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Description of the termite genus *Prohamitermes* (Termitinae) with new characters from the Leuser Ecosystem, Sumatra, Indonesia

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Abstract. *Muarrif S, Samadi S, Jauharlina J, Syaukani S. 2023. Description of the termite genus* Prohamitermes (*Termitinae*) *with new characters from the Leuser Ecosystem, Sumatra, Indonesia. Biodiversitas 24: 6119-6125. Prohamitermes* is a termite genus that belongs to the subfamily Termitinae, alongside 61 other genera, within the family Termitidae. Termitidae, comprising 70% of all termite species, is the most prominent family in Isoptera. However, limited information about this *Prohamitermes* genus is available. Consequently, researchers and experts in the field have encountered challenges in acquiring comprehensive knowledge about the genus due to the need for more relevant literature. This paucity of information needs to improve our understanding of its characteristics, behavior, and ecological significance. Therefore, describing *Prohamitermes* is necessary to taxonomically identify termites from the subfamily Termitinae. This comprehensive study was meticulously conducted within the pristine Leuser Ecosystem (LE), employing a rigorously standardized transect protocol specifically developed to ensure accurate termite analysis. The genus is characterized by certain features present in its head capsule. Firstly, the shape of the front in a lateral view is a distinguishing characteristic, followed by the shape of the lateral sides (left and right) of the head capsule as observed from a dorsal view. While previous journals have described this termite genus based on the shape of its labrum and mandibles, this article focuses on the shape of its head capsule, specifically the front and lateral head capsule. Additionally, the article discusses the ecology of *Prohamitermes*. The morphological description presented in this study is expected to contribute to termite research, particularly in termite taxonomy and control.

Keywords: Anterolateral, dorsal, frons, head-capsule, lateral, morphology, *Prohamitermes mirabilis*, soldier

INTRODUCTION

Termites are a diverse group of social insects within the order Isoptera (Suganthy and Pretheepkumar 2019; Tolossa 2022), comprising approximately 3,000 documented species (Krishna et al. 2013; Bourguignon et al. 2016; Constantino 2021; Das and Choudhury 2023), and a significant component of ecosystems, account for approximately 10% of the animal biomass present (Lertlumnaphakul et al. 2022). Termites have been observed to display a remarkable sensitivity to variations in temperature and humidity within their immediate environment, as demonstrated in studies conducted by Patel et al. (2019). Additionally, these insects selectively choose and consume wood of higher density, showcasing their discerning dietary preferences (Paulyne et al. 2016; Oberst et al. 2018). Termites are classified into various groups based on their dietary preferences, such as wood-feeding, grass-harvesting, and fungus-growing (Bourguignon et al. 2015; Chiu et al. 2015; Subekti et al. 2018; Sharaf et al. 2021; Bhanupriya and Gupta 2022). Another fascinating aspect of termites is their ability to impact the chemical properties of soil, including carbon and nitrogen levels, through the introduction of nest materials (Jouquet et al. 2015; Lind and Davies 2019; Hasan et al. 2021; Arinana et al. 2022; Zaman et al. 2022).

Termitidae, specifically higher termites, exhibit a remarkable capacity to sustain a stable gut microorganism community, which consistently persists across various colonies of the same species within a given ecosystem (Su et al. 2016; Schyra et al. 2019). Termitidae is further divided into several subfamilies, including Macrotermitinae, Sphaerotermitinae, Foraminitermitinae, Apicotermitinae, Syntermitinae, Termitinae, and Nasutitermitinae (Krishna et al. 2013). Termitinae, a subfamily of Termitidae, is classified as a soil-feeding group because it feeds on soil-rich organic matter (Kouakou et al. 2022). The taxonomy of the Termitinae subfamily poses challenges, leading to over 500 unidentified termite samples, as reported by Eggleton (Eggleton 2011). Likewise, the Nasutitermitinae subfamily within Termitidae also faces the same taxonomy difficulties, as Boulogne et al. (2017) highlighted. Each genus within the Termitinae subfamily employs distinct characteristics in its identification process, resulting in a wide range of morphological variations (Eggleton 2011). The subfamily Termitinae, one of Termitidae's traditionally acknowledged subfamilies, must be more defined (Hellemans et al. 2017).

Prohamitermes is one of the 61 genera within the subfamily Termitinae (Krishna et al. 2013). This termite genus was initially described by Holmgren in 1912, primarily based on the characteristics of its labrum and mandibles (Thapa 1981). The soldier caste of *Prohamitermes* exhibits symmetrical mandibles and a labrum resembling a tongue, as described by Holmgren in 1912 and cited in Thapa (1981). These termites can be found in various locations, including Sabah, Sarawak, Singapore, Eastern Sumatra (Chhotani 1987), and Thailand (Sornnuwat et al. 2004). The present study focuses on a specific genus of termites discovered in the Leuser Ecosystem (LE) in western Sumatra.

Haviland (1898) played a crucial role in providing the initial description of *Prohamitermes mirabilis*, originally referred to as *Termes mirabilis*. Haviland's work was based on samples collected from Sarawak in Borneo and Singapore. This early description established the foundation for further research and exploration into the taxonomy and characteristics of *Prohamitermes* termites within the subfamily Termitinae, belonging to the family Termitidae. Thapa (1981) expanded upon Haviland's work by providing additional morphological characteristics of *Prohamitermes mirabilis*. Thapa's study significantly contributed to understanding and classifying this termite species. The detailed description of these termites remains highly relevant in termite taxonomy, particularly for *Prohamitermes* termites (Termitinae, Termitidae).

The study investigates morphological traits of *Prohamitermes* termites across various habitats and altitudes in the Leuser Ecosystem (LE), collecting 148 samples to identify new characteristics for accurate species identification. The study introduces novel genus-specific morphological traits that are the basic groundwork for taxonomy and ecology research, assisting species identification in the LE and similar regions. These traits deepen comprehension of evolutionary relationships and ecological roles of Prohamitermes, enhancing knowledge of these termites across varied LE habitats.

MATERIALS AND METHODS

Study area

Prohamitermes mirabilis in this study was discovered in the Leuser Ecosystem (LE), northern Sumatra, Indonesia at three distinct locations, as indicated in Table 1, i.e.: Bukit Lawang (3° 33' 18.270" N, 98° 8' 50.130" E), Sikundur (3° 58' 5.000" N, 98° 4' 58.900" E), and Bengkung (2° 58' 27.360" N, 97° 55' 47.65" E) (Figure 1 and Table 1). Bukit Lawang (3° 33' 18.27" N, 98° 8' 50.13" E) is situated in Bohorok, Langkat District, North Sumatra Province, with altitudes ranging from 150 to 350 meters above sea level (masl). Sikundur (3° 58' 5" N, 98° 4' 58.9" E) is located in Besitang, Langkat District, North Sumatra Province, approximately 40 masl. Bengkung (2° 51' 13.19" N, 97° 53' 56" E) is situated in Subulussalam City, Aceh Province, at an altitude of around 80 masl. All three research sites are encompassed within the Leuser Ecosystem (LE). The LE covers an area of 2.6 million hectares (approximately 600.000 hectares were collected for termite), with Aceh Province and North Sumatra Province serving as its administrative regions, of which 2.25 million hectares fall within Aceh Province. This region serves as a sanctuary for various wildlife species, including mammals and a diverse array of birds. Additionally, Gunung Leuser National Park, located within the area, is designated as a World Heritage Site for conservation purposes.

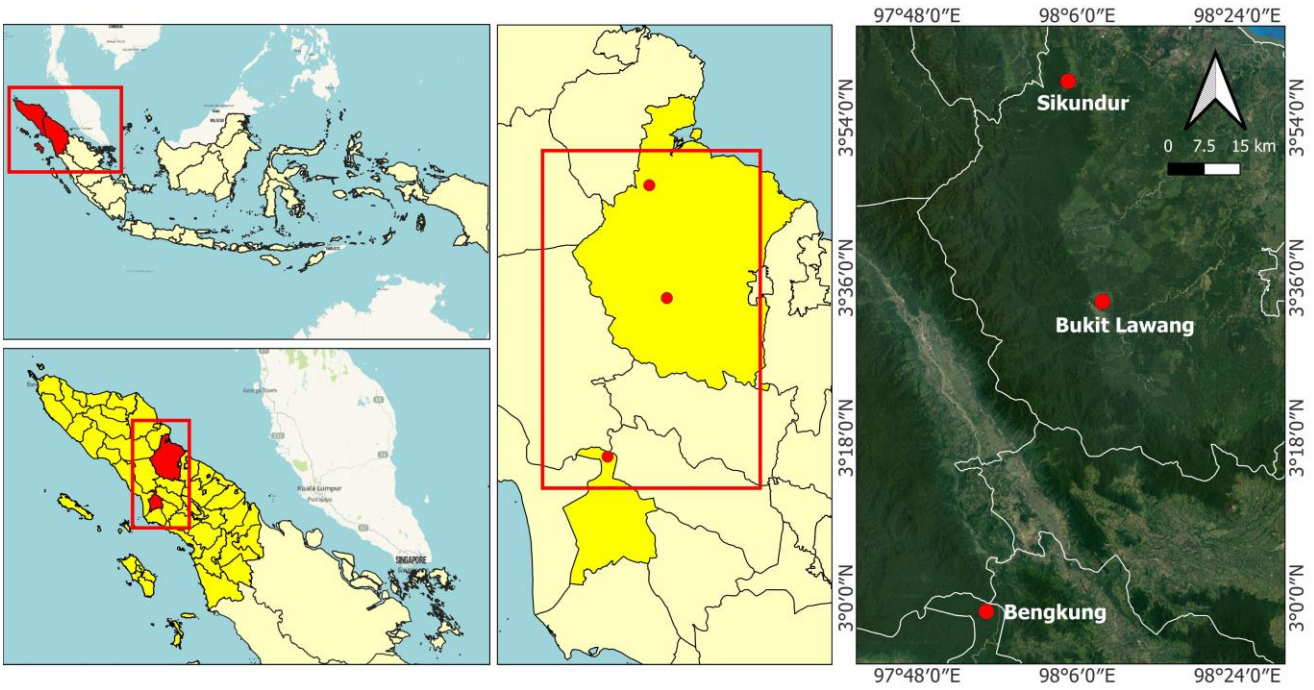

Figure 1. Sample collection site in the Leuser Ecosystem, northern Sumatra, Indonesia

Table 1. List of sample collection locations

Sites	Coordinates	Altitude (m asl.)	Forest-type
Bengkung	02° 58' 27.36" N, 97° 55' 47.65" E	450	Primary tropical rainforest
Bukit Lawang	03° 33' 18.27" N, 98° 08' 50.13" E	150-350	Primary low land dipterocarp
Sikundur	03° 58' 05.00" N, 98° 04' 58.90" E	50	Secondary low land dipterocarp

Procedures

The research method employed was the observational method, in which the researchers conducted explorations in cardinal directions to search for termite colonies in locations where the existence of termite colonies was likely based on the microclimatic conditions of the environment. Samples of termite soldiers and workers were collected through manual sorting and placed in sample bottles containing 70% alcohol. The termite sampling was conducted in accordance with Jones and Eggleton (2000) using a standardized transect protocol. Each transect, measuring 100 meters in length and 2 meters in width, is subdivided into 20 adjacent segments, each of which spans 5 meters by 2 meters. Two individuals are tasked with sampling each segment for a period of 30 minutes, amounting to a total of 1 hour of sample collection for each segment. Within each segment, the following microenvironments are investigated: approximately 12 samples of surface soil, each measuring 12 cm x 12 cm with a depth of 10 cm; the accumulation of leaf litter and humus at the base of trees and among supporting roots; the interior of deceased tree trunks, tree stumps, branches, and twigs; soil and humus within and underneath significantly decayed tree logs; all subterranean nests, mounds, cardboard mounds, and pathways above vegetation, as well as arboreal nests up to 2 meters above ground level. All termite castes are collected if present, with particular emphasis on locating soldiers and workers, as they are the most readily identifiable. Termites are carefully placed in bottles containing 70% alcohol and are labeled with the corresponding section number. The samples were appropriately labeled and stored in the laboratory for subsequent morphological characterization.

Identification of material

This study used samples from the Zoology Laboratory of Faculty Mathematics and Natural Sciences (FMNS) Syiah Kuala University collected in 1999 and 2001. A total of 148 colonies were examined in the Zoology Lab using a 10X ocular dilated LEYBOLD (TM) stereo microscope. The samples were observed under a LEYBOLD (TM) microscope in a container filled with silica powder and alcohol. The features examined for identification included the antennae, mandibles, pronotum, labrum, postmentum, and head capsule. The identification was based on relevant literature, specifically Haviland (1898) and Thapa (1981).

Data analysis

Morphological characteristics that are considered include the lateral and dorsal views of the head capsule, as well as the dorsal view of the pronotum. In the lateral view of the head capsule, the front capsule can be observed to determine whether it is elevated or flat. In the dorsal view, the left and right sides of the lateral aspect can be examined to determine whether they are convex or slightly convex, as depicted in Figure 2. Another crucial characteristic is the presence or absence of an indentation on the anterior of the pronotum. These characteristics align with Chiu et al. (2016) approach, where he distinguishes termite samples by examining the front and lateral parts of the head capsule.

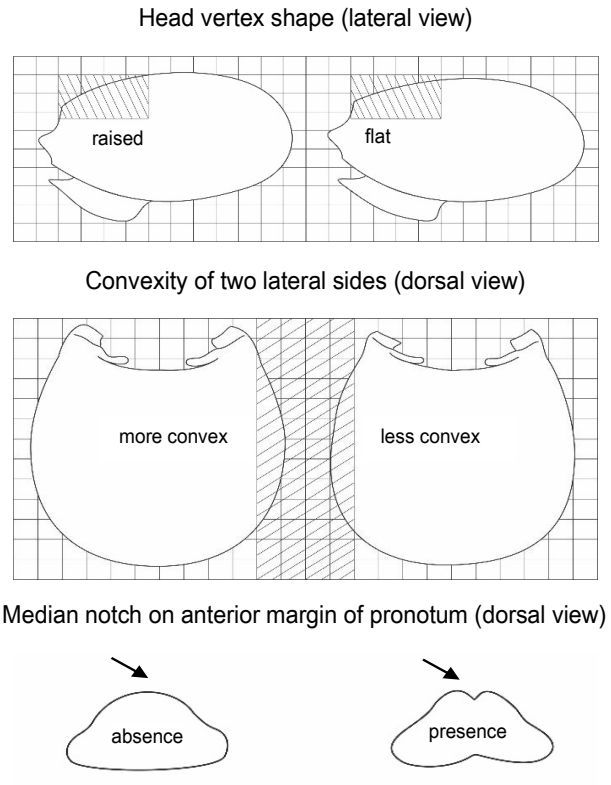

Figure 2. Definition of three soldier diagnostic characters according to Chiu et al. (2016)

RESULTS AND DISCUSSION

Systematics

Family Termitidae Latreille, 1802
Genus *Prohamitermes* Holmgren, 1912
Prohamitermes mirabilis Haviland, 1898 (Haviland 1898; Thapa 1981)

Descriptions

Soldier

The head capsule is reddish yellow, the anteclypeus is whitish, and the labrum is yellow. The antennae are yellow, with distal segments exhibiting a reddish tinge. The pronotum is yellow with a tawny tinge, while the mandibles are reddish brown and paler at the base. The tergite abdomen and legs are pale yellow. The head has a few scattered hairs; the labrum has a row of hairs on the sides and a pair of long hairs at the tip. The postmentum has a few hairs along the anterior and anterolateral edges. The pronotum has long and short hairs along the edges, and the tergite abdomen has a posterior row of long hairs.

The head capsule is oval, slightly longer than wide, with the broadest side in the posterior third and slightly narrowing towards the anterior. The fontanelle is short, indistinct, located in the anterior third, and has a short tube directed forward. The mandibles are long and sword-shaped, with the tip strongly curved inwards. The left mandible has two marginal teeth below the middle, a wide indentation before the first marginal tooth and after the second marginal tooth. The first marginal tooth is triangular and approximately equal in size to the second. The posterior margin of the first marginal tooth and the anterior margin of the second marginal tooth form a concave cutting edge. The right mandible has two marginal teeth of equal size and shape to the left mandible. The antenna consists of 14 elongated segments, with the third segment slightly longer than the second and the fourth segment shorter than the second. Segments 5 to 14 gradually increased in length. The anteclypeus is trapezoid in shape, and the postclypeus is slightly swollen and bilobed. The triangular labrum has straight lateral edges and fused anterolateral edges, forming a pointed tip. The postmentum is enormously swollen and dilated in the anterior four-fifths, appearing oblong in ventral view and narrow in the posterior one-fifth. The pronotum is saddle-shaped, with the anterior lobe as long as the posterior lobe, lacking an indentation in the center of the anterior margin and having narrowly rounded lateral lobes and a relatively straight posterior margin. The legs are long.

Worker

The head appears round from the dorsal perspective and is adorned with numerous fine hairs. The right mandible exhibits an apical tooth, a first marginal tooth longer than the apical tooth, a second marginal tooth shorter than the apical tooth, and a molar plate. Similarly, the left mandible possesses an apical tooth, a first marginal tooth longer than the apical, a second marginal tooth shorter than the apical, and a prominent molar. The antenna consists of 14 segments, with the third segment longer than the second, the fourth segment shorter than the second, and the fifth to thirteenth segments gradually elongated. The final segment is oval. The head, antennae, and legs are yellow, while the abdomen displays a slightly transparent yellow hue. The mandibles are of a yellowish-brown coloration.

Discussion

The external structure of termites has long been emphasized in studies related to their systematics and classification (Akoth et al. 2022). Thapa (1981) identifies *Prohamitermes mirabilis* based on the shape of the labrum, which can be either tongue-shaped or convex, resembling a semicircle. Sornnuwat et al. (2004) distinguish this termite from others by its long and highly curved mandibles. The genus *Prohamitermes* exhibits distinctive morphological characteristics primarily observed in its head capsule, both from lateral and dorsal views. In contrast to previous studies, this research focuses on describing *P. mirabilis* based on the morphology of its head capsule, as depicted in Figure 3. The dorsal view of the head capsule allows for observation of its left and right sides, revealing whether it possesses a strongly convex or slightly convex shape. The lateral view of the head capsule, specifically the front, examines whether this area is elevated (bulge) or flat, as illustrated in Figure 5.

As many as 148 colonies were examined, and we found new morphological characters helpful in identifying the genus in addition to the previous characteristics, such as the labrum and mandible. These new characters include the front of the head capsule and the edge of the head capsule in a dorsal view. These characteristics reveal distinct differences in the shape of the head capsule compared to *P. mirabilis*, as depicted in Figure 3. The head capsule exhibits variations in which the anterolateral part is relatively longer or shorter than that of *P. mirabilis*, and the edge appears relatively flatter than that of *P. mirabilis*, as shown in Figure 4. Furthermore, Figure 5 illustrates the front of the head capsule, showcasing whether it exhibits an elevation or a flat shape.

Based on the image in Figure 3, notable variations were observed among sketches A, B, C, and D. Sketch D represents *P. mirabilis*. In contrast, the remaining three sketches depict *Prohamitermes* termites, which differ from *P. mirabilis* in the shape of their head capsules. The critical distinctions between Sketch A and Sketch D (*P. mirabilis*) are the more extended anterolateral feature in Sketch A and the less pronounced convexity of the lateral capsule in the head. Sketch B demonstrates a variation from Sketch D, specifically in the shorter length of the anterolateral section. Sketch C exhibits a distinct dissimilarity compared to sketch D, as it possesses a lateral aspect that is relatively even or not curved outward, and its lateral capsule is not aligned in parallel.

The sketch presented in Figure 3 was created based on microscope photographs, as illustrated in Figure 4. Sketch A was derived from the photograph displayed in Figure 4A, sketch B from Figure 4B, and Sketch C from Figure 4C. Additionally, Figure 5 portrays the lateral view of the sample captured in Figure 4. This image highlights subtle variations in the shape of the front of the head capsule. Figure 5A showcases a relatively flat front, Figure 5B exhibits a slight protrusion, while Figure 5C displays a more noticeable protrusion.

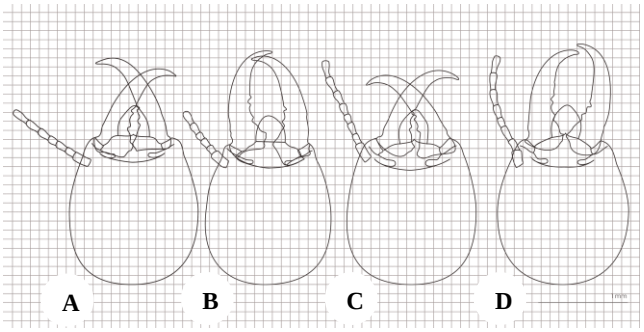

Figure 3. Front-capsule comparison. A. Relatively longer than *Prohamitermes. mirabilis*, B. Relatively shorter than *P. mirabilis*, C. Relatively flat edge shape compared to others, D. *P. mirabilis* - 1 mm scale

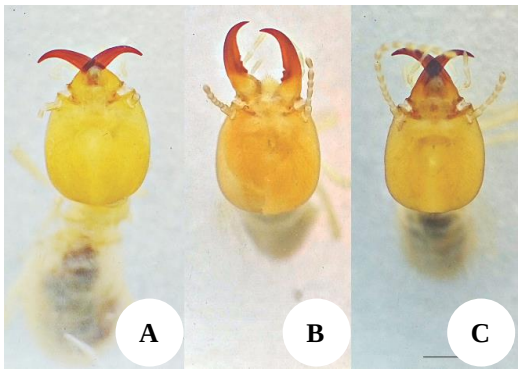

Figure 4. Edge/capsule shape of the head. A. Relatively longer than *Prohamitermes mirabilis*, B. Relatively shorter than *P. mirabilis*, C. Relatively flat edge shape compared to others. 1 mm scale

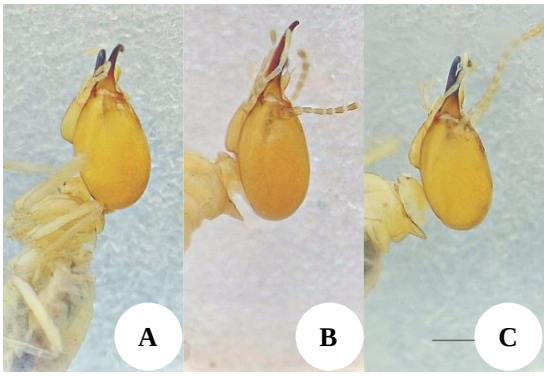

Figure 5. The shape of the head capsule frons. A. Flat, B. Slightly protruding, C. Prominent. Scale 1 mm

Termites, in general, are known to consume plants or cellulose and its derivatives as their primary food source. However, they exhibit specific dietary preferences, including wood, humus, grass, or soil (Inward et al. 2007). *P. mirabilis*, belonging to the Termitinae subfamily, is classified as a humus-feeding termite species. According to Jones and Brendell (1998), *P. mirabilis* prefers humus or wood as its food source. The research indicates that *Prohamitermes* termites are predominantly found in soil, as illustrated in Figure 6. This observation aligns with the findings presented by Jones and Prasetyo (2002), which suggest that these termites construct subterranean nests within the soil. Therefore, it is a logical expectation that this termite genus has a higher occurrence in soil habitats.

The study uses samples from the Zoology Laboratory of FMNS Syiah Kuala University, collected from three locations at various elevations, as indicated in Table 1. Generally, termites are commonly found at lower altitudes and rarely observed at higher altitudes, seldom above 1,000 masl. Indrayani (2022) emphasized the significant impact of altitude on termite abundance. Eggleton (2000) states termites are most abundant in lowland tropical forests. Figure 7 illustrates that termites are predominantly found at altitudes ranging from 150 to 350 masl, which aligns with the altitude range of Bukit Lawang, a lowland tropical forest. This study's second most common termite altitude range is between 50 and 150 masl. On the other hand, termites were least frequently observed at the highest altitude recorded in this study, which was 450 masl. This observation is consistent with the statement made by Gathorne-Hardy (Gathorne-Hardy et al. 2001), who stated that as altitude increases, the abundance of termites decreases.

Contrary to Gathorne-Hardy's findings (Gathorne-Hardy et al. 2001), who stated that the altitude range from 50 to 150 masl would have the highest abundance of termites compared to other altitudes, the sample collection site in Sikundur, located within this altitude range, has experienced extensive logging activities. Marsh et al. research (2022) confirms that logging has caused significant damage to the Sikundur ecosystem. Consequently, the termites' abundance in Sikundur is expected to be lower, at 32% lower than Bukit Lawang, at 59%.

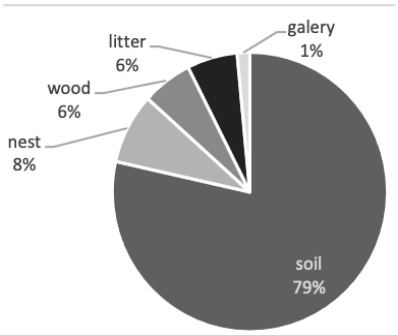

Figure 6. Termite sample finding substrate

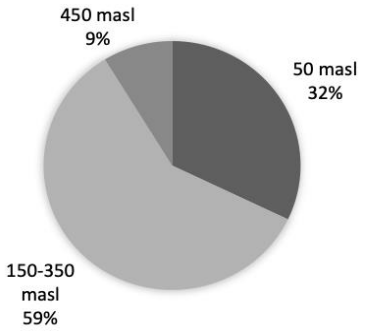

Figure 7. Several samples from each altitude

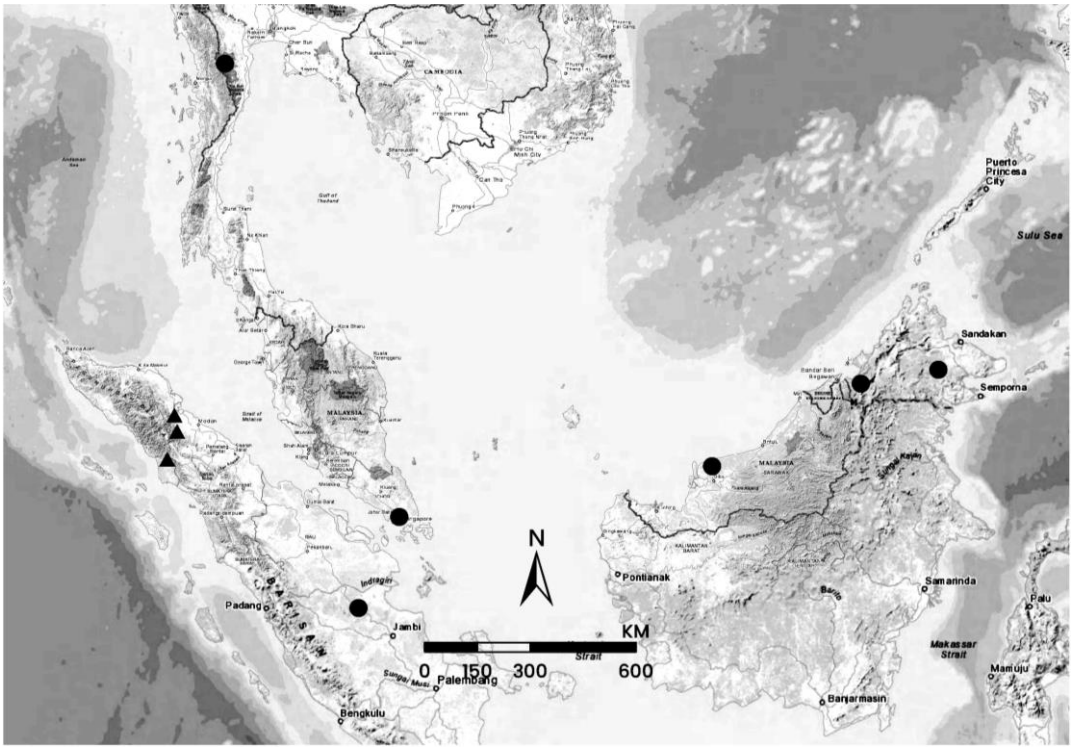

Figure 8. Geography record of *Prohamitermes mirabilis* ● (Chhotani 1987; Sornnuwat et al. 2004); ▲ this study

The existence of this species in Southeast Asia has been documented in previous research (Chhotani 1987; Sornnuwat et al. 2004; Arumugam et al. 2020). Chhotani (1987) provided an account of the distribution of these species in Singapore, Malaysia (namely Sabah and Sarawak), and Indonesia (specifically East Sumatra). Arumugam (2020) also recollected this species in Sabah, while Sornnuwat et al. (2004) reported the distribution of this species inside Thailand's geographical region. The present study identified *P. mirabilis* termites in Western Sumatra (LE) in contrast to Chhotani's findings in East Sumatra. Figure 8 illustrates the current distribution of *P. mirabilis* termites in South East Asian.

Previously, the shape of the mandibles and labrum of the soldier caste were used as morphological characters to identify *Prohamitermes* termites. However, the study has demonstrated that head capsule characteristics, including the lateral shape, anterolateral distance, and shape of protrusions on the front, are useful to differentiate between *P. mirabilis* and other *Prohamitermes* samples. These new characteristics can be used to help identify termite species of the genus *Prohamitermes*. Furthermore, environmental factors, such as altitude, influence the abundance of termites. Moreover, environmental damage, such as encroachment and land clearing, also affects termite populations, as termites are sensitive to environmental changes. Utilizing these characteristics in future studies could potentially discover new species within the *Prohamitermes* genus and enhance taxonomic confirmation for the species for which the availability of references is rare.

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