MORPHOMETRICS ANALYSIS OF STINGLESS BEES *Geniotrigona thoracica* AND *Wallacetrigona incise* (Apidae: Meliponini)

UNDERGRADUATE THESIS

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ARIYAN AGUSMAN

ID2010422023

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SUPERVISOR:

1. PROF. DR. HENNY HERWINA
2. DR. SIH KAHONO

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Undergraduate Thesis Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science

By :

ARIYAN AGUSMAN

ID 2010422023

Padang, 28th August 2025

Approved By :

Supervisor	Co - Supervisor
Prof. Dr. Henny Herwina	**Dr. Sih Kahono M.Sc**
NIP. 1987302262006042001	**NIP. 197002121994032001**

This undergraduate thesis has been defended in front of the Committee of Bachelor Degree Examination of Biology Department, Faculty of Mathematics and Natural Sciences, Universitas Andalas, Padang.

In Thursday, 28th August 2025

No.	Name	Position	Signature
1.	Muhammad Nazri Janra, M.Si, MA	Chairman	
2.	Prof. Dr. Henny Herwina	Secretary	
3.	Dr. Sih Kahono	Member	
4.	Prof. Dr. Dahelmi	Member	
5.	Dr. Mairawita	Member	

STATEMENT OF AUTHENTICITY

Here I hereby declare that:

My undergraduate thesis is original and has never been submitted for a bachelor's degree at either Andalas University or any other institution. This undergraduate thesis is entirely my own idea, formulation, and research, without any assistance except from my supervisor.

In this undergraduate thesis, there are no works or opinions written or published by others, except those clearly stated in the bibliography.

I make this statement truthfully, and if in the future any discrepancies or inaccuracies are found, I am willing to accept academic sanctions in accordance with the applicable regulations.

Padang, 28th August 2025

The author

Ariyan Agusman

2010422023

بسم الله الرحمن الرحيم

Alhamdulillāhi rabbil 'ālamīn. All praise is due to Allah SWT, the Lord of all worlds, for His endless mercy, guidance, and blessings, through which this undergraduate thesis has been successfully completed. May peace and blessings be upon the Prophet Muhammad SAW.

This thesis is sincerely dedicated to my family: ayah Budiman and mama Maiwati. Thank you for your unwavering prayers, endless support, and the love that has accompanied every step of my journey. Your sacrifices and encouragement have been the greatest strength throughout my years of study.

To my special partner Mimma L. Daraquthni thank you for the constant support, motivation, and presence throughout this academic journey.

I also dedicate this work to myself - for enduring the challenges, staying patient through every difficulty, and continuing to grow despite the setbacks. May this achievement serve as a reminder that persistence and faith always lead to meaningful progress.

May this thesis become a small but meaningful step for my growth and future journey. Aamiin Yā Rabbal 'Ālamīn.

Ariyan Agusman, S.Si

PREFACE

Praise and gratitude to Allah SWT who always gives strength and health to the author, so that the author can complete this thesis on time as a graduation requirement at the Department of Biology, Faculty of Mathematics and Natural Sciences, UniversitasAndalas, Padang.

This thesis is the author's final assignment research, entitled "Morphometrics Analysis of Stingless Bees *Geniotrigona thoracica* and *Wallacetrigona incisa* (Apidae: Meliponini)". The writer also extends deep gratitude to the academic supervisors, Prof. Dr. Henny Herwina and Dr. Sih Kahono for their valuable guidance, insightful suggestions, encouragement, and continuous assistance throughout both the research process and the preparation of this thesis. On this occasion, the writer would like to express sincere appreciation to the Badan Riset dan Inovasi Nasional (BRIN) and the Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Andalas. Furthermore, the writer wishes to convey appreciation to all individuals who have contributed, either directly or indirectly, to the successful completion of this undergraduate thesis:

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Padang, 28th August 2025

Ariyan Agusman

ABSTRACT

The stingless bee genus *Geniotrigona* (Apinae: Meliponini) was originally composed of three species: *Geniotrigona lacteifasciata* and *G. thoracica*, distributed in the Indo-Malaysian region, and *G. incisa* in the highlands of Sulawesi. Based on a newly identified character on the inner side of the tibia, Engel and Rasmussen reclassified *G. incisa* into a new genus, *Wallacetrigona incisa*. In this study, morphometric analysis was conducted on 32 characters measured from 10 specimens of each species using advanced microscopy techniques. The results revealed significant size differences, with *G. thoracica* exhibiting larger dimensions across multiple traits, including forewing length and body length. Statistical analysis showed that 96.975% of the measured characters differed significantly, while only 3.025% were similar, particularly in interocellar distance. These findings contribute to the taxonomic understanding of stingless bees in Indonesia by highlighting the distinct characteristics that separate *Wallacetrigona incisa* from its former placement in *Geniotrigona*. Moreover, the study underscores the role of ecological factors in shaping bee morphology and emphasizes the importance of morphometric research for biodiversity conservation.

Keywords : *Geniotrigona thoracica*, Morphometrics, Stingless bees, *Wallacetrigona insica*

ABSTRAK

Genus lebah tanpa sengat *Geniotrigona* (Apinae: Meliponini) awalnya terdiri atas tiga spesies, yaitu *Geniotrigona lacteifasciata* dan *G. thoracica* yang tersebar di wilayah Indo-Malaysia, serta *G. incisa* yang ditemukan di daerah dataran tinggi Sulawesi. Berdasarkan karakter baru yang teridentifikasi pada sisi dalam tibia, Engel dan Rasmussen mengklasifikasikan ulang *G. incisa* ke dalam genus baru, yaitu *Wallacetrigona incisa*. Dalam penelitian ini, analisis morfometrik dilakukan terhadap 32 karakter morfologi yang diukur dari 10 spesimen masing-masing spesies dengan menggunakan teknik mikroskopi canggih. Hasil analisis menunjukkan perbedaan ukuran yang signifikan, di mana *G. thoracica* memiliki dimensi yang lebih besar pada berbagai sifat morfologis, termasuk panjang sayap depan dan panjang tubuh. Analisis statistik menunjukkan bahwa 96,975% dari karakter yang diukur berbeda secara signifikan, sementara hanya 3,025% yang menunjukkan kesamaan, khususnya pada jarak antarocelli. Temuan ini memberikan kontribusi terhadap pemahaman taksonomi lebah tanpa sengat di Indonesia dengan menekankan karakter-karakter khas yang membedakan *Wallacetrigona incisa* dari penempatan sebelumnya dalam genus *Geniotrigona*. Selain itu, penelitian ini juga menyoroti peran faktor ekologi dalam membentuk morfologi lebah serta menekankan pentingnya penelitian morfometrik dalam upaya konservasi keanekaragaman hayati.

Keywords : *Geniotrigona thoracica*, Morphometrics, Stingless bees, *Wallacetrigona insica*

TABLE OF CONTENTS

I. INTRODUCTION

1.1 Research Background

Indonesia is home to at least 46 species of stingless bees belonging to 10 genera, distributed widely across the archipelago and showing a high degree of endemicity. The western islands host the greatest diversity, with 23 species recorded in Sumatra, 7 in Java, and 29 in Borneo. Further east, 3 species are found in Sulawesi, 2 in Ambon, 1 in Timor, and 9 in Papua (Salatnaya et al., 2023). Traditionally, stingless bee identification has relied on morphological and morphometric traits, such as body size and coloration, hair distribution on specific body parts, and leg structures (Sakagami et al., 1990; Azizi et al., 2020).

More recently, additional diagnostic features have been incorporated, including nest entrance architecture, brood and food storage structures, as well as genetic markers, thereby revealing a more complex species diversity (Trianto & Purwanto, 2022). Key morphological traits used in identification include the hind tibia, hind basitarsus, malar space, mandibles, clypeus, propodeum, mesoscutum, mesoscutellum, antennae, eyes, forewings, wing venation, hamuli, and body coloration (Sakagami et al., 1990; Azizi et al., 2020). Wing venation, in particular, has been widely applied in morphometric studies to assess interspecific relationships (Laksono et al., 2020).

Phylogenetic studies focusing on Old World stingless bees (Rasmussen & Cameron, 2007; Rasmussen, 2008) emphasized the need for taxonomic revision beyond the traditional classification, aligning more closely with Moure's (1961) evolutionary framework. Within this context, Trigona (*Geniotrigona) incisa* Sakagami & Inoue, originally described from Sulawesi (Sakagami & Inoue, 1989), was shown to render the genus *Geniotrigona* polyphyletic. Subsequent analyses placed *G. incisa* as the sister group to *Lepidotrigona*, indicating that it should not be accommodated within *Geniotrigona* (Rasmussen & Cameron, 2007). Morphologically, *G. incisa* differs from other *Geniotrigona* species despite superficial similarities, most notably in characters of the inner tibia (Rasmussen, 2007). As a result, Engel and Rasmussen (2010) established a new genus, *Wallacetrigona*, to accommodate *W. incisa*.

Members of *Geniotrigona* are generally large-bodied and distinct from other Asian stingless bees by their elongate malar area (more than twice the diameter of the third flagellomere), short mesoscutellum and propodeum, a raised ridge on the vertex, and dense plumose setae that obscure much of the mesosoma (Schwarz, 1939; Sakagami & Michener, 1987; Rasmussen, 2007). In contrast, *Wallacetrigona incisa*, endemic to Sulawesi, is recognized as a golden stingless bee with black legs and translucent wings (Engel et al., 2018). Meanwhile, *Geniotrigona thoracica* is more widely distributed across Thailand, Cambodia, Singapore, Malaysia, and Indonesia. The distribution of *Wallacetrigona* east of the Wallace Line contrasts with *Geniotrigona*, which is restricted to Sundaland. This biogeographical separation, supported by phylogenetic and morphological evidence, highlights the importance of revising Meliponini taxonomy in Indonesia and provides new insights into the evolutionary history of stingless bees in the region.

1.2 Research Problem

The research questions in this study are as follows:

1. What are the differences in morphometric characteristics between *Geniotrigona thoracica* and *Wallacetrigona incisa*?
2. What extent do *Geniotrigona thoracica* and *Wallacetrigona incisa* differ morphologically, andwhich morphological character shows the highest degree of similarity between the two species?

1.3 Research Objective

1. To determine differences in morphological size between *Geniotrigona thoracica* and *Wallacetrigona incisa*.
2. To analyze the degree of morphological differentiation between the two species and identify the morphological character that shows the greatest similarity.

1.4 Research Significant

The Significance of the Research This study provides morphometric data on *Geniotrigona thoracica* and *Wallacetrigona incisa*, which can serve as comparative references for research in other regions beyond serving as baseline data, the findings contribute to the refinement of stingless bee taxonomy, improve understanding of species-level morphological differentiation, and support ecological and biogeographical studies in Indonesia and Southeast Asia. Furthermore, by highlighting diagnostic traits that distinguish closely related species, this research offers valuable insights for biodiversity monitoring.

II. LITERATURE REVIEW

2.1 Stingless Bee

Stingless Bees Identification of stingless bees at the genus and species levels is primarily based on morphological and coloration traits, including the structure and pigmentation of the antennae, head, thorax, wings, legs, and abdomen. Among them, *Geniotrigona* represents one of the largest genera in terms of body size, consistent with previous reports (Roubik, 1989). Stingless bees are generalist foragers; females collect pollen, carrion, and even inorganic salts from diverse sources. Their flight activity is strongly influenced by environmental factors such as temperature, relative humidity, moderate light intensity, and photoperiod (Asiah et al., 2015). While nectar is the principal energy source, stingless bees may also consume honeydew produced by aphids as an alternative carbohydrate resource.

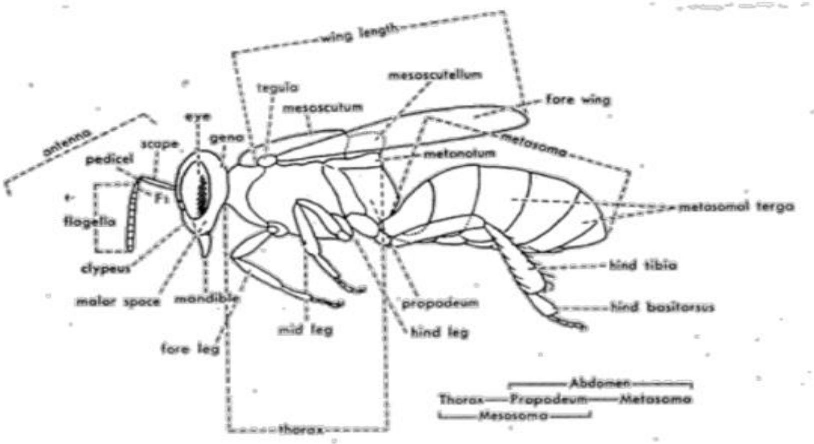

Figure 1. Structure Morphology of Stingless bee (Sakagami et al., 1990).

Stingless bees belong to the corbiculate bee tribe Meliponini (Michener, 2007) and are distinguished from other social corbiculate bees by a unique combination of morphological traits, including reduced distal forewing venation, presence of a jugal lobe in the hindwing, reduction of the sting apparatus, loss of outer mandibular grooves, absence of metatibial spurs, absence of an auricle, and the lack of an inner ramus on pretarsal claws (simple ungues) (Engel, 2001; Michener, 2007). Morphometric approaches are increasingly applied in insect systematics, but their reliability has not been fully evaluated. Research in this field remains limited, particularly in Indonesia, despite its potential to clarify species boundaries.

Stingless bees are important pollinators in tropical rainforests (Eltz et al., 2003) and are also used in commercial pollination, for example in strawberry cultivation in Japan (Kukutani et al., 1993). They can be distinguished from honey bees by the presence of a penicillum (a dense row of long setae) on the hind tibia and weaker wing venation (Wille, 1983). Like other corbiculate bees, including honey bees (Apini), bumble bees (Bombini), and orchid bees (Euglossini), stingless bees possess a corbicula on the hind legs for carrying pollen (Michener, 2007). Although they are among the smallest bees capable of producing honey within the subfamily Meliponinae, they construct elaborate nests using a mixture of wax, resin, and plant gums; some species additionally use mud collected by workers (Klakasikorn et al., 2005). Nest entrances are species-specific and may be regulated under certain environmental conditions (Danaraddi et al., 2009). While some species nest underground, most build nests inside tree cavities (Velthuis, 1997).

Research has shown that morphometric studies are reproducible when standard protocols are followed. Consequently, morphometric data are widely transferable and remain a valuable resource for alpha taxonomy (Esquerré et al., 2020). In stingless bees, several morphological characters can be used to differentiate species, including the hind tibia, posterior basitarsus, malar space, mandibles, head, clypeus, propodeum, mesoscutum, mesoscutellum, antennae, eyes, gena, forewings, wing venation, hamuli, and body coloration (head, clypeus, thorax, abdomen, tegula, and wings) (Sakagami et al., 1990).

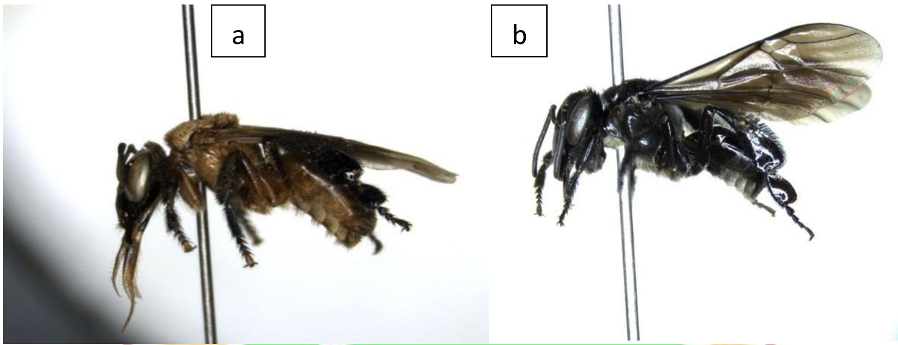

Figure 2.(a) *Geniotrigona thoracica*, (b) *Wallacetrigona incisa* picture.

Classification of the genus of *Geniotrigona*:

Kingdom : Animalia

Phylum : Arthropoda

Class : Insecta

Order : Hymenopetra

Suborder : Apocrita

Family : Apidae

Genus : *Geniotrigona*

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According to Siregar et al. (2011), stingless bees offer several advantages: (1) they produce propolis as a natural defense for the nest; (2) although honey production is relatively low, it is highly nutritious; (3) they are safe to cultivate, as they only bite and do not sting; and (4) their maintenance is relatively easy, since their nectar requirements are lower than those of larger *Apis* bees. Bees are among the most important pollinators, collecting both nectar and pollen. Social bees, in particular, are recognized as effective pollinators that can enhance agricultural productivity (Thomas et al., 2009). Plants require reliable pollen transfer at minimal energetic cost, while pollinators seek floral rewards that can be harvested efficiently, a reciprocal relationship often referred to as “balanced mutual exploitation” (Kooi et al., 2021).

Stingless bees are well-known pollinators in tropical rainforests (Eltz et al., 2003) and have also been successfully used for strawberry pollination in Japan (Kukutani et al., 1993). They can be readily distinguished from honey bees by the presence of a penicillum (a row of long setae) on the hind tibia and their reduced wing venation (Wille, 1983). Like other corbiculate bees, including honey bees (Apini), bumble bees (Bombini), and orchid bees (Euglossini), stingless bees also possess corbiculae on the hind legs for carrying pollen (Michener, 2007). They are among the smallest bees capable of producing honey within the subfamily *Meliponinae*. Nests are typically constructed from a mixture of wax, resin, and plant gums, although some species incorporate mud collected by workers (Klakasikorn et al., 2005). Nest entrances are species-specific in structure and can be modified in size depending on environmental conditions (Danaraddi et al., 2009). While some species construct underground nests, most build within tree cavities (Velthuis, 1997).

Stingless bees are characterized by a reduced, non-functional sting (Wille, 1983) and are widely distributed throughout tropical and subtropical regions. They are eusocial insects that live in perennial colonies composed of a queen, sterile female workers, and males (drones). Their life cycle consists of four stages: egg, larva, pupa, and adult (imago). Eggs are soft, small, and elongated; larvae are whitish and feed on provisions stored in brood cells; pupae have relatively soft integuments, folded body structures, and developing wings (Michener, 2007). Worker bees are responsible for nest construction and defense, as well as foraging activities that maintain reproductive stability and colony metabolism (Nagamitsu & Inoue, 2005).

2.2 *Geniotrigona thoracica*

The stingless bee *Geniotrigona thoracica* is commonly recognized as the “golden stingless bee” or “kelulut deer,” characterized by its golden-brown appearance, black legs, and slightly faded wings (Engel et al., 2018; Azizi et al., 2020). It is one of the largest stingless bee species in Asia, with an average body length of approximately 7.58–8.0 mm, and is known for producing comparatively higher amounts of honey than most other stingless bee species (Salmah, 2017). The species has a flight range of up to 2 km, which, combined with its relatively large size and productivity, makes it highly suitable for meliponiculture.

MorphologicallyG. *thoracica* can be distinguished from other stingless bees by several external characters. The scutellum and propodeum are short, and the forewings are relatively long, while the abdomen is often triangular in shape and not broadened as in certain other stingless bee groups. Diagnostic features used in species identification include the hind tibia and basitarsus, mandibles, head, clypeus, propodeum, mesoscutum, mesoscutellum, antennae, compound eyes, gena, wing venation, hamuli, malar space, as well as the coloration of the head, thorax, abdomen, tegulae, and wings (Sakagami et al., 1990; Samsudin et al., 2018).

Detailed descriptions of *G. thoracica* morphology have been provided by Samsudin et al. (2018). The head is predominantly black, with the frons densely covered by fine brown hairs and the ferruginous clypeus covered with yellowish-brown hairs. Compound eyes are reddish, while the ocelli are blackish. The antennal socket is grey, the scape is black with slightly brown basal and apical regions, the pedicel and flagella are blackish-brown. The mandibles are mostly blackish-brown, darker at the base, and possess two apical teeth. The mesoscutum is entirely brown with two vertical black stripes medially and is covered with brown setae anteriorly. The scutellum is brown and similarly covered with setae. Tegulae are brown, and the forewings are semi-transparent with uneven coloration; venation is dark brown at the base and slightly lighter apically. Hindwings are semi-transparent and possess five hamuli along the anterior margin. The hind tibiae are long, pear-shaped, and form corbiculae covered sparsely with short setae, while the basitarsi are elongated and densely covered with setae. The abdomen shows smooth gastral tergites I–III, while tergites IV–VI are rougher and bear fine setae. The sternites are also completely setose. Overall, the structural combination of head, thoracic, wing, and abdominal characters makes *G. thoracica* the largest and one of the most morphologically distinctive members of the genus *Geniotrigona*.

2.3 *Wallacetrigonaincisa*

Trigona incisa, now recognized as *Wallacetrigona incisa* (Sakagami & Inoue, 1989; Sayusti et al., 2021), is a stingless bee endemic to Sulawesi. The species is generally benign and low-odor, exhibits high production potential, and is comparatively easy to manage and control relative to other *Trigona* in diverse agroforestry systems. It can yield a broad portfolio of hive products—often cited as up to 12 types of high-value commodities (e.g., honey, pollen, propolis, royal jelly, wax, and bee venom)and typically forms large colonies (≈100,000 individuals), conferring strong pollination services.

Nevertheless, species-specific traits and performance in different agroforestry settings remain insufficiently documented. Adoption within apisilviculture models could help farmers and agroforestry managers valorize currently underutilized floral resources into marketable products while simultaneously enhancing crop pollination. A new genus of stingless bees (*Wallacetrigona*) was established for this species from Sulawesi, which had previously been placed in *Geniotrigona* Moure. Phylogenetic analyses demonstrated that inclusion of *Geniotrigona incisa* rendered *Geniotrigona* polyphyletic, with *G. incisa* supported as sister *to Lepidotrigona* (Rasmussen & Cameron, 2007, 2010).

In addition, morphological and behavioral characterssuch as scale-like setae along the mesoscutal margin (Schwarz, 1939) and distinct oviposition rituals (Sakagami & Michener, 1987)argue against retaining *G. incisa* within *Geniotrigona*. Consequently, the taxon was transferred to *Wallacetrigona* as *W. incisa*. Biogeographically, *Wallacetrigona* occurs east of the Wallace Line and is currently unknown beyond the Weber Line, whereas *Geniotrigona* is otherwise restricted to Sundaland. A hierarchical classification and revised keys to Indomalayan and Australasian stingless bee genera and subgenera are provided by Hasan et al. (2017).

III. RESEARCH METHODOLOGY

3.1 Time and Place of Research

The research was conducted from May2024 to August2025. Preparation of specimens, specimens collection and morphometric measurement were carried out at Entomology Laboratory, Museum Zoologicum Bogoriense, Widyasatwaloka building, KST Soekarno-BRIN Cibinong, Bogor regency.

3.2 Material and Tools

Figure 3. Offsets tools and camera lucida with software LA.S. 4.13,0 mounted on Leica Z6 APO Microscope.

The tools and materials used in this research included 10 specimens of *G. thoracica* (10♀), originating from Jambi, Batang Hari, Bajubang, Bungku. and 10 specimens of *W. incisa* (10♀) originating from West Sulawesi, Mamasa, Mt. Gandang Dewata. Other tools needed in this research include insect pint, collection styrofoam, insect tweezers, laboratorium paper, scissors, hand loupe, point card,micro pint, point card, pinning block, cabin collection, camera lucida with software LA.S. 4.13,0 mounted on Leica Z6 APO Microscope (Figure 3).

3.3 Procedure

3.1.1 Preparation of specimens

The specimens used in this study include *G. thoracica* (10 ♀), originating from Jambi, Batang Hari, Bajubang, and Bungku. Additionally, 10 specimens of *W. incisa* (10 ♀), originating from West Sulawesi, Mamasa, Gandang Dewata Mountain have been obtained from the Entomology collection of the Bogoriense Zoologicum Museum, BRIN KST Soekarno, Cibinong, Bogor Regency.

Figure 4.*Geniotrigona thoracica* and *Wallacetrigona incisa* sampels.

3.1.2 Morphometry measurements

This Measurement was performed using the LA.S. 4.13.0 software, mounted on a Leica Z6 APO Microscope. Morphometric measurements consisted of 32 characters, namely 1. Body Length (BL) 2. Head Length (HL), 3. Head Width (HW), 4. Clypeus Length (CL), 5. Lower Introcellular Distance (LID), 6. Upper Introcellular Distance (UID), 7. Eye Width (EW), 8. Eye Length (EL), 9. Maximum Interorbital Distance (MOD), 10. Minimum Interorbital Distance (LOD), 11. Antenoaccelar Distance (AD), 12. Inter Ocellar Distance (IOD), 13. Ocelloaccelar Distance (OOD) , 14. Inter Antenna Distance (ID), 15. Ghena Width (GW), 16.

Length of Flagellomere 4 (FL4), 17. Witdth of Flagellomere 4 (FW4), 18. Length of Mallar Space (LMS), 19. Mesoscutum Length (MCL), 20. Mesoscutum Width (MSW), 21. Length of Forewings (LOF), 22. Width of Forewings (WOF), 23. Length of Rarewings (LOR), 24. Width of Rarewings (WOR), 25. Length Distance between M-Cu Venation (M-CU), 26. Length of Forewing with Tegula (WL1), 27. Mandible Length (ML), 28. Mandible Width (MW), 29. Widht of Hind Tibia (HTW), 30. Length of Hind Tibia (HTL) , 31. Width Hind Basitarsus (HBW), 32. Hind Basitarsus Length (HBL). (Sakagami et al., 1990; Schwarz, 1993).

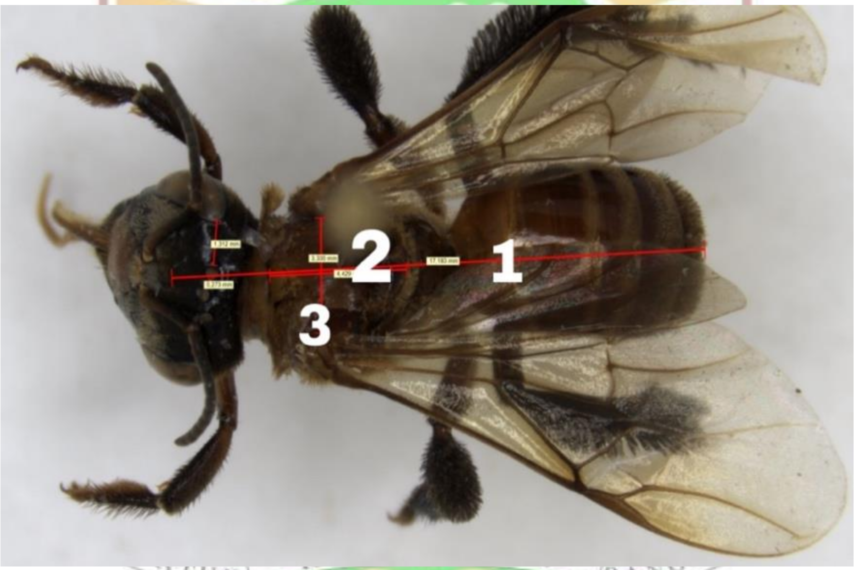

Figure 5. Dorsal measurement of stinglessbee (1. body length (BL) 2. length mesoscutum (LOM) 3. width of mesoscutum (MCW) (Sakagami et al., 1990).

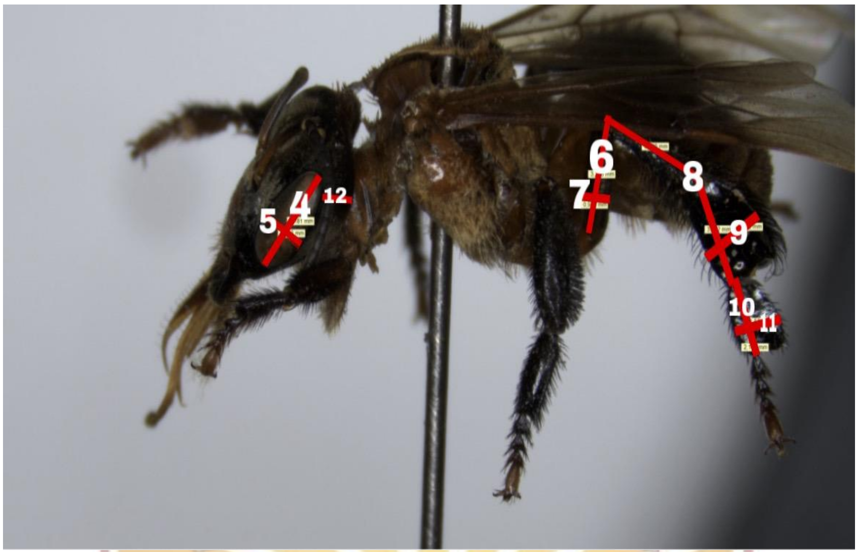

Figure 6. Lateral measurement of stinglessbee 4. eye length (EL), 5. eye width (EW), 6. length of hind tibia (HTL), 7. widht of hind tibia (HTW), 8. width hind basitarsus (HBW), 9. hind basitarsus length (HBL), 10. gena width (GW) (Sakagami et al., 1990).

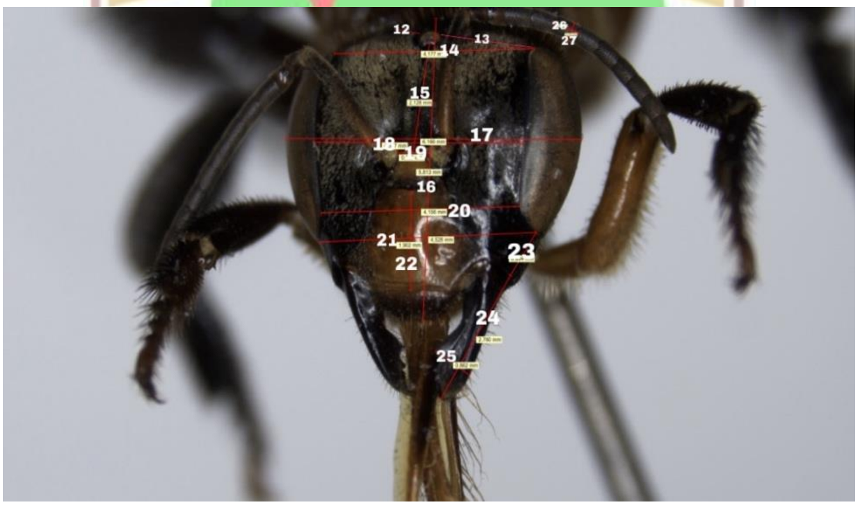

Figure 7. Frontal measurement of stinglessbee 11. ocella ocellar distance (OOD), 12. interocella distance (IOD), 13. upper intro cellular distance (UID), 14. antennae ocellae distance (AOD), 15. Head length (HL), 16. Head width (HW), 17. minimum interorbital distance (LOD), 18. inter antenna distance (IAD), 19, lower intro cellular distance (LID), 20. maximum interorbital distance (MOD), 21. clypeus length (CL), 22. Length of malar space (LMS), 23. length of mandible(LOM), 24. width of mandible (WOM), 25. length of flagellomere 4 (FL4), 26. witdth of flagellomere 4 (FW4) (Sakagami et al., 1990).

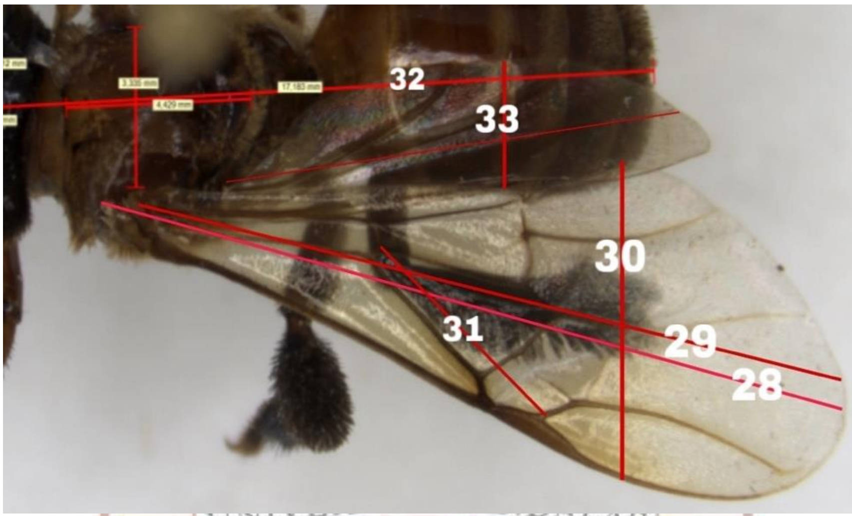

Figure 8. Wings measurements of stinglessbee27. length of forewing with tegula (WL1), 28. length of forewings (LOF), 29. width of forewings (WOF), 30. length distance between M-Cu venation, 31. length of rarewings (LOR), 32. width of rarewings (WOR) (Sakagami et al., 1990).

3.4 Data Analysis

The results of morphometric measurements were analyzed using a sample t test using IBM SPSS version 29.0.1.0 software to see whether or not there were significant differences in the morphometry characteristics of two species in the Genus *Geniotrigona*(*G. thoracica*and *W. incisa*). Morphometric characters will also be analyzed using the Principal Components Analysis (PCA) method using PAST software version 4.7.0.0 to see the most dominant characters.

IV. RESULTAND DISCUSSION

Morphometric analysis of *G. thoracica* and *W. incisa* was conducted to examine population variation, using 10 worker bees from each species. A total of 32 morphometric characters were measured, and the variations were analyzed. The mean values of 14 selected characters were presented in Table 1. Significant differences were found in all measured traits, with *G. thoracica* consistently larger than *W. incisa*. These morphometric differences provide additional evidence supporting the placement of *W. incisa* in the new genus *Wallacetrigona*. In particular, forewing length (with tegula), forewing length, and body length were greater in *G. thoracica*. Larger wings and body size were advantageous for a longer flight range in stingless bees.

The results of this study indicate clear morphometric differentiation between *G. thoracica* and *W. incisa*. The larger body and wing dimensions observed in *G. thoracica* are consistent with previous findings that body size in stingless bees was correlated with flight capacity and foraging distance (Criveau et al., 2016; Laksono et al., 2020). In contrast, the smaller size *of W. incisa* may reflect specific ecological adaptations within Sulawesi's agroforestry habitats, where shorter foraging distances and high colony populations (±100,000 individuals) compensate for reduced individual flight range.

Morphometric variation has long been recognized as a reliable tool for taxonomic clarification (Esquerré et al., 2020). In this case, the significant differences between *G. thoracica* and *W. incisa* support the taxonomic revision placing *W. incisa* in the genus *Wallacetrigona* (Rasmussen & Cameron, 2007; Hasan et al., 2017). Such differentiation highlights the evolutionary divergence of stingless bee lineages across the Wallacea region, separating them from Sundaland and Sahul faunas. Furthermore, the larger morphometric size of *G. thoracica* may enhance pollination efficiency in crops requiring wider foraging ranges, whereas *W. incisa* may provide advantages in localized pollination due to its high colony size and potential to produce diverse hive products. These findings suggest that both species have distinct ecological and economic roles, making them valuable candidates for pollination services in different agroforestry contexts.

4.1 Measurements of*Geniotrigona thoracica* and *Wallacetrigonainsica*

4.1.1 Result of Measurements *Geniotrigona thoracica*

Measurements of 10 worker bees of *G. thoracica* from Jambi, Batang Hari, Bajubang, were taken using a camera lucida with LA.S. 4.13.0 software mounted on a Leica Z6 APO microscope. A total of 32 characters were recorded (Table 2). The results showed that the length of the forewings with tegula (WL1) ranged from 8.12 mm to 9.29 mm, the length of the forewings (LOF) ranged from 7.30 mm to 8.88 mm, and the body length (BL) ranged from 8.40 mm to 8.94 mm.

These were the largest measurements recorded and were considered advantageous for *G. thoracica*, as larger body size and longer wings allow stingless bees to travel greater distances. Conversely, the smallest body size features of *G. thoracica* were the width of flagellomere-4 (FW-4), ranging from 0.165 mm to 0.197 mm, followed by the length of flagellomere-4 (FL), ranging from 0.222 mm to 0.274 mm, and the inter-antennal distance, ranging from 0.291 mm to 0.325 mm. The body size and forewing length with tegula of *G. thoracica* were among the largest compared to other stingless bee species. Differences in the size of pollen pots and honey pots were influenced by body size, forage availability, and colony development. Erwan (2020) reported that body size directly affects honey pot capacity. With a flight range of up to 2 km, the availability of forage vegetation was an important factor in maximizing pollen and honey production (Laksono et al., 2020).

Tabel 1. Results of measurements of 10 worker bee *G. thoracica* from Jambi, Batang Hari, Bajubang.

No	Characters (mm)	*Geniotrigona thoracica*										
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Average**
1	BL	8,5915	8,7725	8,8775	8,9425	8,5315	8,6205	8,8725	8,403	8,7505	8,6005	8,696
2	HL	2,9065	2,508	2,7495	2,885	2,7325	2,8175	2,5065	2,7415	2,8535	2,798	2,749
3	HW	3,083	3,2265	3,2025	3,0585	2,889	3,2505	3,378	3,3725	3,115	3,302	3,187
4	CL	0,951	0,746	0,7495	0,792	0,85	0,966	0,8945	0,938	0,856	0,937	0,868
5	LID	2,078	2,116	2,2675	2,26	2,2865	2,3375	2,221	2,2455	2,2965	2,483	2,259
6	UID	2,129	2,211	2,1995	2,11	2,084	2,1825	2,106	2,0255	2,0785	2,255	2,138
7	EW	0,7465	0,688	0,787	0,7265	0,739	0,6775	0,616	0,6675	0,802	0,76	0,721
8	EL	1,5905	1,7435	1,8145	-	1,4895	1,768	1,689	1,817	1,5495	1,866	1,703
9	MOD	2,1835	2,2935	2,302	2,2785	2,2735	2,235	2,1875	2,2135	2,118	2,371	2,245
10	LOD	2,078	2,2955	2,1625	2,154	2,166	2,124	2,0725	2,1035	2,235	2,2535	2,164
11	AD	1,064	-	1,181	1,192	1,182	1,0785	1,0195	1,137	1,105	1,1105	1,118
12	IOD	0,435	0,4105	0,4485	0,496	-	0,433	-	0,412	0,402	0,424	0,4326
13	OOD	0,656	0,693	0,6925	0,6815	0,67	0,685	0,66	0,6375	0,6665	0,6955	0,673
14	ID	0,315	0,3255	0,2855	0,3085	0,3235	0,2965	0,2915	0,306	0,3245	0,3095	0,308
15	GW	0,599	0,538	0,7555	0,492	0,4275	0,5575	0,488	0,4895	-	0,541	0,543
16	FL4	0,2745	0,257	0,2665	0,2365	0,241	0,243	0,2375	0,2595	0,2275	0,2735	0,251
17	FW4	0,1865	0,1655	0,1755	0,1975	0,1975	0,1785	0,1805	0,1745	0,1895	0,173	0,181
18	LMS	0,497	0,5365	0,4785	0,3385	0,338	0,3375	0,3085	0,3015	0,309	0,513	0,395
19	MCL	2,2145	2,324	2,081	1,982	1,7975	1,804	1,625	1,529	2,292	2,3735	2,002
20	MCW	1,6675	1,8135	1,782	1,823	1,8155	1,754	1,7045	1,8975	1,782	1,843	1,788
21	LOF	8,5935	8,865	8,8765	8,486	7,911	7,2955	8,488	8,175	8,76	8,33	8,378
22	WOF	3,189	3,1945	3,0165	2,551	3,2095	2,5985	2,6105	1,0535	2,707	2,5105	2,664
23	LOR	5,923	5,3665	5,8135	5,8265	5,178	5,9305	5,619	5,945	6,059	5,935	5,759
24	WOR	1,3455	1,313	1,128	1,186	1,5765	1,26	1,5085	1,369	1,121	1,21	1,301

25	M-Cu	2,467	2,334	2,286	2,1335	2,1965	2,2575	2,2675	2,317	2,4275	2,3275	2,301
26	WL1	9,038	9,0915	8,438	8,7435	8,411	8,222	8,12	9,287	9,411	9,236	8,799
27	ML	1,39	1,154	1,4745	1,4685	1,412	1,473	1,59	1,456	1,4835	1,5185	1,44
28	MW	0,431	0,3615	0,2575	0,3745	0,3015	0,2895	0,3835	0,407	0,386	0,402	0,359
29	HTW	1,056	0,8485	0,959	1,0195	1,1575	0,952	1,0295	1,042	0,9575	1,136	1,015
30	HTL	3,404	3,1365	3,3345	3,2155	2,8905	3,351	3,119	3,06	2,8605	3,4595	3,183
31	HBW	0,788	0,735	0,705	0,728	0,757	0,6885	0,702	0,693	0,675	0,7615	0,723
32	HBL	1,0555	1,22	1,107	0,877	1,2225	1,265	0,9715	1,079	1,1365	1,161	1,109

Description : 1. Body Length (BL) 2. Head Length (HL), 3. Head Width (HW), 4. Clypeus Length (CL), 5. Lower Introcellular Distance (LID), 6. Upper Introcellular Distance (UID), 7. Eye Width (EW), 8. Eye Length (EL), 9. Maximum Interorbital Distance (MOD), 10. Minimum Interorbital Distance (LOD), 11. Antenoaccelar Distance (AD), 12. InterOcellar Distance (IOD), 13. Ocelloaccelar Distance (OOD) , 14. Inter Antenna Distance (ID), 15. Ghena Width (GW), 16. Length of Flagellomere 4 (FL4), 17. Witdth of Flagellomere 4 (FW4), 18. Length of Mallar Space (LMS), 19. Mesoscutum Length (MCL), 20. Mesoscutum Width (MSW), 21. Length of Forewings (LOF), 22. Width of Forewings (WOF), 23. Length of Rarewings (LOR), 24. Width of Rarewings (WOR), 25. Length Distance between M-Cu Venation (M-CU), 26. Length of Forewing with Tegula (WL1), 27. MandibleLength (ML), 28. Mandible Width (MW), 29. Widht of Hind Tibia (HTW), 30. Length of Hind Tibia (HTL), 31. Width Hind Basitarsus (HBW), 32. Hind Basitarsus Length (HBL).

4.1.2 Results of Measurements *Wallacetrigonaincisa*

Measurements of 10 worker bees of *Wallacetrigona incisa*, an endemic species from West Sulawesi (Mamasa, Mt. Gandangdewata), were taken using a camera lucida with LA.S. 4.13.0 software mounted on a Leica Z6 APO microscope. A total of 32 characters were recorded (Table 3). The results showed that the largest body size measurements of *W. incisa* were the length of the forewings with tegula (WL1), ranging from 6.56 mm to 7.11 mm, followed by the length of the forewings (LOF), ranging from 6.50 mm to 7.07 mm, and the body length (BL), ranging from 5.07 mm to 5.49 mm. Although smaller than *G. thoracica*, *W. incisa*was still considered relatively large compared to other stingless bee species.

This larger size was advantageous, as *W. incisa* requires large trees as nesting sites and shows adaptations to high-altitude mountain environments. The smallest measurements of *W. incisa* were the width of flagellomere-4 (FW-4), ranging from 0.147 mm to 0.176 mm, followed by the length of the malar space (LMS), ranging from 0.199 mm to 0.247 mm. The body size and wing length of *W. incisa* may play an important role in determining its habitat preferences and ecological adaptations. These dimensions could influence its flight capability, foraging range, and nesting behavior. The primary vegetation associated with *W. incisa* was*Agathis*, while several pollen sources, particularly species of the Ericaceae family endemic to the Latimojong mountain range, serve as its main food plants (Maulidiyah et al., 2023).

Table 2. Results of measurements of 10 worker bee*Wallacetrigona insica*from West Sulawesi, Mamasa, Mnt. Ganda dewata.

No	Characters (mm)	*Wallacetrigona incisa*										
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Average**
1	BL	5,2825	5,007	5,122	5,373	5,3895	5,4855	5,0805	5,0855	5,4665	5,1505	5,244
2	HL	1,899	1,8535	1,9745	1,9605	2,0895	2,1075	1,9635	1,935	1,962	2,049	1,979
3	HW	2,317	2,31	2,336	2,378	2,3725	2,349	2,313	2,334	2,347	2,318	2,337
4	CL	0,6165	0,6225	0,5915	0,59	0,6235	0,629	0,576	0,644	0,584	0,635	0,611
5	LID	1,6165	1,566	1,5575	1,5595	1,592	1,6	1,5585	1,5865	1,5645	1,59	1,579
6	UID	1,598	1,5675	1,5665	1,657	1,6835	1,6295	1,5845	1,6315	1,6185	1,627	1,616
7	EW	0,4995	0,52	0,4675	0,4905	0,4805	0,503	0,4565	0,394	0,482	0,446	0,473
8	EL	1,286	1,3755	1,2635	1,4175	1,2505	1,398	1,2805	1,37	1,3765	1,4875	1,350
9	MOD	1,7105	1,681	1,6855	1,719	1,7255	1,7465	1,7025	1,696	1,674	1,6855	1,702
10	LOD	1,511	1,421	1,4785	1,4985	1,5335	1,6295	1,454	1,467	1,501	1,5355	1,502
11	AD	0,9075	0,828	0,93	0,9745	0,9075	0,9405	0,932	0,8685	0,9465	0,931	0,916
12	IOD	0,4195	0,4395	0,4255	0,406	0,4435	0,4205	0,421	0,4405	0,4175	0,419	0,425
13	OOD	0,4495	0,4405	0,463	0,4715	0,476	0,477	0,465	0,4715	0,4625	0,4685	0,464
14	ID	0,225	0,2315	0,2265	0,2345	0,243	0,236	0,229	0,2325	0,245	0,213	0,231
15	GW	0,395	0,342	0,411	0,416	0,4455	0,3575	0,4365	0,446	0,456	0,482	0,4187
16	FL4	0,1825	0,1775	0,1805	0,175	0,208	0,1835	0,186	1,775	0,1735	0,1895	0,343
17	FW4	0,1475	0,176	0,156	0,1575	0,1585	0,1685	0,1685	0,157	0,162	0,164	0,161
18	LMS	0,2125	0,247	0,2375	0,1995	0,2335	0,2235	0,232	0,245	0,2285	0,2	0,225
19	MCL	1,598	1,664	1,5775	1,615	1,5565	1,9605	1,606	1,65	1,5805	1,6675	1,647
20	MCW	1,325	1,3185	1,4345	1,523	1,3655	1,4055	1,386	1,356	1,5355	1,5195	1,416
21	LOF	6,341	6,6335	6,279	6,524	6,283	6,6805	6,201	6,053	6,0805	7,0735	6,414
22	WOF	1,7595	1,9005	1,831	1,7505	2,156	2,178	2,1735	2,226	2,248	2,1985	2,042
23	LOR	-	4,667	-	-	4,4525	4,9145	4,4315	-	4,2135	4,566	4,540

24	WOR	-	1,059	-	-	1,055	1,218	1,1605	-	1,11	1,184	1,1310
25	M-Cu	2,022	1,9585	1,9825	1,756	2,0255	1,908	1,805	1,946	1,738	1,974	1,911
26	WL1	6,9795	7,0875	7,107	7,0665	6,9565	7,11	6,9345	6,643	6,5605	7,0735	6,951
27	ML	0,9515	0,938	0,9285	0,9305	0,897	0,9625	0,934	0,9115	1,0115	0,983	0,944
28	MW	0,263	0,2485	0,2095	0,2425	0,281	0,249	0,196	0,259	0,193	0,218	0,235
29	HTW	0,7545	0,77	0,7325	0,77	0,755	0,6825	0,7415	0,7615	0,789	0,7195	0,747
30	HTL	2,472	2,3715	2,4315	2,251	2,108	2,374	2,32	2,168	2,468	2,3725	2,333
31	HBW	0,513	0,5345	0,54	0,543	0,5585	0,522	0,504	0,547	0,567	0,484	0,531
32	HBL	0,9055	0,998	0,8795	0,933	0,9655	0,905	0,9	0,9305	0,7705	0,908	0,909

A comparative morphometric analysis was conducted to assess character differences between *Geniotrigona thoracica* and *Wallacetrigona incisa*. Non-parametric tests (Kruskal-Wallis and Mann-Whitney; Table 3) were applied in PAST 4 to determine significant variations among characters and to accurately identify interspecific morphological divergence.

Table3. Kruskal wallis and Mann whitneywith PAST 4 X* (X=Characters, *=Non Significant), Xa/Xb (X=average ofmeasurements, a/b= symbol for variable) in *Geniotrigona thoracica* and *Wallacetrigona insica* to observe characters with specific differences.

No	Characters	*Geniotrigona thoracica*	*Wallacetrigona incisa*
1	BL*	8,696 a	5,244 b
2	HL*	2,749 a	1,979 b
3	HW*	3,187 a	2,337 b
4	CL*	0,868 a	0,611 b
5	LID*	2,259 a	1,579 b
6	UID*	2,138 a	1,616 b
7	EW*	0,721 a	0,473 b
8	EL*	1,703 a	1,350 b
9	MOD*	2,245 a	1,702 b
10	LOD*	2,164 a	1,502 b
11	AD*	1,118 a	0,916 b
12	IOD NS	0,4326 a	0,425 a
13	OOD*	0,673 a	0,464 b
14	ID*	0,308 a	0,231 b
15	GW*	0,543 a	0,4187 b
16	FL4*	0,251 a	0,343 b
17	FW4*	0,181 a	0,161 b
18	LMS*	0,395 a	0,225 b
19	MCL*	2,002 a	1,647 b
20	MCW*	1,788 a	1,416 b
21	LFW*	8,378 a	6,414 b
22	WFW*	2,664 a	2,042 b
23	LBW*	5,759 a	4,540 b
24	WBW*	1,301 a	1,131 b
25	M-CU*	2,301 a	1,911 b
26	WL1*	8,799 a	6,951 b
27	LM*	1,44 a	0,944 b
28	WM*	0,359 a	0,235 b
29	HTW*	1,015 a	0,747 b

30	HTL*	3,183 a	2,333 b
31	HBW*	0,723 a	0,531 b
32	HBL*	1,109 a	0,909 b

The results of Kruskal-Wallis and Mann-Whitney tests, conducted on 32 morphometric characters of *Geniotrigona thoracica* and *Wallacetrigonainsica*. These characters include head size, Body Length (BL), Wings Width, Antenocellar Length (AL), and other morphological parameters,96.975% of the measured characteristics were significantly different. Only a small proportion 3.025% showed significant similarity, specifically in the interocellar distance (IOD).The results indicated that most of the characters show statistically significant differences between the two species (representated by an asterisk "*"), with the exception of one character, IOD (Interocular Distance), which was marked as non-significant (NS), suggesting a similarity in eye spacing between the species.

The average measurement values ($\bar{X}$) for each character were indicated by the symbol "a" for *W. incisa* and "b" for *G. thoracica*. Nearly all measured values were higher in *G. thoracica* than in *W. incisa*, reflecting that *G. thoracica* generally possesses a larger body size and more developed morphological features. For example, the average body length (BL) in *G. thoracica* is 8,696 mm, which was significantly bigger than the 5,244 mm of *W. incisa*. This trend was consistent across other characters such as head length (HL), head width (HW), and forewing length (LFW).

These statistically significant differences clearly distinguish *G. thoracica* from *W. incisa* in terms of morphometric characteristics, and these differences can serve as a reliable basis for species taxonomy and identification. This finding further supports the PCA results (Figure 9), which showed the two species forming distinct clusters in the biplot, indicating consistent and significant morphometric divergence.Interocellar distance referred to the space between the left and right ocelli, three small eyes used for light detection in stingless bees. Due to their role in detecting light, these eyes generally exhibited a conserved size and form across stingless bee species (Ribi et al., 1989).

The observed differences in body size between *G. thoracica* and *W. incisa* were attributed to several environmental factors, including habitat type, altitude, temperature, humidity, and the availability of food sources. The size of worker bees was influenced by food availability at the nest site, which in turn affected their foraging range. The identification of stingless bee genera and species in this study was based on morphological characteristics and coloration, including the structure and color of the antennae, head, thorax, wings, legs, and abdomenbased on (Ador et al., 2023).

Different species were originally described as *Trigona (Geniotrigona) incisa* Sakagami and Inoue from Sulawesimakes the genus *Geniotrigona* Moure polyphyletic. The findings of this study further supported that the morphological variations observed between *G. thoracica* and *W. incisa* were statistically significant, indicating distinct morphometric characteristics between the two species. These differences were evident in key morphometric parameters, reinforcing the taxonomic distinction based on physical traits (Sakagami and Inoue, 1989).

The findings of this research supported previous reports by (Samsudin et al., 2018), confirming that *Geniotrigona* represented the largest genus in terms of body size. Therefore, the morphometric data obtained in this study provided supporting evidence that *Wallacetrigona incisa* possessed distinct characteristics when compared to the previously studied genus *Geniotrigona.*

Tabel 4. Eigenvalue and % Variance Measurements of *Geniotrigona thoracica* and *Wallacetrigona incisa* with PAST 4.

PC	Eigenvalue	%variance
1	1,2436	2,7352
2	1,4524	2,0836
3	1,2833	1,9363
4	0,2883	0,9503

Based on the results of the Principal Component Analysis (PCA), it was found that the principal components have eigenvalues bigger than 1, indicating that these components were significant and capable of explaining a substantial portion of the data variance. An eigenvalue bigger than 1 suggests that the component contributes more information than the average contribution of the original variables. Therefore, these principal components are considered important and relevant in describing the differences or patterns within the data, particularly in distinguishing species groups based on the analyzed morphometric characteristics.

The morphometric data of *Geniotrigona thoracica* and *Wallacetrigona incisa* showed variation in body sizes (Table 3). This morphometric data was analyzed using Principal Component Analysis (PCA) to identify the dominant characters with grouping influencing the variation and clustering patterns of individuals. The PCA results illustrated the clustering pattern of the samples based on the contribution of each morphological character to the grouping process. Principal Component Analysis was performed using the collected data (Trianto et al., 2020).

The correlation analysis between groups resulted in eigenvalues and percentage variances, as presented in Table 4, while the biplot of the PCA results was shown in Figure 9.PCA, an analytical technique widely used in taxonomic research, helped determine the contribution of each character in the formation of clusters. The results of the principal component analysis were visualized in a PCA diagram (Figure 9). The PCA results supported the groupings formed through cluster analysis, reinforcing the classification patterns observed in the study.

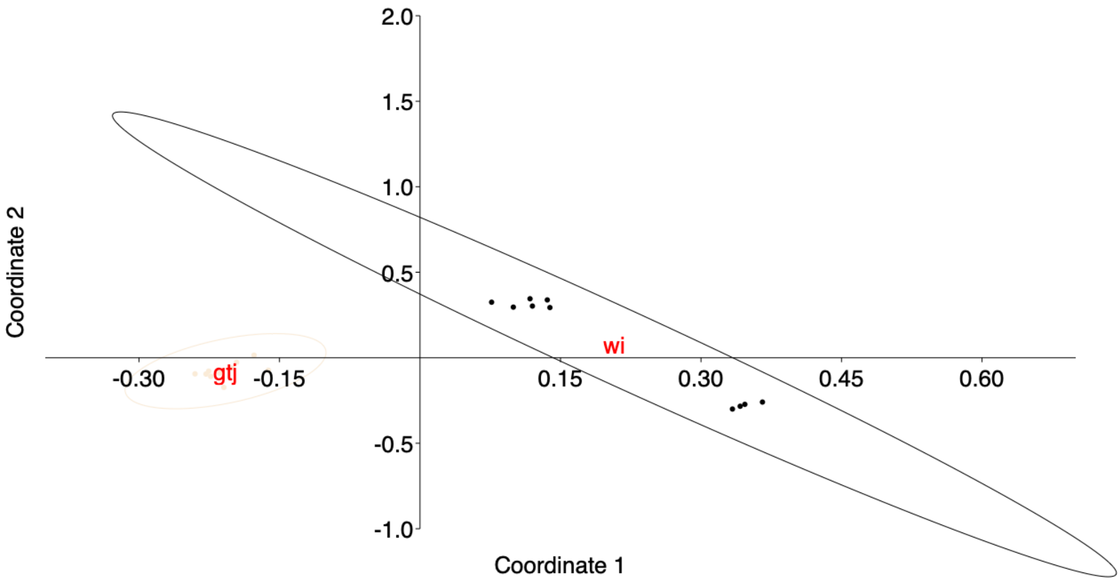

Figure 9. Biplot of Principal Component Analysis (PCA) results of *Geniotrigona thoracica* and *Wallacetrigona incisa.*[wi:*Wallacetrigona insica* and gtj:*Genotrigona insica*.].

The biplot results demonstrate clear clustering patterns, where individuals of each species form distinct groups. Notably, the plots representing *Geniotrigona thoracica* and *Wallacetrigona insica*were clearly separated, indicating that these two species exhibit significant differences in their morphometric characteristics. This distinct grouping in the biplot supports the conclusion that *G. thoracica* and *W. incisa* possess divergent traits, reflecting their taxonomic and phenotypic differentiation.

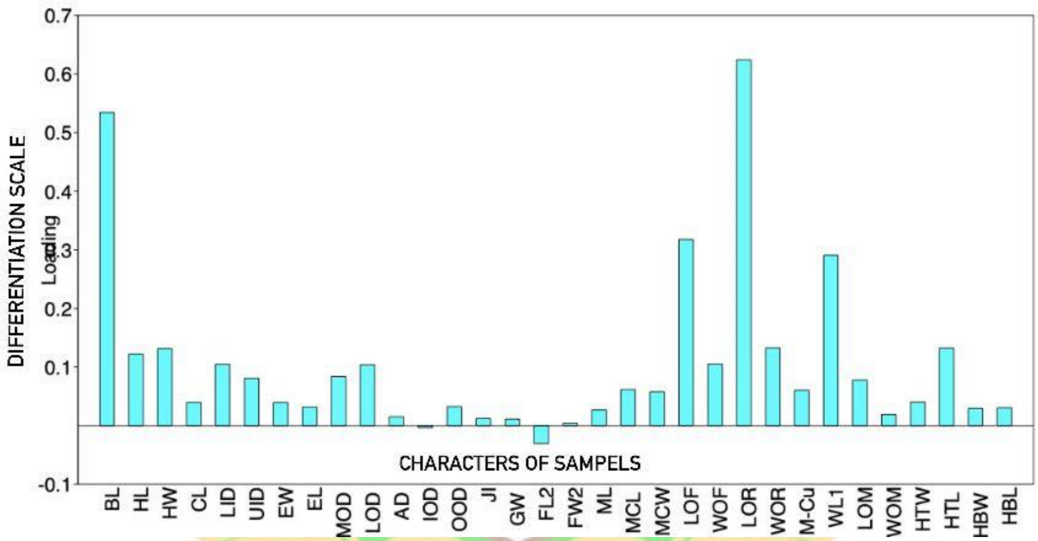

Figure 10. The loading plot Principal Component Analysis (PCA) of component for dominant character in measurements of *Geniotrigona thoracica* and *Wallacetrigona insica*.

Based on the results of the Principal Component Analysis (PCA) variations that were observed in the individual measurements of *G. thoracica* and *W. incisa*, the most dominant characters contributing to species clustering was Body Length (BL), followed by the Length of the Forewing (LOR) and the Forewing Including Tegula (WL1). This was evident from the vector lengths shown in the PCA biplot (Figure

10). The longer the arrow and the higher the position on the graph, the greater the influence of that character in the formation of the clusters.

V. CONCLUSION AND SUGGESTION

5.1 Conclusion

1. The morphometric analysis revealed that *G. thoracica* possesses significantly different which larger body dimensions than *W. incisa*, particularly in Forewing Length with Tegula (WL1), Forewing Length (LOF), and Body Length (BL). These differences suggest that *G. thoracica* may have distinct ecological or functional adaptations compared to *W. incisa*.
2. *G. thoracica* and *W. incisa* exhibit a high degree of morphological divergence, with a 96.975% difference in overall morphology. Notably, the only significant morphological similarity between the two species was in the Inter-Ocellar Distance (IOD), which shows a minimal similarity of 3.025%.

5.2 Suggestion

1. Further research was needed to explore more morphometric characteristics of *G. thoracica* and *W. incisa* in order to more completely analyze their genetic diversity and strengthen the phylogenetic analysis, which was crucial for understanding their evolutionary relationships.
2. Future research should focus on analyzing the biogeographic and ecological factors related to the distribution of this species across a broader range of regions.

BIBLIOGRAPHY

Ador, K., Gobilik, J., & Benedick, S. 2023. Phylogenetic and Morphological Characteristics Reveal Cryptic Speciation in Stingless Bee, Tetragonula Laeviceps Sl Smith 1857 (Hymenoptera; Meliponinae). *Insects*: *14*(5), 438.

Asiah W. N, W.M.A, Sajap, A.S., Adam, N.A. & Hamid, M.N. 2015. Flight Intensity of Two Species of Stingless Bees *Heterotrigona itama* and *Geniotrigona thoracica* and Its Relationships With Temperature, Light Intensity and Relative Humidity. *Serangga*: *20*(1), 35-42.

Azizi, M. G., Priawandiputra, W., & Raffiudin, R. 2020. Identifikasi Morfologi Lebah Tak Bersengat Dari Belitung. Dalam *IOP Conference Series: Earth and Environmental Science* (Vol. 457, No. 1, p. 012011). IOP Publishing.

Basari, N., Ramli, S. N., & Mohd Khairi, N. A. S. 2018. Imbalan Makanan dan Jarak Memengaruhi Pola Mencari Makan Lebah Tanpa Sengat, *Heterotrigona itama*. *Serangga*: *9* (4), 138.

Cameron, P. 1902. Deskripsi Spesies Baru Aculeate *Hymenoptera* dari Kalimantan.

Cameron, S. A., Hines, H. M., & Williams, P. H. 2007. Filogeni Komprehensif Lebah (Bombus). *Jurnal biologi Linnean Society*: *91* (1), 161-188.

Danaraddi, C. S., Shashidhar Viraktamath, S. V., Basavanagoud, K., & Bhat, A. R. S. 2009. Kebiasaan Bersarang dan Struktur Sarang Lebah Tak Bersengat, *Trigona iridipennis* Smith di Dharwad, Karnataka.

Eltz, T., Brühl, C.A., Imiyabir, Z. & Linsenmair, K.E. 2003. Nesting and Nest Trees of Stingless Bees (Apidae: Meliponini) in Lowland Dipterocarp Forests in Sabah, Malaysia, With Implications for Forest Management. *Forest Ecology and Management*: *172*, 301.

Engel, M.S. & Rasmussen, C. 1999. A New Subgenus of *Heterotrigona* From New Guinea (Hymenoptera: Apidae). *Journal of Melittology*: *73*, 1-16.

Heard, T. 2016. The Australian Native Bee Book: Keeping Stingless Bee Hives for Pets, Pollination and Sugarbag Honey. Queensland: Sugarbag Bees: 246 pp.

Engel, M.S. 2001. A Monograph of The Baltic Amber Bees and Evolution of The Apoidea (Hymenoptera). *Bulletin of the American Museum of Natural History: 259*, 1-192.

Engel, M.S. 2012. The Honey Bees of Indonesia (Hymenoptera: Apidae). *Treubia*, :*39*, 41-49.

Erwan, E., Harun, M., & Muhsinin, M. 2020. Kualitas Madu *Apis mellifera*Dengan Nektar Ekstrafloral di Lombok, Nusa Tenggara Barat, Indonesia. *Jurnal Sains dan Pendidikan IPA*: *1* (1), 1-7.

Esquerré, D., Donnellan, S., Brennan, I. G., Lemmon, A. R., Lemmon, E. M., Zaher, H., Grazziotin, G. G., & Keogh, J. S. 2020. Filogenomik, Biogeografi, dan Morfometrik Mengungkap Evolusi Fenotipik Yang Cepat Pada Ular Piton Setelah Melewati Garis Keturunan Wallace . *Biologi Sistematika*: *69*(6), 1039-1051.

Hasan Z.A, Shamsul,&B., Adam, S. 2017. Ultra Structure Comparison of Three Stingless bees Species of Borneo.

Heard, M. S., Baas, J., Dorne, J. L., Lahive, E., Robinson, A. G., Rortais, A., & Hesketh, H. 2018.Comparative Toxicity of Pesticides and Environmental Contaminants on Bees: Are Honey Bees a Useful Proxy for Wild Bee Species. *Science of the Total Environment*:*578* , 357-365.

Herwina, H., Salmah, S., Janra, M. N., Christy, B. Y., Sari, D. A., & Putri, G. 2021, May. West Sumatran Stingless Bees (Hymenoptera: Apidae: Meliponini): What Can Be Told From Its Local Distribution. *In IOP Conference Series: Earth and Environmental Science* (Vol. 757, No. 1, p. 012084). IOP Publishing.

Kahono, S., Chantawannakul, P. & Engel, M.S. 2018. Social Bees And The Current Status Of Beekeeping In Indonesia. In P. Chantawannakul, G. Williams & P. Neumann, eds. Asian Beekeeping in the 21st Century. *Springer Verlag*: 287–306.

Klakasikorn, A., Wongsiri, S., Deowanish, S. & Duangpakdee, O. 2005. New Record of Stingless Bees (Meliponini: Trigona) in Thailand. *The Natural History Journal of Chulalongkorn University*: 5(1), 1-7.

Kukutani, T., Inoue, T. & Maeta, Y. 1993. Pollination Of Strawberry By The Stingless Bee, Trigona Minangkabao, And The Honeybee, Apis Mellifera: An Experimental Study Of Fertilization Efficience. *Research in Population Ecology*: 35 95-111.

Laksono P. Raffiudin& R. Juliandi B. 2020. Stingless Bees *Tetragonula laeviceps* and *T. aff. biroi*: Geo-Metric Morphometry Analysis Of Wing Venation Variations.

Mason, W.R.M. 1986. Standard Drawing Conventions And Definitions For Venational And Other Features Of Wings Of Hymenoptera. *Proceedings Of The Entomological Society Of Washington*: 88(1), 1–7.

Maulidiyah, A. G., Kahono, S.,& Syamsir, S., 2023. Distribution, Nest Architecture, And Forage Plants Of An Endemic Wallacean Species Of Stingless Bee

Wallacetrigona Incisa (Apidae: Meliponini) In Sulawesi, Indonesia. *Journal Of Research Square*.

Michener, C.D. 2007. The Bees of the World (Ed 2) Baltimore: The Johns Hopkins University Press. Michener, C.D. & Boongird, S. 2004. A New Species Of Trigona From Peninsular Thailand (Hymenoptera: Apidae: Meliponini). *Journal of the Kansas Entomological Society*: 77, 143-146.

Moure, J. S. 1964. Dua Genus Baru Lebah Halictine Dari Subwilayah Araucanian Di Amerika Selatan (Hymenoptera: Apoidea). *Jurnal Masyarakat Entomologi Kansas*: *37* (4), 265-275.

Nagamitsu, T & Inoue, T. 2005. Floral resource utilization by stingless bees (Apidae, Meliponini). In. Roubik, D.W., Sakai, S. & Hamid, A.A. (Eds.). Pollination Ecology and the Rain Forest: Sarawak Studies, pp. 73-88. Berlin: *Springer Science & Business Media*.

Nogueiro-Neto, P. 1953. A Criação de Abelhas Indígenas sem Ferrão (Meliponinae). Chácaras e Quintais.

Radloff, S.E., Hepburn, H.R. & Engel, M.S. 2011. The Asian species of Apis. In H.R. Hepburn & S.E. Radloff, eds. Honeybees of Asia. Springer Verlag: 1–22.

Rasmussen, C. 2008. Catalog of the Indo-Malayan / Australasian stingless bees (Hymenoptera: Apidae: Meliponini). *Zootaxa*: 1935, 1–80.

Rasmussen, C., Thomas, J.C. & Engel, M.S. 2017. A new genus of Eastern Hemisphere stingless bees (Hymenoptera: Apidae), with a key to the supraspecific groups of Indomalayan and Australasian Meliponini. *American Museum Novitates*: 3888, 1–33.

Rasmussen, C., & Cameron, S. A. 2007. Filogeni molekuler lebah tanpa sengat Dunia Lama (Hymenoptera: Apidae: Meliponini) dan non-monofili genus besar Trigona. *Entomologi Sistematis*: *32* (1), 26-39.

Rasmussen, C. 2008. Catalog of The Indo-Malayan/Australasian Stingless Bees (Hymenoptera: Apidae: Meliponini). *Zootaxa*:1935, 1-8.

Rasmussen, C., & Cameron, S. A. 2010. Filogeni lebah tanpa sengat global mendukung divergensi purba, vikariansi, dan penyebaran jarak jauh. *Jurnal Biologi Linnean Society*: *99* (1), 206-232.

Ribi, W. A, Engels, E., & Engels, W. 1989. Struktur Mata Khusus Jenis Kelamin Dan Kasta Pada Lebah Tanpa Sengat Dan Lebah Madu (Hymenoptera: Trigonidae, Apidae). *Entomologia Generalis*: *14* , 233-242.

Roubik, D.W. 1989. Ecology and Natural History of Tropical Bees. Cambridge: *Cambridge University Press*.

Sakagami, S. F., & Michener, C. D. 1987. Tribes of Xylocopinae and origin of the Apidae (Hymenoptera: Apoidea). *Annals of the Entomological Society of America*: *80*(3), 439-450.

Sakagami, S. F., Inoue, T., Yamane, S., & Salmah, S. 1989. Nests Of The Myrmecophilous Stingless Bee, Trigona Moorei: How Do Bees Initiate Their Nest Within An Arboreal Ant Nest?. *Biotropica*: 265-274.

Sakagami S. F, Inoue T, &Salmah S. 1990. Stingless Bees Of Central Sumatra. Di Dalam: Sakagami SF, Ohgushi R, Roubik DW (Eds.) Natural History Of Social Wasps And Bees In Equatorial Sumatra.*Sapporo: Hokkaido Univ Press*. hlm: 125–137.

Salmah, S., & Swasti, E.2017. Aktivitas Terbang Harian *Trigona Laeviceps* Dan *T. Minangkabau* Pada Pertanaman Cabai Merah (Capsicum Annuum L.) Di Dataran Rendah Dan Tinggi Sumatera Barat. *Jurnal Internasional Ilmu Lingkungan Terapa*: *12* (8), 1497-1508.

Salatnaya, H., Kahono, S., Suhri, A. G. M. I., Ismanto, A., Anggraeni, I., Fara, S. B., ... & Hashifah, F. N. 2023. *Diversity, Distribution, Nesting, and Foraging Behavior of Stingless Bees and Recent Meliponiculture in Indonesia. In Melittology-New Advances.*

Samsudin S.S., Mohd, R. M., &Izfa, R. H. 2018. Taxonomy Study On Selected Species Of Stingless Bee (Hymenoptera: Apidae: Meliponini) In Peninsular Malaysia.

Sayusti, T., Raffiudin, R., Kahono, S., & Nagir, T.2021. Lebah Tanpa Sengat (Hymenoptera: Apidae) Di Sulawesi Selatan Dan Barat, Indonesia: Morfologi, Struktur Sarang, Dan Karakteristik Molekuler. *Jurnal Penelitian Apikultur*: *60* (1), 143-156.

Schwarz, H.F. 1939. Results Of The Oxford University Sarawak (Borneo) Expedition: Bornean Stingless Bees Of The Genus Trigona. *Bulletin Of The American Museum Of Natural History*: 7, 281–328.

Siregar, H. C. H., A. M. Fuah, & Y. Octaviany. 2011. Propolis Madu Multikasiat. Penebar Swadaya, Jakarta.

Smith, F. G. 1957. Bee botany in East Africa. *The East African Agricultural Journal*: *23*(2), 119-126.

Thomas, S. G., Rehel, S. M., Varghese, A., Davidar, P., & Potts, S. G. 2009. Lebah Sosial Dan Asosiasi Tanaman Pangan Di Cagar Biosfer Nilgiri, India. *Ekologi Tropis*: *50* (1), 79.

Trianto M, &Purwanto T. 2020. Morphological Characteristics And Morphometrics Of Stingless Bees (Hymenoptera: Meliponini) In Yogyakarta, Indonesia

Trianto, M., & Purwanto, H. 2022. Diversity, abundance, and distribution patterns of stingless bees (Hymenoptera: Meliponini) in Yogyakarta, Indonesia. *Biodiversitas Journal of Biological Diversity*: 23(2).

Van Der Kooi, C. J., Vallejo-Marín, M., & Leonhardt, S. D. 2021. Mutualisms and (a) symmetry in plant–pollinator interactions. *Current Biology*: 31(2), R91-R99.

Velthuis, H.H.W. 1997. The Biology of Stingless Bees. Utrecht: Utrecht University Press.

Wille, A. 1983. Biology of stingless bees. *Annual Review of Entomology*: 28(1), 41-64.

APPENDICES

Appendix 1. The Measurements of *Geniotrigona thoracica* And *Wallacetrigona incisa.*

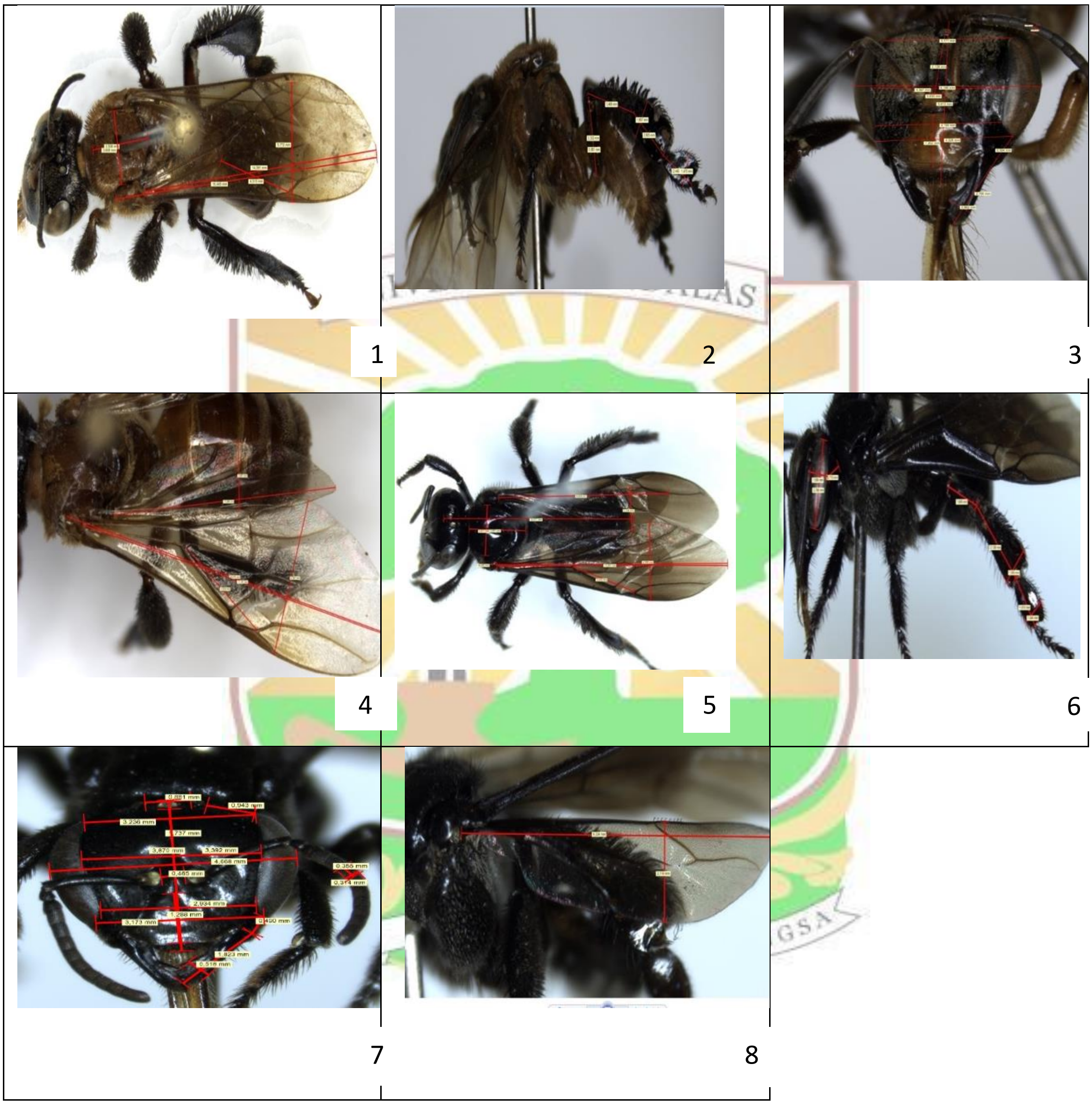

Figure 1. Measuremets with camera lucida with software LA.S. 4.13,0 mounted on Leica Z6 APO Microscope 1. Dorsal side, 2. Ventral side, 3 Frontal side 4. Wings of *Geniotrigona thoracica* from Jambi, Batang Hari, Bajubang. 5. Dorsal side, 6. Ventral side 7. Frontal side 8. Rarewings of *Wallacetrigona incisa* from West Sulawesi, Mamasa, Mnt. Ganda dewata**.**

Appendix2. Kruskall-Wallis For Looking Differences Characteristics.

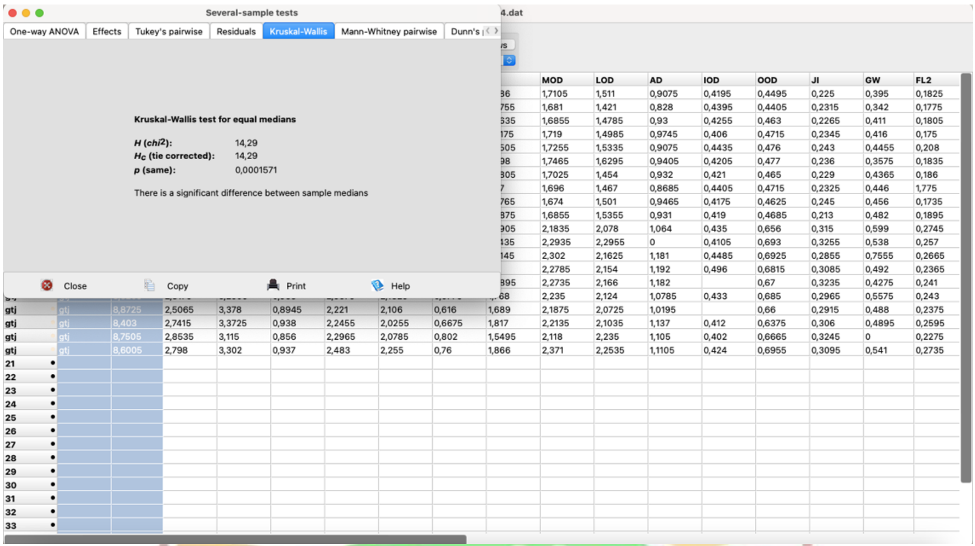

Figure 2. Results of Characteristics that have Significant Differences Test (Kruskal-Wallis).

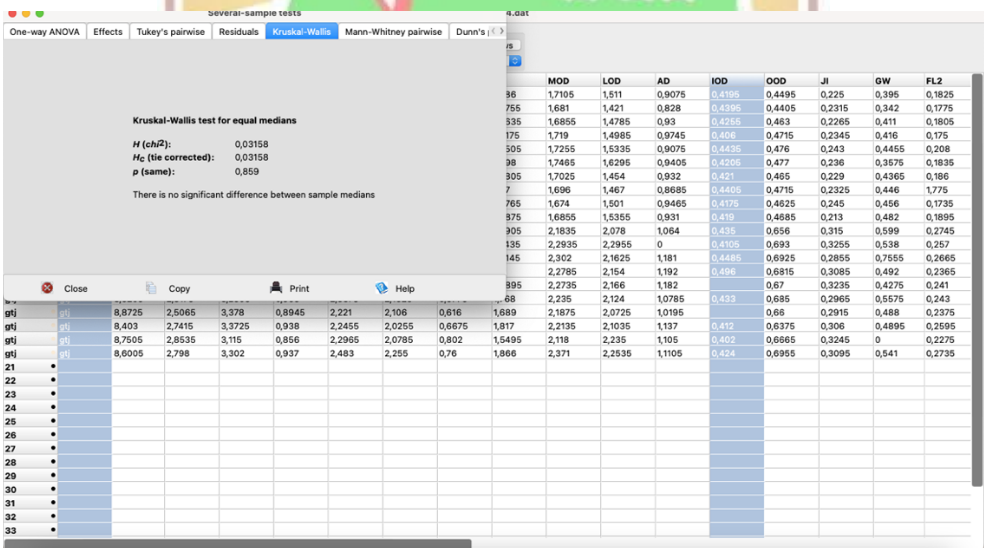

Figure 3. Results of Characteristics that have No Significant Differences (Simmilarty) with Kruskal-Wallis.

Appendix3. Research Documentations.

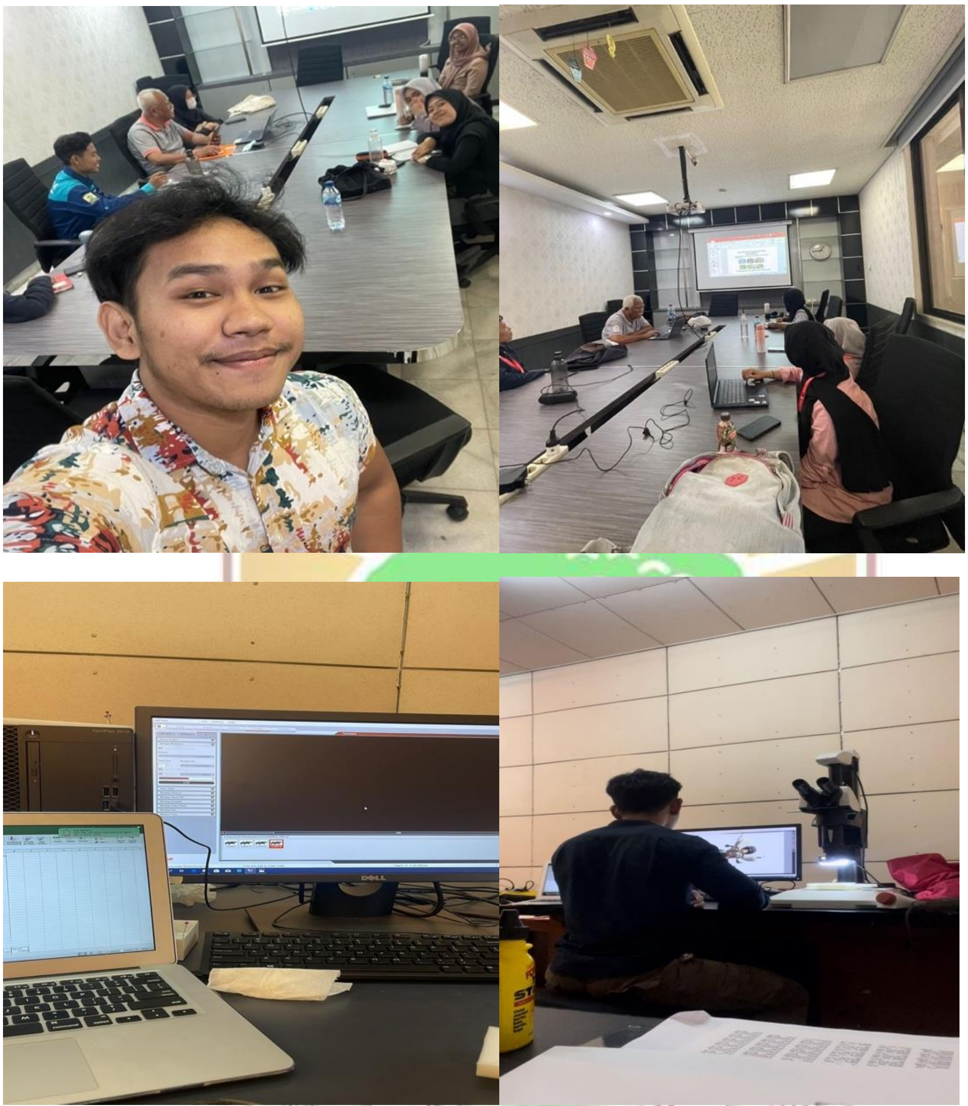

Figure 3. Documentations of Intrenship in BRIN Cibinong.

PROFILE OF AUTHOR

Name	: Ariyan Agusman
ID Number	: 2010422023
Place/Date of Birth	: Padang/August, 27th 2002
Gender	: Male
Addres	: Komp. Berlindo Sungai Sapih, Kuranji, Padang
Study Period	: 5 Years 3 Month
Phone Number	: 08993496161
Email	: ariyanagusman@gmail.com
Parents Name	
Father	: Budiman
Mother	: Maiwati

Educational History

2008 - 2014	: SD Negeri 27 Padang
2014 - 2017	: SMP Perti Padang
2017 - 2020	: SMA Negeri 16 Padang
2020 - 2025	: S1 Biology, Universitas Andalas, Padang, Sumatera Barat