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Biodiversity and distribution of termite nests in West Papua, Indonesia

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Abstract. *Subekti N, Nurvaizah I, Nunaki JN, Wambrau HK, Mar'ah R. 2018. Biodiversity and distribution of termite nests in West Papua, Indonesia. Biodiversitas 19: 1659-1664.* Termites play an important role in plant nutritive cycles by contributing to the disintegration and decomposition of organic matter. However, termites also cause damage to wood in nature as well as in buildings. Therefore, termites are potential pests and need to be controlled. Effective control of termites requires knowledge about their species prevalence and distribution. The current study aimed to identify the termite species and nest distributions in West Papua. A survey to determine the distribution of termite nests used the transect line method with intervals of 50 m in width and length. The results showed that there were 35 termite nests on 10 host trees species, namely *Calophyllum inophyllum* (Bintanggur), *Mastixiodendron pachyclados* (Lancat), *Intsia bijuga* (Kayu besi), *Inocarpus fagifer* (Gayang), *Canarium hirsutum* (Kenari), *Horsfieldia parviflora* (Pala hutan), *Diospyros papuana* (Black wood), *Aleurites moluccana* (Kemiri), *Pometia coreacea* (Matoa), and *Vatica rassak* (Resak). These nests harbored three termite genera, including *Microcerotermes*, *Longipeditermes*, and *Bulbitermes*. *Microcerotermes* were the most commonly found and had a wide distribution across almost all points of observation.

Keywords: Biodiversity, distribution, Papua, termites nest

INTRODUCTION

Termites play an important role in the recycling of plant nutrients through the disintegration and decomposition of organic materials found in wood and plant litter. The insects' main food sources are wood, cellulose materials, and fungi. However, termites frequently destroy wood and other cellulose materials in built structures and attack living trees and plants and are thus considered pests (Subekti 2016). The total annual economic losses associated with termite infestation of buildings and preventive treatments worldwide were estimated to be US$40 billion in 2012 (Ghaly and Edwards 2011).

Termites have a high species diversity, with 2500 species having been successfully identified. Termite species are divided into seven families, 15 subfamilies, and 200 genera, which occur in various countries around the world (Nandika et al. 2015). In Indonesia, 200 species of termites within three families (Kalotermitidae, Rhinotermitidae, and Termitidae) have been identified. Termites have a high diversity in tropical forests because these areas have diverse ecosystems (Indrawan et al. 2007). The main environmental factors that affect the distribution of termite nests include the temperature and humidity, while other factors are precipitation and vegetation structure (Cookson and Trajstman 2002). Each of these factors varies, which has driven the ability of termites to adapt and survive and to develop colonies under a broad range of conditions.

Climatic and soil conditions in Indonesia strongly support termite survival (Indrayani et al. 2017). In almost all tropical and subtropical areas, termites (Ordo: Isoptera) have become pests that pose a large damage threat to various crops and forest products (Subekti 2016). Based on observations in West Papua, Indonesia wood-feeding termites can attack a living tree and build a nest in it, which eventually kills the tree. Manokwari, the capital of the province of West Papua, Indonesia, is ecologically suitable for breeding termites. Termite colonies can be easily found in the city, especially in areas of vegetation.

Manokwari (0.015′-3.025′ S, 132.035′-134.045′ E) has flora and fauna that is very different from the other major islands of the country. Research on the types and distribution of termites in West Papua has never been done. However, West Papua is a natural laboratory that contains a large biodiversity of flora and fauna, even in the heart of the city of Manokwari.

Observationally, termite nests often occur in several tree species in West Papua. Since some trees are grown for harvest, termites have the potential to cause economic harm in the region. However, detailed information about termites in West Papua is not yet available, which hinders the development of effective control measures.

MATERIALS AND METHODS

Termite sampling was conducted at the Gunung Meja Nature Tourism Park, Manokwari, West Papua, Indonesia.

The identification of host plants was done in the Biology Laboratory of the University of Papua, Manokwari, Indonesia, while termite identification and data analysis were conducted at the Laboratory of Biology, State University of Semarang, Central Java, Indonesia.

Soldier caste termites were collected from the Gunung Meja Nature Tourism Park, Manokwari and placed in 70% alcohol. A global positioning system (GPS) was used to pinpoint geographical locations, and a lux meter was used for measuring the intensity of light. Additional equipment included a thermohygrometer to measure air temperature, a soil tester for measuring soil moisture and pH, a compass, a machete, plastic containers, tweezers, petri dishes, brushes, sample bottles, raffia, plastic straps, stationery, a digital camera, a microscope, markers, paper labels, measuring tape to determine the height and diameter of nests, tally sheets, and identification books.

A survey to determine the distribution of termite nests was done using the transect line method (Turner 2000; Lee et al. 2003). This method is often used to collect data on species and the number of termite nests. The observation path was systematically specified for the entire forest, with intervals of 50 m in width and length. When, a nest of termites was found researchers recorded the location using GPS. The starting point for each line of observation was marked with the direction in which observations were made, using the compass. The data collected included the position of termite nests according to the GPS, the height and the size of the nest, and the species of tree in which it was found. Termite nests were classified according to size, namely, small (nest height $\leq$ 0.49 m), medium (0.5-0.99 m), and large ($\geq$1 m) (Subekti et al. 2008).

Soldier caste termites, up to 25 from each site, were collected using tweezers or paint brushes and placed in sample bottles containing 70% alcohol. Each sample bottle was with a number, the number of nests (to assign an identifying number to each nest) and the nest location.

Termite identification was based on soldier caste termites. The sample insects were examined with a binocular microscope to observe the morphological characteristics, including the length of the mandibles, the length of the head and length of antennae. After photomicrographs were taken, the insects were stored in specimen containers. Termite identification was done to the level of the species based on Sornuwat et al. (2004) and Tho (1992).

The identification of host plant species was based on Womersley (1978) and Lekitoo et al. (2008). Determination of the distribution of the termites used the points of observation of nests in the field using GPS, with further processing with the software ArcView 10. The results are presented as a map of termite species in forested areas.

RESULTS AND DISCUSSION

Termite species diversity

The results of the identification of the termite species according to Sornuwat et al. (2004) and Tho (1992) indicated that three termite species occur in the Gunung Meja Nature Tourism Park, Manokwari. These species are from the family Termitidae and belong to three genera (*Microcerotermes*, *Longipeditermes*, and *Bulbitermes*) from two subfamilies (Amitermitinae and Nasutitermitinae).

Termites are polymorphic social insects that live in colonies. A caste system exists in each colony, and each caste has a different body morphology. In this study, termite identification was based on soldier caste termites because insects in this caste have a distinct mandible shape that differs by species, permitting easy identification (Haneda and Firmansyah 2012).

Microcerotermes spp. have small soldiers that are similar in size to their workers. Typical morphological characteristics of soldier caste termites of *Microcerotermes* spp. were a rectangular head capsule and curved, serrated mandibles (Figure 1.A). The length of the head in *Microcerotermes* spp. was half of the body length, and the insects had paired antennae with 13 segments. According to Sornuwat et al. (2004), this genus has a rectangular shaped head with curved mandibles and antennae with 13-14 segments. Based on the results of the study, *Microcerotermes* spp. were identified as nesting in trees on living and dead wood. In addition, this species of *Microcerotermes* spp. made nests from cardboard.

Microcerotermes spp. generally nest in trees, but close to the ground. The termites cause damage to the trees in which they nest because they eat wood of living or dead trees. *Microcerotermes spp.* usually nest on the main stem of a tree. Nest material is a mixture of chewed wood and dirt (Nandika et al. 2015).

A B C

Figure 1. Morphology of termites found in Gunung Meja Nature Tourism Park Manokwari West Papua: A. *Microcerotermes*, B. *Longipeditermes*, and C. *Bulbitermes;* 40 × 10 magnification

The soldier caste *Longipeditermes* sp. termites had a dark brown to blackish head capsule. The length of the rostrum can exceed the length of the head by more than half, and the antennae and legs were tinted light brown. Antennae had 14 segments. The third segment was three times as long as the second segment and less than twice the length of the fourth segment (Figure 1.B). These traits are similar to those described by Sornuwat et al. (2004).

Longipeditermes termites are often found on the tropical forest floor. These termites do not require burrows to move and do other works. Their dark coloring and rapid movements help termites of this species avoid predators. Activities outside the colony are often done in the morning and afternoon to reduce the risk of predation. Because of their color and rapid movement in the forest litter, individual termites are not easy to find and collect (Syaukani 2011).

Soldier caste termites of *Bulbitermes* spp. were found to have morphological characteristics including brown coloring, the head is triangular, and antenna with 13 segments. The average body length was 3.75 mm, and the head length with the mandible was 0.98 mm. The insects were found burrowing in living trees (Figure 1.C). According to Husni and Syaukani (2012), *Bulbitermes* spp. have triangular-shaped heads and antennae with 12-14 segments. The length of the head up to the nasus is 1.24-1.45 mm, the length of the head with the mandible is 0.98-1.12 mm, the length of the rostrum is 0.32-0.37 mm, and the length of the pronotum 0.26-0.18 mm.

The morphological features are similar to those of *Nasutitermes* spp., but the two species can be distinguished by the shape of the head. *Bulbitermes* spp. are also characterized by having a monomorphic soldier caste of soldiers and living in burrows (non-free-ranging species). The upper teeth (left mandible) are generally the same length or shorter than the first teeth, and the notch located at the tip of the right mandible is not well developed. The important characteristics used to identify the genus are based on the worker caste. Some morphological characters have been tested for consistency with molecular characteristics (Syaukani and Thompson 2011).

The *Bulbitermes* nests are round or oval-shaped, depending on the burrows. The main nest materials are small fragments of decayed or rotten wood, dried foliage, and soil that is attached with saliva. The nest lining is composed of two layers. The outer layer is relatively thin and soft, and it is instrumental in protecting the nest from rain. The inner layer is relatively hard and stiff, and it is primarily composed of rotted wood and soil.

Distribution of termite nests

Gunung Meja Nature Tourism Park Manokwari has an area 460.25 ha with varies topography from sloping, slightly wavy, and light to heavy, with the highest peak (Bonay peak) ± 177 m asl. The area with a sloping topography is found on a ridge that is relatively flat and resembles as table, light wavy topography is on the hillside to a height of 70 m asl, whereas the heavy wavy topography is on the north and the south ridge. We found 35 termite nests that were evenly spread evenly along the Gunung Meja Nature Tourism Park, Manokwari and followed the distribution pattern of primer plant in the area (Figure 2). Termites tend to build nests near river by utilizing moist soil to be inserted in the nests in order to keep the humidity and water flow inside the nests (Gautam & Henderson 2014). The 35 termite nests occurred in 10 species of host trees, namely, *Calophyllum inophyllum* (Bintanggur), *Mastixiodendron pachyclados* (Lancat), *Intsia bijuga* (Kayu besi), *Inocarpus fagifer* (Gayang), *Canarium hirsutum* (Kenari), *Horsfieldia parviflora* (Pala hutan), *Diospyros papuana* (Black wood), *Aleurites moluccana* (Kemiri), *Pometia coreacea* (Matoa), and *Vatica rassak* (Resak).

According to Lekitoo et al (2008), there are two groups of flora in the Gunung Meja Nature Tourism Park, which are woody plant (woody vegetation) and non-woody plant (non-woody vegetation). The dominant two of woody plant species in tree level are *P. coreacea* dan *I. bijuga,* whereas in the stake level is dominated by *Horsfieldia sp.* In accordance with Agriculture Department of Directorate General of Forestry, Indonesia, *Pometia sp.* has a hardy wood but is not resistant against termites and moss attack, while *C. inophyllum*, *M. pachyclados, H. parviflora*, *A. moluccana* and *Canarium sp.* have a slightly hardy and heavy wood, so that is easy to be attacked by termites. Nakayama & Osbrink (2010) reported that *A. moluccana* oil can not act as toxic agent for termites and only can be the feeding deterrent at more than 27% concentration. This is the reason why termites utilize *A. moluccana* as their host tree in the area. There is no relationship between specific plant communities and termite nests, but the occurrence of the nests in a certain area can induce the increasing of woody and forbs plant diversity (Gbeffe et al. 2017).

Based on the results of this study, the dominant termite species was *Microcerotermes* spp. As many as 33 termite nests were built by a *Microcerotermes* sp., which included eight large nests (height ≥ 1m), 12 medium nests (height 0.5-0.99 m), and 13 small nests (height ≤ 0.49 m). The nests were located at an altitude of 124-223 m asl. Only one nest each was found for *Longipeditermes* spp. and *Bulbitermes* spp., specifically, nests number 5 and number 13 (Figure 3). These nests were medium size (0.52 m and 0.72 m) and located at an elevation of 149 m asl and 161 m asl. The spread of termites in natural forests at varying elevations shows their adaptability to diverse habitat conditions. High termite colony distribution found along elevation were truly influenced by climate changes and vegetation around there (Nunes et al 2017).

Cheng et al. (2008) stated that land with a mineral soil type will be dominated by members of the Termitidae. It may be for that reason that only species of Termitidae were found in Gunung Meja Nature Tourism Park. The land in this forest area is a bit acidic to neutral, the availability of C-organic was very low to high, with N, P_2O_5, Ca, Mg, K, and Na (Lekitoo et al. 2008). Chemical elements content such as K, P, Ca, Mg, C-organic (Kaschuk et al. 2006), NH_4^+ and NO_3^- (Muvengwi et al. 2016) in the termite nest soil is higher than in the surrounding soils.

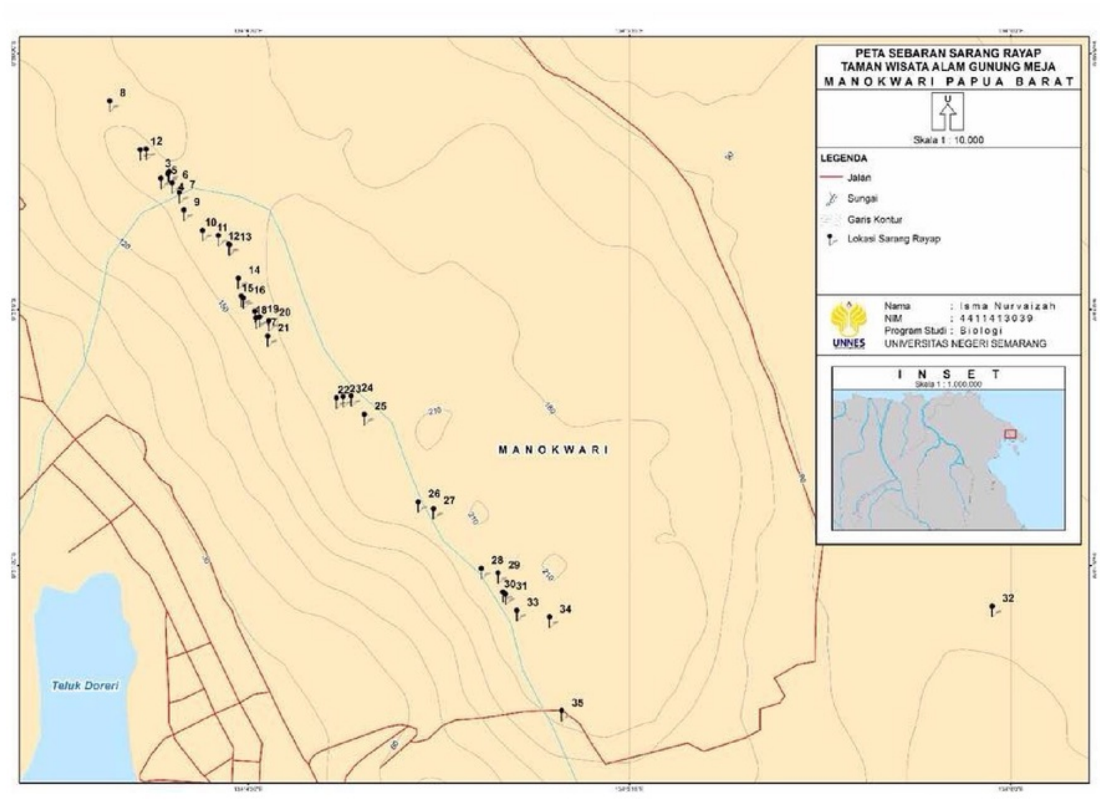

Figure 2. Map of termite nest distribution in Gunung Meja Nature Tourism Park, Manokwari, West Papua, Indonesia

A B C

Figure 3. Nests of three termite species found in Gunung Meja Nature Tourism Park, Manokwari, West Papua, Indonesia. (A) *Microcerotermes* spp., (B) *Longipeditermes* spp., and (C) *Bulbitermes* spp.

Termite nests/mounds characteristic depends on the surrounding soil properties. Soil in Gunung Meja Nature Tourism Park greatly varies and generally has very thin topsoil (<30 cm). The Soil variety consists of clay, calcareous soil, rocky soil and coral soil. This variation caused the differences of vegetation in the forest area. Sample soil analysis conducted by Soil Research Association Bogor confirmed that soil texture in Gunung

Meja Nature Tourism Park consists of loamy clay, dusty loam, dusty loamy clay and loam. de Lima et al. (2018) reported that soil with termite mounds performed higher clay content, acidity, and Al^{3+} content. Moreover explained by Mujinya et al. (2013) that clay content in termite nests/mounds can be twice higher than in the surrounding soil. This proves that soil in Gunung Meja Nature Tourism Park which tends to clay, can be the preferred place for termite to build nests by utilizing mineral clay contents. So that termites play an important role as weathering agents of clay minerals (Jouquet et al. 2002). Abe & Wakatsuki (2010) found that termites of Termitidae preferred to collect clay particles from argillic horizon (illuvial) because of the existence of phyllosilicates and crystalline sesquioxides minerals. Mica group is one of phyllosilicates contained in the nest. Crystalline sesquioxides in the termite nest are different in content, for example, Mn oxides (Mn_2O_3) in the nest was relatively greater than Fe oxides (Fe_2O_3). The poorly Fe oxides in the nest caused the higher degree of clay dispersibility than in the surrounding soil (Mujinya et al. 2013). The other Sesquioxides such as Al oxides (Al_2O_3) was used as the main aggregating agent especially as water-stable aggregates (Barthès et al. 2008).

Microcerotermes spp. are included among termites feeding on wood and litter, and they may potentially be pests in natural forest areas. These findings accord with previous research (Cheng et al. 2008; Vaessen et al. 2011; Bong et al. 2012; Kon et al. 2012). Wood-feeding termites are the type of termites that are most likely to be pests (Hanis et al. 2014). The species are present in abundant quantities in the forest area because of the presence of plant residues containing cellulose being abundant.

Nasutitermitinae is found in secondary forests that have highly diverse flora. They can be bioindicators of forest health because they are a soil-feeding group and they include wood eaters who inhabit relatively undisturbed forests (Syaukani 2013). *Longipeditermes* spp. and *Bulbitermes* spp. belong to the Termitidae family, and they eat soil with a high organic content (Faszly et al. 2005). *Longipeditermes* spp. and *Bulbitermes* spp. can be difficult to find because these termites have a specific habitat that is rarely to be found in this area.

Generally, the nest architecture of *Microcerotermes* spp., *Longipeditermes* spp., and *Bulbitermes* spp. in the Gunung Meja Nature Tourism Park Manokwari did not differ by species. Termite nests are among the most complex and sophisticated structures built by insects (Himmi et al. 2015). The selection of certain microhabitats for nest building is presumed to be associated with reducing the risk of predation by the ants, birds, lizards, bears, and orangutans. Some colonies build nests that are round- or oval-shaped, depending on the host tree. The main nest materials consist of small fractions of decayed or rotten wood, dried foliage, and soil that is attached with saliva. Lining nest is composed of two parts: the outer layer is relatively thin and soft is more instrumental in preventing the nest when the rain, while the inner layer is relatively hard, stiff, and there are many kinds of wood rotted material and soil.

Nest architecture features connected rooms, with hallways always guarded by soldier caste termites. If soldier caste termites are harassed, they immediately go from the nest and confront the attacked. Young soldiers preferred to be the royal guard and the older soldiers were in charge to encounter the more hazardous task (Yanagihara et al. 2018). Meanwhile, the worker caste termites hide in the nest and return their normal activity if the conditions are secure. Du et al. (2016) found that most of young workers performed the grooming in the central nest, whereas the older workers maintained the nest and sanitation, especially looking after for the royal pair and the royal chamber. The room of the king and queen (royal chamber) is not easy to find. This structure is undoubtedly built under pheromone regulation, especially cement pheromone emitting by queen. This pheromone can enhance not only the shape of royal chamber but also the dome foundation (Nakanishi et al. 2017). The characteristics of the royal chamber for termites of all species do not differ from the conditions of the rooms of other castes.

Architecture of termite nest is likely influenced by soil properties utilized to build the nest, and this certainly depends on the ecological needs of termite in controlling temperature and humidity inside the nest. Jouquet et al. (2015) confirmed that soil properties can affect the physicochemical characteristics of *Odontotermes obesus* (Termitidae) nest material and also impress their nest shape. Nest termite architecture is also equipped by solar-powered ventilation in order to adapt with environmental changes, and it seems like external lung system in human (Ocko et al. 2017).

Shelter-tube architecture of termite colony can be different between each species, even between one and another colony from the same species. Mizumoto & Matsuura (2013) demonstrated that each termite colony builds a specific architecture model referring to its shelter-tube construction system. Shelter-tube architecture built by groups of individuals from the same colony presented similar construction pattern, whereas groups of individuals from the different colony performed a different construction pattern. This is associated to those foraging strategy differences of termites, and also related to the distribution of food resources in their environment.

Based on the research in this study, three genera of termites are present in West Papua, including *Microcerotermes Longipeditermes*, and *Bulbitermes*. The termites were found in 35 different nests. *Microcerotermes* were the most commonly found and had a wide distribution, being present at almost all points of observation. *Longipeditermes* and *Bulbitermes* were less common, with only within one point observation each.

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