Ant diversity inhabited oil palm plantations in a peatland in Sumatra, Indonesia

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Abstract. Johari A, Hermanto MA, Wulandari T. 2021. Ant diversity inhabited oil palm plantations in a peatland in Sumatra, Indonesia. Nusantara Bioscience 13: 158-163. Ant community is one of the soil biotic components with diverse roles, including pollinators, predators, decomposers, parasites, and herbivores. Changes in land use from natural habitats to plantations affect the diversity and composition of ants because these groups are very vulnerable to environmental changes. The purpose of the study was to analyze the diversity of ants (Formicidae) found in peatland planted with oil palm. The study was conducted on peatland in Gambut Jaya village, Sungai Gelam sub-district, Muaro Jambi district, Indonesia from October 2019 to May 2020. The research was conducted through surveys in two peatland locations (natural peatland and oil palm plantation) using the purposive sampling technique through the stages of transect making, field sampling, sample preparation, and identification. A total of 2636 individuals of ants were collected from natural peatland, while 3183 individuals were found in oil palm plantations. Eight ant species were identified from both study sites belong to four subfamilies, namely Dolichoderinae, Formicinae, Myrmicinae, and ponerine. Among the species, Dolichoderus thoracicus were most dominant, composed 63.6% in natural peatland and 73.6% in oil palm plantation. The diversity index of ant species in natural peatland was higher (0.97) than that in oil palm plantations (0.88), indicate the change in the abundance and diversity of ant species in oil palm plantations. Therefore, efforts to preserve the habitat of ants by maintaining their microhabitat and resource, as well as conserving the important species such as natural enemies of pests, need to be taken into account in peatland management.

Keywords: Ant type, diversity, palm plants, peatlands

INTRODUCTION

Palm oil is one of the leading commodities in Indonesia, which is mostly developed on peatlands. To meet national and global demand, extensive forest landscapes conversion to oil palm plantation occurred rapidly between the mid-1990s and 2015 (Tsujino et al. 2016). Conversion of peatland into palm oil plantations involves many physical activities such as land clearing and drainage channels that play a role in changing the physical and chemical properties of peatlands (Wang and Foster 2015). These changes have affected directly or indirectly the local organisms and thus led to a diversity crisis (Sodhi et al. 2010). One of the local organisms inhabited in peatlands areas is ant (Hymenoptera).

In addition to oil palm plantations, studies of ant diversity have been carried out in many plantation habitats, including coffee (Urrutia-Escobar and Armbrecht 2013), mango (Carvalheiro et al. 2012; Diame et al. 2015), citrus (Calabuig et al. 2015; Martinez- Ferrer and Campos-Rivela 2017), rubber (Hosoiishi et al. 2013), and eucalyptus (Suguituru et al. 2011; de Queiroz et al. 2020). This is due to the simplification of the agroecosystems because industrialization of agriculture can lead to loss of animal biodiversity related to both vertebrates and invertebrates (Urrutia-Escobar and Armbrecht 2013; de Queiroz et al. 2020). This is due to changes in resources for the survival of ants. Another attraction for ants is their very complex functional role in the ecosystem. The ants have several main roles in an ecosystem, including pollinators, predators, decomposers, parasites, and herbivores (Kovar et al. 2013). The ants have the potential to transform soil litter to organic matter and as an environmental balance. They have a narrow tolerance for environmental changes and hence can be used as bioindicator organisms (Fitzherbert et al. 2008; Chen et al. 2011). The ability of ants as bioindicators is generally studied at the community level. A study of the ability of ant communities to forest restoration conducted in Brazil showed that species composition changes with the recovery gradient, and the dissimilarity between ant species composition in grassland and forest habitat increases with the age of the remaining forest. In addition to changes in composition, the presence of indicator species also supports the ability of ants as bioindicators. Variations in ant species composition from both groups of habitat types (grassland and forest) were caused by differences in the responses of open habitat ants and forest specialist ants to the increase in vegetation cover along the recovery gradient (Schmidt et al. 2013). Therefore, ants in peatlands are ideal insects to determine the state of the peatland ecosystem.

Several studies of ant communities in peatland planted with oil palm and adjacent natural habitat have been reported (Lucey et al. 2014; Darmi et al. 2015; Wang and
Foster 2015; Rizali et al. 2020). Previous research conducted by Darmi et al. (2015) compared the differences of ant communities in the oil palm stands with different ages. However, this study lacks non-oil palm habitat comparison. A study comparing ant communities between natural forests and oil palm plantations was conducted by Yulminarti et al. (2012) focused on ant population ratios. Bruhl and Eltz (2010) studied the loss of forest the ant species in oil palm plantations in Sabah, Malaysia. The study of Hardianti et al. (2019) evaluated ant communities on peatlands in Kalimantan. These studies generally only use the pitfall trap method. Research using a combination of pitfall trap and monolith methods is rarely done. Therefore, it is important to study ant communities (Hymenoptera: Formicidae) on peatland planted with oil palm with more varied methods to evaluate the ants inhabited in the studied habitat.

Sungai Gelam is located in Jambi Province, Sumatra, Indonesia. The area has approximately 2,568 ha of peatland ecosystems. However, some peatlands in the area have been converted, including oil palm plantations. The activity of changing the function of peatlands causes conditions on the surface of peatlands to change a lot. Differences in environmental conditions on peatland without oil palm and peatland with oil palm plantations are thought to affect the presence of ant species. This study aims to determine the diversity of ant species found on peatland without oil palm and peatland with oil palm plantations, and the results of the study are expected to be used as input in peatland management.

MATERIALS AND METHODS

The study was conducted on peatland in Gambut Jaya Village, Sungai Gelam Sub-district, Muaro Jambi District, Jambi Province, Indonesia (Figure 1) from October 2019 to May 2020. The stages of this research consisted of sampling in the field, sample preparation, measurement of physical and chemical factors, data analysis, and identification.

Figure 1. Map of research locations and trap placement design in Gambut Jaya Village, Muaro Jambi District, Indonesia
The pitfall trap combined with the monolith methods were applied to collect the samples. A total of 60 pitfall traps were installed in the ground, consisting of 30 at each station, with a distance between plots was 10 meters. The pitfall trap method, consisting of a plastic cylinder measuring 10 cm in diameter and 15 cm in height, was buried in the soil until its open tip was leveled at the soil surface. The traps were filled with alcohol and a few drop of detergent. The traps were maintained for 24 hours in the field. Meanwhile, 48 units of monoliths were used consisted of 24 units at each station. The monolith was placed with a distance between plots was 5 meters. Soil Monolith (25 × 25 cm) was used to sample 5 cm wide and 10 cm depth of soil and litter outside the monolith (Figure 1). The sampling frequency was repeated 3 times. Identification of ant species is carried out based on morphological characteristics, referring to the book Yashimoto (2003). The identified samples were analyzed for species diversity index, evenness, and similarity index. Selanjutnya nilai hasil analisis diklasifikasikan berdasarkan Odum and Barret (2004). The diversity index diklasifikasikan sebagai berikut: low (H’ less than 1), moderate (H’ range from 1 to 3), high (H’ more than 3). Species Eveness index diklasifikasikan sebagai berikut: low (E less than 0.4), moderate (H’ range from 0.4 to 0.6), high (H’ more than 0.6). Similarity index diklasifikasikan sebagai berikut: low (SI less than 50%), and high (SI more than 50%).

RESULTS AND DISCUSSION

Results
A total of 2636 individuals of ants were collected from natural peatland, while 3183 individuals were found in oil palm plantations. Eight ant species were identified from both study sites belong to four subfamilies, namely Dolichoderinae, Formicinae, Myrmicinae and Ponerinae. Dolichoderinae subfamily has dominated the samples from both study sites. Among the species, Dolichoderus thoracicus were most dominant, composed 63.6% in natural peat-land and 73.6% in oil palm plantation. In addition, the ant species Oecophylla smaradigna was merely collected from an oil palm plantation with two specimens (Table 1). There were differences in the number of individuals and the number of species found in the two study sites.

The results of the data analysis of the Diversity Index, Similarity and Dominance of ants at the two research locations are presented in Figure 3. The diversity index at both locations is categorized as low (< 1), the dominance index is moderate, and the similarity index is high (>0.8). Ant diversity in Natural peat-land was higher than that in oil palm plantations (Figure 2).

In addition to the results presented above, measurements of physical environmental and chemical factors were also carried out at the two research sites. Physical environmental factors are used to see the relationship with the presence of ants. Ant activity is largely determined by physical environmental factors. The light intensity, aerial temperature, and soil temperature in Natural peat-land were higher than those in oil palm plantations, while soil humidity was lower (Table 2).

| Subfamily      | Species                        | Abundance Natural peatland | Oil palm plantation |
|----------------|--------------------------------|----------------------------|---------------------|
| Dolichoderinae | Dolichoderus thoracicus        | 1677                       | 2376                |
| Formicinae     | Anoplolepis gracilipes         | 641                        | 127                 |
|                | Euprenolepis procera           | 254                        | 463                 |
|                | Camponotus arrogans            | 4                          | 49                  |
|                | Camponotus pensylvanicus       | 31                         | 137                 |
|                | Oecophylla smaradigna          | 0                          | 2                   |
| Myrmicinae     | Pheidole megacephala           | 22                         | 20                  |
| Ponerinae      | Odontomachus aciculatus        | 7                          | 9                   |

Total abundance | 2636 | 3183
Total subfamily | 4 | 4
Total species | 7 | 8
Diversity (H’) | 0.97 | 0.88
Dominance (D) | 0.47 | 0.58
Similarity (IBC) | 0.93 | 0.93

Table 2. The environmental factor between the study sites

| Environmental factors | Natural peat-land | Oil palm plantation |
|-----------------------|-------------------|---------------------|
| Light intensity (Lux) | 1.064             | 763                 |
| Aerial temperature (°C)| 31                | 28                  |
| Soil pH | 5.3 | 5.3 |
| Soil humidity (%) | 52.8 | 55.3 |
| Soil temperature (°C) | 28.5 | 28.3 |

Figure 2. Diversity Index, Similarity and Dominance of Ants
Discussion

Our study found that the two most common ant species found in two locations were Dolichoderus thoracicus dan Anoplolepis gracillipes. This is because litter is still found in two locations that allow this species to gather and make nests. In addition, the availability of vegetation also greatly affects the presence of insects because the vegetation can be used as a food source, nesting place, and shelter (Johari et al. 2019). Natural peatland generally has vegetation types in the form of ferns, while oil palm plantation has vegetation types in the form of ferns and oil palms. Ants from the genus Dolichoderus are commonly found in litter on the surface of the soil consisting of rotting dry leaves such as coconut leaves, palm leaves, banana leaves, and cocoa leaves. Latumahina et al. (2015) stated that the genus Dolichoderus was the dominant group of ants found due to its very active and aggressive nature. In addition, ants of this genus can conduct intense competition between colonies and generally act as a forager. Thus, they are found in many types of habitats. In addition, ants of the genus Dolichoderus can dominate in disturbed environments. This is supported by Yulminarti et al. (2012) that of all the types of ants obtained, it can be seen that ants with the role of forager are the most commonly found. The black-ant Dolichoderus thoracicus is classified as a common ant distributed wide in Southeast Asia (Jitjak and Sanoamuang 2019). This species is used as pest control in cocoa plantations. However, its presence in residential areas is considered disturbing, and the ant treats as a pest. Recent research reports that the ant has experienced a population increase in Taiwan and has been shown to invade human settlements frequently (Lin et al. 2021). Yellow crazy ant (Anoplolepis gracillipes) is a native ant in Southeast Asia. It is classified as an ant that is often studied because it has an invasive nature, so it can be considered a threat to local ant species. Habitat invasion by Anoplolepis gracillipes (yellow crazy ant) harms the entire ecosystem and the interactions that occur within it. The existence of this ant species disrupts the balance in the habitat it enters and often causes the exclusion of other species that inhabit the habitat. This was reported in a study in Malaysian Borneo. The study reported that the successful establishment of A. gracillipes in anthropogenically disturbed habitats might negatively affect residents ant communities through high levels of direct interspecific aggression and almost complete monopolization of resources within high-density supercolonies. The other study reported that yellow crazy ants are a significant threat to biodiversity in Hawaii due to a rapidly expanding range and the potential to disrupt ecosystem interactions at multiple trophic levels wedge-tailed shearwater (Ardenia pacifica) (Plentovich et al. 2018). This species is also reported to be an expansive species in India (Sinu et al. 2017) and Korea (Jung et al. 2017).

Oecophylla smaragdina (weaver ants) was the species with the least number, which was only found in oil palm plantations. Only two individual of this species was found because these ants generally nest in the tree canopy. Weaver ants use large trees to make nests by knitting leaves on trees. In addition, catching using a baited pitfall trap method is thought to be able to lure this type of ant into the trap. The same result was also reported by Latumahina et al. (2015) that the ant Oecophylla smaragdina was obtained using the baiting method. Ants (Formicidae) are a large group of organisms that are colonies and forage for food outside the nest (Gesriantuti et al. 2016).

The value of the diversity index of ant species in the two locations is different, although in the same category. The diversity index value at natural peat-land was slightly higher than that in the oil palm plantation. The diversity index at both locations was low because there was a dominant species Dolichoderus thoracicus in both study sites. The diversity index is strongly influenced by the number of individuals and the number of species. If the number of individuals is high, the diversity index value will be small. If the number of species is high, then the diversity index is high (Srinivasan 2009).

This study found a total of 5819 individuals belong to 8 ant species from all study sites. Compared with the other studies, the number of ant species in this study is relatively lower. However, our conclusion that oil palm plantations reduce diversity was consistent with the other studies. The results of research on peat-lands with palm stands from a young age to old reported that 15 ant species were found (Darmi et al. 2015). Rizali et al. (2020) found 7 to 22 ant species in several oil palm plantation lands adjacent to natural habitats. According to Yulminarti et al. (2012) found 53 species from 316 individuals in peat swamp forest, while the one-year-old palm oil plantation found 24 species from 237 individuals. A study in Sabah (Borneo), Malaysia found 23 ant species baited in the plantations. Nine of them were different from those inside the forest. All numerically dominant ants were non-forest species. The most common species was Anoplolepis gracillipes, an invasive species present at 70% of all bait sites and known to cause ‘ecological meltdowns’ in other situations (Bruhl and Eltz 2010). Moreover, compared to the study results of Hardianti et al. (2019), the result would be more similar. That study in secondary peatlands located in Kubu Raya District found 7 species from 228 individuals. The high diversity of ant species in several oil palm habitats is due to their adaptability. Ants are less sensitive to changes in land use, with a much higher degree of similarity in species assemblages across habitats than other groups such as butterflies (Lucey and Hill 2012).

The low diversity index can be influenced by food availability and physical environmental factors (Johari et al. 2019). At the research location at natural peat-land, generally, it consisted of various types of fern vegetation, which were more heterogeneous, which supported the presence of ants when compared to oil palm plantation, which was more homogeneous with oil palm plants. In addition, there are environmental pressures that occur in oil palm plantations in the form of land clearing, fertilization, and other human activities such as nurseries and the use of heavy equipment that can affect ant activity. These agricultural practices may affect the presence of ants.

Ant diversity is strongly influenced by food availability, vegetation, and changes in ant activity (Kovar et al. 2013;
Kumar 2017). Several physical environmental factors obtained in the two locations in this study have a value difference that is not too significant. Soil pH at both research study sites was 5.3, while the soil temperature at natural peat-land was 28.5°C, and oil palm plantation was 28.3°C. According to Latumahina et al. (2015), the ideal soil pH range for ant life is 4.5-6.8, while according to Melina et al. (2017) the optimum and tolerant soil temperature range is 25-32°C. Based on this statement, the soil pH and soil temperature at natural peat-land and oil palm plantations were still in optimal conditions for the survival of the ants.

Air temperature also affects the presence of ants. Air temperature affects the development of ants. Based on the results of measurements of air temperature between the two research locations are quite different. The air temperature at natural peat-land has an average of 31°C, while the air temperature at oil palm plantation has an average of 28°C. The vegetation in natural peatland does not provide canopy cover, so there is no barrier to sunlight. This is what causes the air temperature at natural peat-land to be higher than oil palm plantation, which has a canopy cover of palm trees. Generally, soil ants have an optimum temperature for growth and development. According to Melina et al. (2017) that the optimal and tolerant temperature range is 25-32°C. Based on this statement, the air temperature in the two research locations is still optimum for the survival of the ants.

Ant diversity is also affected by soil moisture. Soil moisture shows a negative correlation with ant diversity. Increased soil moisture causes various types of fauna cannot to adapt to high water content because it will be more difficult to get oxygen in the soil. If there are fauna that can adapt to soils with high water content, then this fauna dominates the area so that the diversity will decrease. The dominance index values in the two locations have different values. Natural peat-land (0.47) while oil palm plantation (0.58) is in the moderate category. If the dominance index of the study site is moderate, then several species dominate the samples.

The similarity index value between the two research locations is 93%. The value of this similarity index is considered high, this occurred because there were many same species found at both natural peat-land and oil palm plantations. The similarity index criterion is high if the value is more than 50%. Ecologically, the observation locations that have a high similarity index value indicate that the composition of the ant species that comprise the community is relatively similar. From the results of this study, it can be emphasized that the conversion of peatland into oil palm land quantitatively affects the diversity of ants. On peatland planted with oil palm, it was found that the number of species and the number of individual ants was higher than that on peatland that was not planted with oil palm, with a low category diversity index.

In conclusion, in peatland without oil palm, 7 ant species were recorded, while in oil palm peatlands, 8 species were found. Dolichoderus thoracicus and Anoplolepis gracilipes were the dominant species in the sample. The diversity of ant species in peatland without oil palm (0.97) and peatland planted with oil palm (0.88) was categorized as low. The dominance index on peatland without oil palm (0.47), while peatland planted with oil palm (0.58) is considered moderate. The similarity index was considered high. Therefore, efforts to preserve the habitat of ants by maintaining their microhabitat and resource, as well as conserving the important species such as natural enemies of pests, need to be taken into account in peatland management.

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