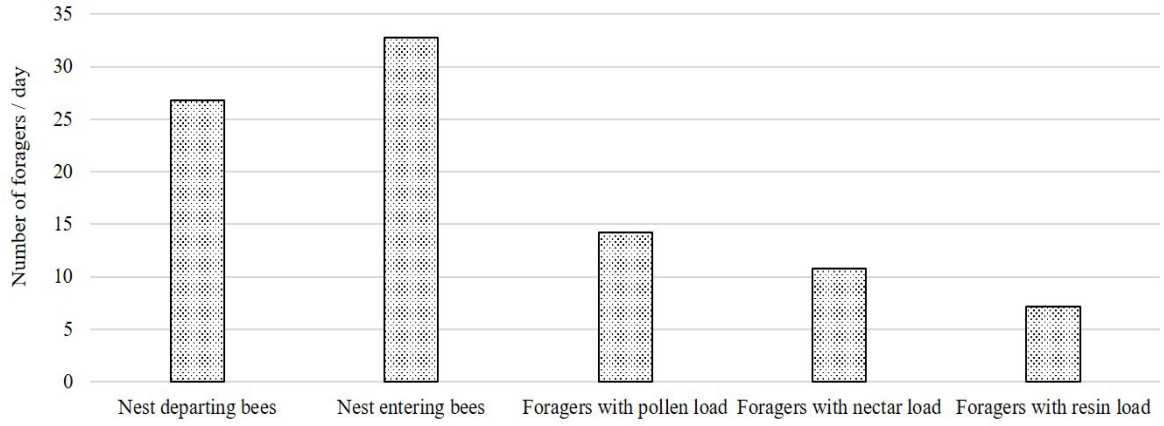

Fig 1. Foraging activity of bees after acceptance of coconut shell traps.

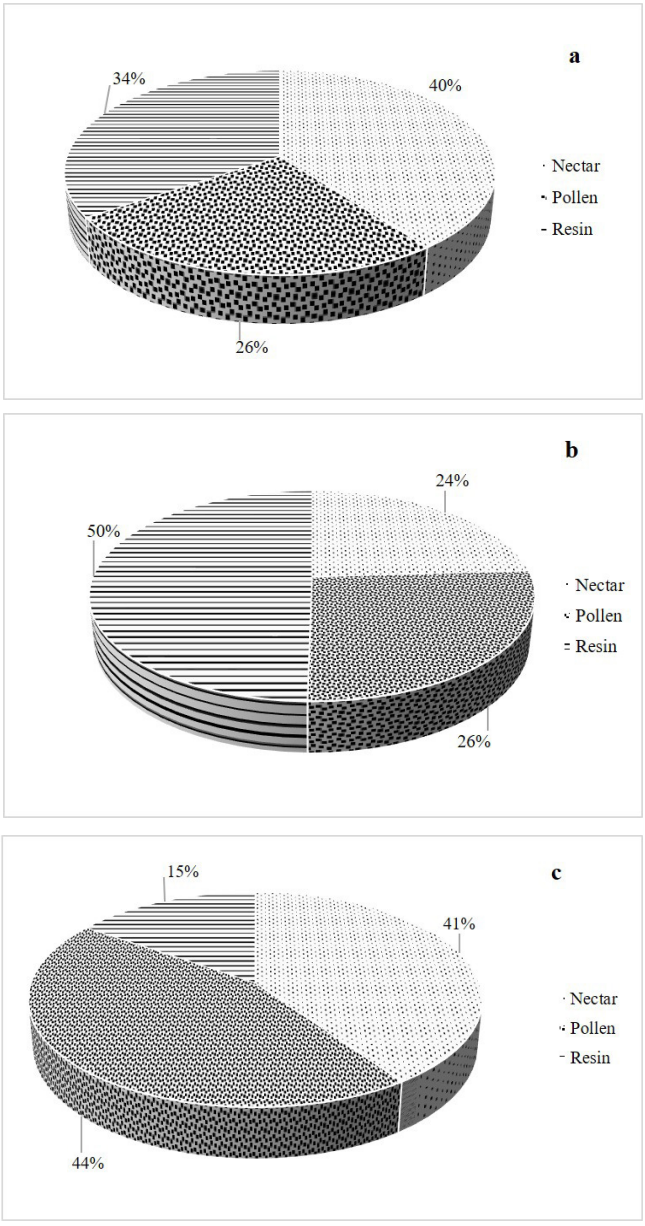

Fig 2. Forage resource partitioning during 15 (a), 30 (b) and 45 (c) days after acceptance of traps by stingless bees

Discussion

The colony development parameters and foraging behaviour of the swarming population of stingless bees in the coconut shells were studied (Fig 3a-c). The swarms accepted the traps in a two weeks time period. Guard bees were often sighted at the nest entrance soon after acceptance of the nest by the bees. The nest entrance guards has been reported to guard the in-nest resources like food stores and developing broods (Holldobler & Wilson, 2009). The filling of storage pots was observed at the end of the three weeks after acceptance of the traps. Honey was filled initially compared to pollen in the storage pots. During the early period of nest acceptance by the swarms, there was a significant increase in the number of nectar foraging bees as compared to other resources' foragers resulting in filling of honey pots first. The honey pots appeared pale brown in colour made of cerumen and were similar in size and shape. Further the honey pots were built closer to the nest entrance as compared to the pollen pots. Pollen pots appeared yellowish brown in colour with their shape and size slightly smaller than honey pots. The preparation of storage pots soon after acceptance of the traps indicated the preparedness of the foragers for the brood provisioning in the hive. Previously, Mounika et al. (2019) reported that newly manually divided colonies of *T. iridipennis* established in a time period of 40 to 107 days and storage pots were constructed in a time interval of 8-17 days after colony division. This difference in the time period of colony establishment and construction of storage pots might be due to the ready resources provided to the foragers during manual division of colonies unlike the natural swarming population.

Swarming occurs in a gradual phase in stingless bees where in scouts move out of the hive in small numbers seeking new nest site (Van Veen & Sommeijer, 2000) unlike honeybees wherein swarming occurs as a singular event in mass numbers of whole colony (Winston, 1987). The bees after accepting the trap started constructing the involucrum inside the trap. There were drops of propolis deposits in the

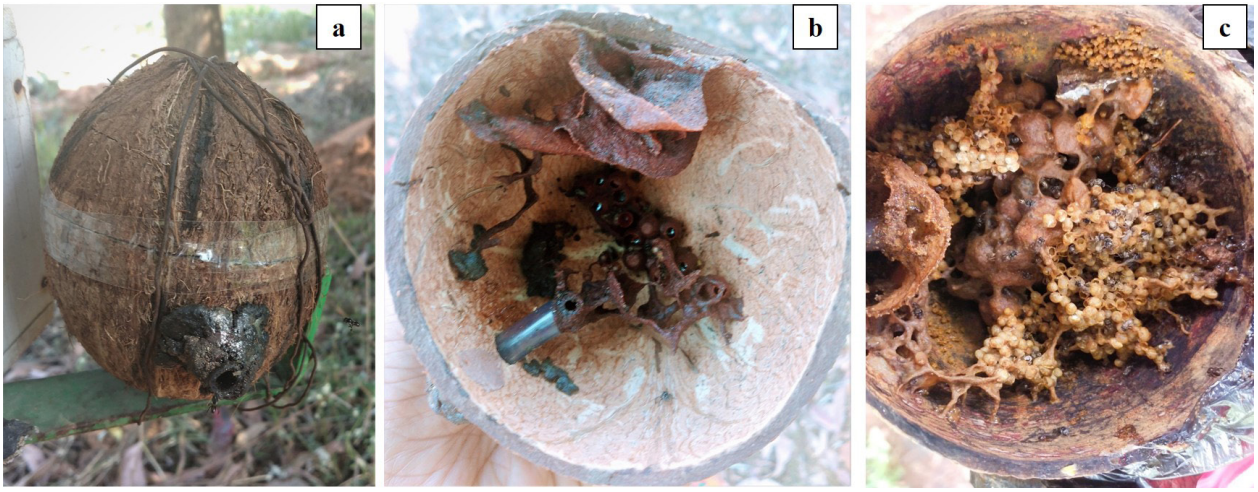

Fig 3a-c: Development of stingless bee colony in coconut shell. a. Foragers in the accepted coconut shell traps. b. Honey pots formed during the initial days of acceptance of shell traps. c. Fully established colony.

accepted traps within few days after acceptance of the traps by the bees. Propolis is a substance collected by the bees from the plant parts or wounded trees (Cherbuliez, 2013) used for hive construction and protection of the colony from microbial infections (Bankova et al., 2003). The swarming scouts were observed seeking new nest site at a relatively closer vicinity of two years older strong colony of stingless bees maintained in the study site. In addition to nest entering foragers, the outgoing foragers were observed to carry resin materials in their corbicula from the mother colony. The scouts of the stingless bees in a swarm were reported to seek a new nesting site closer to mother nest (Kazhuiro et al., 1999). The scouts were also reported to carry resources like resin from mother nest to new site of nesting for easier establishment (Vijayakumar et al., 2013). The foragers constructed honey pots filled with honey at the bottom layer which was intermingled with few brood cells during the early stage of acceptance of the trap.

Stingless bees use wing fanning mechanism to thermoregulate the inside hive temperature (Hazelhoff, 1954; Moritz & Crewe, 1988). Greater hive space also has a negative role in maintenance of CO_2 balance inside the hive by the workers during the initial phase of nest establishment (Kronenberg & Heller, 1982). Smaller nesting space could help in successful and easier establishment of stingless bees as less energy is to be spent in thermoregulation of nesting space in smaller hives. Bamboo and wooden trap nests of 2 litres capacity attracted the swarming population of stingless bee, *Trigona* (*Tetragonula*) *minangkabau* with 6% occupancy rate of the traps for nesting (Inoue et al., 1993). Keeping stingless bee colonies in coconut shells is a common practice adopted in Kerala in India, but utilisation of coconut shell traps to attract the swarms is being reported for the first time through this study. Trapping the swarms is also a viable method for conserving the natural population of stingless bees. The results of the present study indicated that coconut shells could be easily used for trapping stingless bees and maintain their colony in the urban households. Empty coconut shells find a new value addition as 'stingless bee nest' apart from other uses. *T. iridipennis* was reported to construct its nests in relatively unusual sites in varied rural/urban households, wherein such shell traps can be suitably used for trapping the swarming bees. The well-established trap nests of coconut shells can be employed in pollination of crops under protected cultivation.

Author's contribution

AU conceptualised, recorded field observations and analysed the data. TMS provided technical guidance in conduct of the study. ANS aided in design of the experiments. All the authors read and approved the manuscript.

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