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Diversity and abundance of termites along altitudinal gradient and slopes in Mount Slamet, Central Java, Indonesia

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Abstract. *Pratiknyo H, Ahmad I, Bambang Heru Budianto BH. 2018. Diversity and abundance of termites along altitudinal gradient and slopes in Mount Slamet, Central Java, Indonesia. Biodiversitas 19: 1649-1658.* A study on diversity and abundance of termites along an altitudinal gradient and the different slope was done in plantation forest of Mount Slamet. This research aimed to define the species composition along the altitudinal gradient and slope and to define the environmental factors affecting it. The sampling of termites was carried out following standardized belt transects (100 m x 2 m) laid vertically on the altitude of 700 up to 1300 m asl on four slopes. Each 100 m length of the belt transects was divided into 20 sections (5 m x 2 m), and termites were taken in each section from the trees, branches, barks and the ground. Data of termites composition were analyzed for diversity index (Shanon-Wiener, H') and domination index (Simson, D); the correlation among environmental factors with the family were analyzed by multivariate correlation, and then a Canonical Correspondence Analysis (CCA) was used to define the most associated environmental factor to the diversity and abundance of termites. A total of 7349 individuals belonging to 11 species in nine genera, five subfamilies, and two families were recorded. Four wood feeder species were *Schedorinotermes javanicus, Macrotermes gilvus, Odontotermes javanicus* and *Microtermes insperatus*, while humus feeder was *Capritermes samarangi, Procapritermes stiger*, *Nasutitermes matangensis*, *N. matangensiformis*, *Bulbitermes* spp., and the soil feeders were *PeriCapritermes javanicus and P. dolichocephalus*. Based on the Shanon-Wiener index, the Western Slope was the highest in diversity with five main environmental factors (altitudes, maximal rainfall, N content, manure application and light intensity) the most influencing while the CCA ordination showed that the canopy closure and light intensity were the most associated factor to the diversity and abundance of termites. In conclusion, the slopes caused the species richness differently with the most associated environmental factors was the canopy closure and light intensity.

Keywords: Altitude, plantation, Mount Slamet, slope

INTRODUCTION

Termites are an integral part of tropical rainforest ecosystems (Ackermans at al.2009). Termites activity, such as mound-building, tunneling, and soil-feeding improves soil structure and quality (Lavelle et al. 2007), therefore, information of the species composition of termites be important to understand how the role of termites in their habitat (Jones and Prasetyo (2002).

Species composition, to most organisms, may decrease as air temperature decrease and is correlated to the increase of altitudinal gradient (Willig et al. 2003). Termite species composition and abundance generally decline with the increasing altitudinal gradient (Kayani et al.1979; Gao et al. 1981; Akhtar et al. 1992; Gathorne-Hardy et al. 2001), unlike wild bees pollinator that showed increases in mid-elevation (Widhiono and Sudiana 2016). Air temperature is considered a primary factor of the termite's species composition in the tropical area of South East Asia (Inoue et al. 2006). That species composition pattern declines due to increasing altitudes is monotic (Gathorne-Hardy 2001) as a research result in the Leuser Ecosystem of Aceh Province, Indonesia. To this phenomenon, Gathorne-Hardy et al. (2001) stated that termites species composition and abundance decrease is explained by the reduction of temperature, linked to the metabolic rate of termites as ectothermic fauna, where air temperatures drop by 1°C in every increase of 100 m in altitude. However, Stevens (1992) argued that any other factor caused the termites' species composition declines monotically. The monotonic decrease of termites species richness with altitudinal mirrors is often attributed to productivity and area, besides the reduction in temperature (Colwell and Lees 2000). According to this species composition pattern, Lomolino (2001) stated that there are other patterns of increasing of altitudinal gradient effect on declining of termites species composition, where the species composition initially increased in the lower to mid elevation, then decreased gradually on the higher elevation. This phenomenon is called the mid-domain elevation effect. Another species richness pattern, widely observed to closely associated with increasing altitude, is the mid-elevation peak (or hump-shaped curve) (Lomolino 2001); a pattern often explained by the presence of optimal climatic at mid-elevations, by the ecotone effect and/or by the mid-domain effect. The majority of species richness studies on tropical invertebrates show a mid-elevation peak pattern. This mid-elevation peaks in the termite species composition have been reported (Donovan et al. 2002; Inoue et al. 2006), which have been attributed to factors such as anthropogenic disturbance and the limited altitudinal range of the study.

Termites were also found to have a smaller elevation range on smaller mountains as compared to the large ones. This is attributed to the Massenerhebung effect, a phenomenon in which cloud formation occurs at lower altitudes on smaller mountains, which in turn is reflecting sunlight and reducing daytime temperatures at lower elevations (Gathorne-Hardy et al. 2001). Mount Slamet is the most prominent mountain and the second highest mountain of 3428 m asl in Java Island (Daldjoeni 1982). Initially, the natural forest of Mount Slamet was a spot of tropical rainforest of Southeast Asia (Withmore 1998) but since colonial Deutch in 1917, the natural forest of Mount Slamet being converted to dammar plantation then in 1943 to pinus plantation (Richard 1979). Such conversion may cause to species composition of termites (Okwakol 2000; Jones et al. 2003; Turner and Foster 2008). Unfortunately, data on Massenerhebung effect in plantation forest of Mount Slamet has not been reported yet.

Although air temperature is often considered the critical factor influencing termite species composition, other non-mutually exclusive factors that may explain changes in termite species composition with altitude include slope, rainfall and the size of the regional species pool. Mount Slamet has four slopes with different microclimate. The slope is an important ecological gradient factor for species diversity and abundance. The western and eastern slope of Mount Slamet may receive higher sunlight radiation and more light intensity than other slopes. The slopes affect the nutrient cycling (Davies et al. 2003) although the distance is only a few hundred meters. The microclimate condition of slopes of Mount Slamet varies with the mountain altitude, where the southern and western slopes have a higher annual rainfall (4500-6500) mm than the Eastern and Northern slopes (3500-4800) mm (KPH Banyumas Timur 2015). Rainfall can have an adverse effect on termite species richness and abundance in tropical rainforest systems, as very high moisture can lead to inundated microhabitats and colony death (Dibog et al. 1999; Eggleton et al. 1997). Furthermore, termite species composition and abundance are correlated with human activity in farming by manure application which enables the increase of organic content of soil. Since 1987, State Forest Management (Perum Perhutani) Unit II Central Java (Semarang) has been allowing the local farmers to plant cereals under main trees without logging, and the last factor that may affect the species composition of termite is canopy loss (Davies et al. 2003).

As ectothermic fauna, the body temperature of termites depends on environmental temperature even though they respond it differently. The feeding group of soil feeders, for example, is generally more negatively affected. This is likely because soil feeder termites depend on lower energy food substrates than feeding group of wood feeders, providing them with less colony-wide energy to overcome the physiological costs of living at lower temperatures (Jones et al. 2000; Davies et al. 2003).

At the continental, level of termite species composition is anomalous; with South East Asia is the smallest species pool as compared to South America and Africa (Eggleton et al. 1996; Davies et al. 2003). Research on termites richness, relationship and bioindicator in various land use types in Mount Slamet had been done (Arthadi 1982; Pribadi et al. 2011); however, there is no information on species composition and abundance of termites in correlation with slope and altitudinal gradient. This research aimed to define how is the species composition and abundance of termites along an altitudinal gradient with the different slope, and what is the environmental factor affecting it in plantation forest of Mount Slamet, Central Java, Indonesia.

MATERIALS AND METHODS

Study site

The study was conducted in the plantation forest of Mount Slamet, Central Java, Indonesia (Figure 1), located in (S: 07° 18' 26.2"-E: 109° 14'26") up to (S: 07° 16' 27,3"-E: 109° 14' 25) and (S: 07° 16' 03.2"-E: 109° 18' 26.7") up to (S: 07° 16' 32,8"-E: 109° 04' 57), on the altitude of 700-1300 m above sea level (asl).

Sampling procedure

Termites collection

Termites were sampled followed a standardized transect method (Jones and Eggleton 2000). Plantation Forest of Mount Slamet was divided into four slopes (southern, eastern, northern and western) and each slope was split into six altitudes (700-800, 801-900, 901-1000, 1001-1100, 1101-1200 and 1201-1300) m asl. A belt transect (100 m x 2 m) was laid in each range of altitude vertically, and each of 100 m belt transect was divided into 20 sections (5 m x 2 m). On each section, one man searched termites for one hour on surface soil or humus, trees, roots, branches, and stumps, arboreal nests up to a height of 2 m above ground. Mainly the soldier and worker castes were collected. The collected specimen was stored in 80% alcohol for identification. The number of encountered termites (hits) along a transect was used as an indicator of the relative abundance of species within that plot. An encounter was defined as the presence of a species in one section (5 m x 2m). Thus, the relative abundance of a species per transect maximally was 20 individuals (Inoue et al. 2006; Vaessen, at al 2011)). Termites were divided into four putative feeding groups based on the site of discovery, the color of the abdomen and known dietary requirements of the workers. Feeding group ranged from groups 1 to 4 in which the diet of workers followed an increased humification gradient (Eggleton and Tayashu 2001). Nesting guilds included hypogeal nesters that build the subterranean nest, epigeal nesters that build aboveground mounds, hypogeal nesters that have partially subterranean and partially above ground nests, arboreal nesters that nested on living or dead trees, and wood nesters that nested in dead wood.

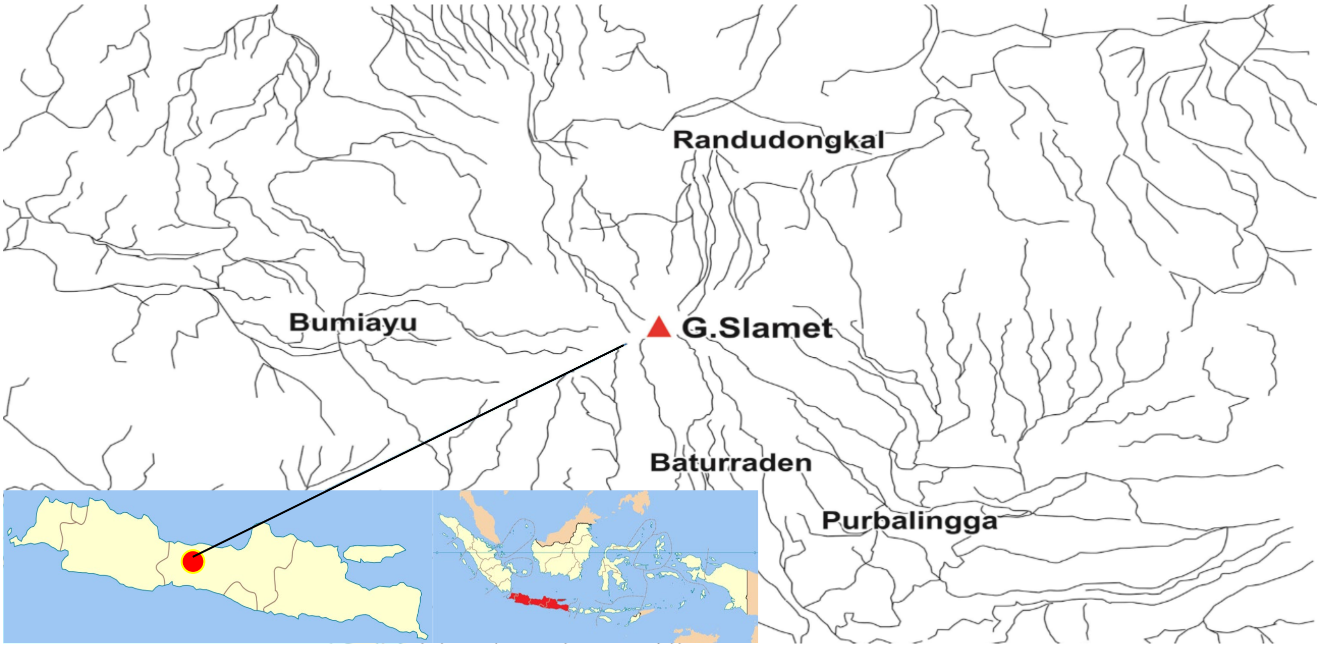

Figure 1. Sampling areas of termites in plantation forest of Mount Slamet, Java Island, Indonesia

Termites identification

The pictures of the specimen were taken under a Nikon Microscopes with 400x enlargement. Termites sampled were determined on basis of species identity, using the information given by Ahmad (1954), Thapa (1981) and relevant references. Recorded termites were placed into a feeding group based on their identity using the classification of Donovan et al. (1999), also certified by Research Center for Biology, Indonesian Institute of Science (LIPI), Bogor, Indonesia.

Data analysis

Species richness of each slope was analyzed for diversity (Shanon-Wiener) index and Domination (Sorensen) index by using PAST software. The differences in species composition and abundance of termites among slope and altitude was analyzed using ANOVA performed using SPP.S 11.0 software, and the correlation of environmental factor with species composition and abundance of each family was subjected to multivariate correlation analysis, and the most associated environmental factors of total termites was ordinated by Canonical Correspondence Analysis (CCA).

RESULTS AND DISCUSSION

Termites diversity

During sampling time we found two families, they were Rhinotermitidae and Termitidae. Familia Rhinotermitidae consisted of one subfamily Schedorhinotermitinae with only one genus, and the species found was *Shedorhinotermes javanicus.* Meanwhile, Family Termitidae comprised of four Subfamily, i.e., Macrotermitinae, Microtermitinae, Termitinae, and Nasutitermitinae. Subfamily Macrotermitinae consisted of two genera, i.e., *Odontotermes* and *Macrotermes*, each has one species (*Odontotermes javanicus* and *Macrotermes javanicus*). Sub-family Microtermitinae has one genus Microtomes with one species (*Microtermes insperatus).* The Termitinae Subfamily has three genera, i.e., *Procapritermes*, *Capritermes*, and *PeriCapritermes*. The Genus *Procapritermes* consisted of one species (*Procapritermes stiger*), Genus *Capritermes* of one species (*Capritermes semarangi*). Genus *Pericapritermes* has two species (*P. dolichocephalus* and *P. javanicus). Nasutitermitinae* genera (Nasutitermes and *Bulbitermes*), where the genus *Nasutitermes* comprises species (*Nasutitermes matangensis* and *N. matangensiformis*) and the genus *Bulbitermes*, has one species (*B. constrictoides*) (Table S1). The diversity and dominance indices of termites in all the slopes are presented in Table 1. Meanwhile, the termite's species dominance in each slope is shown in Table 2.

Table 1. List of Shanon-Wienner indices (H') and Dominance (Sorensen) indices (D) in each slope

Indices	Slopes			
	South	East	West	North
H'	1.389	1.381	2.298	2.237
D	0.75	0.76	0.79	0.81

Table 2. Termite species dominance in each slope of Mount Slamet, Central Java, Indonesia

Species	Slopes			
	South	East	West	North
S. javanicus	(52.5%)	-	(51.9%)	-
C. semarangi	-	(27.8 %)	-	
O. javanicus	-	-	-	(19.7%)

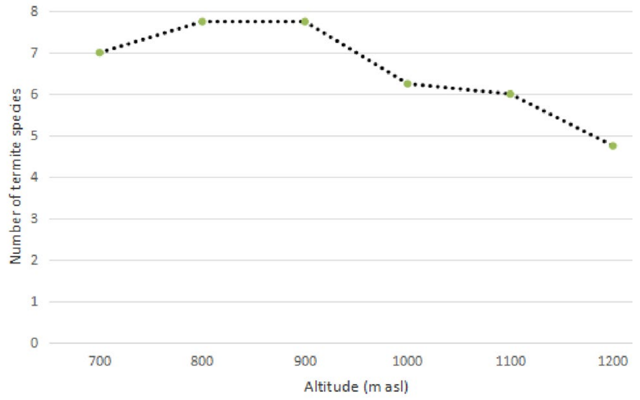

Figure 2. Correlation between the number of termites species and the altitude

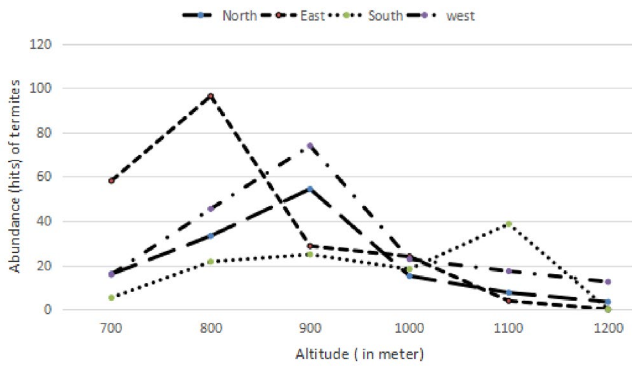

Figure 3. The pattern of correlation between altitudinal gradient with abundance (hits)

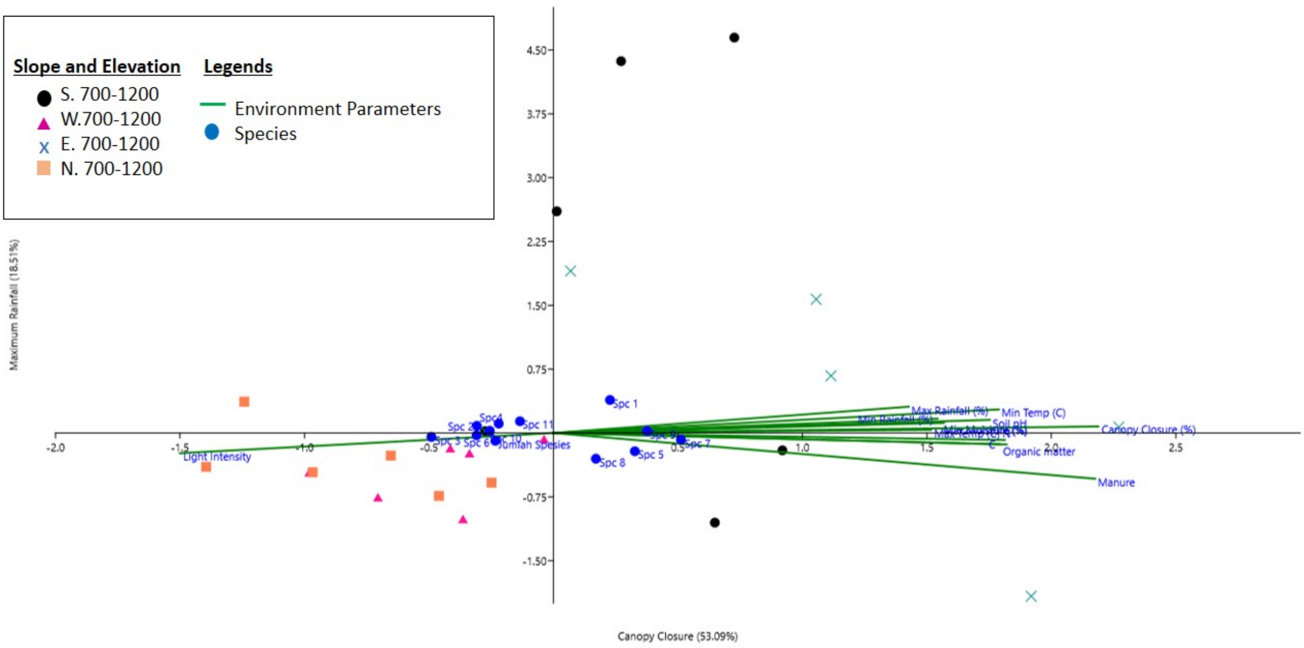

Figure 4. Visualization of ordination for 12 environmental factors on diversity and abundance of termites

The effect of slopes on the diversity of termites was significant (P<0.05), as well, the effect of slope on abundance (hits) except on altitudinal range of 1201-1300 m asl. The effect of altitudinal gradient on the diversity of termites was not significant (P>0.05) for all altitudinal range (700-1300 m asl) as well on the abundance of termites, except South Slope.

The pattern of correlation between altitudinal gradient and number species is shown in Figure 2. The pattern of correlation between altitudinal gradient with termite's abundance is shown in Figure 3. The effect of 12 environmental factors (Table S2) on diversity and abundance of termites is shown in Canonical Correspondence Analysis (Figure 4).

The most associated environmental factors on the abundance of Families Rhinotermitidae and Termitidae in Mount Slamet were altitude (not for Termitidae), N content (not for Rhinotermitidae), maximum rainfall, canopy closure and manure application.

Discussion

Environmental variables

Air temperature and soil temperature decreased with the increase of altitude. Air temperature dropped from 31.5 °C in the lowland plantation forest (700 m asl) to 28.5 °C at the highest sampling area (1300 m asl), except South Slope at the foggy condition, the temperature reached 15 °C. Soil temperature decrease from 24.5-22.5 °C. Canopy closure in Southern/Northern slopes (50% - semi-opened forest) were significantly different from that of Eastern/Western Slope (0%), especially at the mid-elevation site (800-1100 m asl). Annual rainfall peaked at Southern/Western Slopes (4500-6500 mm) in all elevation (700-1300 m asl), which were higher than Eastern/Northern Slopes (3800-4500 mm). The light intensity in Southern/Northern Slope was higher than that of Western/Eastern Slopes (Table S2).

Termites and slopes

ANOVAs results showed that number of termites species among the slopes differed significantly ($p<0.05$). The Western Slope had the highest species richness (11 species), followed by Northern Slope (10 species), Southern Slope (7 species), and the lowest was Eastern Slope with only six species (Table 1). The difference in termite species number in each slope of Mount Slamet was also shown by Shanon-Wiener index (Table 2). Based on Shanon-Wienner index, we could state that the Western Slope is the highest in species diversity. It was supposed that western slope has most appropriate microclimate and abiotic environmental factors for termites. Daldjoeni (1982) stated that Southern and Western Slopes of Mount Slamet has an Af microclimate type, where the microclimate is wet. This microclimate occurred along Serayu River, the big river with upstream from an area in Eastern Slope, flowing to the Indian Ocean. Consequently, the microclimate factor in the Southern and Western Slopes are wet, with the highest annual rainfall (4500-6500 mm), air temperature (23-26°C), and air humidity (95%). On the contrary, Northern and Eastern slopes of Mount Slamet are the area with an Am microclimate type, where the microclimate is drier than Af, with lower annual rainfall of 3800-4500 mm, hotter air temperature of 24-28°C and lower humidity of 90%. This microclimate occurs along Northern Coast of Java Island.

Even though there is a sharp difference of microclimate between Western and Northern Slope, they have an equal average number of species (10.66 and 10.55 species) as well, between Southern and Eastern Slope was 2.33 and 3.88 species, respectively. So, this result likely implies that the rainfall is not the single factor causing the high or low diversity of termites in Mount Slamet. We presumed initially that the average of number species would be divided into two group (Southern and Western in one group, then Northern and Eastern Slope in another group) based on the intensity of annual rainfall. But, rainfall factor likely has a close correlation to the species domination, where the species *O.javanicus* belonging to Subfamily Macrotermitinae was dominant in Northern Slope (higher air temperature and lower annual rainfall). This finding is in line with Collins (1980); Davies (1997); and Gathorne-Hardy at al. (2001) that the Subfamily Macrotermitinae is at a competitive advantage over other subfamilies in the area of high air temperature and low rainfall. Thus, in wet microclimate, the Subfamily Macrotermitinae appears to be replaced by wood-feeding from other subfamilies such as Nasutitermitinae and Termitinae. That is the reason why the Subfamily Macrotermitinae was more dominant at the Northern Slope. On the other hand, *S. javanicus* (Familia Rhinotermitidae) was dominant on two slopes with higher annually rainfall, i.e., the Western and Southern Slopes (Table 2). This fact was in accordance with statement by Nandika et al. (2006) that *S. javanicus* is very adaptive so that this species can be found at an altitude of more than 1000 m asl. This species is wood feeder termite, living in the xylem of the wood, adaptable to the high rainfall. Eventhough Dibog et al. (1998) and Bignell and Eggleton (2000) stated that rains could have an adverse effect on termite species richness in tropical rainforest systems, as very high levels of rain can lead to inundated microhabitats and colony death. The species *S. javanicus* has a good strategy to overcome extreme environmental factors such as low air temperature and high rainfalls by using the xylem of wood as a buffer.

The effect of Slope on abundance was significant ($F<0.05$) except in altitude of 1201-1300 m asl. The differences of microclimate such as rainfall, air temperature, air humidity, canopy closure and sunlight intensity are the likely causes of the observed variation in the termite abundance, but the most likely outstanding factors were air temperature and humidity. The altitude at 1201-1300 m asl have more extreme air temperature and humidity, the deep chasms preserves the fog. The elevation of 1201-1300 m asl is a permanent cloudy area at night and a temporal cloudy area in rainy season. The air temperature in the foggy condition of the altitude was very low (under 4 °C), which caused the decline in the termite survival, and hence, the poorest termites diversity. Furthermore, the fog reduces light intensity and light daytimes, which may also have affected the termite survival and abundance. The highly varied microclimate conditions affected organisms at all levels (Auslander et al. 2003). Davies et al. (2003) stated that lower light intensity causes the temperature becomes lower as well and affect termites inhabited in that habitat. Maintaining the environmental air temperature in a constant state is vital for the survival of termite colonies (Korb and Linsenmair 1998). Unstable air temperature cause colony death (Bong 2012). Therefore, only certain species can survive at both hotter and cooler air temperatures. This fact is closely related with the domination of species (Table 2), where *S. javanicus (*Family Rhinotermitidae) was dominant in the Southern Slope while *O. javanicus* (Family Termitidae) was dominant in the Northern Slope.

In the Southern Slope, a half of 120 sections of termites sampling are semi-opened area (appendix 2). This semi-opened forest enables affect soil, and humus feeder termites than wood feeder termites (De Souza and Brown 1994) and soil be drier (Vaessen 2011). In Southern Slope, the local farmers are forbidden by the State Forest Management Unit II to plant any cereal under the main plantation. Consequently, organic content in soil of the slope was the lowest. The most critical factor to the termites species is availability of food (FAO 2000). This condition tends as supporting factor of changing as pest. On the contrary, in other slopes, the local farmers were planting cereals under main plantation trees, and along altitudinal gradient 700-1200 m asl, they applied manure periodically per year, which enabled the feeding group of soil termites became abundant, especially in the Western and Eastern Slope. Likely, manure application support food availability of soil termites. This finding is in line to the state of Ngugi et al. (2011) that soil feeder termites prefer to use simple component of sugar in peptide form as nutrient.

Termites and altitudinal gradient

The effect of altitudinal gradient on termite species number was not significant (p>0.05) except for the Southern Slope. Figure 1 shows that species number initially increased in altitude 800-900 m asl then finally decreased. This phenomenon is called *mid-elevation effect* (Lomolino 2001); a pattern often explained by the presence of optimal climatic condition at mid-elevations, by the ecotone effect and/or by the mid-domain effect (Lomolino 2001). The majority of species richness studies on tropical invertebrates showed a mid-elevation peak pattern. This mid-elevation peaks in the termite species composition have been documented (Donovan et al. 2002; Inoue et al. 2006), which have been attributed to factors such as anthropogenic disturbance and the limited altitudinal range of the study. This result was different with that of research by Gathorny-Hardy (2001) in the Leuser Ecosystem, where the pattern of declining diversity by increasing altitudinal gradient was monotically.

The effect of altitudinal gradient on the abundance of termites on all the slopes was not significant (P>0.05), except for the Southern Slope. Similar with the effect of altitudinal gradient on the species number, it is supposed that these altitudes (700 up to 1300 m asl) have identical range of air temperature (23-28°C), which enable all inhabitant species to develop well, but in the Southern Slope, the air temperature sometimes remarkably dropped under 4°C at night with air humidity reached up to 95%, which is detrimental for termites (Korb and Lismaier 1998). This phenomenon is called the *Messernerhebung* effect, caused by lack of sunlight covered by the thin cloud rising in specific elevation. The Southern slope has a deep chasm laying to the bottom of the Mount, which keeps the cloudy air along the altitude of 700-1300 m asl.

Distribution and effect of the environmental factor

The termite species identified from this research were the wood feeder consisted of *S. Javanicus, O javanicus, M gilvus Microtermes. insperatus,* while the humus feeders termites consisted of *N. matangensis, N. matangensiformis Bulbitermes constrictoides* and *Procapritermes stiger.* Furthermore, the soil feeder consisted of *P. dolichocephalus, P javanicus.* and *C. semarangi*. These results were new record findings at the plantation forest of Mount Slamet. It is likely that these results were caused by the belt transect sampling methods used in the study. This method is different with the method used in the previous research carried out in Plantation forest of Mount Slamet, namely *direct* sampling or *biting sampling* methods. The two last methods are appropriate and relevant to the wood feeder species. It means that the change of the sampling method to the belt transect sampling method resulted in more reliable species discovered, consist of the wood, humus and soil feeder.

Data on the distribution and composition of termites among four slopes showed that *P. stiger* occurred only in the southern and western slope while *B. constrictoides* occurred in the western slope, both were specifically inhabiting humus habitat under Pinus trees. The Pinus leaf waste layer was up to 10 cm thickness with humus acidity 6. Gathorne-Hardi et al. (2001) stated that *Bulbitermes* is one of the genera having broad environmental tolerance. In this research, *Bulbitermes* was found at the base of hill with mid-elevation of 900 m-1000 m asl with a high slope of 60-70°. Such steep slope with water runoff enables nutrient to accumulate (Hemachandra et al. 2010; Rao 2012). *Bulbitermes* spp was firstly found in plantation forest in the eastern part of Mount Slamet (Pribadi at al 2011).

Certain species were found to dominate in the Plantation Forest of Mount Slamet. Calculated Dominance (Simson) index showed the dominance index was more than 75%. The highest dominance index was shown by the Northern slope (0.81) suggesting that the Northern slope was the most preferred ecosystem for certain termites. The most dominant species in Southern and Western slope was *S. javanicus*, and the most dominant in Northern slope was *O. javanicus*, while that in the Eastern slope was *C. semarangi.*

Based on feeding habit, the most abundant termites in the Northern Slope with a hotter air temperature hotter (24-26°C) and the maximal annual rainfall lower (3500-4500 mm), and N content of 0.7%, was the wood eater *O. javanicus.* On the contrary, the Sothern and Western slope with lower air temperature (23-25°C) and maximal annual rainfall (6000-6500 mm) and N content of 0.6%, was dominated by low-level wood feeder termite *Schedorhinotermes javanicus.* Based on this fact, likely rainfall factor affects the preference of termites species in choose of slope. That finding is in line with the state of De Blauwe et al. (2008) that scale spatial potential affects diversity of Termites.

Analysis of 12 environmental factors showed that only five environmental factors have significant (F<0.05) relationship with termite's abundance. The five environmental factors were the percentage of canopy closure, maximal rainfall, altitudes, N content, and manure application. These five ecological factors have a close correlation with the termite's abundance (R=62%). Furthermore, the ordination of Canonical Correspondence Analysis (CCA) shows that canopy closure (eigenvalue 53.09%) and maximal rainfall (eigenvalue 18.51%) were the most associated environmental factors to the species number and abundance of termites in Mount Slamet Plantation. In accordance with to this result, Davies et al. (2003) stated that the local factor such as canopy closure is more attributable effect on termites species number and abundance. There are coexistence relationships between termites composition and canopy closure of vegetation; in a denser canopy, the termites are more potential to inhabit and develop than in opened area. Canopy closure decreases diversity and abundance of termites (Carrijo et al. 2009). Also, canopy closure factor keeps soil humidity in optimal condition for the development of termites diversity. (Davies et al. 2003).

Ordination of CCA also showed that almost all of the environmental factors were positively associated with species number and abundance of termites species 1 (*S. javanicus*), species 5 (*P. delicocephalus*), species 7 (*C. semarangi*), species 8 (*P. stiger.*), and species 9 (*N. matangensiformis*) in Southern and Eastern slope while light intensity factor was associated with number species and abundance of species 2 (*O. javanicus*), species 3 (*M. gilvus*), species 4 (*M. insperatus*) and species 6 (*P.javanicus*) in the northern and western slopes.

In conclusion, Mount Slamet is relatively low in diversity with only two families (Rhinotermitidae an Termitidae) comprised of five subfamilies (Rhinotermitinae, Macrotermitinae, Microtermitinae Termitinae and Nasutitermitinae), nine genera (*Schedorhinotermes, Macrotermes, Odontotermes, Microtermes, Pericapritermes, Procapritermes, Capritermes, Nasutiermes,* and *Bulbitermes*) and eleven species. There was domination of individual species in each slope, i.e., *S. javanicus* was dominant on the Western and Southern slopes*, O. javanicus* was dominant on the Northern slope, and *C. semarangi* was dominant on the Eastern slope. However, Western Slope was the wealthiest slope. The environmental factors mostly affected diversity and abundance of termites in the plantation forest of Mount Slamet were light intensity, maximal rainfall, altitudes, N content, canopy closure and manure application.

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Table S1. Termites that were sampled during research in Mount Slamet, Central Java, Indonesia

		Slope	SS							WS							ES							NS						
		Altitude (100 m)	7- 8	8-9	9-10	10-11	11-12	12-13	∑	7- 8	8-9	9-10	10-11	11-12	12-13	∑	7-8	8-9	9-10	10-11	11-12	12-13	∑	7- 8	8-9	9-10	10-11	11-12	12-13	∑
F	SF	Species																												
Rhi	Rhino termitinae	*S. javanicus*	50	65	377	195	137	5	829	12	147	67	18	53	5	22	235	243	98	50	42	5	673	15	42	124	33	26	10	250
Ter	Macrotermitinae	*O. javanicus*	8	9	39	7	48	0	111	8	14	5	13	9	4	3	29	31	0	0	0	0	60	59	126	170	12	8	6	381
		M. gilvus□	2	6	10	5	0	0	23	12	34	7	26	17	1	87	0	0	0	0	0	0	0	46	118	158	21	7	0	350
	Microtermitinae	*M. insperatus*	4	7	10	6	3	0	30	3	12	4	0	0	0	9	0	0	0	0	0	0	0	14	23	23	1	7	4	72
	Termitinae	*P. dolichocephalus*□	2	5	14	9	0	0	30	9	45	0	31	21	8	94	100	108	98	69	0	0	375	15	23	45	24	11	2	120
		P. javanicus	2	9	20	6	0	0	37	23	31	47	15	18	6	280	0	0	0	0	0	0	0	8	16	34	27	13	4	102
		C. semarangi	3	8	18	7	2	0	38	50	67	0	56	23	2	288	54	200	30	23	0	0	307	7	11	28	21	5	4	76
		P. stiger	0	149	0	0	0	0	149	37	82	1	45	19	9	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nasutitermitinae	*N. matangensi formis*	31	40	83	38	28	0	220	11	15	3	13	7	5	4	21	133	50	11	0	0	215	6	8	8	3	3	5	33
		B. constrictoides	0	0	0	0	0	0	0	7	48	3	26	19	3	96	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		N. matangesis	20	39	70	28	21	0	178	2	5	7	7	4	4	9	200	341	39	11	0	0	591	5	9	9	6	3	2	34
		Taxa_S	9	10	9	9	6	1	1645	11	11	11	10	10	10	2065	6	6	5	5	1	1	2221	9	9	9	9	9	8	1418
		Individuals	122	337	641	301	239	5		174	500	814	250	190	137		639	1056	315	164	42	5		175	376	599	148	83	37	
		Dominance_D	0.27	0.26	0.38	0.44	0.39	1		0.16	0.15	0.13	0.13	0.14	00.2		0.27	0.22	0.24	0.29	1	1		0.20	0.23	0.20	0.15	0.17	0.16	
		Shannon_H	1.59	1.67	1.41	1.26	1.2	0		2.04	2.06	2.14	2.13	2.10	10.9		1.48	1.61	1.50	1.36	0	0		1.82	1.72	1.78	1.94	1.97	1.95	
		Simpson_1-D	0.73	0.73	0.62	0.55	0.61	0		0.83	.841	0.86	0.86	0.85	00.8		0.73	0.77	0.75	0.70	0	0		0.79	0.76	0.79	0.84	0.83	0.84	
		Evenness_e^H/S	0.55	0.53	0.46	0.39	0.55	1		0.70	0.71	0.77	0.84	0.81	00.7		0.73	0.83	0.89	0.78	1	1		0.69	0.62	0.66	0.77	0.80	0.88	

Note: F: Family, SF: Subfamily, Rhi: Rhinotermitidae, Ter: Termitidae

Table S2. Environmental factors conditions of Mount Slamet, Central Java, Indonesia during research

Slopes and Altitudes (m)	Organic content	N content	C content	T soil (°C)	T air (°C)	R Min (%)	RFMax (%)	RF Min (mm)	RF Max (mm)	Manure (time/y)	Soil pH	Light Intensity (candela)	Canopy closure (%)
Southern Slope													
S. 700	17.88	0.71	11.19	25	32	80	95	4500	6500	0	4.50	69802	100
S. 800	17.60	0.70	11.09	24	31	80	95	4500	6500	0	4.50	69800	50
S. 900	16.81	0.70	10.20	23	31	80	95	4500	6500	0	4.50	69800	50
S.1000	16.78	0.70	10.02	23	30	85	97	4500	6500	0	4.50	69801	50
S.1100	15.60	0.70	09.19	22	29	85	97	4500	6500	0	4.50	69802	100
S.1200	15.50	0.69	09.10	22	29	85	97	4500	6500	0	4.50	69803	100
Western Slope													
W. 700	22.98	0.91	13.39	24	31	80	95	4500	6500	1	4.50	56200	100
W 800	22.70	0.90	13.19	23	30	80	95	4500	6500	1	4.50	56200	100
W.900	21.90	0.90	12.90	22	29	80	95	4500	6500	1	4.50	56200	100
W.1000	21.78	0.90	12.80	21	28	85	97	4500	6500	1	4.50	56200	100
W.1100	20.91	0.90	11.39	20	27	85	97	4500	6500	1	4.50	56200	100
W.1200	20.68	0.89	11.30	20	27	85	96	4500	6500	1	4.50	56200	100
Eastern Slope													
E. 700	22.90	0.91	13.39	24	31	80	90	3800	4500	1	4.40	56220	100
E. 800	22.78	0.90	13.00	24	30	80	90	3800	4500	1	4.40	56202	100
E. 900	21.80	0.90	12.19	24	29	80	90	3800	4500	1	4.40	56204	100
E 1000	21.18	0.90	12.00	24	29	85	95	3800	4500	1	4.40	56202	100
E.1100	20.91	0.90	11.13	24	28	85	95	3800	4500	1	4.40	56204	100
E.1200	20.79	0.70	11.00	24	28	85	97	3800	4500	1	4.40	56201	100
Northern Slopes													
N. 700	17.68	0.71	10.69	25	32	80	90	3800	4500	0	4.00	69805	100
N. 800	17.18	0.70	10.50	24	32	80	90	3800	4500	0	4.00	56203	100
N. 900	16.80	0.70	09.69	23	32	80	90	3800	4500	0	4.00	56204	50
N.1000	16.28	0.70	09.50	22	32	85	95	3800	4500	0	4.00	69803	50
N.1100	15.68	0.70	09.50	22	32	85	97	3800	4500	0	4.00	69805	50
N.1200	15.28	0.69	09.45	21	32	85	97	3800	4500	0	4.00	69804	100

Notes: T= air temperature, R= Air humidity, RF= Rainfall, S= South, E=East, W=West, N=North, LS = Light Intensity