INVENTORY OF STINGLESS BEES BASED ON NESTING AND NEST TREES AT TUANAN ORANGUTAN RESEARCH STATION CENTRAL KALIMANTAN INDONESIA

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Article History: Received: 10.02.2023 **Revised:** 24.03.2023 **Accepted:** 10.05.2023

Abstract

Stingless bees act as the most important pollinators for many wild and topical plants including in the forests of Kalimantan Indonesian. The presence of stingless bees in the forests of Kalimantan is also determined by the presence of nest trees where the colonies live. This study aims to carry out an inventory of the types of stingless bees based on their nesting and nests trees at the Tuanan Orangutan Research Station (TORS) in the remote forests of Central Kalimantan, Indonesia. The research was carried out by determining the placement of the plots. After finding the first nest in the nest tree, the researchers drew a plot measuring 20 x 20 meters and we searched for other nests and inventoried trees in the plot. There were nine plots which were considered to be the study sites. We took 10 stingless bees as samples from each nest and five individuals were preserved dry and wet. Identification was carried out at the National Research and Innovation Agency, Cibinong, West Java. Tree identification was carried out based on the information database in TORS. From that process, we found 13 nests of stingless bees in nine plots. The identification results showed three species of stingless bees, namely Tetragonula laeviceps, Lepidotrigona terminata and Tetrigona apicalis. There was only one type of nests tree which was used as a nest for stingless bees, namely Diospyros pseudomalabarica (tutup kabali). The three stingless bee's species construct a unique, distinctive and different-shaped entrance so that it can be a sign of a nest where the stingless bee colony is located.

Keywords: nest, nest entrance, nest tree, stingless bees.

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DOI: 10.31838/ecb/2023.12.s3.284

1. Introduction

Many conservation areas depend upon preservation of bee populations, for if the bees disappear, reproduction of major elements of the flora may be severely limited. As a result, it will create problems in providing food, cover for, and surviving wildlife in an area (Michener, 2000). Bees are stated to represent the most significant group of pollinators in the tropical world (Michener, 2007).

Stingless bee (Hymenoptera: Apidae: *Meliponini)* is an important pollinator for the reproduction of various types of plants in various regions. Among existing bees, stingless bees are a very prominent visitors to flowering plants in various environments (Grüter, 2020). The stingless bees are considered eusocial organisms that live in tropical and subtropical regions, including the American tropics (Neotropics), sub-Saharan African (Afrotropical), and the Indo-Australian (Australasian) regions. More than 600 species of stingless bees have been described worldwide (Roubik, 2023). The continental distribution on which stingless bees take place denotes the importance of ecological role as pollinators of native wild plants and crops (Ayala et al, 2013).

All stingless bees live in colonies consisting of tens to hundreds of thousands of workers, and usually a single queen. At any given time, the number of males present in a colony can range from zero to dozens; males and workers are usually similar in size and appearance, while queens are morphologically distinct (Michener, 2013). Stingless bees feed on nectar and pollen collected by foraging workers. The honey made from the nectar is placed in a separate pots from pollen (Toledo-Hernández et al, 2022).

The Tuanan Orangutan Research Station (TORS) is one of the orangutan habitats in Central Kalimantan. In general, this is a peatland forest with homogeneous vegetation types and low fruit productivity (Vogel et al, 2017). In fact, orangutans are primarily a type of frugivorous primate, meaning that they spend more time feeding on fruits than leaves, bark, or insects (Russon et al, 2009). They clearly use fruit as the main resources on their eating activity. Meanwhile, adapting to the lower levels of fruit availability and the season, they appear to be more flexible to choose their diet (Knott, 1999). Orangutans prefer to consume ripe fruit (Hamilton & Galdikas, 1994). Fruit is an important diet component for wild orangutans and may provide valuable behavioral stimulation (Dierenfeld, 1997). In addition, fruit is usually considered of higher quality since they are generally much richer in energy than leaves (Conklin-Brittain, 2006).

To successfully produce fruit, flowers need pollinating. This is usually done by flying insects such as stingless bees, therefore stingless bees in TORS play a crucial role in this process which results in rich quantity of fruit for orangutans and other wild animals in these places. One thing that is important for stingless bees is where the stingless bee's colony make their nest. Trees are one of the nesting places for stingless bees. It is known that at least some species are discovered to make their nest in association with canopy trees (Ramalho, 2004).

This research objective is to identify stingless bees based on nests found in nest trees at Tuanan Orangutan Research Station Central Kalimantan, Indonesian.

2. Method

Study site

The research was conducted at the Tuanan Orangutan Research Station Central Kalimantan, Indonesian (2°09'Sand114°26' E) (Harison et al, 2010) (Figure 1). The location had been divided into many transects with the abbreviated name of each transect (Figure 2).

Figure 1. Map of Tuanan Orangutan Research Station Central Kalimantan, Indonesian (Credit Will Aguado, 2020)

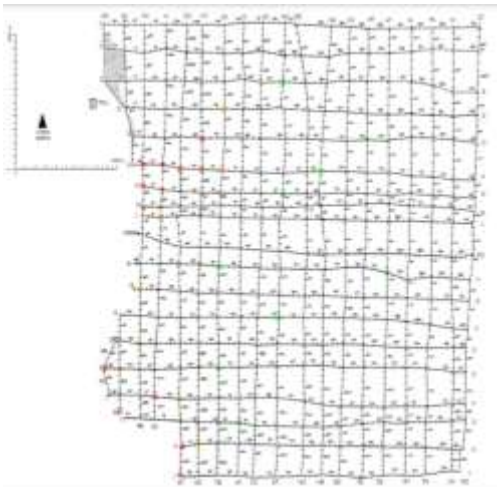

Figure 2. Transects at the Tuanan Orangutan Research Station Research Location (Credit TORS)

Tools and Materials

The tools used were binoculars, cameras, stationery, data tabulation, GPS (Global Positioning System), sweeping nets, tweezers, preparation bags, plastic tubes. The materials used were 70% alcohol and silica gel.

Research Process

1. Plot Determination

Prior to data collection, preliminary observations were carried out to identify the condition of the study site and determine plot points for data collection. Determining the placement of plots begun with a survey of the presence of nests for each transect within 10 meters to the right and left. After finding the first nest, the researchers drew a plot measuring 20 x 20 meters and other nests were searched for in the plot. Nest data collection was carried out by looking at the shape of the nest enterance, measuring the nest entrance, the nest location, and the species of nest tree. After collecting the bee nest data, another data was collected on the abundance of tree species measuring 200 x 10 meters from the center point of the nest plot.

2. Stingless Bee Sampling

The researchers took 10 stingless bees from each nest, 5 of which were put into a tube filled with 70% alcohol (wet preparation) and the other bees were put into a preparation bag (dry preparation) containing silica gel.

3. Observations in the laboratory

Samples obtained from the field were observed at the Entomology Laboratory, National Research and Innovation Agency to determine the sample type obtained based on Sakagami, S. F., Ōgushi, R., & Roubik, D. W. (Eds.). (1990). Natural history of social wasps and bees in equatorial Sumatra. Sapporo: Hokkaido University Press.

The main characteristics used in identification are the feathers on the hind limbs, the number of serrations on the mandible, the clypeus color, the shape of the *mesoscutum* and *mesoscutellum* and the venation of the wings, body color, and size (Sakagami et al, 1990).

4. Data Collection of bee nest

The observation-based data of stingless bee nest was collected by looking at the shape of the nest door, measuring the nest entrance, the nest height, and the type of nest tree.

5. Identification of Tree

The researchers identified the types of nest trees and the types of trees in the plot based on the data base included in the verified TORS (Harisson et al, 2010).

6. Abundance of trees in the plot

The number of individual trees per plot (abundance) was calculated directly in the field to determine relative density (Indriyanto, 2006). There were 10 trees with the highest relative density percentage presented in this current study.

3. Result and Discussion

Location of stingless bees nesting and nests tree

There are 9 plots in the study area that have trees with stingless bee nests. In each of these plots there are one to three stingless bee nests, as follows: Plot 1 (AI transect) has 1 nest; plot 2 (HR transect) 1 nest; plot 3 (AM transect) 1 nest; plot 4 (EF transect) 1 nest; plot 5 (MA transect) 2 nests; plot 6 (HB transect) 1 nest; plot 7 (ML transect) 3 nests; plot 8 (RB transect) 2 nests; and plot 9 (AR transect) 1 nest (Figure 3).

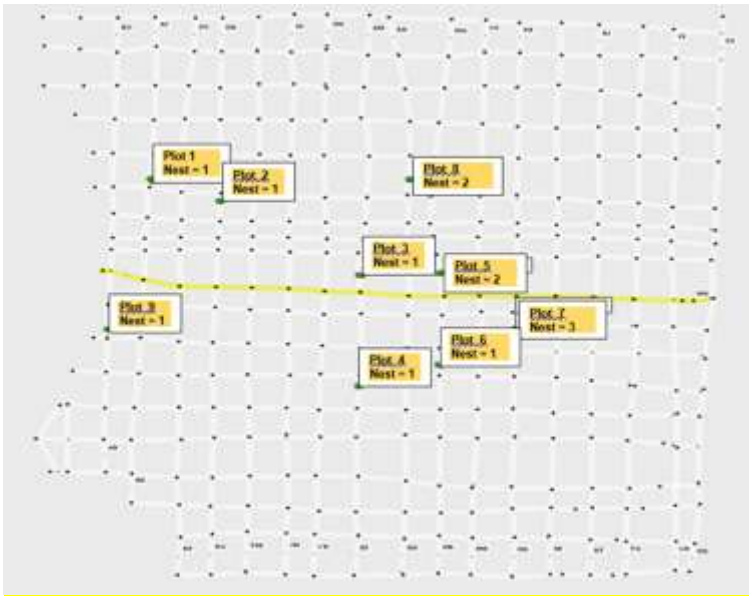

Figure 3. Nest plot locations and number of nests on transects in TORS

Type of Stingless bee

Species 1 has 4 mm of body length size, clearly visible mandibles and proboscis with three pairs of teeth, black hairs over the eyes of the ocelli, brown-black compound eyes. Its forewings are brown transparent, with five saw-shaped hamuli. It has fully round dark brown in dorsal abdomen while black in ventral, and its tibia has no hair. Based on the identification book, this species is considered as the *Tetragonula laeviceps* species (Figure 4).

Figure 4. Morphological characteristics of *T. laeviceps*

Species 2 has a body length size of 6 mm, reduced wing venation, and a narrower pterostigma. The edges of the mesoscutum and mesoscutellum are surrounded by yellowish hard hair resembling thorns. On the edges of the hind limbs there are hairs that do not branch out and the ends of the legs are larger. Based on the identification book, this species is considered as the *Lepidotrigona terminata* species (Figure 5).

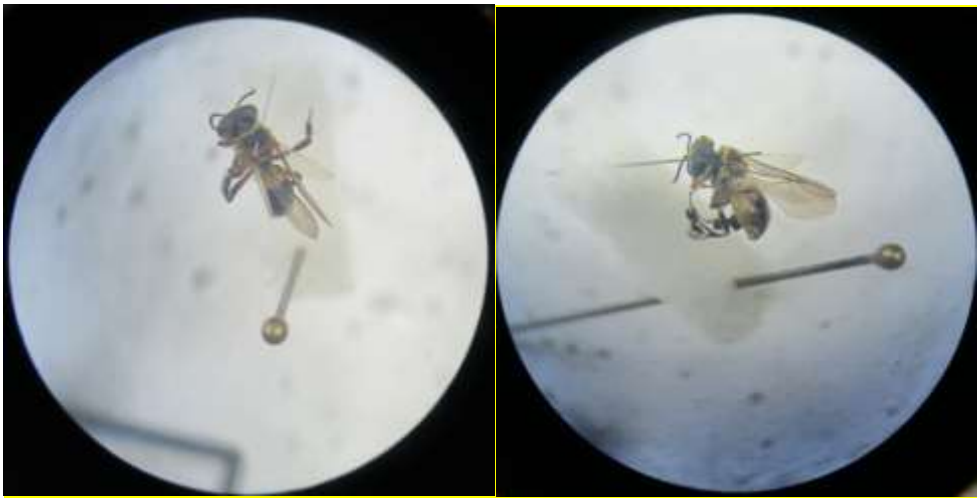

Figure 5. Morphological characteristics of L. terminata

Species 3 has 8 mm of body length size, two perfect mandibular jaws, black thorax and yellow belly. It has dark color wings with the white edges. The back of the propodeum has light hairs with bright shiny marks. It also has hairy posterior edge of the tibia. Based on the identification book, this species is considered as the *Homotrigona apicalis* species (Figure 6).

Figure 6. Morphological characteristics *of H. apicalis.*

Stingless bee nest characteristics found

Based on the results of the study, 13 nests of stingless bees were found from 9 plots in 9 observation transects (Table 1), all of which were found in the tutup kabali tree (*Diospyros pseudomalabarica*`).

Table 1. Types of stingless bees and characteristics of their nest

Plot	**No Nest**	**Transect Code**	**Jenis Stingless bees**	**Opening shape**	**Color**	**Nest height from ground level (cm)**	**Opening Diameter/ width (cm)**
1	1	AI	*H. apicalis*	Oval Extended funnel entrance	Broken white	50	15
2	1	HR	*L. terminata*	Cylindrical tube entrance	Yellowish	60	7
3	1	AM	*T. laeviceps*	Cylindrical tube entrance	Blackish brown	130	3.5
4	1	EF	*H. apicalis*	Longitudinal narrow slit entrance	Brown	140	15
5	1	MA	*H. apicalis*	Triangle tube entrance	Grayish	10	25.5
	2		*L. terminata*	Cylindrical tube entrance	Yellowish Blackish	16.5 & 18	4
6	1	HB	*T laeviceps*	Cylindrical tube entrance	Brown	42	4
7	1	ML	*L. terminata*	Cylindrical tube entrance	Yellowish Brown	108	4.5
	2		*T. laeviceps*	Cylindrical tube entrance	Brown	67	3.7
	3		*H. apicalis*	Longitudinal narrow slit entrance	Yellowish	51	18

8	1	RB	*H. apicalis*	Longitudinal narrow slit entrance	Dark Grayish	54	20.5
	2		*L. terminata*	Cylindrical tube entrance	Yellowish, Brown	53	4.7
9	1	AR	*H. apicalis*	Irregular short funnel entrance	Blackish brown	41	7

Stingless bees from *T. laeviceps* and *L. terminata* species have typical nest entrance (Figures 7 and 9). On the other hand, *H. apicalis* species has relatively varies nest entrance (Figure 9). An overview of the characteristics of the stingless bee nest entrance based on the species found is presented in Figures 7, 8 and 9.

Plot 3 Plot 6 Plot 7

Figure 7. Nest entrance characteristic of T. laeviceps in each plot

Plot 2 Plot 5 Plot 7 Plot 8

Figure 8. Nest enterance characteristic of L. terminata in each plot

Plot 1 Plot 4 Plot 5

Plot 7 Plot 8 Plot 9

Figure 9. Nest enterance characteristic of *H. apicalis* in each plot

Stingless Bees Nest Tree

Of all the study plots, only one type of stingless bee nest tree was found, namely *Diospyros pseudomalabarica* (tutup kabali) (Figure 10).

Figure 10. Description of the trunk and fruit of a *D. pseudomalabarica* tree

The Highest Number of Tree Species in Each Plot

The total tree species in each plot varied. Total tree species in plot 1 (46 species), plot 2 (51 species), plot 3 (55 species), plot 4 (54 species), plot 5 (43 species), plot 6 (38 species), plot 7 (35 species), plot 8 (51 species), plot 9 (40 species). The total tree species presented in all plots was 79 tree species (data not presented). The ten highest relative density values in all plots are presented in table 2

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Table 2. Ten tree species with the highest relative density values

Local Name	Scientific Name	Relative Density (%)
Rambangon	*Bauea oppositifolia*	7.56
Karandau	*Neoscortechina kingii*	6.75
Tarantang	*Campnosperma coriaceum*	4.23
Maranti daun kecil	*Shorea sp.*	3.90
Tutup kabali	*Diospyros pseudomalabarica*	3.46
Nyatoh puntik	*Palaqium pseudorostratum*	3.33
Kayu lalas	*Musaendopsis beccariana*	3.17
Tagula daun besar	*Alseodaphne sp.*	3.09
Keput bajuku	*Stemonurus scorpioides*	2.93

Mangkinang blawau	*Elaeocarpus matersii*	2.52

4. Discussion

There are three species of stingless bees found in TORS based on nests in nest trees, namely *T. laeviceps, L. terminata* and *H. apicalis*. These three species are stingless bees found in Indonesia from 46 species (Kahono et al, 2018). These three species are also found in other areas in Indonesia. *T. laeviceps* is widely distributed and covering the whole of Indonesia (Sakagami et al, 1990, Syafrizal et al, 2020, Buchori et al, 2022). Whereas, *L. terminata* spread across Sumatra, Java and Kalimantan (Syafrizal et al, 2020, Buchori et al, 2022). Likewise, *H. apicalis* is also found in Sumatra and Kalimantan (Buchori et al, 2022). The three stingless bees are not only found in the wild, but also being cultivated by people in meliponiculture (Syafrizal et al, 2020, Buchori et al, 2022). Stingless bees not only provide ecological services such as pollination, but also collect nectar, pollen, and resin. Stingless bees' colonies produce honey and propolis which have high economic value. Stingless honey offers a distinctive aroma and taste and is reported to have medicinal value (Rao et al, 2016).

Most stingless bees' nests are hidden, and nest colonies can host hundreds to tens of thousands of worker bees. The height of the stingless bees' nest entrance found in TORS range from 10 cm to 140 cm from the ground level. The entrance to the nest is marked with a distinctive exterior of the nest and is known to have a diameter of between 3.5 – 25.5 cm. Stingless bee nests occupy tree cavities and on the outside of the nest. Nest site preference and nest architecture are studied in the ecology of stingless bees related to pollination behavior and as a basis for developing species-specific conservation strategies (Choudhary et al, 2021).

The entrance to the stingless bees' nest is an architecture built from various materials around the nest. Hidden nests in tree trunks, aggregation of nests and height above the ground can provide defenses against robbers and enemies (Choudhary et al, 2021). Bees harvest antimicrobial resins from plants and use these materials for a variety of purposes, from nest construction to defense against predators and pathogens. Resin use is considered to have facilitated the evolution of sociality in stingless bees, and today, resin use remains fundamentally important for the function of stingless bee colonies. Most species use the resin to build brood combs, storage pots for honey and pollen, and various protective structures inside the nest. Many also use resin to protect their nests from predators, fortifying the nest entrance with a barrier of sticky resin droplets or applying resin directly to would-be invaders (Shackleton et al, 2019; Shanahan & Spivak, 2021). Plants secrete resin from buds, wounds, fruits, and flowers to defend themselves from herbivores and microorganisms, and, in some cases, to attract pollinators and seed dispersers (Wallace et al, 2010). Entrance structures of stingless bees' nests, apart from being constructed by resin, are built from mud, wax, or soil (Shackleton et al, 2019).

From the results of tree data collection in all plots, 79 tree species were obtained. The five highest relative density of trees was rambangon trees (*B. oppositifolia*) 7.56%; karandau (*N. kingii*) 6.75%; tarantang (*C. coriaceum*) 4.23%; small leaf meranti (*Shorea sp*.) 3.9%; tutup kabali (*D. pseudomalabarica*) 3.46% (Table 2). However, the results showed that all the nests of stingless bees found were in the tutup kabali or *D. pseudomalabarica* tree. The *D. pseudomalabarica* tree has the characteristics of a large tree with a height of up to 50 m, a trunk diameter of up to 70 cm, a smooth to scaly, even rough, hollow, gray, brown or black bark surface (Prosea, 2016; Thomas, 2018). This is in accordance with the characteristics of the three mentioned-stingless bees. They tend to occupy large trees due to the dense canopy so that the surrounding air is more stable and the availability of a microclimate is more suitable for the life of stingess bees (Yoza et al, 2013).

Tutup kabali (*D. pseudomalabarica*) is a plant that has a phenological type that bears fruit all year round in TORS and acts as a buffer for fruit availability (Ariyanto, 2015). Tutup kabali has the characteristics of a round fruit with 6-10 seeds inside, brownish yellow when ripe, soft flesh and elongated seeds 2x3 cm (Thomas, 2018). The fruit of *D. pseudomalabarica* is known as one of the main foods for the Bornean orangutan (*Pongo pygmaeus wurmbii*) (Saputra et al, 2018). The *D. pseudomalabarica* tree is also one of the trees used by orangutans to make nests during the day (Prasetyo et al, 2017).

Beside the character of the *D. pseudomalabarica* tree being hollow and having a dense canopy, the phenology type bears fruit all year round at TORS become the reason why stingless bees feel comfort nesting in *D. pseudomalabarica* trees. This is because it provides nectar and pollen. In terms of other ecological services, stingless bees are known to have a limited flight range of not reaching 1 km. The maximum foraging distance for stingless bees is estimated to be around 300 m (Van Nieuwstadt & Iraheta, 1996). Research showed that the maximum home range for *T. carbonaria* was 712 m (Smith et al. 2017). Therefore, it is very possible for stingless bees to pollinate *D. pseudomalabarica* trees, as well as trees in one plot or other plots to bear fruit and become food for the orangutans in TORS. Fruit trees in the research plots and used as food for orangutans

include *N. kingii* (Hasan, 2020) and *C. coriaceum* (Bastian et al. 2010).

5. Conclusion

Three species of stingless bees based on nesting and nest trees were found at the Tuanan Orangutan Research Station, namely *Tetragonula laeviceps, Lepidotrigona terminata* and *Homotrigona apicalis.* The nest entrance of the three species has specific characteristics. Only one nest tree found and observed at the study site, namely the tutup kabali tree (*Diospyros pseudomalabarica*) which has the characteristic of making stingless bees comfortable nesting in this tree.

Acknowledgement
The authors are thankful to Dr. Erin Rebecca Vogel from Rutgers University USA who has provided the opportunity, funding and support in carrying out this research and to Dr. Sih Kahono and staff of the Entomology Laboratory of the National Research and Innovation Agency who have facilitated the identification of stingless bees.

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