

## Short Communication: The diversity of termites along the altitudinal gradient in a Karst Area of Southern Gombong, Central Java, Indonesia

**HERY PRATIKNYO\*, ENDANG ARIYANI SETYOWATI**

Faculty of Biology, Universitas Jenderal Soedirman. Jl. Dr. Suparno No. 63, Purwokerto Utara, Banyumas 53122, Central Java, Indonesia.  
Tel./fax.: +62-281-625865, \*email: hery.pratiknyo17@gmail.com

Manuscript received: 15 November 2019. Revision accepted: 30 March 2020.

**Abstract.** Pratiknyo H, Setyowati EA. 2020. Short Communication: The diversity of termites along the altitudinal gradient in a Karst Area of Southern Gombong, Central Java, Indonesia. *Biodiversitas* 21: 1730-1734. A karst area of Southern Gombong at altitudes of 0-500 m has a porous substrate whose soil content decreases as the altitude gets higher toward the top of the hill. This area is characterized by poor soil nutrient, but it has high CaCO<sub>3</sub> and pH, which is not a favorable habitat for many species of termites which depend on soil substrate, as source of nutrient for community development, especially soil-feeding termites, as habitat for fungi as secondary daily diet, and as a stabilizer of the nest humidity. The aims of this research were to determine the diversity of termites along the altitudinal gradient in this karst area, and to determine the correlation between altitude and the termite diversity. The area was divided into 5 segments based on the altitudes, i.e., 0-100 m, 100-200 m, 200-300 m, 300-400 m, and 400-500 m. In each segment, a transect belt, 100 m long and 2 m wide, was made. Each transect was divided into 20 sections. Termites were sampled from living trees, branches, bark, litter and soil for 30 minutes per person in each section. The data were analyzed to determine the Shannon-Wiener diversity index (H'), Shannon-Evenness index (E), and Simpson's Dominance index, and to find the correlation between the species diversity and altitude. The results showed that the termite diversity in the study site was low. Only four termite species were found with the indexes of diversity (H'), evenness (E), and dominance (D) of 1.01, 0.73 and 0.44 respectively. There was no linear correlation between termite diversity and altitude; the highest diversity was found in the middle altitudes, following the mid-domain effect model.

**Keywords:** Diversity, Gombong, karst, termites

**Abbreviations:** CaCO<sub>3</sub>: Calcium carbonate, pH: Power of hydrogen, H': Shanon\_Wiener Index, E: Shanon evenness index, D: dominance Simpson Index

### INTRODUCTION

Termites are dominant invertebrate fauna of tropical land forest (Wood and Sand 1978) and their role as decomposers in terrestrial ecosystem is very important (Lee and Wood 1971; Matsumoto and Abe 1979; Yamada et al. 2005). Carbon mineralization process and nitrogen fixation during decomposition process depend on them (Yamada et al. 2005). The role of termites in their habitat is expressed in their feeding habits. At the present, at least there are four groups of termites based on their feeding habits, i.e., wood-only feeders, wood and fungi feeders, humus feeders and soil feeders (Yamada et al. 2005). The diversity (species richness and abundance) of termites inhabiting an ecosystem needs to be studied because the roles of termites on their habitat are affected by their diversity (Jones and Prasetyo 2002).

Diversity of termites is influenced by many environmental factors, such as forest canopy closure (Carrizo et al. 2009), altitudes (Gathorne-Hardy et al. 2001), air temperature and transpiration (Choosai et al. 2009). Davies et al. (2003) state that local factors such as the loss of forest canopy and forest degradation have significant impact on the diversity of termites. Dense

canopy creates optimal soil humidity for termite community development (Choosai et al. 2009) while the loss of canopy decreases termite diversity (Carrizo et al. 2009). There is a correlation between termite diversity and vegetation density (Davies et al. 2003).

Gathorne-Hardy et al. (2001) state that altitudinal factor significantly affects the diversity of termites in tropical land forest because the metabolism processes in termites' body depend on air temperature which declines approximately 1°C with 100 m-increase in altitudes. This is one reason why density of termites is higher on low land than on high land, even though some termite species may be found in altitudes higher than 3000 m. Termites usually live optimally at air temperature of 15-38°C with relative humidity of 75-90% and soil pH of 7. The genera *Microtermes*, *Macrotermes*, and *Odontotermes* prefer this interval air temperature to the lower one because that level of air temperature and soil pH are optimal for the growth of fungi as additional diets for higher termites besides wood as the main diet (Korb and Linsmaier 1998).

The effect of altitude on termite diversity can be studied in a karst hill in Gombong, Central Java. Previously, there had been no study of termites in this karst area, while in Mountain Slamet, which is only 40 km from the karst

area, a study has found 9 genera of termites (Pratiknyo et al. 2018). We assumed that the termite diversity in the karst hill was lower than that in Mount Slamet for two reasons. First, the karst hill has a homogenous forest of teak (*Tectona grandis*) which shed leaves during dry season, so the sunlight can reach the forest floor, causing high air temperature, while the Mount Slamet has a mixed stand of *Pinus merkusii* and *Recinus damara* trees with dense canopy which effectively reduce sunlight reaching the forest floor. Second, the karst area is lack of soil nutrient because of the dominance of limestone under the teak stand.

The aims of this research were to determine the termite diversity at different altitudes (100, 200, 300, 400 and 500 m) of karst area, and to know the correlation between termite diversity and altitude on the karst area of Southern Gombang, Central Java.

## MATERIALS AND METHODS

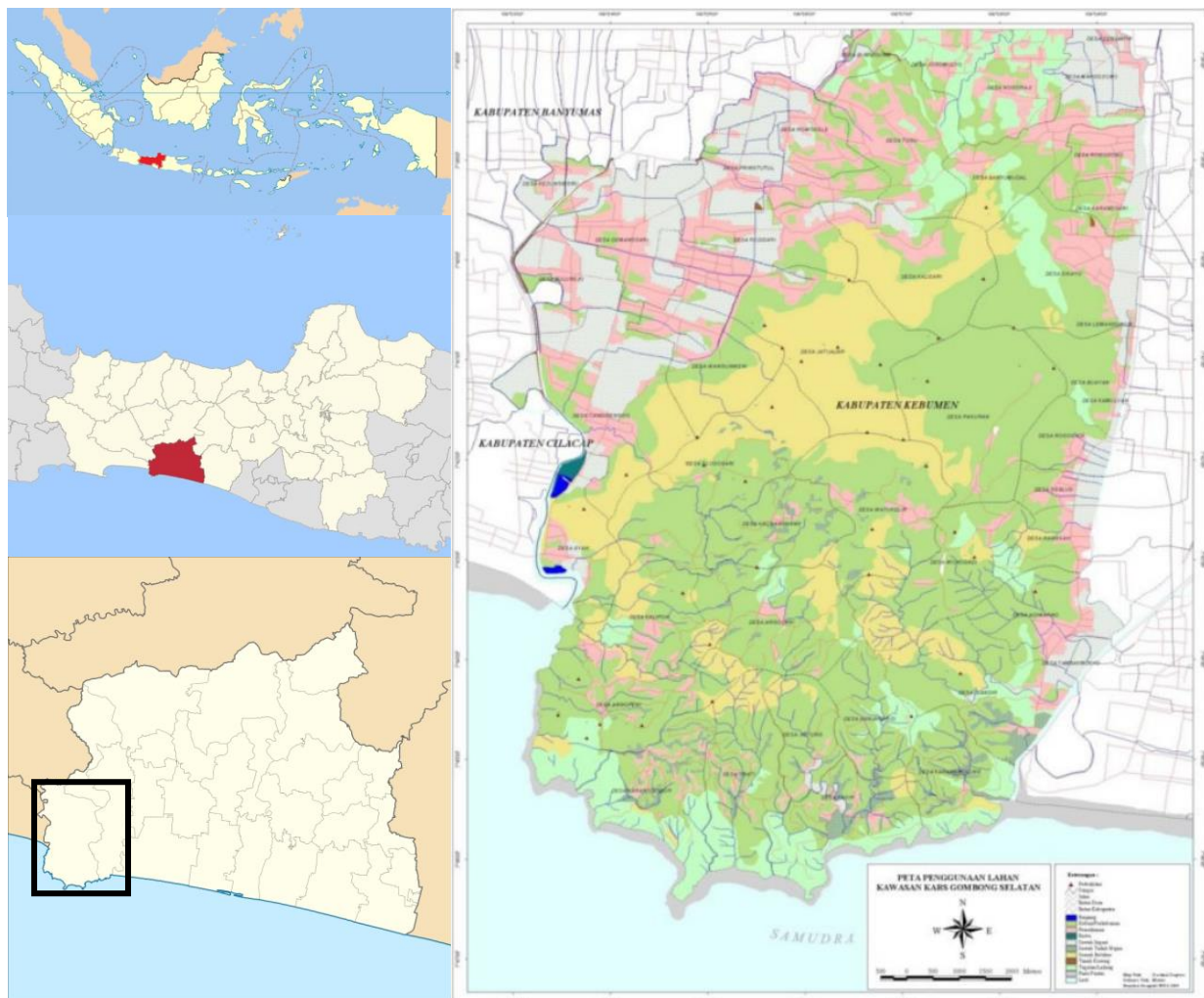
### Study area

This study was conducted in a karst hill of Southern Gombang, Central Java. It is a well developed porous

landscape with specific conditions as a result of soluble rock development through a process of karstification. This karst hill is located next to the Indian Ocean beach in Central Java. This area covers three sub-districts, namely Rowokele, Ayah and Buayan Sub-districts. The limestone hill is 8 km long and 3 km wide with a total area of more than 40 km<sup>2</sup>, located between 7<sup>o</sup> 42' 10,91" and 7<sup>o</sup> 42' 4,4" S, and between 109<sup>o</sup> 26' 46,39" and 109<sup>o</sup> 26' 38,15" E, with altitudinal range from 0 to 500 m. This karst area is a cockpit type, which is a karst hill having a cone shape, tight and having a bird's nest-like form, and it is one of the most interesting karst types in the world (Suhendar et al. 2018).

Materials and Methods should emphasize on the procedures and data analysis. For field study, it is better if study site is included (Figure 1).

The study area has annual rainfall of 139 mm, air temperature 26-31 °C, relative air humidity 78-85%, canopy opening of *T. grandis* 90-100%, and the thickness of the teak leaf litter 1-5 cm with relative humidity of the karst soil 60-75% . The thin forest soil is dominated by limestone with a pH of 7.3.



**Figure 1.** Location of Southern Gombang karst area in Kebumen District, Central Java, Indonesia

### Data collection

The tools used in this study were pin sets, plastic vials, altimeter, pH meter, termohyrometer and stereo microscopes. Termites were sampled using belt transect method, in *T. grandis* forest, at altitudes from 0 to 500 m, divided into 5 segments. In each 100 m-segment, a belt transect, 100 m long and 2 m wide, was made. Each belt transect was divided into 20 sections (L: 5 m, W: 2 m) as sampling units. The termites were taken from the living trees, branches, bark, litter, and soil for 30 minutes per person in each section. The specimens of termites found were then kept in alcohol 70% in the plastic vials. The identification of termite specimens was done following Ahmad (1958).

### Data analysis

The termite data were analyzed to determine the indexes of diversity, evenness and dominance for each 100 m segment. (Magurran 1988). The formula used was:

$$\text{Shannon-Wiener index of diversity: } H' = - \sum_{i=1}^{\infty} p_i (\ln p_i)$$

Where:

- H' : diversity index of Shannon-Wiener
- $p_i$  : proportion of species  $i$  to total species
- ln : normal logarithm
- $n_i$  : number of individuals of species  $i$
- N : total number of all species

$$\text{Shannon-Evenness index: } E = \frac{H'}{\ln S}$$

Where:

- E : Shannon-Evenness index
- H' : diversity index of Shannon-Wiener
- S : number species

$$\text{Dominance index of Simpson: } D = \sum_{i=1}^n (p_i)^2$$

Where:

- D : dominance index of Simpson
- $p_i$  : proportion of species  $i$  to total species

Correlation between species number and individual density with altitude was determined using regression analysis

## RESULTS AND DISCUSSION

### Results

The results showed that all of the termites found were wood feeders, consisting of higher termites (three species) and lower termites (one species). No litter-feeding and soil-feeding termites were found. *Macrotermes gilvus* had the highest abundance, followed by *Microtermes insperatus*, *Schedorhinotermes javanicus* and *O. javanicus* (Table 1). The highest individual density occurred in altitudes of 201-300 m, while the lowest in altitudes of 401-500 m.

The termite community in the karst area had low indexes of diversity, and dominance but relatively high evenness index (Table 2).

The pattern of the species number of termites in all of altitudes showed the highest number in the middle altitudes (Figure 2), and so did the individual density (Figure 3).

The regression between diversity of termites with altitude (100, 200, 300, 400 and 500 m. asl) showed low correlation ( $R=0.289$ ).

### Discussion

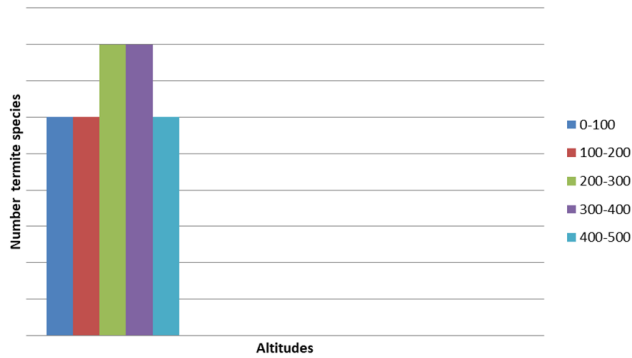
The condition of teak forest along altitudinal gradient of 0-500 m forest was dry, with air temperature of 26-31°C, relative humidity 78-85%, mean of soil pH 7.3, canopy opening 90-100% on the transect. Four species of termites were found, i.e., *S. javanicus* belonging to Family Rhinotermitidae, then *O. javanicus*, *M. gilvus* and *M. insperatus* belonging to Family Termitidae. Species *S. javanicus* is the only one belonging to Family Rhinotermitidae found. This species is wood feeder of lower termites, with the number of taxa lower than wood feeder of higher termites such as Termitidae, which is easily found in many kinds of habitat. Kambhampati and Eggleton (2000) state that Family Termitidae is the biggest family in the Order Isoptera and consist of 3/4 of species of Isoptera known.

**Table 2.** Shannon-Wiener diversity index ( $H'$ ), Shannon evenness index  $E$  and Simpson dominance index ( $D$ ) of termites in the karst area

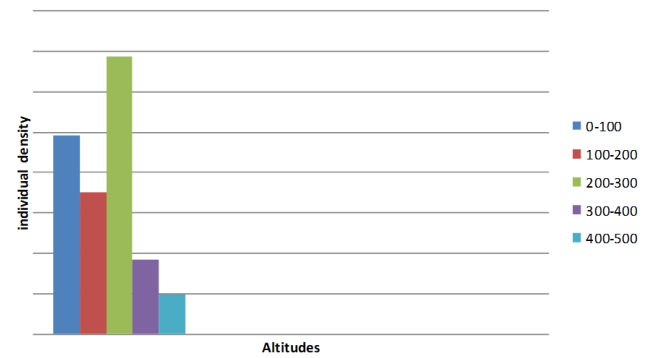
Altitudes	$H'$	$E$	$D$
0-500 m	1.01	0.74	0.44

**Table 1.** The abundance of each termite species in karst area of Southern Gombong, Central Java, Indonesia

Altitudes (m asl)	<i>Macrotermes Gilvus</i>	<i>Microtermes insperatus</i>	<i>Schedorhinotermes javanicus</i>	<i>Odontotermes javanicus</i>	Individual density
0-100	378	399	208	0	985
101-200	443	141	118	0	702
201-300	838	273	145	118	1374
301-400	238	16	102	14	370
401-500	183	5	0	10	198
Abundance	2680	834	670	142	-



**Figure 2.** Number of termite species in each of altitudinal segment



**Figure 3.** Termite individual density in each altitudinal segment in Karst area

This research found lower number of termite species than that in Mount Slamet with 11 species belonging to 9 genera (Pratiknyo et al. 2018). All of the species found in the karst hill were the wood-feeding termites, different from those found in Mount Slamet. The soil in karst area of Southern Gombong was presumably too dry for litter-or soil-feeding termites. Also, limestone in karst area is poor source of soil nutrients. The floor of teak forest in karst area with the canopy opening of 90-100% received direct sunlight for long time every day. There was no undergrowth vegetation such as found in forest in Mount Slamet. The humidity of the karst soil 60-75%, while soil-feeding termites prefer wet soil with humidity 78-85% under the closed canopy. The floor of karst area forest was covered with dry teak leaves, but they had not been decomposed yet, which presumably were unpalatable for litter-feeding and soil-feeding termites, such as *Procapritermes stiger*, *Pericapritermes javanicus*, and genus *Nasutitermes*, found abundant in Mount Slamet forest.

The Shannon-Wiener diversity index ( $H'$ ) of termites in teak forest in the karst area was 1.01, categorized as low according to Odum and Barrett (2004). De Souza and Brown (1994) state that loose canopy is one of important factors affecting the diversity of termites in tropical forests. The Shannon-Evenness index ( $E$ ) was 0.73, categorized as moderately high. It means that the number of individuals among species did not differ much. In other words, no species dominated the community. As a result, the Simpson dominance index was relatively low, i.e., 0.44.

The regression between diversity of termites with altitude (100, 200, 300, 400 and 500 m) showed low correlation ( $R = 0,289$ ). This was an interesting phenomenon, different from the result of similar research by Gathorny-Hardy et al. (2001) in primer forest in Leuser Aceh Province, showing that the termites diversity was strongly correlated negatively with altitudes. Gathorny-Hardy et al. (2001) state that in tropical land forest, the increased altitude is the main factor that reduces the species diversity of termites because the increase of 100 m in altitude lowers the air temperature up to 1°C. This research showed that the highest diversity of termites occurred in

mid altitudes of 200-300 m (Figures 2 and 3). This result is in line with that of Palin et al. (2011) and Lomolino (2001) that state that the pattern of diversity along altitudinal gradient follows the *mid domain effect* hypothesis, i.e., the highest diversity is found in mid altitudes. The result of this study was in line with that of Inoue et al. (2006) who found in national park of Khao Kitchagoot Thailand that the altitudes did not affect the diversity of termites linearly. Hermacandra (2003) states that people activities such as forest fragmentation and other activities reduce diversity of termites. The low diversity of termites on altitudes of 0-100 m was presumably due to its close distance to the people's settlement, so the people activities such as taking water, dry branches or litter under the forest possibly affect the termites' life. Meanwhile, the factor causing the low termite diversity in the top altitude, on 400-500 m, was presumably the low volume of soil substrate because of  $\text{CaCO}_3$  limestone abundance with pH of 7.3, whereas many species of termites especially the soil and litter feeders depend on simple sugar component from the soil substrate. Thus, the  $\text{CaCO}_3$  acts as a limiting factor for the termites.

Another interesting result of this research was the presence of *O. javanicus* on higher altitude of 200-500 m. Usually, the Subfamily Macrotermitinae, such as *O. javanicus*, prefer hotter air temperature (24-28°C) with high relative air humidity (90%) and areas with people activities. It is assumed that *O. javanicus* migrate passively by riding on the wood or bamboo used by the workers in lime mining area or brought accidentally by people who visited the old lime cave of Jatijajar tourism object.

The correlation between altitude and diversity of wood-feeding termites in South East Asia was stated by Inoue et.al (2006) that Subfamily Macrotermitinae showed increasing abundance with the increasing altitude. On the contrary, the abundance of Subfamily Nasutitermitinae decreases with the increasing altitude. Unfortunately the genus *Nasutitermes* was not found in karst area of Southern Gombong because in this teak forest which had opened canopy there was no lichen, the main diet of this genus. Setyawan (2000) states that lichens grow optimally under the closed canopy that prevents sunlight penetration, creating humid environment.

Based on feeding habits, the termites found in the karst area of southern Gombong can be grouped into two groups, i.e., (i) the *non-fungus-infected wood feeders* (deadwood feeders), and (ii) the *fungus-infected wood feeders* (wood, litter, grasses and microepiphytes feeders). The first group was represented by *S. javanicus*, as stated by Faszly et al. (2005) that the genus of *Schedorhinotermes* consists of lower termites that consume dead wood materials, usually called as group I. The second group was represented by *O. javanicus*, *M. gilvus*, and *M. insperatus*. Food and Agriculture Organization (2000) states that some species of termites belonging to subfamily Macrotermitinae, such as *O. javanicus*, *M. gilvus*, and *M. Insperatus*, show preference to the fungi of Termitomycetes. These fungi are an important component in the food chain for subfamily Macrotermitinae. In the karst area litter-feeding termites, such as *Nasutitermes matangensis* and *N. matangensisiformis* were not found. Food and Agriculture Organization (2000) states that food sources for genus *Nasutitermes* are wood, lichens, and humus. Soil-feeding termites such as *Pericapritermes javanicus* and *Capritermes semarangi* were not found either. Faszly et al. (2005) state that genera of *Pericapritermes* and *Capritermes* are the members of Family of Termitidae that consume soil only.

This study concluded that (i) the termite diversity in karst area at Southern Gombong was categorized as low, and no species dominated the area, and (ii) the highest diversity of termites was found in mid altitudes, in line with *mid-domain effect* hypothesis. We suggest that further research should be done in wet season to get comprehensive results.

## ACKNOWLEDGEMENTS

We thank local BKPH Gombong Selatan for their kind cooperation. We are most grateful to Prof. Rifda Naufalin, the head of LPPM Unsoed, Purwokerto Utara, Indonesia for her support in funding the research.

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