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Species Richness and Nesting Sites of Stingless Bees in the Forest and Settlement Areas in Banten Province, Indonesia and their Morphometry

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ABSTRACT

Stingless bees (Apidae: Meliponinae) are distributed in the tropics, and there are more than 600 species worldwide, Forty-six species were recorded in Indonesia. Nest of the species is generally found in tree holes, rocks, house walls, house wooden, bamboo cavities, and soil. Current research explores the species richness, nesting sites and morphometry of stingless bee species in the forest and settlement areas in Banten province, Indonesia. Road- and purposive sampling methods were used to explore the stingless bee species. Thirty-five body characters of each stingless bee species were measured. Results showed four stingless bee species found were *Tetragonula laeviceps, Heterotrigona itama, Lepidotrogona terminata,* and *Tetragonula* sp. The dominant species found was *L. terminata* in the forest, while *T. laeviceps* in the settlement areas. The nesting sites of stingless bees in the forests were found in the tree cavities of various plant species with tree diameter range 39.3-87.3 cm. In contrast, the nest of *T. laeviceps* was found in the tree of *Swietenia mahagoni, Lansium parasiticum*, and bamboo cavities of houses in the settlement areas. The nest entrances of stingless bees varied, i.e., oval-rounded, tubular with varied diameters, and blackish-brown in color. The internal structure of the nest consists of brood cells, pollen cells, and honey cells. *Heterotrigona itama* has the largest body size (5.52 mm in length), followed by *L. terminata* (4.99 mm in length) and *T. laeviceps* (3.86 mm in length). Thirty-three characters of *H. itama* were larger than *L. terminata* and *T. laeviceps*, except for gena width and malar length.

1. Introduction

Stingless bees (Apidae: Meliponinae) have a wide distribution in tropics and subtropic areas of the world (Neotropical, Afrotropical, and Indo-Malaya) (Grüter 2020) and were estimated to consist of 700 species (Heard 1999). In Indonesia, 46 species of the bees were reported (Sakagami *et al.* 1990; Rasmussen 2008; Rasmussen *et al.* 2017) that distributed in Sumatera (23 species) and Borneo (29 species), and Java (7 species. The stingless bee species in Java consist of *Tetrigona apicalis, T. vidua, Lepidotrogona javanica, L. terminata, L. ventralis, Tetragonula drescheri, T. laeviceps*) (Kahono *et al.* 2018). Stingless bees have a small body size (2-14 mm). The species has no sting, and biting is their defence if disturbed. The nest of the species is found in trees, soil, rock, house wall, and bamboo cavities (Michener 1974; Sakagami *et al.* 1983; Dollin *et al.* 1997). Jesajas *et al.* (2023) reported nesting site of two species of stingless in Papua, i.e., *T. sapiens* in house foundation, while *Heterotrigona planifrons* in coconut palm cavities. Suriawanto *et al.* (2017) reported nesting sites of three species of stingless bees in Sulawesi, i.e., *T. sapiens* in stone cavities, *T. laeviceps* in wooden walls, *T. fuscobalteata* in the bamboo cavities, iron, stone, brick wall, and wooden wall, while *T. biroi* in the brick, wooden wall, and stone cavities. Stingless bees are highly eusocial bees, live in colonies, and have morphologically and behaviorally different in female, queens, and

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workers (Michener 2007). Intercaste morphological differentiation may occur in higher taxonomic groups of stingless bees. In *Meliponula bocandei* (Spinola), queens have smaller heads than workers and males (Sakagami 1982). In contrast, in *Tetragonula carbonaria* Smith, queens have distinctly larger heads, mesosomata, and metasomata than workers (Dollin *et al.* 1997). In stingless bees, the pattern and degree of intercaste morphological differences may reflect their phylogenetic background and their social life patterns (Sung *et al.* 2004). Worker bees are tasked in guarding of the hive, building new nest, and also looking for nectar, pollen, and resin (Inoue *et al.* 1984).

As a social insect that nurse the brood, stingless bees need a lot of pollens and nectar for the colony. The large number of individual of worker bees makes the species have a great potential as pollinator in the forest (Eltz *et al.* 2002) and a good pollinator candidate on agricultural lands (Heard 1999; Slaa *et al.* 2006). In agricultural land in West Java, Indonesia, stingless bees together with other insects are pollinator agents of mustard (*Brassica rapa*) (Atmowidi *et al.* 2007). Pollination by *T. laeviceps* increased the fruit size, number of seeds per fruit, seed germination, and fruit sugar content of melon (*Cucumis melo* L.) (Bahlis *et al.* 2021; Atmowidi *et al.* 2022) and increased the number of fruits formation and vitamin C content of strawberry (Alpionita *et al.* 2021; Atmowidi *et al.* 2022). Djakaria *et al.* (2022) also reported the size and weight of pod, the seed numbers, and fruit set of okra (*Abelmoschus esculentus* L.) were enhanced by pollination of three stingless bee species (*H. itama*, *T. laeviceps*, and *T. clypearis*). In pummelo (*Citrus maxima* (Burm.) Merr.), Atmowidi *et al.* (2022) reported increasing 48% of fruit formation by *T. laeviceps* pollination. As a good pollinator, the species are active throughout the year and are generalists in various plant species (Biesmeijer *et al.* 2005).

In recent years, declining of natural pollinators have been reported (Cortopassi-Laurino *et al.* 2006; Potts *et al.* 2010). Declining pollinators may related to fragmentation and land use interaction (Hadley and Betts 2012), pesticides used, and pathogens (Caesar *et al.* 2019; Tang *et al.* 2021). Until now, lacking of stingless bee publications in Banten province. This study aims to explore the species richness of stingless bees in the forest and settlement areas in Banten province, Indonesia as well as the morphometry of the three species of stingless bees.

2. Materials and Methods

2.1. Observations of Stingless Bee Colony

Observations of stingless bee colonies were carried out in each location, namely coast forest (Ujung Jaya village) of Ujung Kulon National Park (UKNP) (Pandeglang regency), Gunung Kencana forest (Lebak regency), and settlement areas, i.e., Ciranji, Sumur, and Babakan Kalanganyar village (Pandeglang regency) at Banten Province, Indonesia (Figure 1). Observation of stingless bees in the forest (UKNP and Gunung Kencana) were conducted by the road sampling method (Bookhout 1996) by observed in a each track in each location in about two kilo meters in length. While in the settlement areas, stingless bee colonies were observed using purposive sampling method (Etikan and Bala 2017) and using stingless bee nest information from the community. The characteristics of nesting sites were recorded, such as nest location, nest height from the ground, length and shape (rounded or oval), diameter of nest entrance, and species and diameter of nest trees. A total of 30 individuals of each species were collected using an insect net and preserved in 75% ethanol for species identification and measurement of morphometric data.

2.2. Identification of Stingless Bees

The stingless bee specimens collected then were mounted, pinned, and dried in the oven at 40°C for 7 days. Then, bee specimens were identified based on Sakagami (1978), Sakagami and Inoue (1987), Dollin *et al.* (1997), Sakagami *et al.* (1990), and Smith (2012). Some specimens of stingless bees were deposited in the laboratory of Entomology, The National Research and Innovation Agency (BRIN), Bogor, Indonesia.

2.3. Morphometric Measurements of Stingless Bees

Morphometric measurements were carried out on 20 individuals of each of three species of stingless bees, i.e., *T. laeviceps*, *L. terminata*, and *H. itama*. Thirty-five bee body characters were measured based on Sakagami (1978), Michener (2007), Rasmussen (2013), and Klakasikorn *et al.* (2005) consisting of body length (BL), head length (HL),

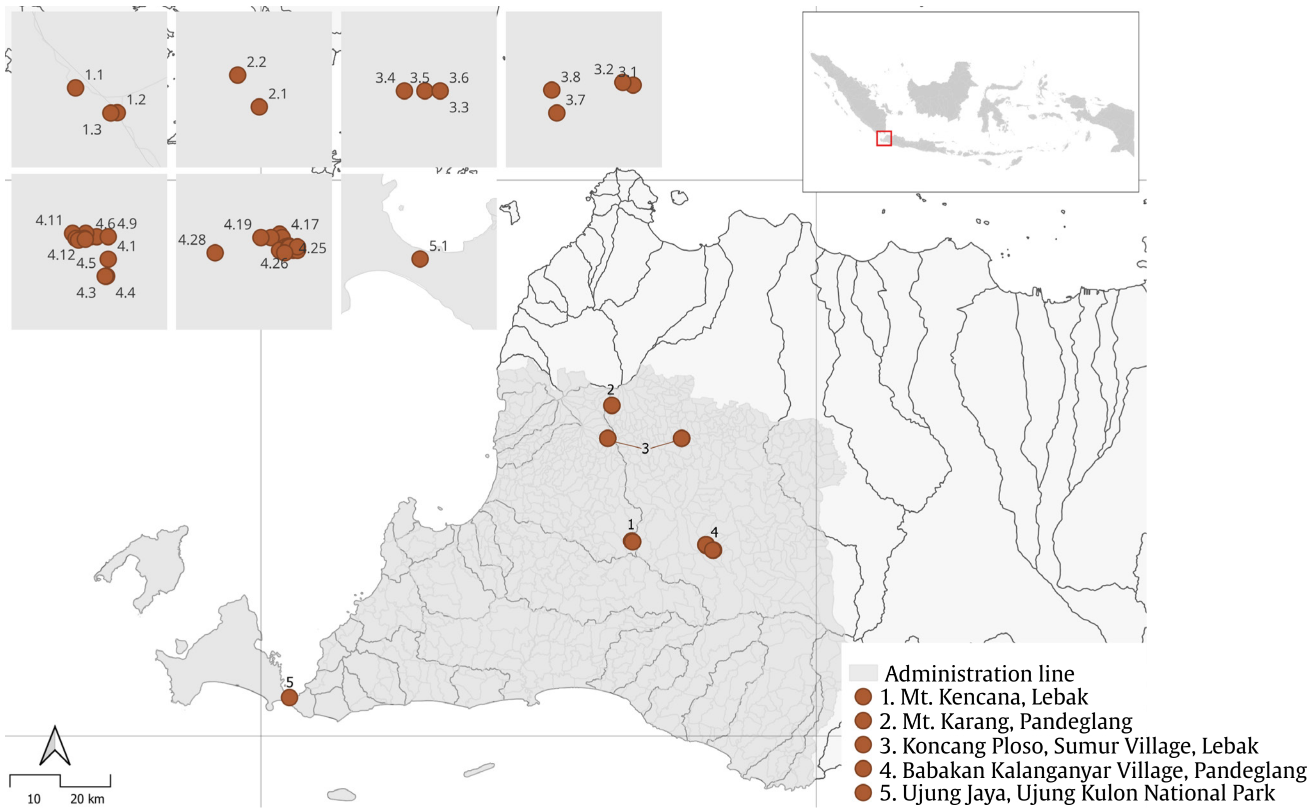

Figure 1. Map of observation sites of stingless bees in Banten province, Indonesia

head width (HW), mandible length (MdL), mandible width (MdW), clypeus length (CL), lower interocular distance (LID), upper interocular distance (UID), eye width (EW), eye length (EL), maximum interorbital distances (MOD), lower interorbital distances (LOD), interantennal distance (IAD), interocellar distance (IOD), ocellocular distance (OOD), antennocular distance (AUD), gena width (GW), flagellomere IV length (FL), flagellomere IV width (FW), malar length (ML), mesoscutum length (MCL), mesoscutum width (MCW), fore-wing length including tegula (WL1), length of M-Cu bifurcation to the basal tip of the marginal cell (WL2), fore-wing length (FWL), fore-wing width (FWW), hind wing length (HWL), hind wing width (HWW), hamuli number (HN), hind femur length (HFL), hind tibia width (HTW), hind tibia length (HTL), hind basitarsus width (HBW), and hind basitarsus length (HBL). The specimens were photographed using an OptiLab camera embedded in a stereo microscope (Nikon C-LEDS). The images were displayed in Optilab Viewer, and each body character was measured using Image Raster software.

2.4. Data Analysis

Species composition of stingless bees found in each study site was shown in the table and morphology of each species was described. Characteristics of nest entrance was described and shown in a bar graph. Morphometric data for each individual of stingless bee was analyzed using non-Metric Multidimensional Scaling (nMDS) based on the Bray-Curtis similarity in the Palaentological Statistics (PAST) software 4.03 (Hammer *et al.* 2001).

3. Results

3.1. Diversity of Stingless Bees

Observations in three habitats, i.e., forest (UKNP and Gunung Kencana) and settlement areas were found 61 colonies belonging to four species of stingless bees, i.e., *Tetragonula laeviceps, Lepidotrigona terminata, Heterotrigona itama*, and *Tetragonula* sp. The species dominant in UKNP was *L. terminata* (12 colonies), followed by *T. laeviceps* (9 colonies), and *Tetragonula* sp. (6 colonies). In Gunung Kencana forest was found two species, i.e., *T. laeviceps* (3 colonies) and *H. itama* (1 colony). While in settlement areas, was found one species (*T. laeviceps*; 30 colonies).

3.2. Nesting Sites and Nest Entrance Characteristics of Stingless Bees

In UKNP and Gunung Kencana forest, the nesting sites of stingless bees were found in the tree cavities of various plant species, i.e., *Lagerstroemia speciosa, Hibiscus tiliaceus, Ficus benjamina* L, *Spondias pinnata, Intsia bijuga, Parkia speciosa, Millettia pinnata*, and "gendola", "ki sabrang", "ki oray" (Sundanese name) with tree diameter range 39.3-87.3 cm. The nests were located in the varying height from the ground (20-400 cm). In the settlement areas, the nest of *T. laeviveps* were found in mahogany tree (*Swietenia mahagoni*) and longkong (*Lansium parasiticum*) (3 colonies) and bamboo cavities of houses (27 colonies) with height range of 159-400 cm (Table 1).

The nest entrance of stingless bee in forest (UKNP and Gunung Kencana) characterized by tube-like in varying lengths, blackish-brown at the base and light brown at the end of the entrance (Figure 2). In average, the tube-like nest entrance length of *T. laeviceps* was 3.48 cm with 1.32 cm in a longest diameter and 0.67 cm in a shortest diameter (Figure 3).

3.3. Morphology and Morphometric of Three Species of Stingless Bees

Current study showed *H. itama* have a largest body size (5.52 mm in length), followed by *L. terminata* (4.99 mm in length), and *T. laeviceps* (3.86 mm in length) (Figure 4). Worker of *T. laeviceps* are characterized by body predominantly black, clypeus is blackish brown to black, scape of antenna is testaceous, antennae are with 10 flagellomere, malar space is shorter than flagellomere width. Species of *H. terminata* is characterized by yellow-hairs ring in outside of mesoscutellum and mesocutum. Thirty-tree characters of *H. itama* were larger than *L. terminata and T. laeviceps*, except gena width and malar length (Table 2).

Six characters ratio (HTL/WL2, EL/MOD, LOD/MOD, FL/FW, HTW/HTL, and HBW/HTW) of the current study were similar with *T. laeviceps* (Table 3). Analysis of Non-Metric Multidimensional Scaling, nMDS (stress = 0.04119) based on the Bray-Curtis similarity of body characters (stress = 0.04119) showed separation of each species (Figure 5).

Table 1. The species of stingless bees in Ujung Kulon National Park, Gunung Kencana forest, and settlement areas in Banten province, Indonesia

Location	Stingless bees species	Number of colony observed (n)	Average of nest height from the ground (minimum-maximum) (m)	Nest tree species
Ujung Kulon National Park forest	*Tetragonula laeviceps*	9	127.8 (20-260)	*Lagerstroemia speciosa, Hibiscus tiliaceus, Ficus benjamina* L, *Spondias pinnata*
	Tetragonula sp.	6	75.0 (20-220)	*Hibiscus tiliaceus, Ficus benjamina* L.
	Lepidotrigona terminata	12	137.5 (40-400)	*Lagerstroemia speciosa, Intsia bijuga, Spondias pinnata, Parkia speciosa, Ficus benjamina* L., *Millettia pinnata*
Gunung Kencana forest	*Tetragonula laeviceps*	3	167.7 (135-221)	"Gendola", "ki sabrang", "ki oray" (Sundanese name)
	Heterotrigona itama	1	175.0	*Ficus* sp.
Settlement areas	*Tetragonula laeviceps*	3	207.0 (3.40-4.30)	*Swietenia mahagoni, Lansium parasiticum*
	Tetragonula laeviceps	27	249.6 (159-400)	Bamboo housing

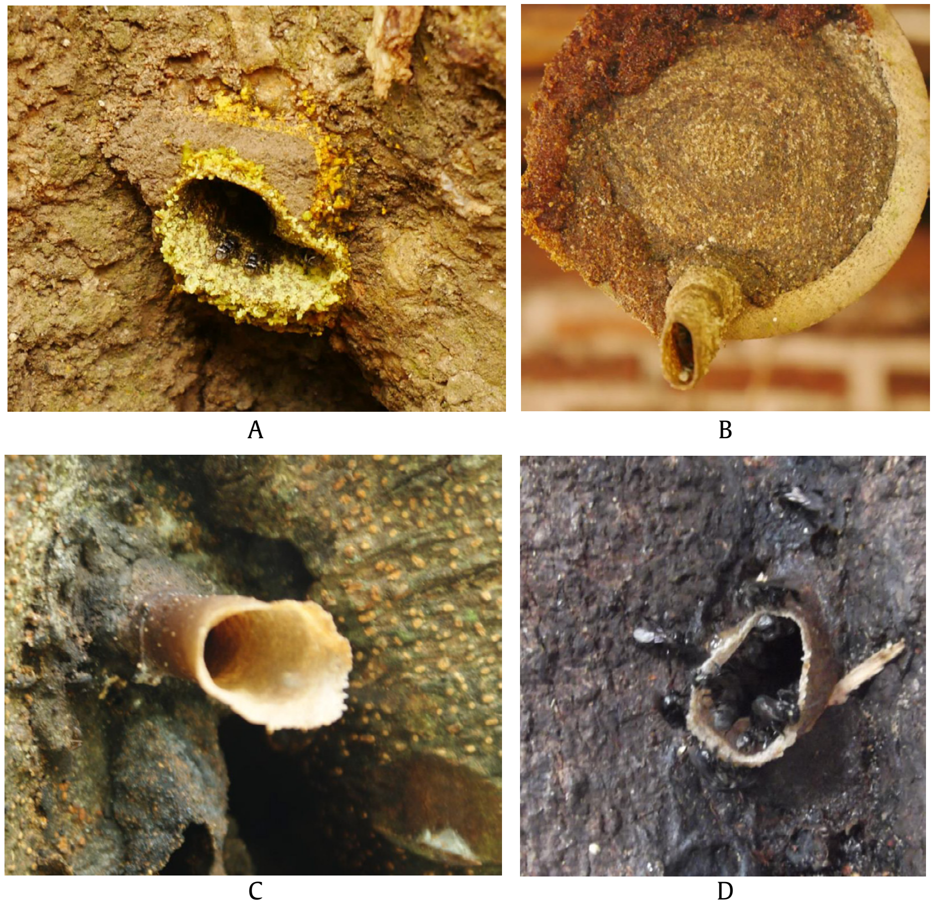

Figure 2. Nest entrance of stingless bees in Banten province, Indonesia: *Tetragonula laeviceps* on longkon tree (A), *Tetragonula laeviceps* on bamboo housing (B), *Lepidotrigona terminata* on ficus tree (C), *Heterotrigona itama* on trees (D)

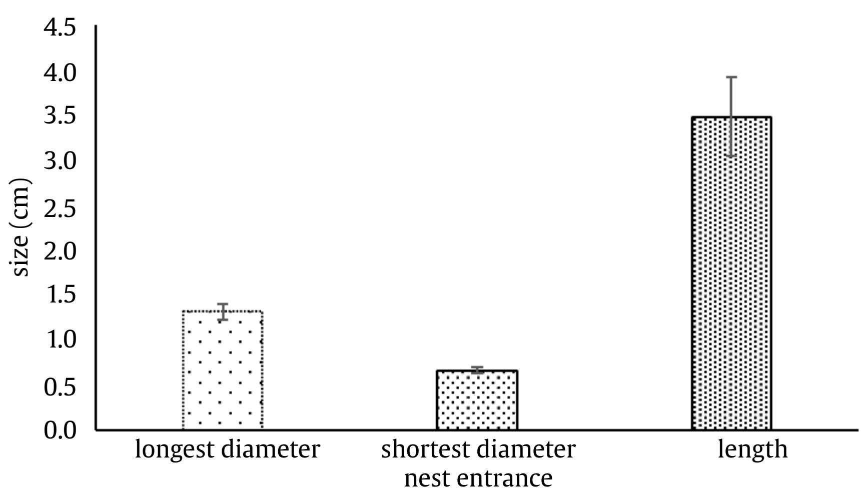

Figure 3. The average size of nest entrance of *Tetragonila laeviceps* in Banten, Indonesia (n = 33). Standard errors are shown in each bar

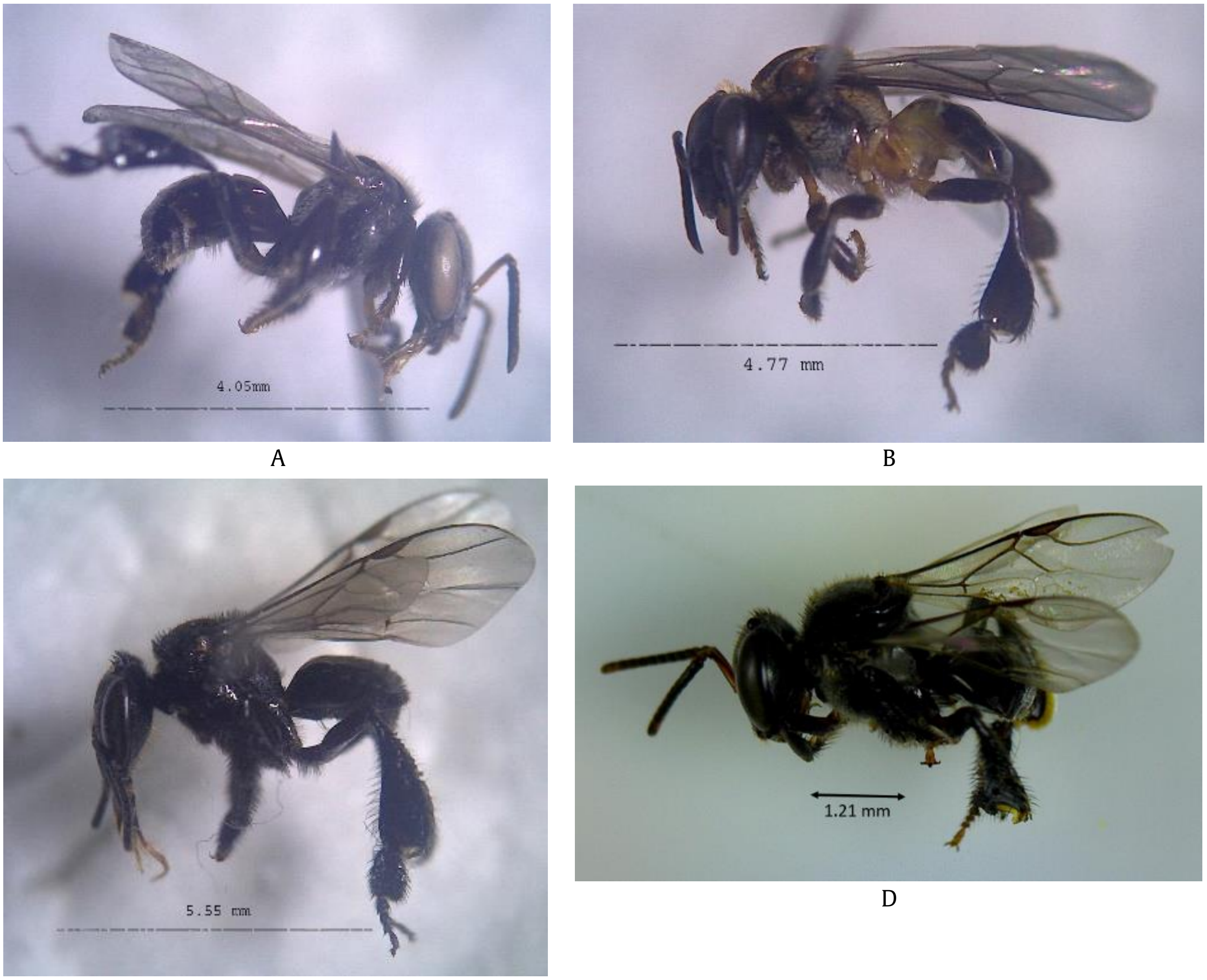

Figure 4. Morphology of stingless bees:(A) *Tetragonula laeviceps*, (B) *Lepidotrigona terminata*, (C) *Heterotrigona itama*, (D) *Tetragonula* sp.

Table 2. Morphometry of stingless bees in Banten province, Indonesia. St.dev: standard deviation

Body characters	*T. laeviceps* (mm)		*L. terminata* (mm)		*H. itama* (mm)	
	Average	St.dev	Average	St.dev	Average	St.dev
Body length (BL)	3.86 (3.68-4.09)	0.14	4.99 (4.51-5.65)	0.32	5.52 (5.09-5.91)	0.20
Head length (HL)	1.37 (1.32-1.41)	0.02	1.59 (1.45-1.71)	0.05	1.97 (1.73-2.07)	0.09
Head width (HW)	1.68 (1.61-1.71)	0.03	2.05 (1.93-2.20)	0.05	2.32 (2.10-2.42)	0.09
Mandible length (MdL)	0.64 (0.60-0.67)	0.02	0.80 (0.72-0.85)	0.03	0.95 (0.84-0.99)	0.04
Mandible width (MdW)	0.20 (0.15-0.22)	0.02	0.28 (0.24-0.31)	0.02	0.30 (0.26-0.32)	0.02
Clypeus length (CL)	0.39 (0.36-0.42)	0.02	0.50 (0.44-0.55)	0.03	0.63 (0.59-0.66)	0.02
Lower interocular distance (LID)	0.91 (0.85-0.93)	0.02	1.30 (1.24-1.37)	0.03	1.46 (1.32-1.53)	0.05
Upper interocular distance (UID)	1.04 (0.99-1.07)	0.02	1.28 (1.22-1.39)	0.03	1.52 (1.38-1.58)	0.05
Eye width (EW)	0.44 (0.38-0.47)	0.02	0.52 (0.49-0.58)	0.02	0.56 (0.50-0.61)	0.04
Eye length (EL)	1.13 (0.96-1.17)	0.04	1.25 (1.15-1.33)	0.04	1.47 (1.33-1.54)	0.06
Maximum interorbital distances (MOD)	1.17 (1.12-1.19)	0.02	1.45 (1.38-1.58)	0.04	1.68 (1.54-1.74)	0.05

Table 2. Continued

Body characters	*T. laeviceps* (mm)		*L. terminata* (mm)		*H. itama* (mm)	
	Average	St.dev	Average	St.dev	Average	St.dev
Lower interorbital distances (LOD)	0.86 (0.82-0.89)	0.02	1.25 (1.20-1.37)	0.04	1.40 (1.25-1.46)	0.05
Interantennal distance (IAD)	0.14 (0.12-0.15)	0.01	0.15 (0.13-0.18)	0.01	0.17 (0.15-0.19)	0.01
Interocellar distance) (IOD)	0.14 (0.13-0.15)	0.01	0.15 (0.13-0.19)	0.01	0.17 (0.16-0.19)	0.01
Ocellocular distance) (OOD)	0.22 (0.20-0.23)	0.01	0.32 (0.29-0.37)	0.02	0.39 (0.37-0.42)	0.01
Antennocellar distance (AOD)	0.67 (0.65-0.69)	0.01	0.78 (0.76-0.84)	0.02	0.81 (0.73-0.85)	0.03
Antennocular distance (AUD)	0.27 (0.25-0.28)	0.01	0.39 (0.34-0.42)	0.02	0.42 (0.37-0.44)	0.02
Gena width (GW)	0.23 (0.18-0.28)	0.03	0.34 (0.28-0.39)	0.04	0.31 (0.22-0.37)	0.04
Flagellomere IV length (FL)	0.12 (0.10-0.13)	0.01	0.14 (0.13-0.16)	0.01	0.16 (0.15-0.17)	0.01
Flagellomere IV width (FW)	0.12 (0.11-0.14)	0.01	0.14 (0.13-0.17)	0.01	0.15 (0.14-0.16)	0.01
Malar length (ML)	0.05 (0.03-0.07)	0.01	0.15 (0.12-0.17)	0.01	0.15 (0.13-0.16)	0.01
Mesoscutum length (MCL)	0.81 (0.74-0.89)	0.04	1.12 (1.09-1.21)	0.03	1.22 (1.10-1.31)	0.05
Mesoscutum width (MCW)	1.06 (0.99-1.12)	0.03	1.33 (1.29-1.45)	0.03	1.53 (1.36-1.67)	0.08
Fore wing length including tegula (WL1)	3.67 (3.13-3.91)	0.20	5.35 (4.62-5.66)	0.22	6.19 (5.60-6.49)	0.22
Length of M-Cu bifurcation to basal tip of marginal cell (WL2)	1.08 (1.05-1.12)	0.02	1.52 (1.33-1.61)	0.06	1.73 (1.62-1.80)	0.05
Fore wing length (FWL)	3.60 (3.51-3.71)	0.06	5.02 (4.42-5.25)	0.19	5.83 (5.50-6.00)	0.15
Fore wing width (FWW)	1.30 (1.21-1.38)	0.05	1.76 (1.37-1.89)	0.11	2.03 (1.82-2.15)	0.08
Hind wing length (HWL)	2.49 (2.43-2.59)	0.04	3.54 (3.19-3.78)	0.11	4.05 (3.76-4.23)	0.12
Hind wing width (HWW)	0.63 (0.54-0.68)	0.05	0.83 (0.74-1.08)	0.07	0.97 (0.84-1.06)	0.06
Hamuli number (HN)	4.90 (4.00-5.00)	0.31	6.30 (6.00-7.00)	0.47	7.10 (6.00-8.00)	0.45
Hind femur length (HFL)	1.03 (0.98-1.06)	0.02	1.39 (1.27-1.44)	0.04	1.56 (1.42-1.62)	0.05
Hind tibia width (HTW)	0.46 (0.39-0.50)	0.04	0.69 (0.61-0.77)	0.04	0.81 (0.70-0.91)	0.05
Hind tibia length (HTL)	1.43 (1.40-1.45)	0.02	1.83 (1.57-1.93)	0.10	2.14 (1.85-2.34)	0.11
Hind basitarsus width (HBW)	0.28 (0.24-0.31)	0.02	0.51 (0.43-0.57)	0.03	0.52 (0.46-0.57)	0.03
Hind basitarsus length (HBL)	0.56 (0.50-0.60)	0.03	0.80 (0.74-0.87)	0.03	0.86 (0.77-0.92)	0.05

Table 3. Ratio of several body characters of stingless bees in Banten province, Indonesia

Ratio	Species			
	T. laeviceps	*L. terminata*	*H. itama*	*T. laeviceps* (Sakagami 1978)
WL2/HW	0.65	0.74	0.75	0.73
HTL/HW	0.85	0.89	0.92	0.98
HTL/WL2	1.32	1.20	1.24	1.39
EL/MOD	0.96	0.86	0.87	0.99
LOD/MOD	0.73	0.86	0.83	0.75
IOD/OOD	0.65	0.47	0.44	1.54
GW/EW	0.52	0.64	0.55	0.74
FL/FW	0.95	1.02	1.11	0.92
HTW/HTL	0.32	0.38	0.38	0.35
HBW/HTW	0.60	0.73	0.64	0.57

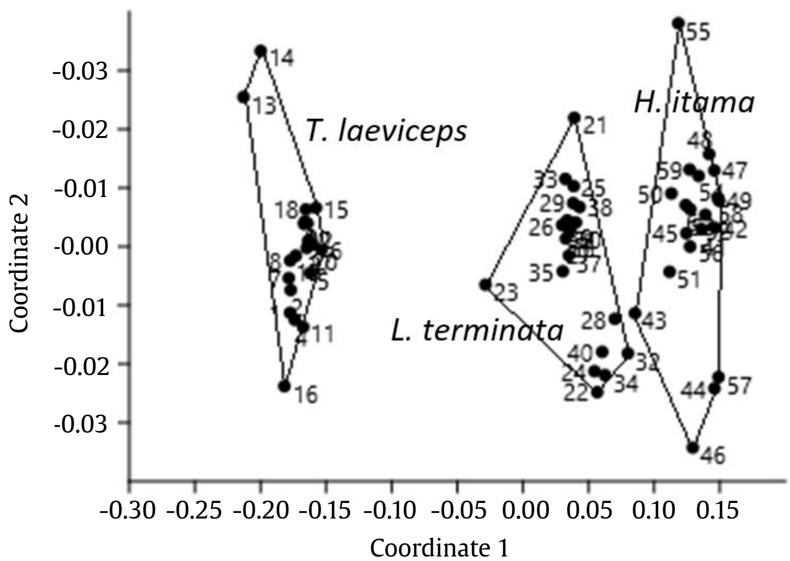

Figure 5. Non-Metric Multidimensional Scaling (nMDS) based on the Bray-Curtis similarity (stress = 0.04119) of body characters of three species stingless bees

4. Discussion

4.1. Diversity of Stingless Bees

Of the four species of stingless bees found, three species of them (*T. laeviceps, L. terminata*, and *H. itama*) also were reported in Yogyakarta, Indonesia (Trianto and Purwanto 2020). Similarly, Chinh *et al.* (2005) also reported three species of stingless bees (*Lisotrigona carpenteri, T. laeviceps*, and *L. ventralis*) were found in buffer zones and tropical primary forest in North Vietnam. In mixed fruit orchards of Southern Thailand, Wayo *et al.* (2020) also reported 13 species of stingless bees and the five most abundant species were *H. itama, T. pagdeni, Tetrigona apicalis, G. thoracica*, and *T. fuscobalteata*.

This study showed the most stingless bees was found in the forest (3 species in UKNP, i.e., *T. laeviceps, L. terminata*, and *Tetragonula* sp. and 2 species in Gunung Kencana forest, i.e., *T. laeviceps* and *H. itama*). While in settlement areas, we only found one species (*T. laeviceps*) of stingless bee. Similar results were reported by Hamid *et al.* (2016) in northern Peninsular Malaysia, *L. terminata, T. iridipennis, H. itama* and *T. laeviceps* were found in forest area and *H. itama* was considered as the common species. The forest is favored by stingless bees, due to high diversity and abundance of flowering plants as a food resource of bees. Otherwise, settlement areas are favored by ornamental or the same type of flowering plants which are probably less preferred by the stingless bees. The richness and abundance of stingless bee significantly was affected by landscape-level. The forest patches are potentially reservoirs for stingless bees and other pollinators and protect the nesting sites and foraging habitat of pollinator taxa (Wayo *et al.* 2020). Previous study showed stingless bee body size in forest area was bigger than that in urban area (Klakasikorn *et al.* 2005; Kuberappa *et al.* 2005), due to the various flowering plants and trees as food sources (Wayo *et al.* 2020).

4.2. Morphometry of Stingless Bees

The worker bee of *T. laeviceps* has smallest body size (3.86 mm in length), compared to *L. terminata* (4.99 mm in length) and *H. itama* (5.52 mm in length). The body length of *T. laeviceps* in the current study was similar to several previous studies, such as in Bogor, Indonesia (3.85 mm) (Cholis *et al.* 2020), Sulawesi, Indonesia (3.40-3.43 mm) (Suriawanto *et al.* 2017), and in Singapore (3.50 mm) (Smith 2012). The body length of the species was smaller than the same species reported in Asia and Sri Lanka (4.0-4.6 mm) (Sakagami 1978) and in Bogor, Indonesia (4.764-4.811 mm) (Efin *et al.* 2019). The current study also showed that the forewing length (WL) and HTW/HTL ratio (3.60 mm and 0.32) of the species was lower than that reported by Dollin *et al.* (1997) (4.00-4.60 mm and 0.35). The head width of the species (1.68 mm) was similar to previous studies; there were 1.65-1.75 mm (Rasmussen and Michener 2010), 1.89 mm (Sakagami 1978), and 1.65 mm (Trianto and Purwanto 2020).

Worker of *L. terminata* of this study (4.99 mm of body length) is similar to the same species of Sulawesi (5.0 mm) (Sayusti *et al.* 2021) and Yogyakarta (4.63 mm) (Trianto and Purwanto 2020). *Lepidotrigona terminata* was characterized by mesonotum enclosed by a yellowish short thick scale-like border, a short scutellum, hind wing usually with six hammuli, posterior hind tibia with simple hairs, and basal tergite of abdomen with an ivory color (Sayusti *et al.* 2021). Meanwhile, the worker of *H. itama* body length of the current study was 5.52 mm. Its body length was slightly smaller than the same species collected in Bogor (5.78 mm) (Cholis *et al.* 2020) and larger than specimen collected in Yogyakarta (4.84 mm) (Trianto and Purwanto 2020). In urban and forest areas of Penang Island, Malaysia, the body length of this species ranged from 2.54-to 5.36 mm (Hamid *et al.* 2016). This species is characterized by head width almost twice than length and covered by short setae, ratio width to length of eye was 0.40-0.43 mm, antennae 10 segmens, mandibles broader on basal half with one tooth (Samsudin *et al.* 2018).

4.3. Nesting Sites and Nest Structure

The current study found that nests of *T. laeviceps* were found in tree- and bamboo cavities. The nest of the species also was reported in parts of housing (Sakagami *et al.* 1983), tree cavities with a diameter of 30-50 cm (Chinh *et al.* 2005). In Philippines, nest of *T. fuscobalteta* and *T. sapiens* were found in bamboo cavities (Starr and Sakagami 1987). The nest entrance of stingless bees varies in shape, color, and texture (Sakagami *et al.* 1983). The results of this study showed the nest entrance of stingless bees are tube-like in varying lengths, blackist-brown at the base and light brown at the end. Chinh *et al.* (2005) reported in north Vietnam, the nest entrance of *T. laeviceps* were cylindrical with 8-11 cm in diameter and 40-90 cm in length. In Sulawesi stingless bees, Sayusti *et al.* (2021) reported six types of entrance opening (irregular, ellipse, triangle round, oval, and longitudinal slit) and three types of entrance shape (cylindrical tube, funnel, and slit). Meanwhile, nests of *L. terminata* in South Sulawesi had a cylindrical entrance (2.9 cm in length and 1.3 cm round opening), light and dark brown with droplets of propolis on the upper surface. Environmental factors, such as rain and predation influenced the nest entrance structures.

The nest structure of stingless bees consists of brood cells, honey- and pollen pots. In *T. laeviceps,* brood cells (4-5 mm long) arranged in amorphous clusters and short pillars are connected among the cells. Several honey and pollen pots are found in the same size (5-7 mm diameter, 12- 15 mm high), and the pollen pots are usually closer to the brood cells. In Meliponini, identical cells are found in males and workers. The queen cells (0-7 cells) are found in irregular sites in the brood clusters (Chinh *et al.* 2005).

Meanwhile in Sulawesi, nests of *L. terminata* was with regular layered comb brood cells with lamellate pillars joined among the combs. The position of mature brood cells (light brown) was on the basal layer comb, while the young broods were in the upper layer. The brood cells of this species were 0.33 cm in diameter and 0.54 cm in height (Sayusti *et al.* 2021).

Our results showed that forests had a high species richness and abundance of stingless bees as part of the pollinator communities. Forests are also reservoirs for other fauna and wild plants (Wayo *et al.* 2020). Habitat loss and fragmentation are the main causes of the decline of both the abundance and species richness of pollinators (Potts *et al.* 2010). Preserving forests and other natural habitats will conserve stingless bees and pollinators.

In conclusion, the forest has a higher species richness of stingless bees than settlement areas. In the forest of Ujung Kulon National Park at least was found four species of stingless bees, i.e., T*etragonula laeviceps, Lepidotrigona terminata, and Heterotrigona itama*, and *Tetragonula* sp. and *L. terminata* were the dominant species. Meanwhile, settlement areas were favoured by one species (*T. laeviceps*). *Heterotrigona itama* have a largest body size and thirty-three body characters of *H. itama* were larger than *L. terminata* and *T. laeviceps*. Analysis of Non-Metric Multidimensional Scaling showed the separation of each stingless bee species. The nest of stingless bees in the forest were in the trees of various plant species with a diameter range of 39.3-87.3 cm. In settlement areas, the nest of *T. laeviceps* was found in some tree species and in the bamboo cavities of houses. The nest entrance of stingless bees were characterized by tube-like in varying length. The internal structure of stingless bee nests consists of brood cells, pollen cells, and honey pots.

Conflict of Interest

The authors declare no conflict of interest.

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