

TAKSONOMI *STINGLESS BEES* SULAWESI (HYMENOPTERA: ASPIDAE: MELIPONINI) BERDASARKAN KARAKTERISTIK MORFOLOGIS, MOLEKULER, DAN STRUKTUR SARANG

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INTISARI

Keanekaragaman *stingless bees* di Indonesia telah tercatat di dalam *Catalog Indo-Malayan* dan *Australasian stingless bees*, namun masih terbatas di pulau-pulau yang termasuk ke dalam wilayah Sundaland. Informasi *stingless bees* di Indonesia khususnya di Pulau Sulawesi belum banyak diketahui, sehingga identifikasi spesies masih mengalami kesulitan. Identifikasi *stingless bees* dapat dilakukan dengan melihat ciri morfologis, arsitektur sarang, dan pendekatan molekuler melalui DNA *barcoding*. Ketiga analisis ini penting dilakukan untuk mendukung studi taksonomi *stingless bees*. Berdasarkan hal tersebut, maka penelitian ini bertujuan untuk memecahkan permasalahan taksonomi dan pengenalan jenis dengan analisis multi karakter (morfologis, molekuler, dan struktur sarang), mengkaji hubungan kekerabatan intra spesies, serta validasi dan deskripsi eksisting spesies dan biogeografi (penyusunan peta distribusi) *stingless bees* di Pulau Sulawesi. Analisa morfologis yang diperiksa mencakup 143 karakter kualitatif dan kuantitatif pada lebah pekerja. Analisis morfometrik geometris juga dilakukan dengan pengambilan gambar sayap lebah dan membuat digitasi *landmark* menggunakan perangkat lunak *Thin Plate Spline* (TPS), *tpsDig2*, *tpsRelw*, dan analisis kekerabatan berdasarkan metode *Neighbor-joining* menggunakan R Studio. Pengamatan arsitektur sarang dilakukan pada bagian pintu masuk sarang dan susunan sel pengeraman. Analisis molekuler dilakukan dengan metode PCR menggunakan primer gen mitokondria *COI* dan *16S rRNA*. Data dianalisis menggunakan GeneStudio, DNASTAR, BLAST, Identification Engine, Mesquite, MEGA11, DnaSP, NETWORK, dan BEAST. Hasil penelitian multikarakter mampu memecahkan permasalahan taksonomi *stingless bees* Sulawesi dengan akurasi yang lebih tinggi dibandingkan dengan karakter tunggal. Kunci identifikasi dikotomi dan pohon filogeni dapat digunakan sebagai pengenalan spesies *stingless bees* di Pulau Sulawesi. Hasil penelitian menunjukkan bahwa spesies *stingless bees* grup Sulawesi memiliki kekerabatan dengan spesies serupa dari Kalimantan, Jawa, dan Sumatera. Saat ini diketahui sebanyak 10 spesies *stingless bees* dari lima genera di Pulau Sulawesi, dua diantaranya adalah catatan baru, yaitu *Heterotrigona itama* dan *Homotrigona canifrons*. Penjelasan rinci, kekerabatan spesies, kunci identifikasi lebah pekerja dan sarang, fotografi dan distribusi spesies disampaikan dalam disertasi ini. Temuan ini telah memperbaharui data keanekaragaman spesies *stingless bees* di Indonesia khususnya di Sulawesi. Hasil analisis multi karakter pada masing-masing spesies diharapkan dapat membantu mengidentifikasi spesies dan memperjelas status spesies *stingless bees* yang dapat digunakan pada studi selanjutnya.

Kata kunci: Taksonomi, spesies *cryptic*, filogenetik, DNA mitokondria

**TAXONOMIC OF SULAWESI STINGLESS BEES (HYMENOPTERA:
ASPIDAE: MELIPONINI) BASED ON MORPHOLOGICAL, MOLECULAR,
AND NEST STRUCTURE CHARACTERISTICS**

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ABSTRACT

The diversity of stingless bees in Indonesia was recorded in the catalogue of Indo-Malayan and Australasian stingless bees, however it is still limited in the islands that belong to Sundaland region. Information on stingless bees in Indonesia, particularly in Sulawesi, is still scarce, posing challenges for species identification. Stingless bees identification can be performed using morphological characteristics, nest architecture, and molecular approaches, such as DNA barcoding. These three analyses are crucial for supporting the taxonomic study of stingless bees. Thus, this study aimed to resolve taxonomic issues and improve species identification using a multi-character analysis (morphological, molecular, and nest structure), examine intraspecific phylogenetic relationships, and validate as well as describe the existing species and their biogeography (distribution mapping) of stingless bees in Sulawesi. Morphological analysis involved examining 143 qualitative and quantitative characters in worker bees. Geometric morphometric analysis was also performed by capturing images of bee wings and digitizing landmarks using Thin Plate Spline (TPS) software, including tpsDig2 and tpsRelw. Phylogenetic relationships were analyzed using the Neighbor-Joining method in R Studio. Nest architecture observations focused on entrance structures and brood cell arrangements. Molecular analysis was conducted using PCR with mitochondrial gene primers *COI* and *16S rRNA*. Genetic data were analyzed using GeneStudio, DNASTAR, BLAST, Identification Engine, Mesquite, MEGA11, DnaSP, NETWORK, and BEAST. Multi-character analysis proved to be more accurate in resolving the taxonomic issues of Sulawesi stingless bees compared to single-character approaches. The dichotomous identification key and phylogenetic tree generated in this study serve as references for species recognition of Sulawesi stingless bees. The findings indicate that Sulawesi stingless bees species share phylogenetic relationships with closely related species from Kalimantan, Java, and Sumatra. Sulawesi currently has 10 known stingless bees species from five genera, two of which are new records, namely *Heterotrigona itama* and *Homotrigona canifrons*. This dissertation provides a complete description, species relationships, key species based on worker bees and nests, as well as photos and species distribution in the Island of Sulawesi. The multi-character analysis for each species is expected to aid species identification and clarify the taxonomic status of stingless bees, providing valuable references for future studies.

Keywords: Taxonomy, cryptic species, phylogenetics, mitochondrial DNA