Morphological characteristics of *Tetragonula* stingless bees (Apidae: Meliponini) at Edufarm Universitas Andalas, West Sumatera

Elni Fatimah[1], *Henny* Herwina[1*], *Dahelmi* Dahelmi[1], *Putra* Santoso[1], *Siti* Salmah[1], *Jasmi* Jasmi[2], *Rusdimansyah* Rusdimansyah[3], *Suat Cheng* Tan[4], *Mohd Zulkifli* Mustafa[4], *Yandrizal* Yandrizal[3], *Muhammad Nazri* Janra[1]

[1]Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Andalas. Limau Manis, 25163 Padang, West Sumatra, Indonesia.
[2]STIKES Indonesia, Jl. Khatib Sulaiman No. 17, 25173 Padang, Indonesia
[3]Department of Animal Production Technology, Faculty of Animal Science, Universitas Andalas, Kampus Limau Manis, 25163 Padang, West Sumatra, Indonesia
[4]School of Health Science, Health Campus, Universiti Sains Malaysia, 16150 Kubang Kerian, Kelantan, Malaysia

Abstract. This study aimed to describe the morphological characteristics of *Tetragonula* stingless bees observed at Edufarm, Universitas Andalas. A total of five *Tetragonula* species were identified and studied. Of five species considered as small-bodied stingless bee, *T. fuscobalteata* was the smallest species with body length 2.79±0.11 mm. Meanwhile, *T. minangkabau* has three vertical smooth bands on mesoscutum, with body length 3.7±0.167 mm; *T. minangkabau* forma *darek* with bicolored body, has a paler body color and larger in size compared to *T. minangkabau*, body length 3.77±0.18 mm, body length 3.77±0.18 mm; *T. testaceitarsis* with glossy black body, body length 4.39±0.24 mm; and *Tetragonilla collina* with different forewing coloration, body length 6.04±0.26 mm. The morphological differences observed, particularly in body size, coloration, wing features, and nest entrance structure provide reliable diagnostic characters for distinguishing closely related *Tetragonula* species.

1. Introduction

Stingless bees (Apidae: Meliponini) are eusocial insects that live in colonies comprise of queen, workers (sterile female) and drones (male bee) [1]. In general, stingless bees are easily distinguished from other bees by the reduction of sting, wing venation, and the presence of penicillum [2]. In natural ecosystems, they play vital role in pollinating flowering plants, thereby supporting biodiversity and agricultural productivity. Besides pollination, bees produce valuable products such as honey, propolis, pollen and beebread which have economic and medicinal value [3]. Stingless bees distribute across three regions: Neotropical, Afrotropical, and Indo-Malay/Australasian [4]. Indonesia, with its high tropical biodiversity, hosts many stingless bee species, reaching 46 species of 10 genera that spread across its archipelago [5]. Sumatra is home for 23 different stingless bee species [6], 18 of them are bred in West Sumatra [7]. Stingless bee is known by various local names such as *galo-galo* (Minang), *linot* (Aceh), *gegalo* (South Sumatra), *teuweul* (Sunda), *klanceng/lancing* (Jawa), and *emuk* (Sulawesi) [8]. Like other eusocial bees such as honey bee (Apini), bumble bee (Bombini) and orchid bee (Euglossini), stingless bee possesses corbicula on their hind leg

* Corresponding author : hennyherwina@sci.unand.ac.id

used to carry pollen [2]. A stingless bee can be easily differentiated from honey bee by its vestigial, non-functional sting, smaller body size, penicilium, a long seta on hind tibia and weak wing venation. Its distinctive morphological characters include tibia, basitarsus, malar space, mandible, head, clypeus, propodeum, mesoscutum, mesoscutellum, antenna, eyes, gena, forewing, wing venation, hamuli, and body color (head, clypeus, thorax, abdomen, tegula, wings) [9].

Edufarm is an educational establishment within Universitas Andalas campus complex designed as a practice and research site for academicians in Faculty of Animal Science, Universitas Andalas. Edufarm has facilities for cattle raising, poultry rearing (eggs and meat), as well as stingless bee breeding in so called "Bee Breeding Center" that housing various stingless bee species. Although the facility aims to include stingless bees, there is no formal publication regarding species and pertinent aspects therein. Therefore, this study aimed to identify and describe the morphological characteristics of stingless bee species from Edufarm in Universitas Andalas. The finding is expected to provide baseline information regarding biological and ecological potency of stingless bees, especially as pollinator and biotic component in environment, as well as the possibility to include it in ecotourism-based meliponiculture that facilitate research, conservation, and development of bee products in West Sumatra.

2. Materials and Methods

2.1 Sampling Site

The stingless bees had been sampled at 20 ha Edufarm area in Universitas Andalas (0°54'43.1"S 100°27'56.8"E, approximately 255 m elevation) (**Fig. 1** and **2**). Flora *Antigonon leptosus* was the predominant plant types as the nectar source for the *Tetragonula* stingless bee (**Fig. 2b**). Five worker bees were sampled from each colony and preserved in 70% ethanol for morphometric measurement and identification process (**Fig. 2c**). Identification and measurement took place at the Laboratory of Animal Taxonomy, Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Andalas, and Laboratory of Biotechnology, Faculty of Animal Science, Universitas Andalas West Sumatera.

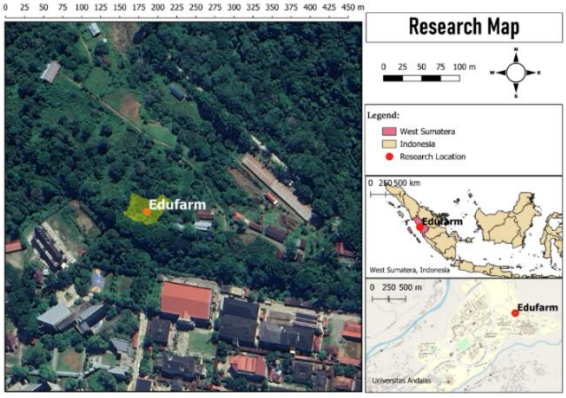

Fig. 1. Study site at Edufarm, Universitas Andalas, Padang, West Sumatera, Indonesia (Source : google satelite)

Fig. 2. Sampling collection and identification of stingless bee found in Edufarm; a) The location of stingless bees colonies in Edufarm, (indicated by the red arrows). (Source : Muhammad Wafi Ardan, 2024), b) Flora *Antigonon leptosus* as the predominant plant types as the nectar source for the *Tetragonula* stingless bee, c) Collection of samples in the field.

2.2 Identification

Specimens were identified based on pre-established morphological characters [1 ;10 ;12 ;13 ;14]. Photographic documentation was performed using a stereomicroscope Nikon Model SMZ1270 mounted with Nikon DS-Ri2 viewer.

3. Results and Discussions

3.1 Stingless Bees Species

This study analyzed and identified five species *Tetragonula* stingless bee from Edufarm Universitas Andalas (**Table 1**). Morphological characters, description, and photographic documentation of each species were given in respective account (**Fig. 4-7**).

Table 1. Species checklist of *Tetragonula* stingless bees collected from Edufarm, Faculty of Animal Science, Universitas Andalas.

Genera	Species	Σ Colony
Genera *Tetragonula* Moure, 1961		
Subgenera *Tetragonula* **Moure, 1961**	*Tetragonula fuscobalteata* (Cameron, 1908)	1
	Tetragonula minangkabau (Sakagami and Inoue, 1985)	20
	Tetragonula minangkabau forma *darek* (Sakagami and Inoue, 1985)	2
	Tetragonula testaceitarsis (Cameron, 1901)	4
Subgenera *Tetragonilla* **Moure, 1961**	*Tetragonilla collina* (Smith, 1857)	1

Fifteen stingless bee species out of 35 species in the genus *Tetragonula* had been reported from Indonesia [5]. In West Sumatra, eleven species of *Tetragonula* were found [11]. Five of these species genus *Tetragonula* had previously been recorded in the UACC (Universitas Andalas Campus Complex), namely *T. reepeni*, *T. fuscobalteata*, *T. geissleri*, *T. minangkabau*, and *T. laeviceps* [13]. These species were found in various locations within the Universitas Andalas campus area. Three species recorded in earlier studies were not found

in the Edufarm area because the previously recorded species had been collected from wild habitats within the campus, and natural colonies had not yet been transferred to managed hives for bee keeping activity.

3.2 Morphological Characteristics of Stingless Bees

3.2.1 Tetragonula fuscobalteata (Cameron, 1908)

Many local beekeepers refer this species as 'galo-galo posco', a name that is most likely derived from its scientific species epithet, fuscobalteata. which most probably derived from its species name 'fuscobalteata.' Its nest entrance was characterized by round-short funnel (**Fig. 3b**). The worker bees were noticeably smaller than those of other stingless bee species, and their bodies display two distinct colour tones (**Fig. 3c**). The head was black and densely covered with fine white hairs. Both the compound eyes and ocelli were brown, while the clypeus was entirely black and also fully covered with fine white hairs (**Fig. 3d**). The thorax was black and had six golden longitudinal hairy bands, along with five glabrous areas on the mesoscutum (**Fig. 3e**). The hind tibia and basitarsus were blackish brown while the hind tibia had plumose hairs, the corbicula was pear-shaped, and an elliptical disc was present on the inner side of the hind basitarsus (**Fig. 3f**). The wings were uniform and semi-transparant (**Fig. 3g**) with five hamuli on anterior margin of hindwings (**Fig. 3h**). The body length ranged from 2.69 to 2.97 mm ($\bar{x}$: 2.79±0.11 mm). It has elliptical disc on inner hind basitarsus, flagellomere segment blackish, clypeus black with short space malar, short mesoscutellum, and two weak teeth [12]. Abdomen pale brown, sometimes darker brown under certain circumstances [1].

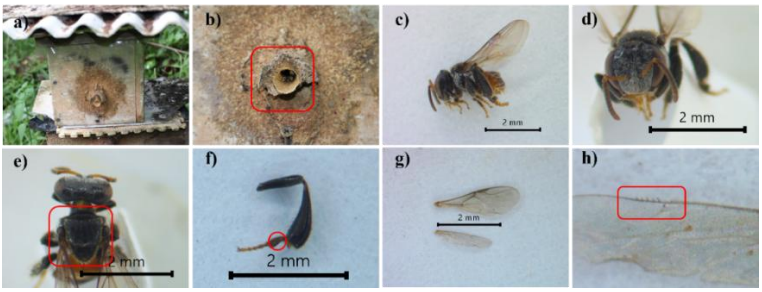

Fig. 3. Colony in artificial nest box (a), nest entrance (b) and morphological characters of *T. fuscobalteata* (Cameron, 1908); lateral habitus (c), frons (d), mesoscutum (e), hind tibia and basitarsus (f), forewing and hindwing (g), hamuli (h). Scale 2.0 mm.

3.2.2 Tetragonula minangkabau (Sakagami and Inoue, 1985)

The epithet *'minangkabau'* was derived from the name of major ethnic in Central Sumatra region, including West Sumatra. Its nest entrance was characterized by an elongated, elliptical funnel shape (**Fig. 4b**). The body had two colors, in which the head and thorax were black, while the abdomen was light brown (**Fig. 4c**). The head was covered with fine grey hairs and the compound eyes and ocelli appeared blackish. The clypeus was ferruginous and covered with fine brown hairs (**Fig. 4d**). The thorax was black with three glabrous areas on mesoscutum section (**Fig. 4e**). The hind tibia and basitarsus were blackish brown; hind tibia had plumose hairs, the corbicula was pear-shaped, and an elliptical disc was present on the inner hind basitarsus (**Fig. 4f**). The wings were uniform and semi-transparant (**Fig. 4g**), with five hamuli on anterior margin of the hindwings (**Fig. 4h**). The body length ranged from 3.44

to 3.86 mm ($\bar{x}$: 3.7±0.17 mm). Stingless bee *T. minangkabau* has smaller size and paler body than *T. laeviceps* [10]. It is black on head and thorax, light brown to chestnut or yellowish brown on abdomen, linear space malar, part of hind leg and basal part of metasoma tend to be pale brown to ferruginous toward the anterior section. Clypeus and tegula range from testaceous to ferruginous in color, sometimes chestnut brown [13]. Antennal socket blackish grey, scape ferruginous, pedicel and first flagellomere brown, second to eighth flagellomeres black, nineth to tenth flagellomeres blackish brown [10]. It possesses three vertical smooth bands on mesoscutum, the middle band quite long than the other two bands [1].

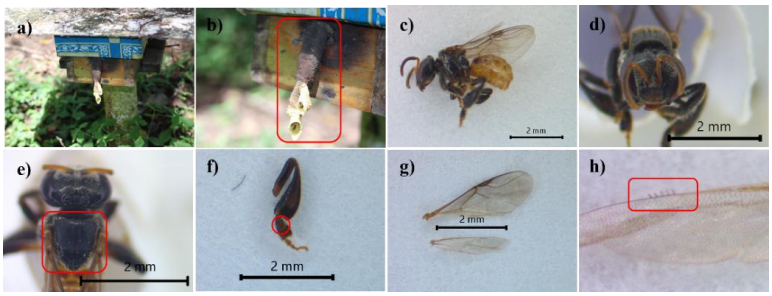

Fig. 4. Colony in artificial nest box (a), nest entrance (b), and morphological characters of *T. minangkabau* (Sakagami and Inoue, 1985); lateral habitus (c), frons (d), mesoscutum (e), hind tibia and basitarsus (f), forewing and hindwing (g), hamuli (h).

3.2.3 Tetragonula minangkabau forma darek (Sakagami and Inoue, 1985)

This species was previously identified as *T. minangkabau*, but further examination revealed several differences in the overall body size, colour of the body, nest entrance structure, brood cell type, and the number of glabrous areas on the mesoscutum, indicating that it was a separate species. The nest entrance of *T. minangkabau* forma *darek* was characterized by an elliptical, funnel-less opening (**Fig. 5b**). The body was bicoloured, with the head and thorax black and the abdomen brown, and both the hind tibia and basitarsus were entirely dark brown (**Fig. 5c**). The head was black, and covered with fine yellow-brown hairs. The compound eyes were brown and ocelli were brown-reddish. The covered with fine yellow-brown hairs. (**Fig. 5d**). The thorax was black and covered with dark brown setae, with unclear glabrous areas on the mesoscutum (**Fig. 5e**). The hind tibia and basitarsus were wholly dark brown; the hind tibia bore plumose hairs, with the pear-shaped corbicula, and an elliptical disc present on the inner hind basitarsus (**Fig. 5f**). The wings were uniform and semi-transparant (**Fig. 5g**), with five hamuli on the anterior margin of the hindwings (**Fig. 5h**). The body length ranged from 3.55 to 3.95 mm (mean: 3.77 ± 0.18 mm).

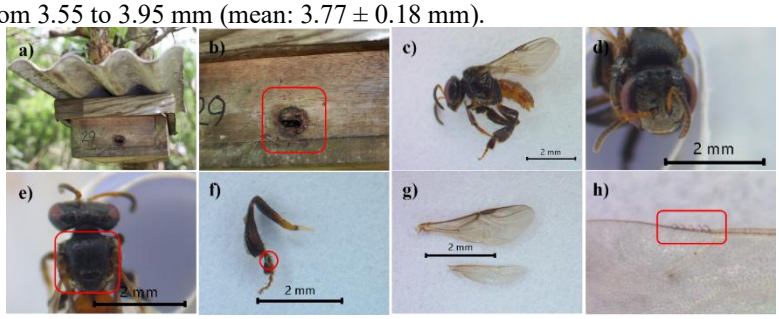

Fig. 5. Colony in artificial nest box (a), nest entrance (b) and morphological characters of *T. minangkabau* forma *darek* (Sakagami and Inoue, 1985); lateral habitus (c), frons (d), mesoscutum (e), hind tibia and basitarsus (f), forewing and hindwing (g), hamuli (h). Scale 2.0 mm.

Workers of *T. Minangkabau* forma *darek* has a larger body size, possessed bigger hind legs and paler colored metasomas *than T. minangkabau* [10; 14]. The body length of *T. minangkabau* forma *darek* ranges from 3.5 to 4.0 mm. The wing length, including the tegula, ranges from 3.9 to 4.2 mm [11].

3.2.4 Tetragonula testaceitarsis (Cameron, 1901)

This species is often called *galo-galo matahari* (sun stingless bee) by beekeepers due to the shape of its nest funnel resembles the sun. Its nest entrance formed a short elliptical funnel with a sun-like appearance (**Fig. 6b**). The body was predominantly black (**Fig. 6c**). The head was black and covered with fine white hairs. The compound eyes and ocelli were blackish, while the clypeus was brown and also covered with fine white hairs (**Fig. 6d**). The thorax was black, and the mesoscutum was black with its margins surrounded by blackish-brown setae, without glabrous areas (**Fig. 6e**). The hind tibia and basitarsus were black; the hind tibia had sparse pubescent hairs, with pear-shaped corbicula, and an elliptical disc present on inner hind basitarsus (**Fig. 6f**). The wings were uniformly semi-transparent (**Fig. 6g**) and contained five hamuli on the anterior margin of the hindwings (**Fig. 6h**). The body length ranged from 3.98 to 4.62 mm (mean: 4.39 ± 0.24 mm). This description is consistent with precious reports on this species [1]. Head and thorax completely black, abdomen dark brown and wings uniformly and semi-transparant. has white hairs on its frons, antennae entirely blackish brown, scape brown. Gastral tergite first to sixth wholly black and blackish brown in some individuals [1].

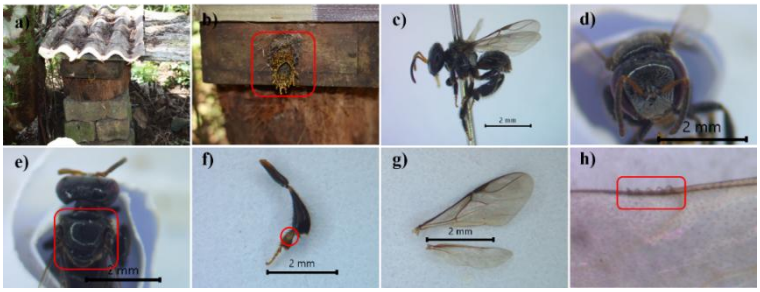

Fig. 6. Colony in artificial nest box (a), nest entrance (b), and morphological characters of *T. testaceitarsis* (Cameron, 1902); lateral habitus (c), frons (d), mesoscutum (e), hind tibia and basitarsus (f), forewing and hindwing (g), hamuli (h).

3.2.5 Tetragonilla collina (Smith, 1857)

T. collina had a nest entrance in a long, round nesting tube shape (**Fig. 7b**). The body was brownish-black (**Fig. 7c**). The head was black and covered with fine brown hairs. The compound eyes and ocelli were blackish, while the clypeus was brown and slightly covered with brown hairs (**Fig. 7d**). The thorax was immaculate black, and the mesoscutum was black covered with black hairs, bearing six longitudinal hairy bands and five small glabrous areas (**Fig. 7e**). The hind tibia and basitarsus were black; the hind tibia had plumose hairs, with pear-shaped corbicula, and an elliptical disc present on inner hind basitarsus (**Fig. 7f**). The wings showed distinct coloration, with the basal half dark brownish-black and the apical half semi-transparent (**Fig. 7g**). They also bore six hamuli on the anterior margin of the hindwing (**Fig. 7h**). The body length ranged from 5.64 to 6.36 mm (mean: 6.04 ± 0.26 mm). This species primarily built subterranean nests, with entrance tubes commonly emerging from the base of trees rather than from the trunks themselves [15]. The mesoscutum was black and covered with black setae, while the tegulae were dark brown. The forewings exhibited uneven

coloration, with the basal half being dark brownish-black and the apical half semi-transparent, whereas the hindwings were dark brownish, similar to the forewings [1].

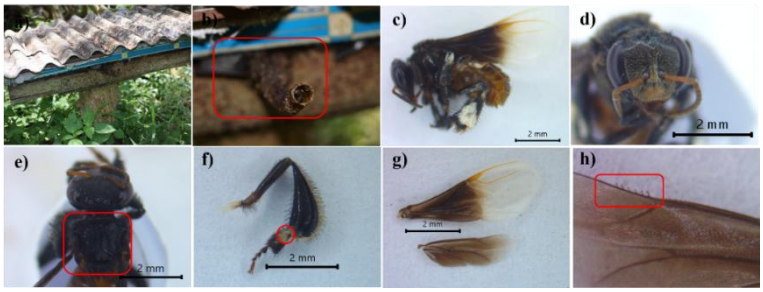

Fig. 7. Colony in artificial nest box (a), nest entrance (b), and morphological characters of *T. collina* (Smith, 1857); lateral habitus (c), frons (d), mesoscutum (e), hind tibia and basitarsus (f), forewing and hindwing (g), hamuli (h).

Table 2. Comparative morphological characters of *Tetragonula* species recorded at Edufarm, Universitas Andalas

Species	***T. fuscobalteata***	***T. minangkabau***	***T. minangkabau* forma *darek***	***T. testaceitarsis***	***T. collina***
Nest Entrance	Round-short funnel	Elongated elliptical funnel	Elliptical, funnel-less	Short elliptical sun-like funnel	Long round nesting tube
Body Colour	Bicoloured; head/thorax black, abdomen pale brown	Black head/thorax, light brown abdomen	Black head/thorax, brown abdomen	Predominantly black	Brownish-black
Head	Black with fine white hairs; brown eyes/ocelli; black clypeus	Black with fine grey hairs; blackish eyes/ocelli; ferruginous clypeus	Black with fine yellow-brown hairs; brown-reddish eyes/ocelli, black clypeus with yellow-brown hairs	Black with fine white hairs; blackish eyes/ocelli; brown clypeus	Black with fine brown hairs; blackish eyes/ocelli; brown clypeus
Thorax	Black with six golden hairy bands; five glabrous areas	Black with three glabrous areas	Black with unclear glabrous areas	Black; no glabrous areas	Immaculate black; six hairy bands; five glabrous areas
Hind Tibia & Basitarsus	blackish brown; pear-shaped corbicula; elliptical disc	Blackish brown; pear-shaped corbicula; elliptical disc	Dark brown; pear-shaped corbicula; elliptical disc	Black; pear-shaped corbicula; elliptical disc	Black; pear-shaped corbicula; elliptical disc
Wings	Uniform semi-transparent	Uniform semi-transparent	Uniform semi-transparent	Uniform semi-transparent	Basal half dark brown-black, apical half semi-transparent
Hamuli	5	5	5	5	6
Body Length (mm)	2.69–2.97 (mean 2.79±0.11)	3.44–3.86 (mean 3.7±0.17)	3.55–3.95 (mean 3.77±0.18)	3.98–4.62 (mean 4.39±0.24)	5.64–6.36 (mean 6.04±0.26)

All specimens analyzed in this study were morphologically identical to the type specimens of these species collected from other regions. Specimens of *T. fuscobaltetata* in this study

have similar morphological characteristics with previous description on this species [1;12]. Specimens of *T. minangkabau* in this study were in accordance with the published description of this species [1;10;13;14]. While specimens of *T. minangkabau* forma *darek* in this study morphologically resemble the description published specimens for this species [10;14] specimen *T. testaceitarsis* in this study has consistent morphological characteristics with its type specimen [1]. And specimen *T. collina* in this study has consistent morphological characteristics with its type specimen [1; 15].

4 Conclusion

These results contribute to the reinforcement of taxonomic resolution within *Tetragonula*, providing clear morphological distinctions that support species delimitation in a genus known for subtle interspecific variation. The variation in body size, coloration, wing morphology, and nest entrance structure also reflects species-specific ecological adaptations. The morphological differences observed, particularly in body size, coloration, wing features, and nest entrance structure provide reliable diagnostic characters for distinguishing closely related *Tetragonula* species.

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