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CHARACTERISTICS OF STINGLESS BEES (HYMENOPTERA: APIDAE: MELIPONINI) FROM UNIVERSITAS ANDALAS LIMAU MANIS CAMPUS COMPLEX AND ITS IMPLICATION IN POLLINATION AND ECOTOURISM

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ABSTRACT

Stingless bees, of the tribe Meliponini, subfamily Meliponinae and family Apidae, have been renowned as honey-producing bees and pollinators. An inventory survey on stingless bees was conducted at Universitas Andalas campus complex (UACC) between 2019-2022 with the aim of documenting their morphological characteristics and nesting behavior that are important for developing meliponiculture. It used direct observation and specimen collection at nest entrances, along with plant species identification from around the nests. A total of nine (37 % of stingless bee species known in Sumatra), of four genera, were recorded at different nesting spots within UACC. Five species were under genus *Tetragonula*, two of genus *Lepidotrigona*, and one each for genera *Tetrigona* and *Heterotrigona*. *Tetragonula fuscobalteata* was the smallest species found in this study, reaching 3.2 mm body length and less than 3.5 mm wing length. On the other hand, *Tetrigona apicalis* was the biggest species, measuring 7 mm body length and more than 7.2 mm wing length. *Tetragonula* consists of members with small bodies and inhabit either anthropogenic areas or natural habitats such as tree hollows, fences, wall crevices or other forms of cavity. Thirty-one plant families were recorded as potential resources around the stingless bee colonies. These families are dominated by *Fabacease, Asteraceae, Moraceae, Euphorbiaceae* and *Verbenaceae*. There might be differences in capacity to provide nectar, pollen, resin or gum among plant families; however, the diversity of plant species in the community should be complementary in providing resources for stingless bee colony. The nine stingless bee species recorded in this study possess an array of potential for meliponiculture and aesthetic purposes. Anthropogenic-tolerant species can be possibly reared and aesthetically integrated with decorative aspects of human settlement. The knowledge on existing stingless bee species, along with their biological aspects become crucial in initiating meliponiculture system within the University boundaries, with possible venture can be extended into ecotourism where people come and enjoy the beekeeping within this scenic University environment.

Key words: Stingless bees, Taxonomy, Morphological, Meliponiculture, Pollinator, Ecotourism, Campus

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INTRODUCTION

Stingless bees constitute the group of honey-producing bee belonging to the tribe Meliponini, subfamily Meliponinae, family Apidae [1]. This kind of bee is widely distributed across the tropics and subtropics, including South America, Australia, Southeast Asia and some parts of Africa [1-6]. The diversity of social bees in Indonesia is among the greatest in Asia, especially with regards to the stingless bees [7]. A total of forty-six stingless bee species have been recorded throughout Indonesia, with the most species diversity centred on Sumatra and Kalimantan. Stingless bee is known by several local names, including *kelulut* (Melayu, Kalimantan, Sumatra), *linot* (Aceh), galo-galo (Minang or West Sumatra), klanceng or lancing (Jawa) and te'uweul (Sunda) [8].

Similar to other groups of bees such as honey bee (Apini), bumble bee (Bombini) and orchid bee (Euglossini), a stingless bee possesses corbicula on its hind leg that it uses to carry pollen [1]. A stingless bee can be easily differentiated from honey bee by its vestigial, non-functional sting and smaller body size [6]. Other definitive characters of this bee include the penicilium, a long seta on hind tibia and weak wing venation [9]. Due to its non-functional sting, a stingless bee defends itself by biting its enemies. In addition, some species have mandibular secretions that are able to inflict painful blisters [10].

A stingless bee uses variable nesting locations, such as tree cavities, termite mounds and ant nests either above ground or subterranean, hollows between tree roots and ground, as well as within the rock crevices [11, 12, 13, 14, 15]. *Tetragonula laeviceps* is highly antropophilous species, in which it frequently makes nests in human constructions like houses, buildings and drainage pipes [2]. Other species construct exposed nests on tree branches, walls or cliffs, instead of occupying cavities [1]. Nests are made from the mixture of wax secreted from the metasomal terga and mixed with resins and gums collected by the worker bees. Some species also add mud, dung or excreta or other materials to certain parts of the nest construction [1, 4].

Similar to the more renowned honey bee, a stingless bee also acts as an important pollinator in tropical rainforest and pollinates various plants [16-19]. Like its honey bee *(Apis spp.)* counterparts, a stingless bee also produces honey, pollen, bee bread and propolis. Propolis is a large deposit of resin stored in the nests by the worker bees. Propolis in stingless bee nests are easier to harvest compared to *A. mellifera.* Both types of propolis can be used in similar ways, where stingless bee propolis have shown stronger antibacterial properties than *A. mellifera* [11]. The main objective of this study was to identify and document the morphological characteristics and nesting habits of stingless bees at the Universitas Andalas campus complex, Limau Manis, Padang. Furthermore, the objective of the study was to provide recommendations on the potency of stingless bee as a pollinator and its involvement in ecotourism within the study area.

METHODS

Sample collection

This study was conducted from June 2019 to August 2022 at the Universitas Andalas campus complex (UACC). Sampling was performed in areas within the Biology Educational and Research Forest (BERF), Medicinal Plant Garden, Arboretum, Animal Science Field Laboratory, Animal Science Front Garden, campus roads, BERF station and other locations. Sampling locations were decided purposively using exploratory survey method. Foraging workers from each identified colony were collected around the nest entrance using insect nets. Stingless bee samples were stored inside collection bottles filled with ethanol 96 % and labeled. The nesting site of each stingless bee colony was determined. Aside from *Heterotrigona (Heterotrigona) itama* colony that has been successfully bred in UACC, other stingless bee species nest in the wild.

The coloration of foraging workers was defined, shape and color of nest entrance were noted in detail and photographed to provide supporting data. Species identification was based on morphological characters specified in the laboratory. Morphological observation on stingless bees was focused on their parametric and color characters based on Sakagami and Inoue [3]. Body parameters included body length, wing length, length of hind tibia, the color of abdomen, wing venation and coloration, also the presence or absence of marking pattern on the mesoscutum. Observations and measurements were assisted by the use of binocular microscopes and all measurements were presented in millimeters. Vegetation survey was opportunistically conducted upon encountering a stingless bee colony, using a 10 x 10 m plot with colony at the center point. Plants within the plots were then identified by using reference collections in Herbarium Universitas Andalas (ANDA). The vegetation data provides essential information regarding the resources used by the stingless bees in sustaining their colonies.

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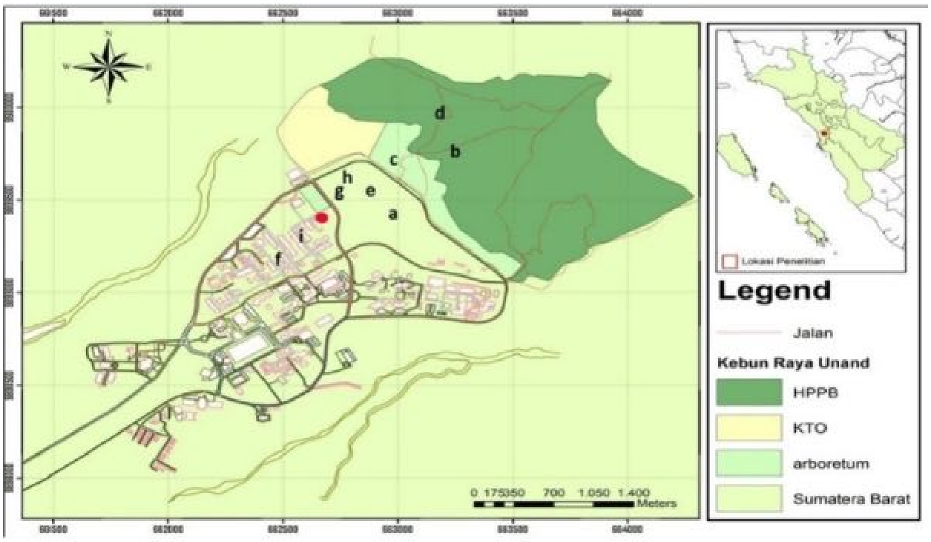

Figure 1: Distribution of Stingless bee colonies at the Universitas Andalas Campus Complex. a = Animal Husbandry field laboratory, b = Research station HPPB, c = Arboretum, d = Permanent Plot in BERF, e = Small storage room near BERF, f = Faculty of Animal Husbandry, g = Arboretum keeper house, h = Area around arboretum keeper house, i = Herbarium ANDA

Data Analysis

Morphological characters of stingless bees were observed using a binocular microscope. Species identification was keyed using relevant guidance provided in Sakagami *et al.* [20]. Data from observation and measurement of morphological characters were organized in Tables. Morphological characteristics and nesting habits from each stingless bee were then descriptively explained.

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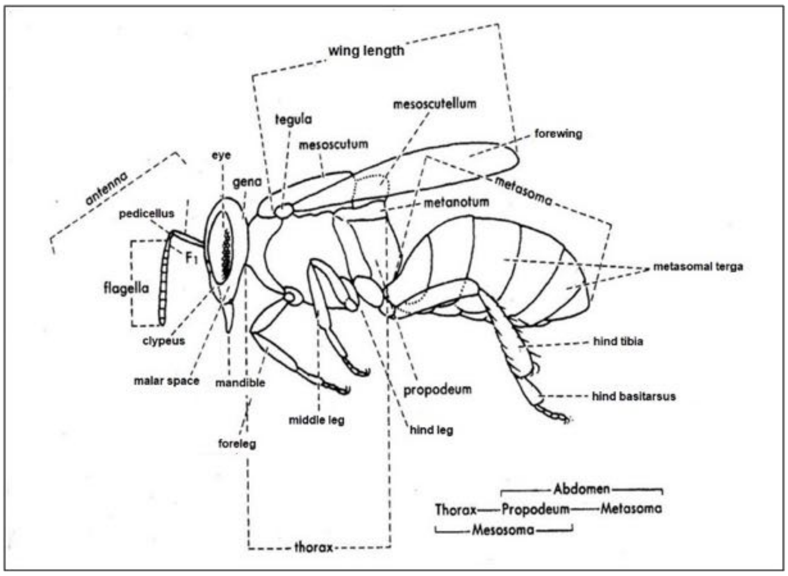

Figure 2: The morphology structure of stingless bee [20]

RESULTS AND DISCUSSION

Characteristics of stingless bee species found in UACC

In total, nine stingless bee species were identified and recorded from the boundaries of UACC. With the current record for Sumatran stingless bee reaching 24 species, the number of species identified in this area comprises 37 % of the total Sumatran record [11]. *Tetragonula* was the genus with most species recorded (five species), followed by *Lepidoptrigona* with two species, while *Tetrigona* and *Heterotrigona* were each found with one species. *Tetragonula fuscobalteata*, with five colonies found, becomes the species with most colonies observed, followed by *T. minangkabau* with three colonies. All other species were observed from one colony (Table 1, Figure 3).

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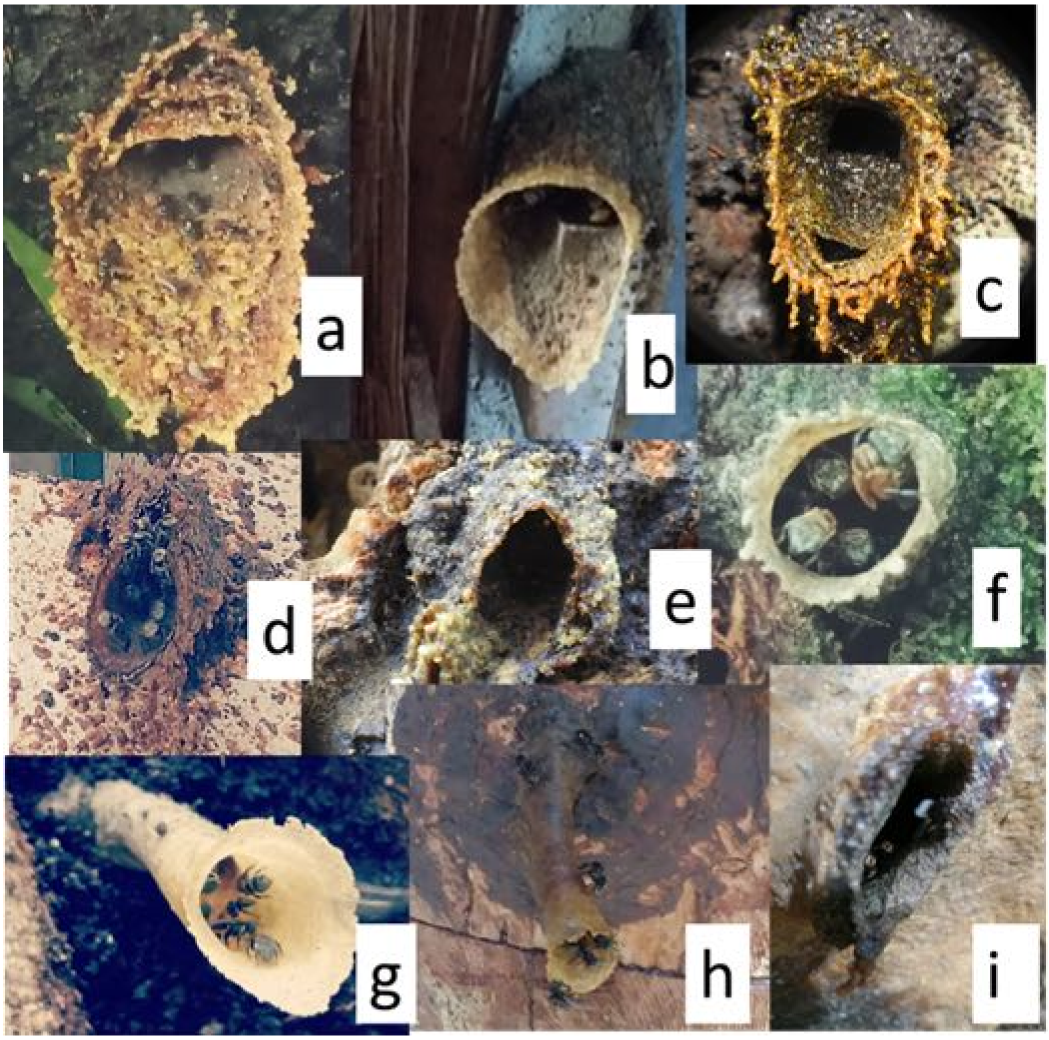

Figure 3: Variation on nest entrance among nine stingless bee species found in UACC. *a = T. reepeni, b = T. fuscobaelata, c = T. geissleri, d =T. minangkabau, e =T. laeviceps, f = L. nitidiventris, g =L. ventralis, h= H. itama and i = T. apicalis*

The description and distribution of each species of stingless bees at the Universitas Andalas Campus complex was as follow:

Tetragonula (Tetragonula) reepeni **(Friese, 1918) – Figure 4a, b**
Trigona (Tetragonula) latigenalis [21], *Trigona (Tetragonula) reepeni* [22], *Tetragonula (Tetragonula) reepeni* [23].

Specimens of these species have five hamuli on the forewing (left side). The middle portion of propodeum is shiny and hairless. The body entirely black and shiny with its length measuring between 4.7 – 5.2 mm, while wing length is from 5.2 – 6 mm. The body length with wing and tegula is more or less 7 mm. The mesoscutellum distinctly projects backwards, exceeding posterior slope of propodeum. The malar space is linear or mostly shorter than the half width of second flagellomere (segment of flagellum of antennae). The mandible has two strong teeth as in *Tetrigona apicalis.* The gena is nearly as wide as the eyes, while ocelloccipital distance nearly is as wide as ocellar diameter [20].

Tetragonula (Tetragonula) fuscobalteata **(Cameron, 1908) – Figure 4c, d**
Trigona fuscobalteta [24], *Trigona atomella* [24], *Trigona (Tetragona) fuscobalteta* var. *fuscobalteta* [25], *Tetragonula fuscobalteta* [26*], Trigona (Tetragonula) fuscobalteta* [2, 21], *Tetragonula (Tetragonula) fuscobalteata* [23].
The specimens body length ranged between 3 – 3.3 mm while for the wing, it was between 3.4 – 3.5 mm. There is an obvious hairband on the dorsal part of the Scutum, formed like three white lines. This observation is in line with the description of *T. fuscobalteata* with mesoscutellum distinctly projecting backwards, while exceeding posterior slope of propodeum [20]. The malar space is linear and, at most, shorter than half the width of second flagellomere. Most parts of the forewing are uniformly transparent or with slight infuscate (darkened with brownish tinge). The species is very small with the body and wing each measuring up to 3.5 mm. Mesoscutal glabrous areas, especially the lateral one (G3) is conspicuous. This species has a small nest volume, with its measured capacity reaching only 0.3 L. The nests are frequently observed in bamboo poles used in house or other constructions, cracks in wooden walls, crevices in rocks and holes in limestone [12].

Tetragonula (Tetragonula) geissleri **(Cockerel, 1918) – Figure 4e, f**
Tetragonula (Tetragonula) geissleri [23], *Tetragonula geissleri* [27]
Morphological observation on specimens of this species showed body length ranging between 4.4 – 4.8 mm and wing length from 5.5 – 6.0 mm. The length of hind tibia is between 2.1 – 2.2 mm. The head and thorax are black, the abdomen is dark to blackish brown while the clypeus and tegula are blackish brown. This species has a similar morphological form with *T. reepeni*, but can be distinguished by weaker teeth on the mandible (as oppossed to strong teeth for *T. reepeni*). The mesoscutellum distinctly projects backward, exceeding posterior slope of propodeum. The malar space is linear and, at most, shorter than half width of flagellomere 2. The mandible is characterized with weak teeth like *Heterotrigona (Sundatrigona) moorei*. The gena is distinctly narrower than the eye. The ocelloccipital distance is about half of the ocelar diameter. The body is predominantly dark, the head is blackish except for clypeus, and mesosomal

dorsum is blackish as well. The forewing is rather uniformly transparent or with slight infuscate. This observation is in concordance with previous record that stated the body length for this species is between 4 – 4.5 mm, wing is from 5 – 5.5 mm, while the hind tibia is more than 2 mm [20]. The antennae entirely blackish brown, scape yellowish brown. Gastral tergite is wholly dark brown and slightly blackish in some individuals [27].

***Tetragonula (Tetragonula) minangkabau* (Sakagami et Inoue, 1985) – Figure 4g, h**

Trigona (Tetragonula) laeviceps (nec Smith 1857) [21, 28,29], *Trigona (Tetragonula) minangkabau* Sakagami et Inoue, 1985 [30, 31], *Tetragonula (Tetragonula) minangkabau* [23].

The body length ranges from 3.2 – 3.5 mm, while the wing length is between 3.8 – 4.0 mm. The head and thorax are black, but the abdomen is light brown to chestnut or yellowish brown. Both clypeus and tegula are light brown. The mesoscutellum distinctly projects backward, exceeding posterior slope of propodeum. The malar space is linear and, at most, shorter than half width of flagellomere 2. The clypeus, tegula, part of hind leg and basal part of metasoma tend to get pale brown to ferruginous toward the anterior. This species is smaller than *T. drescheri.* Paler parts are relatively deeper in tone. Clypeus and tegula range from testaceous to ferruginous in color, sometimes chestnut brown. Metasoma is predominantly chestnut brown [20]. The nests of this species were observed within 20 - 30 cm hollow of rambutan tree *(Nephelium lappaceum),* bamboo pole, gap between wooden boards or walls, and cavities within ferns such as *Cyathea* spp. or *Alsophila* spp. [12].

***Tetragonula (Tetragonula) laeviceps* (Smith, 1857) – Figure 4i, j**

Trigona laeviceps [32], *Trigona iridipennis* [24], *Trigona (Tetragona) iridipennis* var. *iridipennis* [25, 33], *Tetragonula laeviceps, testaceicornis* and *valdezi* [25, 34], *Trigona (Tetragona) iridipennis* var. [35], *Trigona (Tetragonula) laeviceps* [26], *Tetragonula (Tetragonula) laeviceps* [23].

Most of the body parts are dark in coloration. The head and thorax are black, the abdomen is dark brown to blackish brown while tegula is blackish brown. The body length ranges from 4 - 4.4 mm while the wing length is between 4.2 - 4.7 mm and hind tibia is ± 1.8 mm long. Mesoscutellum distinctly projects backward, exceeding posterior slope of propodeum. The malar space is linear and, at most, shorter than half width of flagellomere 2. The body is predominantly dark and smaller than *T. geissleri,* while the length of hind tibia is less than 2 mm. The differences with *T. geissleri* are palpable between males, but rather metrical in female workers [20].

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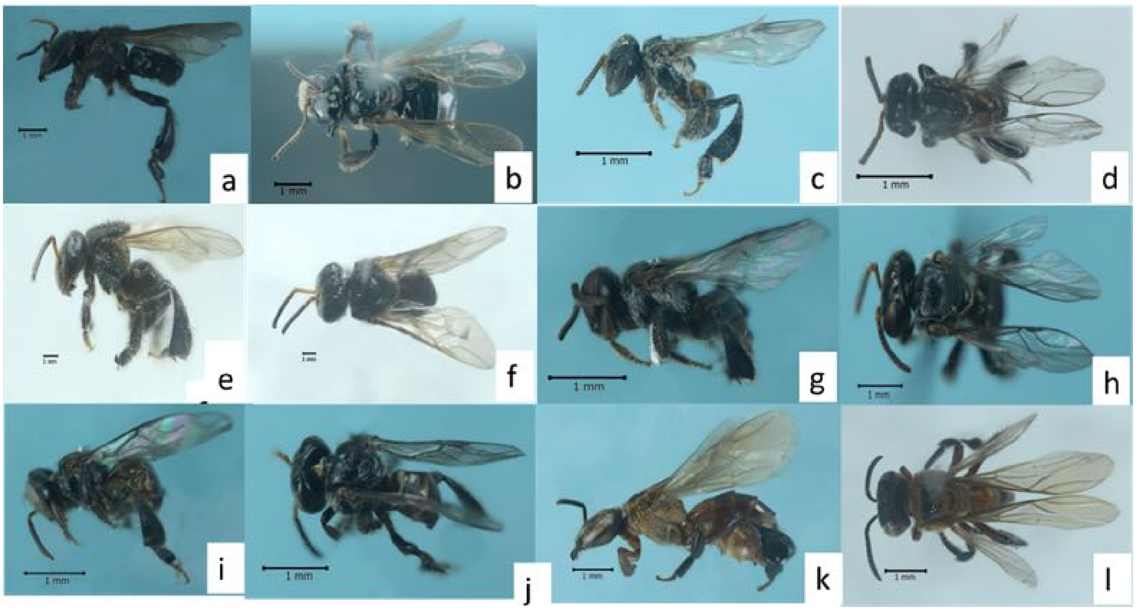

Figure 4: Morphology of stingless bee workers found at UACC (lateral and dorsal habitus). a, b: *Tetragonula (Tetragonula) repeeni* (Friese, 1918); c, d: *Tetragonula (Tetragonula) fuscobalteata* (Cameron, 1908); e, f: *Tetragonula (Tetragonula) geissleri* (Cockerell, 1918); g, h: *Tetragonula (Tetragonula) minangkabau* (Sakagami and Inoue, 1985); i, j: *Tetragonula (Tetragonula) laeviceps*; k, l; *Lepidotrigona nitidiventris* (Smith, 1857)

***Lepidotrigona nitidiventris* (Smith, 1857) – Figure 4k, l**
Trigona nitidiventris [24, 32], ` *(Lepidotrigona) nitidiventris* var. *nitidiventris* [25, 36] *Lepidotrigona nitidiventris* [23, 26].
Studied specimens showed the posterior edge of hind tibia with simple hairs. There is scale-like tomentum structure on the peripheral part of mesoscutum. Mesoscutum tomentum is orange in color, extending from mesoscutum to mesoscutellum. The body length ranges between 4.9 – 5.3 mm, while the wing length is from 5 – 5.5 mm. The hind tibia has a spoon-like form. The head and mesosoma are not coriaceous or tesselate dorsally, neither shiny. The mesoscutum is peripherally covered with scale-like tomentum. Wing venation is less reduced (compared to *Hypotrigona*) and with narrower pterostigma. The species are either medium or large in size with the body and wing measuring more than 4 mm in length. The mesoscutal tomentum is well-developed, extending to mesoscutellum. The legs, especially forelegs and midlegs, are at least partly brownish [20].

***Lepidotrigona ventralis* (Smith, 1857) – Figure 5m, n**

Trigona ventralis [32], *Trigona (Lepidotrigona) ventralis* var. *ventralis* [25], *Lepidotrigona ventralis, flavibasis, doipaensis, arcifera* [26], *Trigona (Lepidotrigona) ventralis flavibasis* [35], *Trigona (Lepidotrigona) ventralis* [37], *Lepidotrigona ventralis* [23].

Posterior of hind tibia is characterized with simple hair, body length of between 4.5 – 4.8 mm and wing length ranging from 4.7 – 5 mm. The apical of hind tibia is somewhat wide. Dorsal head and mesosoma are neither coriaceous or tesselate, nor shiny. Mesoscutum is peripherally covered with scale-like tomentum. Wing venation is less reduced (compared to *Hypotrigona*) and has narrower pterostigma. Small species with body and wing each less than 5 mm length. Mesoscutal tomentum is usually whitish and not extending to mesoscutellum, while hind tibia is not much expanded apically [20].

***Homotrigona (Tetrigona) apicalis* (Smith, 1857) – Figure 5o, p**

Trigona apicalis Smith, 1857 [24, 32], *Trigona (Tetragona) apicalis* var. *apicalis*, [2, 33,34]. *Tetragona apicalis* [26], *Trigona (Tetragona) apicalis apicalis* [35], *Trigona (Tetrigona) apicalis* [36] *Homotrigona (Tetrigona) apicalis* [23].

The body length ranges from 5 - 5.3 mm, while wing length is between 6 - 6.5 mm. The mandible is characterized with strong teeth. The front wing has two colours, white on tip and dark brown on the base, while wing venation is pale orange. Clypeus has erected black bristles that are prominent on apical area. Forewing is bicolorous, basally brown with dark brown veins, contrasting to milk white apical portion with pale orange veins. The malar space is about as long as the width of flagellomer 2. The body coloration appears lighter than *Homotrigona (Tetrigona) melanoleuca* [20]. The nest of this species was found mainly in the gap created between the strangler Ficus and durian *Durio zibethinus*. Some nests were also found among cracks in the stone wall of house basements. The volume of nest cavity is relatively large, reaching 70 L [11].

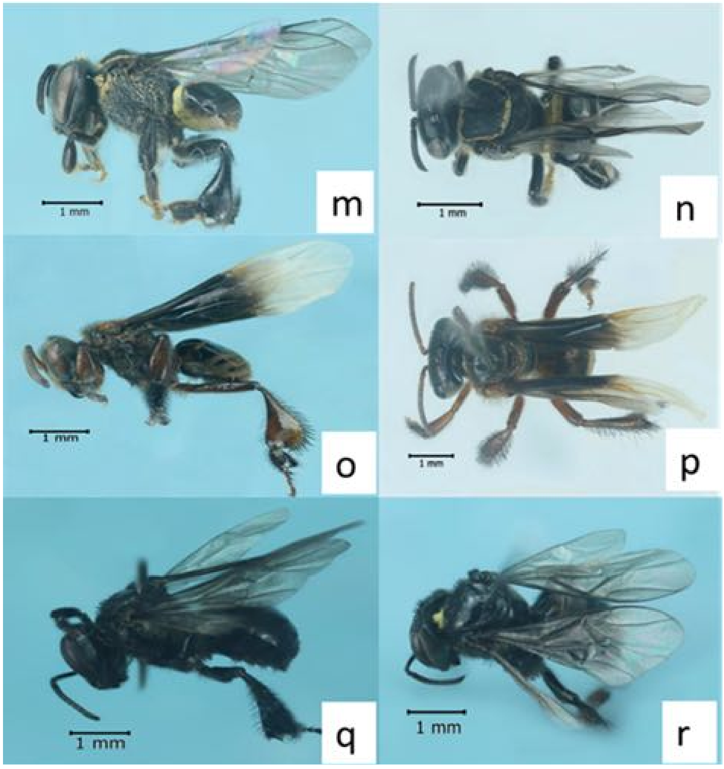

Figure 5: Morphology of stingless bee workers found at UACC (lateral and dorsal habitus). m, n: *Lepidotrigona ventralis* (Smith, 1857); o, p: *Homotrigona (Tetrigona) apicalis*;q, r: *Heterotrigona (Heterotrigona) itama* (Cockerell, 1918)

Heterotrigona (Heterotrigona) itama **(Cockerell, 1918) – Figure 5q, r**
Trigona (Heterotrigona) itama [2, 25, 31, 35, 36], *Heterotrigona itama* [26], *Heterotrigona (Heterotrigona) itama* [23].
The body is entirely black while the wing base is brownish and basally infuscate. The mandible has one weak tooth. The body length is 5 mm, while the body and wing are 7 mm long. All of these features refer to the characteristics of *H. itama* [12]. Hind basitarsus is about two-third as wide as hind tibia. The head is shorter than *H. erythrogastra*, and malar space shorter than *H. erythrogastra* with ratio to width of flagellomer 2 being about 8:6. This species has medium to large nest cavity volume, and the one observed in this study reaches 4.5 L. Some nests are naturally found in holes of clove trees *Eugenia aromatica* or coconut *Cocos nucifera* with 30-50 cm diameter. In addition, nests are also found among crevices in the stone walls.

From species descriptions above, some morphological characters are typical on certain stingless bee species which are later useful for identification during field

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survey in UACC or other areas in Sumatra. In general, size, colour and morphology of a stingless bee are essential in identifying the species (Table 2). *Tetragonula* group consists of small body-size stingless bees, with the smallest species being *T. fulcobalteata* (body length less than 3 mm). *Homotrigona apicalis* is the biggest stingless bee found in UACC with body length of more than 6 mm. Body coloration will also help in identifying species, such as what was observed on *T. laeviceps* and *T. geissleri* whose thorax and abdomen are black, while their relatives *T. minangkabau* and *T. fulcobalteata* have brown or orange abdomen. On *H. apicalis,* its white-tipped wing is the determinant character for its identification. In addition to that, number and morphology of teeth in mandible is another supporting character for identifying stingless bees. The members from genus *Tetragonula, Lepidotrigona* and *Tetrigona* have two teeth on their mandible, while *Heterotrigona* have only one. There was also indication observed in this study that the variation of shape and materials of nest entrance can be used for species identification, however, this requires further investigation.

UACC's stingless bees as pollinators and future involvement in ecotourism

With 150 ha area, UACC harbours 17 colonies and nine species of stingless bee. Furthermore, four stingless bee species, *T. repeeni, T. glisseri, L. nidiventris* and *L. ventralis,* were not recorded elsewhere. This was recognized from the inventory record compiled by HH after her Sumatra stingless bee expedition. The UACC environment with addition of primary and secondary forest within the Biology Education and Research Forest (BERF), medicinal plant areas and campus garden may contribute in the uniqueness of the stingless bee species found here. Vegetation at UACC, along with other micro habitat elements therein, work together in providing suitable habitat for stingless bees [38].

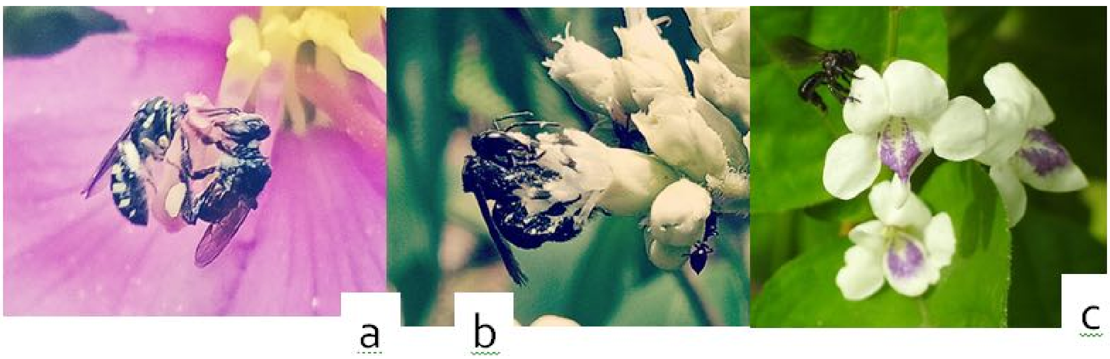

Figure 6: Stingless bees foraging on wild flowers at UACC. a. *Melastoma malabatricum (Melastomatacea),* b. *Glibadium* sp. (Asteracease), c. *Asystacia ganggetica* (Achantaceae)

As indicated in a previous report, bees and stingless bees are the best pollinator insects [39], hence the existence of nine species and fifteen stingless bee colonies within the campus area provides a ready pollinator force to help with the reproduction of local vegetation. The diversity of vegetation in UACC environment supply the stingless bees not only with food, but also with resin tree and location to build their nests. Figure 6 shows the foraging activities of *H. itama* on several wild flowers at the edge of the BERF areas. Furthermore, Table 3 provides a list of potential plants families recorded from the surrounding of UACC's stingless bee colonies that are presumed as food or resin sources as well as nesting location.

These 31 plant families were thought to be potential sources of food, resin, gum or even as nesting that are useful for stingless bees at UACC. Fabaceae was the most common plant found around stingless bee colonies, followed by Asteraceae, Moraceae, Euphorbiaceae and Verbenaceae. There might be differences among the plant families in their capacity to produce nectar, pollen, resin or gum; but overall, a vegetation community can complementarily provide for the development of stingless bee colonies (Table 3). Plant diversity attract bees and other pollinators into the ecosystem, which then guarantee the running of ecological processes within the ecosystem. While in agricultural ecosystem, bees and pollinator insects ensure at least the provision of thirty-five percent of crop production [40].

Nine stingless bee species recorded in this study also provide an array of options for meliponiculture. The existence of stingless bees along with their colonies within or adjacent to anthropogenic area provides opportunity to further develop meliponiculture in such type of environment. Recalling the observed feasibility of UACC environment in supporting the stingless bee colonies, it is not exaggerated to say that UACC can serve as the center for meliponiculture in Padang City, if not for West Sumatra. Integration between meliponiculture effort and UACC as an academic institution could work well, as many studies, researches and innovations potentially resulted from it. As an academic institution, UACC supervises many competent scholars from various disciplines that can be incorporated to work for bettering the meliponiculture venture. The behaviour of stingless bees, on the other hand, may become an interesting aspect and their interaction with their environment including plants can be conceptualized and integrated into education facilities in UACC. Integrating the beautiful natural scenery in UACC with the stingless beekeeping effort provides potential ventures that combines ecotourism and meliponiculture within the campus area.

CONCLUSION

There were nine species of stingless bees collected in the environment of the Universitas Andalas Campus with four species being unique to the UACC area. The uniqueness of UACC's stingless bees, either in its morphological characteristics, colony life, nest forms or behavior provide the possibility to be proposed as ventures in meliponiculture or ecotourism. This is potentially possible through the utilization of UACC environment that is supportive for those causes.

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AUTHOR CONTRIBUTION

Henny Herwina is the main researcher who prepared the main methodology and collected data. She spearheaded data analysis and interpretation, as well as drafted and finalized this manuscript. The authors Y, JN, MNJ, SS, J and BYC are co-authors who contributed to developing of concepts, research objectives, and the methodology. They also participated in data collection, analysis, and interpretation of the results coupled with writing of this manuscript.

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Table 1: List of stingless bee species, information on colonies nests (site, height, position, length and diameter of nest entrance) at the Universitas Andalas Campus Complex

No	Species	Colony's site	Colony Height	Colony position	No of Colony	Length of entrance	Diameter of entrance
1	*Tetragonula (Tetragonula) repeeni* (Friese, 1918)	Acasia tree in front of Herbarium ANDA and surrounding nearby	5 cm, 50 cm	Tree hollow	1	6 cm	8 cm
2	*Tetragonula (Tetragonula) fuscobalteata* (Cameron, 1908)	Small storage room in BERF	100-150 cm	Door	5	2-4 cm	2- 3 cm
3	*Tetragonula (Tetragonula) geissleri* (Cockerell, 1918)	Tree near Faculty of Animal Science	120 cm	Tree hollow	1	10 cm	7 cm
4	*Tetragonula (Tetragonula) minangkabau* (Sakagami and Inoue, 1985)	Arboretum house keeper building	100-150 cm	House wall	3	5-12 cm	2-3 cm
5	*Tetragonula (Tetragonula) laeviceps* (Smith, 1857)	Arboretum keeper house	70 cm	Tree hollow	1	2 cm	cm
6	*Lepidotrigona nitidiventris* (Smith, 1857)	Tree near to the road Arboretum	100 cm	Tree hollow	1	2 cm	2 cm
7	*Lepidotrigona ventralis* (Smith, 1857)	Tree near Permanent Plot in BERF	110 cm	Tree hollow	1	10 cm	1.2 cm
8	*Homotrigona (Tetrigona) apicalis* (Smith, 1857)	Tree near BERF gather house	250 cm	Tree hollow	1	1 cm	2 cm
9	*Heterotrigona (Heterotrigona) itama* (Cockerell, 1918)	Animal Science practice field	120 cm	Bee box	1	3 cm	2 cm

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Table 2: Specific characteristics of stingless bee at UACC

No	Species	Length parameter (mm)			Coloration	Other remarks
		Body	Wing	Tibia		
1	*Tetragonula (Tetragonula) reepeni*	5 – 5.3	5 – 6	< 2	• Dominant black body • Brown/blackish antennae	• Mandible with 2 strong teeth
2	*Tetragonula (Tetragonula) fuscobalteata*	≤ 3	< 3.5	< 2	• Head and thorax black, abdomen beige	• Smooth mesoscutal, especially on its lateral • The dorsal of mesoscutelum has three white stripes
3	*Tetragonula (Tetragonula) geissleri*	4 – 4.5	5 – 5.5	> 2	• Body is dominantly black • Abdomen is dark brown	• Mandible has 2 moderate teeth
4	*Tetragonula (Tetragonula) minangkabau*	3.2 – 3.5	3.8 – 4	< 2	• Head and body are black	• Mesoscutelum is longer than propodeum
5	*Tetragonula (Tetragonula) laeviceps*	> 4	> 4	< 2	• Head and thorax are black • Abdomen dark brown/blackish • Part of clypeus with white hairs	• Mandible has 2 moderate teeth • Mesoscutum has unclear hairband
6	*Lepidotrigona nitidiventris*	> 5	> 6	> 2	• Abdomen is reddish brown • Fore- and mid-legs has brownish parts • Tomentum of mesoscutal is orange, runs from mesoscutum up to mesoscutelum	• The length of body and wings are more than 7 mm • Tibia of hind legs has pilose hairs • Hind tibia is spoon-like form
7	*Lepidotrigona ventralis*	< 5	< 5	< 2	• The body is dominantly black • Mesoscutal tomentum is generally whitish and not extends beyond mesoscutelum	• Size is smaller than *L. nitidiventris* or *L. terminata* • Hind tibia is not too wide (compared with *L. nitidiventris* and *L. terminata)*

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8	*Homotrigona (Tetrigona) apicalis*	> 5	> 6	> 2	• Wings are bicolor (black on basal, milky white on tip) • Abdomen is reddish brown • Clypeus is yellow • Legs are lighter than *T. binghami*	• Resin on nest tunnel is hardened and brittle
9	*Heterotrigona (Heterotrigona) itama*	> 5	> 6	> 2	• Overall body is black • Wing base is dark brown	• The length of body and wing more than 6 mm • Mandible has a small tooth

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Table 3: Plant families at the surrounding of stingless bee colonies, with respective individual count and presumed potency for stingless bee colony; nectar source (N), gum or resin source (G/R) and pollen source (P). *Tetragonula fuscobaelata (Tf), Lepidotrigona nitidiventris (Ln), and Tetragonula reepeni (Tr)* within the UACC. T = Total number of Tf, Ln, and Tr"

No	Family	Ind. count	N	G/R	P	Tf	Ln	Tr	T
1	*Acanthaceae*	1	1		1	1	1	1	3
2	*Apocynaceae*	1		1	1			1	1
3	*Araliaceae*	1		1	1	1	1	1	3
4	*Arecaceae*	2			1	1	1		2
5	*Arecaceae*	1			1		1		1
6	*Asteraceae*	9			1	1	1	1	3
7	*Caricaceae*	1	1	1	1			1	1
8	*Centroplacaceae*	1			1			1	1
9	*Combretaceae*	1			1			1	1
10	*Costaceae*	1	1		1			1	1
11	*Cyperaceae*	2			1	1	1		2
12	*Euphorbiaceae*	6	1	1	1	1	1	1	3
13	*Fabaceae*	11	1	1	1	1	1	1	3
14	*Fagaceae*	1	1		1	1	1	1	3
15	*Ixonantaceae*	1			1		1		1
16	*Lauraceae*	1			1			1	1
17	*Lytrhaceae*	1			1		1	1	2
18	*Malvaceae*	1			1	1			1
19	*Malvaceae*	2	1		1	1	1		2
20	*Melastomataceae*	1			1	1	1	1	3
21	*Meliaceae*	2	1		1	1	1	1	3
22	*Moraceae*	8		1	1	1	1	1	3
23	*Oxalidaceae*	1			1	1	1	1	3
24	*Pinaceae*	1		1	1	1	1		2
25	*Poaceae*	1			1		1		1
26	*Polygalaceae*	1			1	1			1
27	*Rubiaceae*	1			1	1			1
28	*Rutaceae*	1			1			1	1
29	*Symplocaceae*	1			1	1	1		2
30	*Theaceae*	1			1	1	1		2
31	*Verbenaceae*	5	1		1	1	1	1	3
	Total	69	8	6	30	19	20	18	

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