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Ant and termite diversity in Indonesian oil palm plantation: Investigating the effect of natural habitat existence

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Abstract. *Rizali A, Karindah S, Windari A, Rahardjo BT, Nurindah, Sahari B. 2020. Ant and termite diversity in Indonesian oil palm plantation: Investigating the effect of natural habitat existence. Biodiversitas 21: 1326-1331.* Natural habitat existence in oil palm plantation has high conservation value and plays an important role in maintaining biodiversity. However, different taxa may have different responses to the presence of natural habitats. This research was aimed to investigate the effect of natural habitat existence on ant and termite diversity in oil palm plantation. The field research was conducted in oil palm plantation located in Central Kalimantan, Indonesia. Twelve plots of oil palm plantation with different habitat characteristics were selected. Ants and termites were sampled using hand collection in six subplots for each plot. In total, 38 species of ants and 9 species of termites were collected from all research areas. The results showed that the area of natural habitats and the distance of oil palm field to natural habitats affected the diversity of termites in the oil palm plantation, but ant diversity did not show to be affected by the same conditions. Based on the generalized linear model, the area of natural habitats in the oil palm plantation had a negative relationship with the diversity of termites. In conclusion, the termite species community is more affected by natural habitats than ants in oil palm plantation.

Keywords: Ant, area, Central Kalimantan, diversity, species richness, termite

INTRODUCTION

The existence of natural habitats around oil palm plantations has not been studied in terms of its role in supporting the conservation of insect diversity. Natural habitats can support much higher species diversity than oil palm plantation (Fitzherbert et al. 2008). In the landscape matrix of oil palm plantation, the remaining natural habitats are considered if they have high conservation value, especially the ability to maintain biodiversity (Azhar et al. 2011). Research by Koh and Wilcove (2008) showed that 83% of butterfly species were only found in the natural habitats and not in the oil palm plantation. However, the role of natural habitats on social insects such as ants and termites in oil palm plantations still lacks understanding. Ants and termites occur in high abundances and with a high diversity of species in almost all natural ecosystems. Ant diversity can be very rich in species in natural ecosystems and agroecosystems (Alonso and Agosti 2000), while termite diversity is diverse and abundant in lowland forests (Bignell and Eggleton 2000).

Ants and termites play an important role in an agroecosystem. Ants provide important ecosystem services, including biological pest control, seed dispersal, and soil modification (Philpott et al. 2010), while termites are major agents of decomposition and play an important part in nutrient and carbon fluxes (Lawton et al. 1996). An experiment by Evans et al. (2011) showed that ants and termites can increase crop yields in an agroecosystem. However, ants are sensitive to changes in their environment, including changes in dominant vegetation structure, food availability, and nesting resources (Andersen 2000). Meanwhile, several studies have shown that termites are sensitive to habitat disturbance (e.g. Eggleton et al. 2002; Sanabria et al. 2016; Schyra and Korb 2019). Wide-scale agricultural intensification and monoculture system in an oil palm plantation is presumed to be the primary factor that causes biodiversity decline and disturbs the ecological balance (Wood 1971; Vijay et al. 2016). Several studies revealed that monoculture oil palm plantation caused a decrease in arthropod biodiversity (e.g. Gazhali et al. 2016; Ashraf et al. 2018). As a consequence of biodiversity decline, ecological functions in an agroecosystem such as pollination and biological control are also suppressed (Feintrenie et al. 2010).

The diversity of ants and termites in agroecosystem can be affected by agricultural intensification. For example, in a coffee agroecosystem, the reduction in canopy complexity caused a decrease in ant species richness (Philpott et al. 2008). Human disturbance and land-use change are pivotal factors affecting ant (Gómez et al. 2003) and termite diversity (Jones et al. 2003). The communities of ants and termites are also highly sensitive to vegetation cover and agricultural practices (Sanabria et al. 2016). Nevertheless, the composition and richness of insect communities in transformed ecosystems may not be stable, even if management does not change (Kuussaari et al. 2009). Tropical agroecosystems established after forest conversion leads to a strong erosion over time of many forest species such as ants and termites (Luke et al. 2014). Understanding the value of natural habitats for insect conservation in an agroecosystem would be beneficial for developing a strategy to achieve sustainable agriculture. Yet, the conservation of natural habitats, as well as non-crop habitat in an agroecosystem, becomes the critical factor to increase habitat carrying capacity for supporting insects, for instance, the communities of natural enemies (Kruess and Tscharntke 1994).

The objective of this research was to investigate the effect of natural habitat existence on ant and termite diversity in oil palm plantation. Twelve oil palm fields in a plantation were selected by considering the two spatial scales of landscape-scale (distance and area of natural habitats) and field scale (tree age of oil palm and understorey vegetation diversity). The hypothesis tested in this research is that the presence of natural habitats maintains the community of ants and termites in an oil palm plantation.

MATERIALS AND METHODS

Research location

The research was conducted in an oil palm plantation located in Kotawaringin Barat District, Central Kalimantan, Indonesia. Four remaining natural habitats with different areas (536 ha, 62 ha, 18 ha, and 12 ha) within the plantation were designated. Twelve fields of oil palm were selected by considering their distance from those natural habitats. Also, the plots were classified as near (< 0.1 km), medium (1.5-2 km) and far (3-5 km) with each distance group had four replications (Figure 1). The plots of oil palm had a size of 70m x 70m and were selected by considering trees with a range of age between 11 to 18 years old, due to difficulty to found plantation with the same age.

Sampling of ants and termites

Sampling of ants and termites were conducted three times in different months from February to April 2017. In each plot, ants were collected from six subplots with a size of 5 m x 5 m each. Ants sampling was performed by hand collection in each subplot lasted for a maximum of 30 minutes. While termites were observed in each plot within six transects with a size of 5 m x 70 m each. Sampling of termites was also performed by hand collection in each transect lasted for a maximum of 30 minutes. Sampled of ants and termites were stored in small vials with 70% alcohol and given a label in the field before being sorted out and identified in the laboratory.

Specimens were identified using relevant taxonomic literature. Ants were identified to genera level based on Bolton (1994) and termites were based on Krishna et al. (2013). Both ants and termites were then separated into morphospecies level based on different morphological characteristics (Lattke 2000).

Understorey vegetation observation

In each plot, understorey vegetation diversity was observed. The observation was performed using the visual method by determining ten random points of a size of 1 m x 1 m in each plot. For each point, the diversity and density of vegetation were recorded, and each species was sampled and photographed for later identification in the laboratory. Sample and photograph of vegetation were identified using a reference of Xu and Zhou (2017).

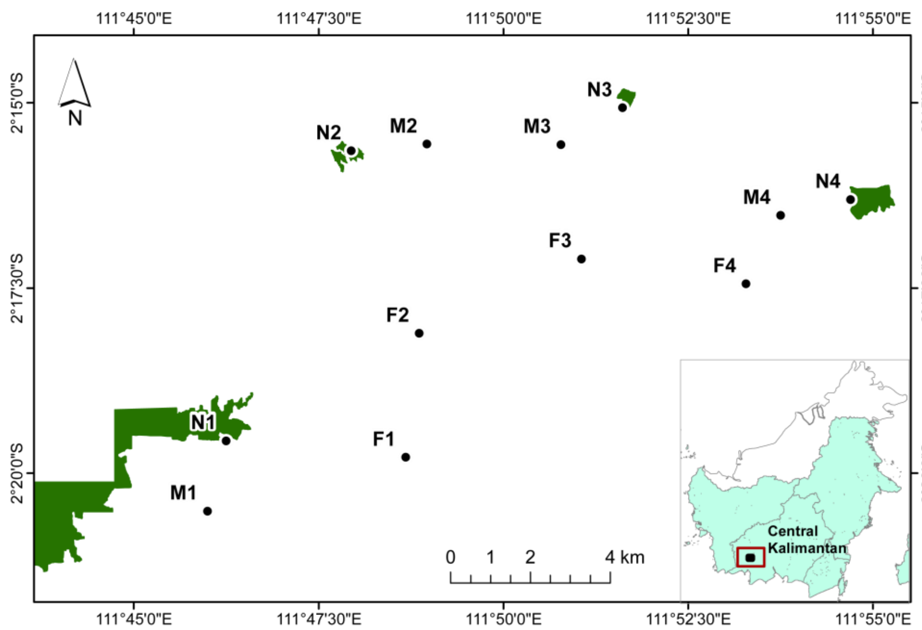

Figure 1. The research site, as an oil palm plantation located in Central Kalimantan, Indonesia (inset). The matrix is covered by the oil palm plantations and green colors indicate natural habitats. Dots with the letters indicate plot codes (N: near, M: medium, and F: far from natural habitat) and the numbers indicate replications

Data analysis

The Kruskal-Wallis test was carried out to compare the significant difference of ant and termite diversity between different areas of natural habitats and between different distances to natural habitats. If significant differences were found, Fisher's least significant difference test was then used to compare the significant differences. The effect of natural habitats and other environmental factors on ant and termite diversity was analyzed by fitting a generalized linear model (GLM) without interactions (Zuur et al. 2009) and using a Gaussian distribution. Explanatory variables included termite/ant diversity, distance and area of natural habitats, tree age of oil palm, and diversity and density of understorey vegetation. All analyses were performed using R statistics (R Core Team 2019).

RESULTS AND DISCUSSION

Diversity of ants and termites in oil palm plantations

In total, 38 species of ants and 9 species of termites were collected from all research plots (Table 1). The result was similar to Luke et al. (2014) who found ants is also more diverse than termites in oil palm plantation in Sabah, Malaysia. The most common ant in oil plantation in Central Kalimantan was *Pheidole* sp2 (83% of the total subplots), while the most common termite was *Macrotermes* sp (15% of the total transects) (Table 2, Figure 2). In this research, we found invasive ant species, *Anoplolepis gracilipes* that known to cause a negative impact on insect biodiversity, although the occurrence (14% of the total subplots) is lower than *Pheidole* sp2 (Table 2). A study by Brühl and Eltz (2009) also reported non-forest species including *A. gracilipes* as the most common ant species in an oil palm plantation in Sabah.

The presence of termites and ants has an important role in oil palm plantations. Termites may contribute to the decomposition of organic matter (Lawton et al. 1996), while ants play an important role as biological pest control (Philpott et al. 2010). The common termite species, *Macrotermes* sp. is known to feed on grass, dead wood, and leaf litter, with the help of fungal symbionts grown inside the nest (Luke et al. 2014). Research by Foster et al. (2011) reported that *Macrotermes gilvus* is the only species as the majority of decomposers in oil palm plantations. While the common ant species, *Pheidole* sp is recognized as widespread species that can dominate resources (Andersen 2000). However, the presence of *A. gracilipes* in oil palm plantations, besides cause negative impact on other ants also may suppress herbivores (Blüthgen and Feldhaar 2010).

Figure 2. The most common species of ant (A) *Pheidole* sp2 and termite (B) *Macrotermes* sp.

Table 1. Ant and termite diversity and plot characteristics in oil palm plantation in Central Kalimantan. The letters of plot codes indicate different distance of oil palm field to natural habitat (N: near, M: medium, and F: far) and the numbers indicate replications

Code	Plot characteristics				Species diversity	
	Distance to natural habitat		Area of natural habitat (ha)	Tree age (years)	Ant	Termite
	Group	Distance (m)				
N1	Near	96	536	14	16	1
N2	Near	86	18	12	13	3
N3	Near	77	12	11	7	0
N4	Near	60	62	17	22	1
M1	Medium	1,775	536	17	8	2
M2	Medium	1,640	18	17	12	1
M3	Medium	1,813	12	16	17	4
M4	Medium	1,770	62	18	13	4
F1	Far	4,183	536	16	17	1
F2	Far	4,500	18	14	13	1
F3	Far	3,928	12	16	10	3
F4	Far	3,223	62	17	13	3
				Total	38	9

Table 2. Species list of ants and termites recorded from all studied plots in oil palm plantation in Central Kalimantan. Data is shown in the occurrence of subplots/transects (Occ.) and the percentage from total subplots/transect (n=72) in the parentheses.

Ant species				Termite species	
Species	Occ. (%)	Species	Occ. (%)	Species	Occ. (%)
Anochetus sp1	4 (6)	*Odontoponera* sp1	30 (42)	*Macrotermes* sp	11 (15)
Anochetus sp2	1 (1)	*Odontoponera* sp2	2 (3)	*Microtermes* sp1	5 (7)
Anoplolepis gracilipes	10 (14)	*Oecophylla smaragdina*	10 (14)	*Microtermes* sp2	2 (3)
Aphaenogaster sp1	15 (21)	*Pheidole* sp2	60 (83)	*Odontotermes* sp1	3 (4)
Camponotus sp1	14 (19)	*Pheidole* sp3	18 (25)	*Odontotermes* sp2	1 (1)
Cardiocandyla sp1	1 (1)	*Pheidole* sp4	2 (3)	*Pericapritermes* sp	1 (1)
Crematogaster sp1	5 (7)	*Pheidole* sp6	21 (29)	*Schedorhinotermes* sp1	9 (13)
Crematogaster sp2	2 (3)	*Polyrhachis abdominalis*	4 (6)	*Schedorhinotermes* sp2	2 (3)
Crematogaster sp3	4 (6)	*Polyrhachis* sp2	1 (1)	*Termes* sp	7 (10)
Dorylus sp1	3 (4)	*Polyrhachis* sp3	6 (8)		
Dorylus sp2	3 (4)	*Polyrhachis* sp4	1 (1)		
Gnamptogenys sp	11 (15)	*Polyrhachis* sp10	2 (3)		
Hypoponera sp1	3 (4)	*Pristomyrmex* sp1	17 (24)		
Hypoponera sp2	4 (6)	*Solenopsis* sp2	1 (1)		
Meranoplus sp1	8 (11)	*Solenopsis* sp4	1 (1)		
Meranoplus sp2	8 (11)	*Strumigenys* sp1	1 (1)		
Myrmicinae sp	1 (1)	*Technomyrmex* sp2	8 (11)		
Nylanderia sp1	25 (35)	*Tetramorium* sp1	11 (15)		
Nylanderia sp2	9 (13)	*Tetramorium* sp2	11 (15)		

Based on the analysis, the area of natural habitats and the distance of oil palm field to natural habitats affected the termite diversity in oil palm plantation and did not affect the ant diversity. Ant diversity showed no difference between area of natural habitats ($\chi^2 = 1.211$, $P = 0.750$) and distance from natural habitats ($\chi^2 = 2.392$, $P = 0.302$) (Figure 3.A and 3.B). In contrast, termite diversity showed a significant difference between area of natural habitats ($\chi^2 = 12.858$, $P = 0.005$) and distance from natural habitats ($\chi^2 = 9.244$, $P = 0.010$). Termite diversity showed lower in oil palm plantations located around a wide area (536 ha) of natural habitats and near (< 0.1 km) from natural habitats (Figure 3.C and 3.D).

Termite diversity showed different than ant diversity in relation to the presence of natural habitats within oil palm plantations. As the species with the greatest richness in a natural ecosystem as well as in an agroecosystem (Alonso and Agosti 2000), ants are also found diverse in an oil palm plantation in Central Kalimantan with different distances from natural habitats. Although ants are sensitive to changes in their environment (Andersen 2000), this research indicated that the spatial difference of oil palm fields around natural habitat did not affect the diversity of ants. Research by Cerda et al. (2009) in homogenous orchards also showed the same pattern that ant diversity was not different among different parts of orchards. This is arguably due to homogenous habitats tend to have similar food resources (Vandermeer et al. 2008) as well as temperature conditions (Wiescher et al. 2011) that shaping the similarity of ant community among oil palm fields. In contrast, termites as the most abundant species in lowland forests (Bignell and Eggleton 2000), their species diversity significantly affected by the spatial difference of oil palm fields. This is possibly related to the small scale effect within oil palm plantations that create a variety of understorey vegetation (Davies et al. 2003) as well as microhabitats for different termite species (Deblauwe et al. 2007).

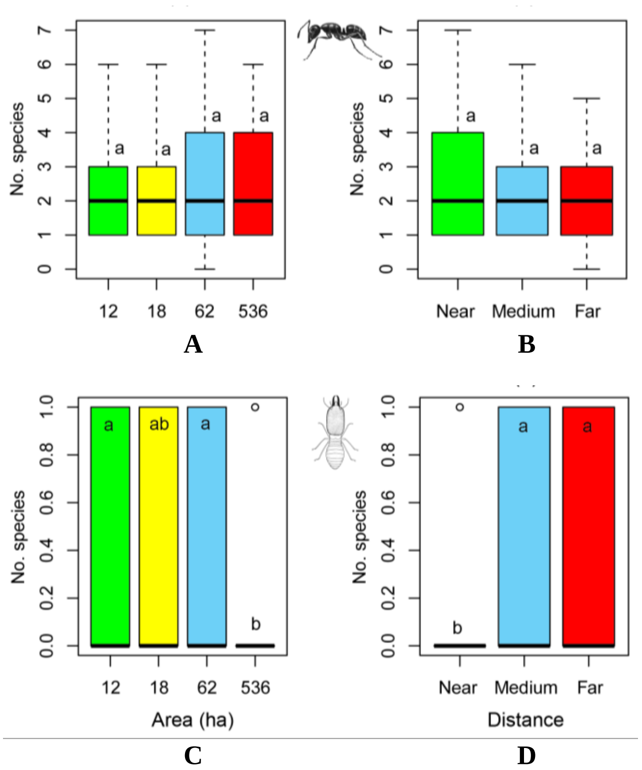

Figure 3. Differences in ant diversity between (A) area of natural habitats (ha) and (B) distance from natural habitats, and termite diversity between (C) area of natural habitats (ha) and (D) distance from natural habitats. Box plot represents the 1st and 3rd quartiles (the lower and upper edges of the box) as well as the median number of species (thick horizontal line in the box). Box with different letters are significantly different at P < 0.05 according to Fisher's least significant difference test

Table 3. Generalized linear models relating diversity of ants and termites to distance from natural habitats, natural habitat area, tree age of oil palm plantations, and diversity and density of understorey vegetation as predictors

Variable	Ant diversity			Termite diversity		
	Estimate	SE	P-value	Estimate	SE	P-value
(Intercept)	2.645	1.21	0.030	0.218	0.39	0.576
Termite diversity	0.167	0.22	0.445			
Ant diversity				0.017	0.02	0.445
Natural habitat distance	-0.000	0.00	0.301	0.000	0.00	0.086
Area of natural habitat	0.000	0.00	0.658	-0.000	0.00	0.018
Tree age of oil palm	0.001	0.05	0.991	0.029	0.02	0.089
Vegetation diversity	-0.027	0.05	0.567	-0.028	0.01	0.054
Vegetation density	0.000	0.00	0.523	0.000	0.00	0.389

Effect of habitat characteristics on ants and termites

The GLMs analyses showed the existence of natural habitats within oil palm plantation did not affect the diversity of ants (P>0.05) but effected the diversity of termites, especially the area of natural habitat (P=0.018, Table 3). The area of natural habitat had a negative relationship with termite diversity. Oil palm fields that located around wide area of natural habitat may unsuitable for termite diversity due to the compatibility of natural habitat to support natural enemies of termites especially birds and mammals (Logan et al. 1990) in relation to the sufficiency in amount or composition to the predator existence (Tscharntke et al. 2016). Although ants are also as potential predator of termites (Logan et al. 1990; Grace 1997), there was no relationship between ant diversity and termite diversity (P=0.445, Table 3). This is because the majority of ant species in this research (Table 2) are not recognized as termite predators (Logan et al. 1990). A study in Amazonian rain forest by Dambros et al. (2016) also revealed that termite diversity was not correlated with non-predatory ant diversity.

The factors that cause the negative relationship between the area of natural habitats and termite diversity are still unclear. Some possibilities might shape the relationship such as the difference of habitat preference among termite species and the effect of termite predators. Specialist and generalist termites have different habitat preferences which specialist termites more prefer in natural habitats than in oil palm plantation (Logan et al. 1990). Also, the area of natural habitats may support termite predators (e.g. insectivorous birds and ants) that can affect the diversity of termites. Research by Heath and Long (2019) revealed that the predation of insectivorous birds increased with an increasing area of semi-natural habitat in orchards. This is related to the needs of insectivorous birds to consume a lot of insects (Nyffeler et al. 2018). Even specialized predators of the hive termites, doryline ants can cause termite extinction in the disturbance environments (Logan et al. 1990).

In conclusion, this study has identified significant differences in the diversity of ants and termites in responding to the existence of natural habitat in oil palm plantation. Although the mechanism is uncertain, the area of natural habitat in oil palm plantation had a negative relationship with termite diversity. It indicates that the termite species community appears more sensitive to the existence of natural habitats than ants.

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