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Research Article

The Diversity of Ants (Hymenoptera: Formicidae) on Industrial Forest in Sungai Merah Village, Sarolangun, Jambi with Its Identification Key

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ABSTRACT
Ants have a very important role in an ecosystem. The insects act as decomposers, pollinators, soil aerators, pest controllers, and predators. Their role is very varied so that they can be easily found in various ecosystems, one of which is the rubber and oil palm ecosystem. The ant's diversity in this forest eventually will affect the productivity of the land. The aim of this study is to determine the diversity and role of ants in the rubber and oil palm plantations in Sungai Merah Village. Both of the plantations dominate the industrial forest in Jambi. The method used in this study was purposive random sampling. Observation plots were installed in the ecosystem of rubber and oil palm plantations; each ecosystem had 4 plots consisting of 9 units of pitfall traps, and 9 units of bait traps. The results of this study show that 15 species of ants are found in the ecosystem of rubber and oil palm plantations. Furthermore, the collected ants consisted of 39.972 individual ants belonging to 12 genera and 5 subfamilies. Ants establish in the ecosystem of rubber and oil palm plantations in Sungai Merah Village have an important role either as predators (*Crematogaster* spp., *Odontomachus rixosus*, *Odontoponera tranversa*, *Pheidole huberi*, *Tetraponera rufonigra*, *Tapinoma melanocephalum*, *Camponotus* spp. and *Colobopsis moeschi*), or foragers such as ants from the genera *Anoplolepis*, *Camponotus*, *Monomorium* and *Polyrhachis*. As predators, *Oecophylla smaragdina*, *Camponotus* spp. and *Crematogaster* spp. also play a role as biological control agents in the ecosystem.

INTRODUCTION
Jambi is one of the rubber and palm oil-producing provinces in Indonesia. In 2017 the statistics agency of Jambi (BPS Jambi) reported that there were at least 669.000 ha of rubber plantations and ± 497.000 ha of oil palm plantations spread across 11 regencies. One of the regencies which have a sizable area of rubber and oil palm plantations is Sarolangun regency.

Geographically Sungai Merah Village is located in Pelawan Subdistrict, Sarolangun Regency, Jambi Province, and based on zoogeography this village is included into the Indomalayan realm, also called as oriental realm by biogeographers (Worboys et al. 2010). Majority population in this village works as rubber farmers and oil palm farmers. The area of rubber plantations in Pelawan-Singkut sub-district ± 31.631 ha

and oil palm plantations area ± 2.769 ha (Hidayat & Yohanes 2007). Furthermore, the area of this plantation area will continue to increase over time with the opening of new land and converting plantations from rubber plantations to oil palm plantations or from other plantations. Therefore, this conversion will cause a change in habitat and affect biodiversity, including ant diversity.

The ecosystems of rubber and oil palm plantations have different characteristics. The litter covers most of the land surface, preventing the growth of weeds or other wild vegetation, but sometimes wild vegetation is also found in this ecosystem (Harwanto et al. 2020). There are various species of wild vegetation in the oil palm plantations (Bilkis et al. 2022) because the litter in this ecosystem does not cover the land surface like the litter in rubber plantations (Roza 2018). The characteristics of the ecosystem will affect organisms, including ants.

Ants are social insects from the order Hymenoptera and the Formicidae family. They have very important roles as pollinators, predators of pests, parasitoids of pests, weed killers, scavengers, decomposers, soil builders, and food providers. Insects are also useful in medicines and have aesthetic and scientific values (Rawal 2020). Because of their very varied role, ants can easily be found in various ecosystems, one of which is the rubber and oil palm plantation.

The diversity of ant species in rubber and oil palm plantations in Sungai Merah Village has never been reported. Therefore, it is necessary to conduct a study on the diversity of ant species found in rubber and oil palm plantations in Sungai Merah Village, specifically its species identification, diversity, and abundance of ant species and to find out the role of these ants based on literature study.

MATERIALS AND METHODS

Materials

The tools used in this study were plastic cups, plastic plates, plastic mica, sample bottles, tweezers, brushes, stationery, small shovels, gloves, bamboo poles, soil meters, plastic bags, thermometer, soil tester, soil thermometer, hygrometer, digital microscope, and camera. Meanwhile, the materials used were research subjects (ants), 70 and 96% alcohol, fish, sugar solution, and cotton.

Methods

Time and Place of Research

The study was conducted from June 2021 – December 2022, which took place in rubber and oil palm plantations located in Sungai Merah Village, Pelawan sub-district, Sarolangun regency Jambi Province, Laboratory of Entomology, Faculty of Biology, Gadjah Mada University and Insect Laboratory of the National Research and Innovation Agency (BRIN).

Collection Method

This study used a purposive random sampling. Sampling was conducted in 2 different ecosystems, in each ecosystem there were 4 plots with a size of 20 x 20 m^2, each plot was installed with 9 units of pitfall traps, 9 units of sugar solution bait traps, and 9 units of fish bait traps.

Pitfall trap

Pitfall traps are used to catch ants that are on the ground. A total of 9 units of pitfall traps were installed in each plot with 10 m between the pitfall traps. Pitfall traps are made of plastic cups with a diameter of 10 cm and a height of 15 cm. The trap was immersed in the soil and the sur-

face of the glass was parallel to the land surface. Each trap was filled with 1/4 of 70% alcohol. Furthermore, to prevent water from entering the trap, a cover made of mica plastic was used which was attached to a bamboo pole. Traps were set for 1 x 24 hours, and sampling was conducted once every 1 week for 3 consecutive weeks. In addition, the ants that were caught were then collected and then put into a sample bottle and labelled (Swift & David 2001).

Bait trap

Bait trap is an ant sampling technique by using bait. The baits used in this study were fish and sugar solution. The bait was put into a flat plate which had a diameter of 20 cm, then the plate was placed around the pitfall trap which was ± 25 cm. Sampling with this technique was conducted within 3 - 4 hours. This sampling was conducted once a week for 3 consecutive weeks. The collected samples were then put into sample bottles and labelled modified by (Wielgoss et al. 2010).

Measurement of Environmental Parameters

Measurement of environmental parameters was conducted at each sampling plot, which included measurements of air temperature, soil temperature, air humidity, soil moisture and soil pH.

Sample Identification

The collected samples were then identified at the Entomology Laboratory of the Biology Study Program, Faculty of Biology, Universitas Gadjah Mada and the Insect Laboratory of the National Research and Innovation Agency (BRIN), referred to the book Identification Guide to The Ant Genera of The World (Bolton 1994) and Identification Manual for Bornean Ants (Hashimoto & Rahman 2003).

Data Analysis

The Shannon-Wiener diversity index (H') was calculated using the following formula.

$$H' = -\sum_{i=1}^{n} Pi\ ln\ ln\ Pi$$

To calculate the evenness index (E) of ant species, the following formula was used.

$$E = \frac{H'}{ln\ ln\ (s)}$$

RESULTS AND DISCUSSION

Based on the study which had been conducted, 15 species of ants had been identified in the rubber and oil palm plantations. The collected ants consisted of 39.972 individual ants belonging to 12 genera and 5 subfamilies. The numbers of ant species in the rubber plantations were 14 species with a total of 17.216 individuals while in the oil palm plantations there were 11 species of ants with a total of 22.756 individuals (Table 1).

Based on the study which had been conducted, we found 15 species of ants belonging to five subfamilies and 12 genera.

Subfamily Ponerinae

The subfamily has 14 genera (Nazarreta 2017) but in this group the abdomen slightly curved, mandible varies from linear to triangular, only consists of two genera that are *Odontoponera* and *Odontomachus* (Figure

Table 1. The species, number of individuals and the role of ants in the rubber and oil palm plantations

No	Species	Sampling Location								Role	References
		Rubber Plantations				Oil Palm Plantations					
		1	2	3	4	1	2	3	4		
1	*Anoplolepis gracilipes*	0	2632	1132	8	2376	425	236	1619	Foragers	Haneda & Yuniar 2020
2	*Camponotus arrogans*	1	2	0	0	9	0	0	0	Foragers, Predator	Haneda & Yuniar 2020; Borbély & Nagy 2022
3	*Camponotus dolichoderoides*	650	33	15	1	36	138	15	37	Foragers, Predator	Haneda & Yuniar 2020; Borbély & Nagy 2022
4	*Colobopsis moeschi*	3	24	1	0	0	0	0	0	Foragers, Predator	Haneda & Yuniar 2020; Borbély & Nagy 2022
5	*Camponotus* sp. 1	0	0	0	0	7449	0	3136	4928	Foragers, Predator	Haneda & Yuniar 2020; Borbély & Nagy 2022
6	*Crematogaster* sp. 1	190	0	54	19	0	457	0	7	Predator, Predator	Sholih et al. 2019
7	*Crematogaster* sp. 2	152	286	55	11	0	72	5	0	Predator, Predator	Sholih et al. 2019
8	*Monomorium* sp. 1	9	100	89	8	25	26	18	26	Foragers, harvester	Haneda & Yuniar 2020
9	*Odontomachus rixosus*	3	17	0	2	3	49	10	7	Predator	Haneda & Yuniar 2020
10	*Odontoponera transversa*	23	72	16	25	44	156	31	92	Predators	Cao et al. 2022
11	*Oecophylla smaragdina*	1916	0	1367	0	0	0	0	0	Predator	Pierre & Idris 2013
12	*Pheidole huberi*	0	10	2	5	208	0	8	0	Seed harvester, omnivore, predator, scavenger	Haneda & Yuniar 2020
13	*Polyrhachis proxima*	11	4	8	0	0	0	0	0	Foragers	Haneda & Yuniar 2020
14	*Tapinoma melanocephalum*	234	24	47	7931	0	28	0	1080	Invasive ants, predator	Rubiana et al. 2015
15	*Tetraponera rufonigra*	24	0	0	0	0	0	0	0	Predator	Pawar 2014

1). Characteristics of subfamily Ponerinae are tangible frontal lobes, sting at the end of the abdomen, mesosoma attached to the abdomen through a single petiole, second segment of slightly curved, mandible varies from linear to triangular.

Characteristics *Odontoponera* mandibles are triangular, frontal lobes are narrowly separated posteromedian portion of clypeus, and anterior clypeal margin is armed with 7-9 of distinct teeth (Nazarreta et al. 2021). There is one species of ant from the genus *Odontoponera* that was found in this study; *Odontoponera transversa* has characteristics short mandible and triangular, body has fine hair and is quite thick, rounded head and has strokes like fingerprint (Figure 1a).

Characteristics *Odontomachus* mandibles long and straight, the top of head has V-shaped lines, and upper-front of the head is sometimes with shallow grooves (Nazarreta et al. 2021). There is one species of ant from genus *Odontomachus* that was found; *Odontomachus rixosus* has characteristics elongated mandible and straight, body has spare fine hairs, head oval, gaster oval and tapered (Figure 1b).

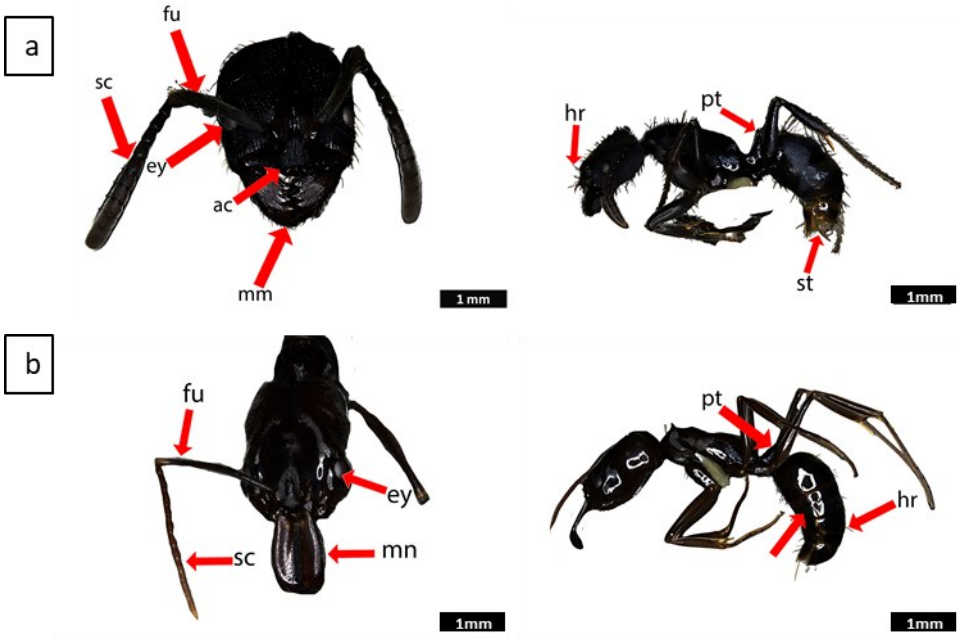


Figure 1. The ants form subfamily Ponerinae (a) *Odontoponera trasnversa*, (b) *Odontomachus rixosus*, (fu) funiculus of antenna, (sc) scape of antenna, (mn) mandible, (ey) eyes, (ac) anterior clypeal, (hr) hair, (st) sting, (pt) petiole, (g) gaster.

Subfamily Myrmicinae

The subfamily has 44 genera (Nazarreta 2017), but we found only three genera; *Crematogaster*, *Monomorium* and *Pheidole* (Figure 2). Characteristic subfamily Myrmicinae has two petioles, a pair of compound eyes which are small and round, the pronotum (the first segment of the mesosoma) is fused with the mesonotum (the second segment of the mesosoma).

Characteristic genus *Crematogaster* post-petiole attached to gaster, gaster viewed from above is roughly heart-shaped (Nazarreta et al. 2021). There are two species of ants that belong to the genus *Crematogaster* was found in this study; *Crematogaster* sp. 1 has characteristic gaster triangularis, rounded head and lot of fine hair, dark-black body (Figure 2a). Meanwhile, *Crematogaster* sp. 2 is characterised by an elongated oval gaster, elongated oval head and spare fine hairs, brownish body (Figure 2b).

Characteristics of the genus *Monomorium* antennae has 3 segment club, post-petiole at most is only slightly wider than long, and front mar-

gin of the clypeus has a single central elongated seta (Nazarreta et al. 2021). There is one species of ant that belongs to the genus *Monomorium*; *Monomorium* sp. 1 has the characteristics triangular mandible and elongated, elongated antennae, eyes clearly visible, antennae 10 segments (Figure 2c).

Pheidole has characteristic antennal scrobes absent, head behind the eye without elongated groove, pronotum forming a high dome like arch (Nazarreta et al. 2021). There is one species of ant that belongs to the genus *Pheidole* was found in this study; *Pheidole huberi* has triangular mandible and short, antenna 12 segments and short, head has strokes like fingerprints (Figure 2d).

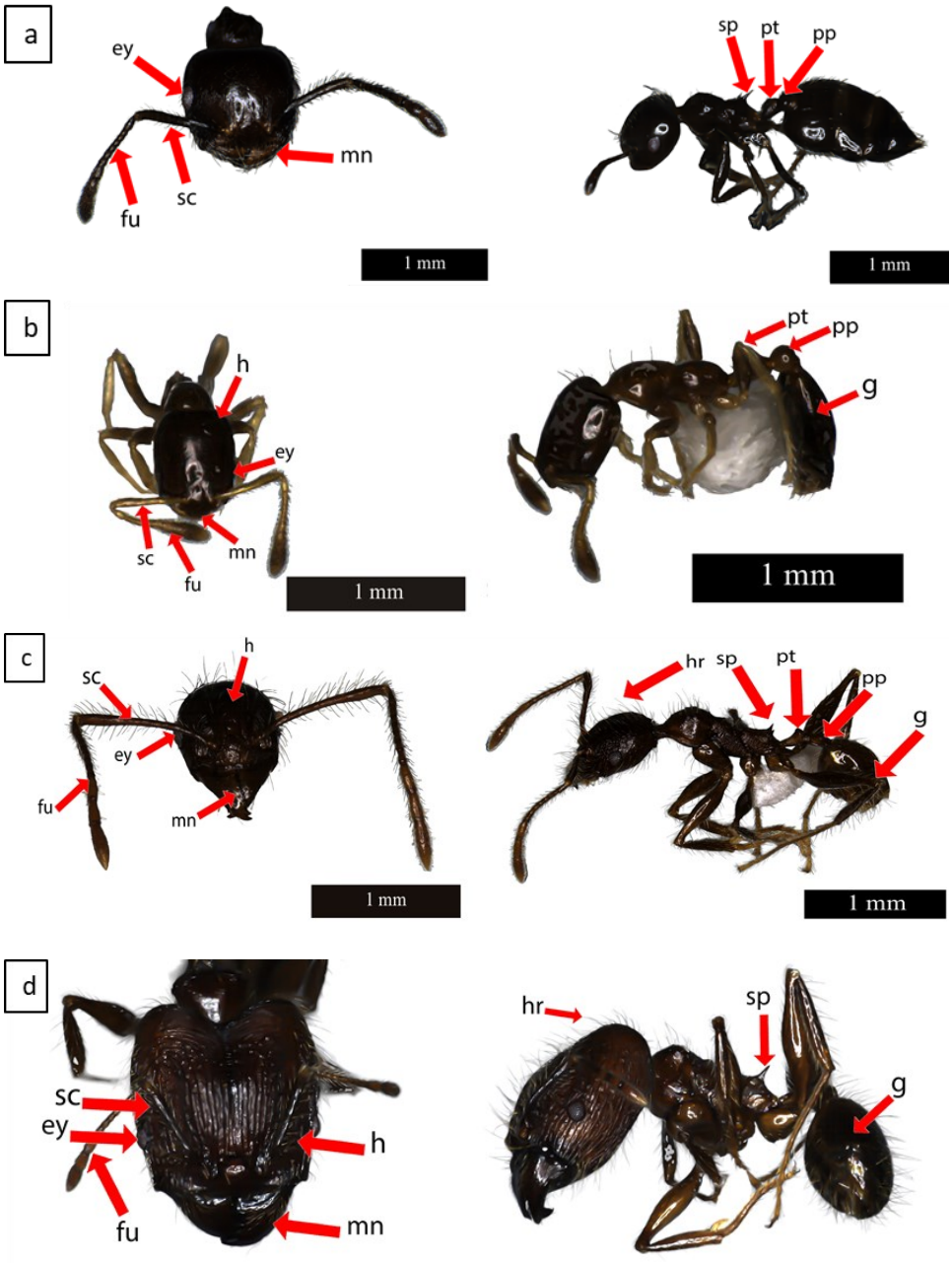


Figure 2. The ants from subfamily Myrmicinae (a) Crematogaster sp. 1, (b) Crematogaster sp. 2, (c) Monomorium sp., (d) Pheidole huberi, (ey) eye, (sc) scape of antenna, (fu) funiculus of antenna, (mn) mandible, (pt) petiole, (pp) postpetiole, (sp) spine, (h) head, (g) gaster, (hr) hair.

Subfamily Pseudomyrmecinae

Only has one genus *Tetraponera*. Characteristics subfamily Pseudomyrmecinae a pair of compound eyes large and elongated, two petioles, pronotum connected to mesonotum by flexible joints (Nazarreta 2017). There is one species was found in this study; *Tetraponera rufonigra* has characteristics head oval and black, thorax red and curved, gaster black (Figure 3).

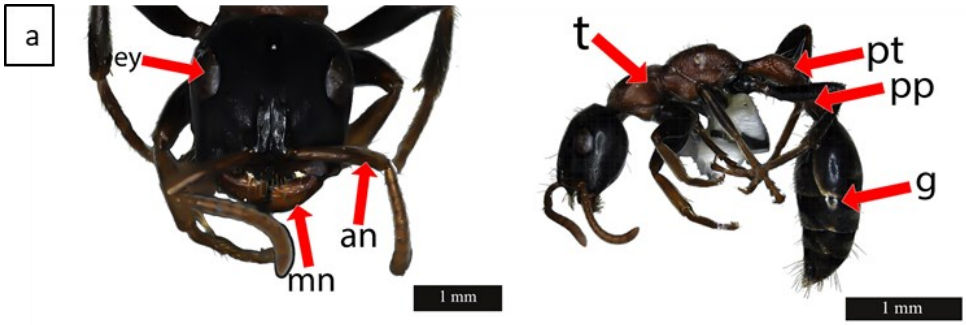


Figure 3. The ant from subfamily Pseudomyrmicinae (a) Tetraponera rufonigra, (mn) mandible, (an) antenna, (ey) eye, (pt) petiole, (pp) post-petiole, (g) gaster, (t) thorax.

Subfamily Dolichorinae

The subfamily has eight genera (Nazarreta 2017), but only genus *Tapinoma* was found in this study. Characteristic subfamily Dolichoderinae has one petiole, acidopore shaped like a slit without any hair around it. Characteristics genus *Tapinoma* petiole is overhung by the first gastral segment, gaster with 4 visible tergites, and the fifth tergite segment is reflected below the fourth (Nazarreta et al. 2021). Only one species was found in this study; *Tapinoma melanocephalum* has characteristic antenna 12 segments, mandible triangular, abdomen consists of 4 segments (Figure 4).

Figure 4. The ant from subfamily Dolichorinae (a) Tapinoma melanocephalum, (ey) eye, (mn) mandible, (sc) scape of antenna, (fu) funiculus of antenna, (pt) petiole, (g) gaster.

Subfamily Formicinae

The subfamily consists of 18 genera (Nazarreta 2017), but only five genera were found in this study; *Polyrhachis*, *Oecophylla*, *Anoplolepis*, *Camponotus*, and *Colobopsis*. Characteristic subfamily Formicinae, one petiole, has acidopore (reduction of the sting) which has short hairs on the edges.

Characteristics genus *Polyrhachis*; antenna 12 segments, mandible subtriangularis, first segment of the gaster smaller than half of the total length of the gaster (Nazarreta et al. 2021). There is only one species of ant that belongs to the genus *Polyrhachis* that is *Polyrhachis proxima*. Characteristics *Polyrhachis proxima* spine on mesosoma (pronotum),

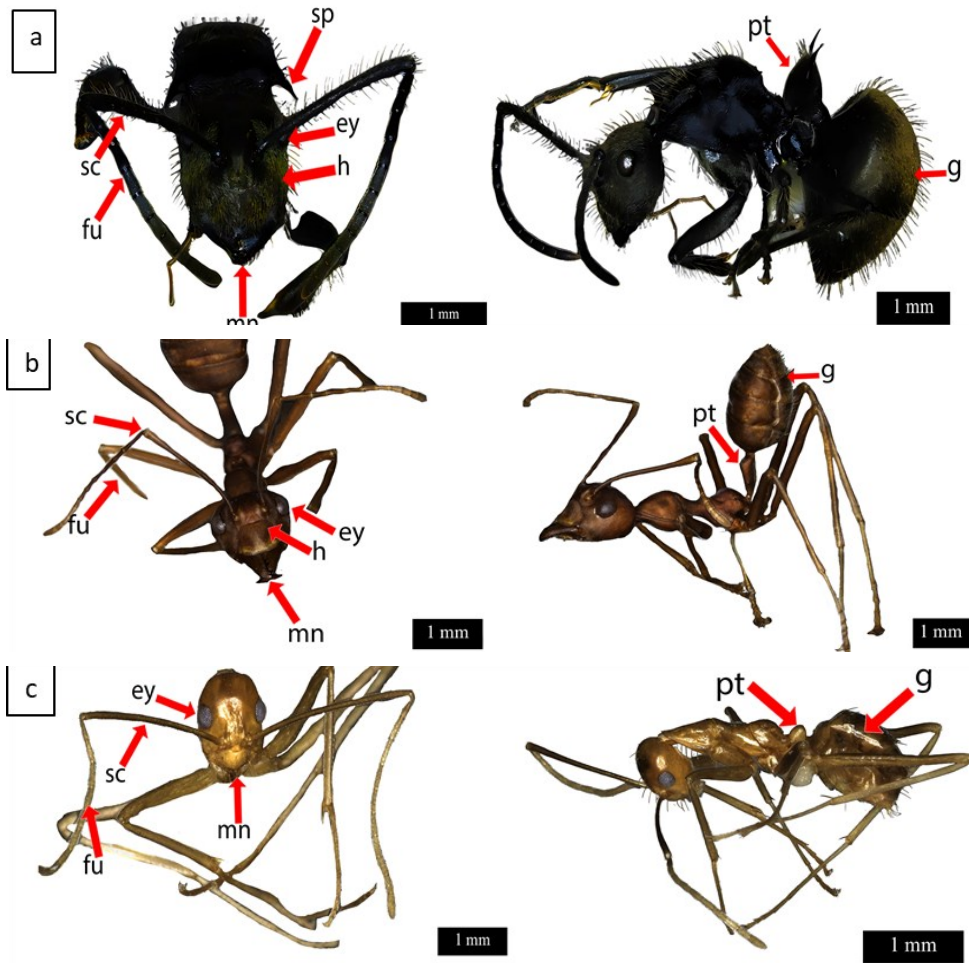
whole body lot of fine hair, body pitch black, gaster round and tapered (Figure 5a).

Characteristics of the genus *Oecophylla* antenna 12 segments, mandible subtriangularis, reduced petiole. Species of ant that belongs to the genus *Oecophylla* that is *Oecophylla smaragdina* has characteristics head without hair, elongated triangular mandible, small eyes that do not extend beyond the sides of the head (Figure 5b).

Characteristics *Anoplolepis* antenna 12 segments, mandible subtriangular, and pronotum elongated. There is one species found in this study, that belongs to the genus *Anoplolepis*; *Anoplolepis gracilipes* has characteristics head oval without hairs, pronotum elongated, long antennal scape (Figure 5c).

Characteristics of *Camponotus* antenna12 segments, mandible subtriangular, antennal socket separate from the clypeus. From this study was found 3 species of ants belonging to the genus *Camponotus* that are *Camponotus* sp. clypeus not clearly visible, whole body black (Figure 5d). *Camponotus arrogans* clypeus clearly visible, head and gaster solid black, mesosoma brown (Figure 5e). *Camponotus dolichoderoides* head heart-shaped, a lot of fine hairs, brown body (Figure 5f).

Characteristic *Colobopsis* having a strongly impressed metanotal groove, raised dorsal face of the propodeum, and compound eyes placed in a relatively posterior position on the head. There is one species was found in this study; *Colobopsis moeschi* has characteristic head oval, there are fine and sparse hairs, and has pale brown body, antennal insertions well separated, occur at about the midlength of the frontal carinae, and clypeus relatively narrow (Ward & Boudinot 2021) (Figure 5g).



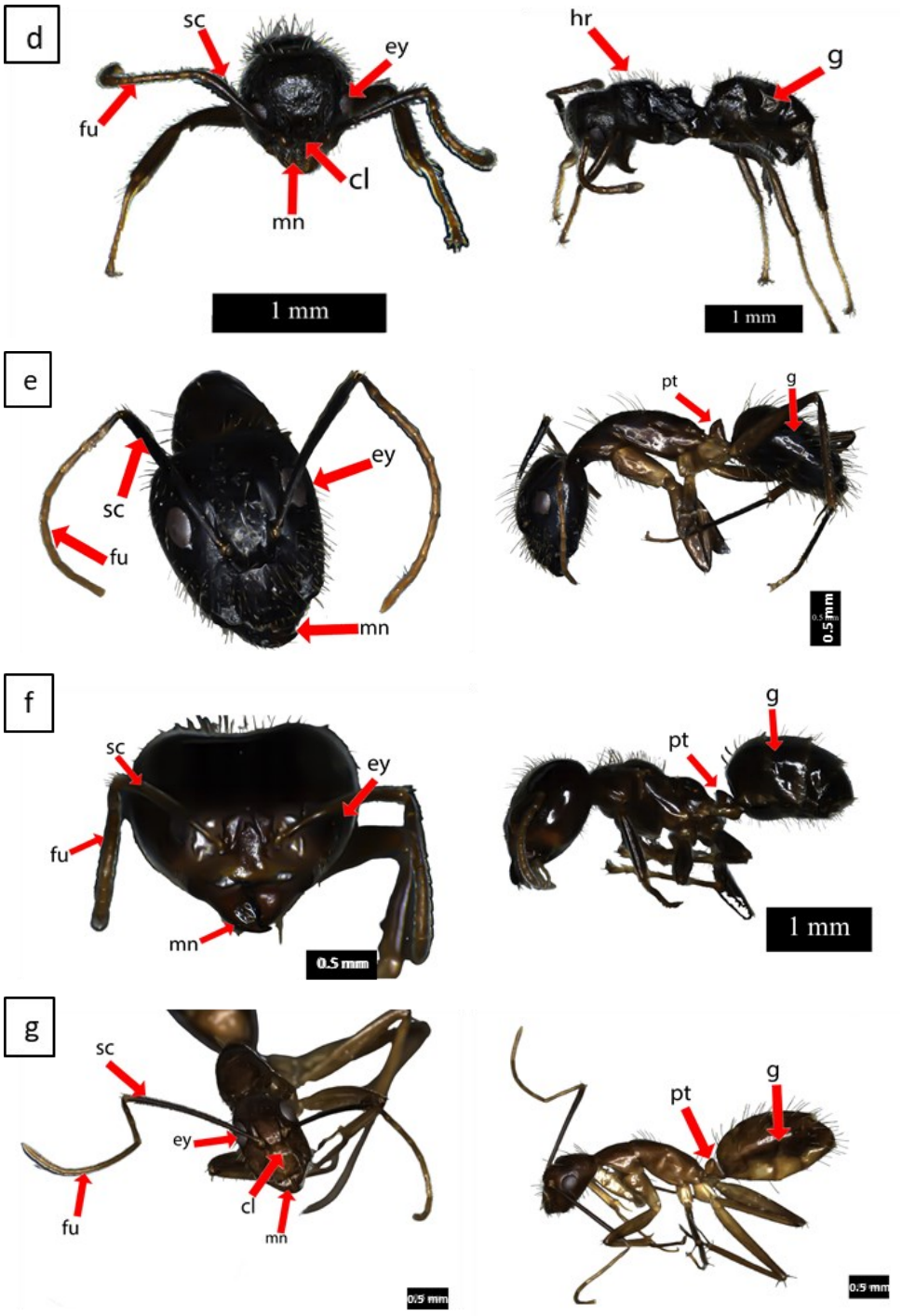


Figure 5. The ants from subfamily Formicinae (a) Polyrhachis proxima, (b) Oecophylla smaragdina, (c) Anoplolepis gracilipes, (d) Camponotus sp., (e) Camponotus arrogans, (f) Camponotus dolichoderoides, (g) Colobopsis moeschi, (mn) mandible, (sc) scape of antenna, (fu) funiculus of antenna, (ey) eye, (sp) spine, (g) gaster, (pt) petiole, (cl) clypeus, (hr) hair (h) head.

Based on the described morphological features, an identification key modified from Nazarreta et al. (2021) to the collected ant species is constructed as follows.

IDENTIFICATION KEY TO ANT SPECIES FROM SUNGAI MERAH VILLAGE SAROLANGUN JAMBI

1. a. Sting present **2**
   b. Sting absent **4**

2. a. Mesosoma attaches to abdomen through single segment (petiole), second segment of abdomen slightly curved, mandible varies from straight (linear) to triangular (Figure 1). .....**Ponerinae (5)**
   b. Mesosoma attaches to abdomen through two segments, has petiole and post petiole ***3***
3. a. Eyes present compound eyes small and round, two petioles, pronotum (first segment of mesosoma) fused with mesonotum (second segment of mesosoma) (Figure 2)..... ..... **Myrmicinae (6)**
   b. Eyes present very large and elongated, two petioles, pronotum connected to mesonotum by flexible joints (Figure 3). .....**Pseudomyrmicinae**; ***Tetraponera rufonigra***
4. a. Has petiole, acidopore (a reduction of the sting) which is shaped like a slit without any hair around it (Figure 4). ... .**Dolichorinae (9)**
   b. Has petiole, acidopore (reduction of the sting) which on the edges there are short hairs (Figure 5). ..... **Formicinae (10)**
5. a. Elongated mandible and straight, body has spare fine hairs, head oval, gaster oval and tapered (Figure 1b). .... ***Odontomachus rixosus***
   b. Short mandible and triangular, body has fine hair and is quite thick, rounded head and have strokes like fingerprints (Figure 1a). ..... ***Odontoponera transversa***
6. a. Antenna 10-11 segments, post-petiole attached to upper gaster (heart-shaped when viewed from above). **7**
   b. Antenna 10 - 12 segments, post-petiole attaches to front gaster (when viewed from above the gaster does not have shape like a heart). **8**
7. a. Gaster triangularis, head rounded and lot of fine hair, dark-black body (Figure 2a) ..... ***Crematogaster* sp. 1**
   b. Elongated oval gaster, elongated oval head and spare fine hairs, brownish body (Figure 2b). ..... ***Crematogaster* sp. 2**
8. a. Triangular mandible and elongated, elongated antennae, eyes clearly visible, antennae 10 segments (Figure 2c). .... ***Monomorium* sp.**
   b. Triangular mandible and short, antenna 12 segments and short, head has strokes like fingerprints (Figure 2d). .... ***Pheidole huberi***
9. a. Antenna 10-11 segments.
   b. Antenna 12 segments, mandible triangular, abdomen consists of 4 segments (Figure 4a). .... ***Tapinoma melanocephalum***
10. a. Antenna 9-11 segments, acidopore clearly visible **11**
    b. Antenna 12 segments, acidopore clearly visible, mandible consists of less than 10..... **12**
11. a. Head oval no hairs, pronotum elongated, long antennal scape (Figure 5c). .....***Anoplolepis gracilipes***
    b. Head no hair, elongated triangular mandible, small eyes do not extend beyond the sides of the head (Figure 5b). .... ***Oecophylla smaragdina***

12. a. Has spines on mesosoma (pronotum), whole body a lot of fine hair, body pitch black, gaster round and tapered (Figure 5a). ..... ***Polyrhachis proxima***
    b. No spines on mesosoma, varies of color **13**
13. a. Head rounded **14**
    b. Head not rounded **15**
14. a. Clypeus clearly visible, head and gaster solid black, mesosoma brown (Figure 5e). ..... ***Camponotus arrogans***
    b. Clypeus not clearly visible, whole body black (Figure 5d). ..... ***Camponotus* sp.**
15. a. Head heart-shaped, lot of fine hairs, brown body (Figure 5f). ..... ***Camponotus dolichoderoides***
    b. Head oval, there are fine and sparse hairs, body pale brown, antennal insertions well separated, occur at about the mid-length of the frontal carinae, and clypeus relatively narrow (Figure 5g). ..... ***Colobopsis moeschi***

The study showed that several species of ants can be found in rubber and oil palm plantations. There are several species of ants which can only be found in rubber plantations, and there are several species of ants which can only be found in oil palm plantations. According to Majeed et al. (2021) ants are cosmopolitan insects, and they can be found in various ecosystems, such as forests, wetlands, water sources, and dry land. Differences in the composition of ant species in a habitat are caused by differences in the response of ants to the habitat. Based on the research, it shows that *Camponotus* sp. is a species which exist only in the oil palm plantations, *Colobopsis moeschi*, *Oecophylla smaragdina*, *Polyrhachis proxima*, and *Tetraponera rufonigra* are the ant species which exist only in the rubber plantations. According to Nazarreta (2017) ants which can only be found in a particular ecosystem, depending on their ability to adapt to that environment, these types of ants are usually referred to as unique species. Therefore, *Camponotus* sp. is a unique species in the oil palm plantations while the unique species in the rubber plantations are *Colobopsis moeschi*, *Oecophylla smaragdina*, *Polyrhachis proxima*, and *Tetraponera rufonigra*.

Similar research on ant diversity had been conducted by Haneda and Yuniar (2015) which was conducted in Bungku Village, Jambi Province. Based on his research, as many as 50 species of ants were identified, belonging to 33 genera and 6 sub families. Siriyah (2016) had conducted research in the Seasonal Forest of Baluran National Park, East Java in which 40 species of ants were identified belonging to 19 genera and 4 subfamilies. Nazarreta et al. (2020) had been conducted a similar a study in Bukit Dua Belas National Park and Bukit Harapan National Park, based on their research it was reported that there are 76,641 ants belonging to 177 species from 7 subfamilies and 54 genera. Compared to these data, the diversity of ants in Sungai Merah Village is lowest.

The ants from genus *Camponotus* were the most numerous in this study, both in terms of the number of species and the number of individuals in both ecosystems. *Camponotus* has a wide distribution so it is very common to find them in large numbers. Ants of genus *Camponotus* can build their nests underground, in dead tree branches, in tree trunks, and plant roots. Ants of this genus are considered opportunistic and generalist in their nesting habits and food sources. Several species of this genus exhibit dietary habits that are eating plants as well as insect exudate, fallen fruit, and insects (Ronque et al. 2018). The ants from genus *Campono-*

tus are known to use crumbs as a source of food; besides, they are also known to be able to eat other insects which have died (Haneda & Yuniar 2020).

Ants from genus *Camponotus* can help control pests, Borbély & Nagy (2022) stated that *Camponotus* ants have a mutualistic symbiotic relationship with apple plants. The disturbing symbiosis of ants and fleas can cause a tremendous decrease in the abundance of fleas due to increased pressure on natural enemies on flea colonies. Moreover, ants from genus *Camponotus* are also known to have a symbiotic mutualism with various plants, since the ants come to the plants to look for nectar, at the same time the ants control pests in these plants (Agrawal & Rastogi 2010). Based on this point, ants from genus *Camponotus* can be used as an effective method which supports environmentally friendly pest control.

The study found several species of ants that have a role as predators such as, *Crematogaster* spp, *Odontomachus rixosus*, *Odontoponera transversa*, *Pheidole huberi*, *Tetraponera rufonigra*, *Tapinoma melanocephalum* and *Camponotus* spp. Haneda & Yuniar (2020) reported that there are several ants that have the potential to be predators in an ecosystem, they are ants from the genus *Odontomachus*, and *Pheidole*. Based on the study of Sholih et al. (2019) *Crematogaster* is the ant that can control *Pseudococcus* sp., bugs on coconut plantations and it has good potential to be used as a predator. According to Rubiana et al. (2015) *Tapinoma melanocephalum* is an invasive ant that can be found in rubber and oil palm plantations, this ant replaces the role of the original ants, due to land conversion and becoming a predatory ant. Moreover, according to Cao et al. (2022) *Odontoponera transversa* is known as a predator. Apart from playing a role as predators, some ants also play a role as foragers such as, the ants from the genera of *Anoplolepis*, *Camponotus*, *Monomorium* and *Polyrhachis* (Haneda & Yuniar 2020). The predatory behaviour of *Oecophylla smaragdina* towards *Pteroma pendula* was confirmed by (Pierre & Idris 2013). *Oecophylla smaragdina* also known as predator of bagworms (*Metisa plana*) in oil palm plantations (Exélis et al. 2023). In rubber plantations, *Oecophylla smaragdina* is known as predator of beetle *Luprops tristis* (Aswathi et al. 2011).

Based on the number of individual ants collected, it shows that the number of individual ants in the rubber plantations is less than the number of individual ants in the oil palm plantations, due to habitat disturbance by humans. The frequency of human activities is higher in the rubber plantations than in the oil palm plantations. Haneda & Yuniar (2015) stated that the activities conducted by humans in rubber plantations have a higher intensity, almost every day rubber farmers conduct tapping activities of rubber trees whereas in the ecosystem of oil palm plantations farmers harvest palm fruit every 2 weeks and care routinely conducted within 4-6 months, relatively long intervals can provide an opportunity for disturbed ant communities to recover.

According to Yaherwandi et al. (2019) habitat modification and forest conversion into rubber and oil palm plantations changes the ant community structure. Habitat changes and disturbances can change the composition of ants by affecting changes in the interaction of tropical ecosystems and food webs. Conversing the land from forests into industrial forest affects the biodiversity of predatory insects, especially ants. The richness and diversity of ant species increase with temperature, and they decrease with decreasing rainfall and altitude. Ants are also sensitive to environmental disturbances. Therefore, ants are often used as bioindicators of health and ecosystem function (Nooten et al. 2019).

Table 2. Analysis of Diversity Index and Evenness Index.

Index Analysis	Sampling Location	
	Rubber Plantations	Oil Palm Plantations
Diversity (H')	1.44	0.99
Evenness (E)	0.54	0.41

The diversity index calculated using the Shannon – Wienner diversity index shows the result that the ant species diversity index in the rubber plantations is moderate with a value of 1.44 while the ant diversity index in the oil palm plantation is relatively low with a value of 0.99. The purpose of calculating this index is to determine the degree of diversity of an organism in an ecosystem. Furthermore, the parameters which are used to determine the diversity index value in an ecosystem are determined by the number of species and the relative abundance of species in an ecosystem. The results of the analysis which had been conducted show that the rubber plantations are more stable when compared to the oil palm plantations. It is not in line with the research which had been conducted by Yaherwandi et al. (2019) that the biodiversity of ants in oil palm plantations is higher than in rubber plantations, secondary forest, and primary forest. This discrepancy can be caused by several factors such as, temperature and humidity so that the diversity of ants in the rubber plantations is more stable.

In our study, low ant diversity in the oil palm ecosystem was affected by domination of one species of ant *Camponotus* sp. The species is only found in the palm oil plantations with the number of individuals reaching 15,513 which is equivalent to 90.1% of the total number of ants found in the rubber plantations. It corroborates the statement of Putra et al. (2021) that diversity is high if the number of individuals of each species found does not occur in inequality one of the species. Otherwise, if it is composed of only one species or only a few species, then the diversity is low. Diversity can also be said to be low if there are several species but with an unequal number of individuals. The existence of a high number of individuals in one species found can also cause a low value of the diversity index at that location.

Calculation of the evenness index shows that the evenness of the ant population in the rubber plantations is moderate with a value of 0.54 while the evenness of the ant population in the oil palm plantations is relatively low with a value of 0.41. It shows that the distribution of individuals in the rubber plantations is more even when compared to the oil palm plantations. Krebs (2014) stated that evenness values range from 0-1 and it is divided into several categories, such as, low community category with a value of less than 0.5; unstable category with a value of 0.5-0.75; and stable category with a value of 0.75-1.

The results of the t-test show that the diversity (H') and evenness (E) of ants in each plot in the rubber and oil palm plantations do not show a significant difference. It shows that there is no significant difference in the factors which support the existence of ants in the two ecosystems. In addition, factors which support ants to live and develop in an ecosystem include sufficient food sources, places to nest and microclimate (Andersen 1995).

Environmental parameter measurements showed that ants can still be found in an ecosystem that have soil temperatures in the range of 25.6 – 27°C. air temperatures in the range of 27.7 – 31.7°C. soil moisture in the range of 36.7 – 73.3% and humidity in the range of 71 – 89%. Based on Riyanto (2007) the optimal and tolerance temperature range for ants in the tropics ranges from 25 – 32°C. Some ants leave the nest to find

Table 3. Measurement of environmental parameters in the rubber and oil palm plantations.

Plot	Environmental Parameters				
	Soil Temperature (°C)	Air temperature (°C)	Soil moisture (%)	Humidity (%)	pH
RP 1	26.3±2.1	28.7±3.6	40.0±17.3	81.0±9.2	6.3±0.3
RP 2	26.3±2.6	31.7±8.7	56.7±5.8	71.0±21.6	5.9±0.1
RP 3	25.6±2.6	28.3±4.1	46.7±5.8	88.7±3.1	6.3±0.1
RP 4	26.3±1.6	27.7±3.1	50.0±0.0	89.0±2.7	6.6±0.0
OPP 1	27.0±2.7	29.3±3.8	36.7±5.8	83.7±8.0	6.8±0.0
OPP 2	26.3±1.6	29.0±3.7	73.3±5.8	78.0±14.7	6.4±0.2
OPP 3	27.0±1.8	29.0±3.5	43.3±5.8	77.7±15.6	6.5±0.2
OPP 4	26.3±2.1	29.3±3.8	70.0±0.0	79.3±12.0	6.46±0.1

food at a surface temperature of 10 - 45°C. According to Latumahina et al. (2015) the average temperature and humidity which can affect the distribution and development of ants is at 27°C and 85% humidity. At a too high temperature, several physiological processes such as reproduction, metabolism, and respiration of ants will be disrupted. The air temperature suitable for the growth of ant ranges from 15 - 27°C, where higher temperatures are tolerable if there is a sufficient shade with optimal humidity. Ants are known to prefer a cool, humid, and not too hot air for their daily activities and reproduction (Shattuck 2000). In addition, the ideal pH value for ants to live and grow is 4.5 – 6.8 (Suin 1997).

The results of the ANOVA one way show that the environmental parameters which have a significant difference between the ecosystems were soil moisture and pH. It implied that soil moisture and pH have a role in the presence of ants in the ecosystem of rubber plantations and oil palm plantations in Sungai Merah Village.

CONCLUSIONS

Based on the study, 15 species of ants have been identified in the ecosystem of rubber plantations and oil palm plantations in Sungai Merah Village. Based on the diversity analysis (H') the diversity of ants in the rubber plantations ecosystem is more stable compared to the diversity of ants in the oil palm ecosystem. Based on the evenness analysis (E), the evenness of ants in the rubber plantations is medium and in oil palm plantations the evenness of ants is low.

The ants found in both of plantations have an important role for the ecosystem, some species play a role as predator (*Crematogaster* spp, *Odontomachus rixosus*, *Odontoponera transversa*, *Pheidole huberi*, *Tetraponera rufonigra*, and *Tapinoma melanocephalum*), meanwhile the ants from the genera *Anoplolepis*, *Camponatus* spp., *Monomorium*, and *Polyrhachis* play a role as foragers, *Oecophylla smaragdina*, *Camponotus* spp., *and Crematogaster* also known as biological control agents in the ecosystem.

AUTHOR CONTRIBUTION

Research concept, design, collected, data analysis, manuscript drafting: N.L.F., supervised all the processes, reviewed, and proofread the final manuscript: H.P., former supervisor, review research design: R.C.H.

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CONFLICT OF INTEREST

The authors declare no conflict of interest related to this work.

REFERENCES

Agrawal, V.M. & Rastogi, N., 2010. Ants as dominant insect visitors of the extrafloral nectaries of sponge gourd plant, *Luffa cylindrica* (L.) (Cucurbitaceae). *Asian Myrmecology*, 3, pp.45-54.

Andersen, A.N., 1995. A classification of Australian ant communities, based on functional groups which parallel plant life-forms in relation to stress and disturbance. *Journal of biogeography*, 22 (1), pp.15-29. doi: 10.2307/2846070

Aswathi, P. & Sabu, T.K., 2011. Weaver ant (Oecophylla smaragdina), huntsman spider (Heteropoda venatoria) and house gecko (Hemidactylus frenatus) as potential biocontrol agents of the nuisance pest, Luprops tristis. *Halteres*, 3(3), pp.56-61.

Bilkis, F.G., Chozin, M.A. & Guntoro, D., 2022. Pergeseran dominasi gulma kebun kelapa sawit IPB Jonggol, dan kemungkinan resistensi terhadap herbisida glifosat. *Indonesian Journal of Agronomy*, 50(1), pp.115-122. doi: 10.24831/jai.v50i1.39921

Bolton, B., 1994. *Identification guide to the ant genera of the world*. Cambridge (UK); Harvard University Pr.

Borbély, C. & Nagy, C., 2022. Providing sugar sources for ants improves the biological control of Aphis spp. in apple orchards. *Biological Control*, 175. doi: 10.1016/j.biocontrol.2022.105056

BPS Jambi. Luas Tanaman Perkebunan Menurut Jenis Tanaman (Hektar), 2018-2020, viewed 6 January 2021 from https://jambi.bps.go.id/indicator/54/514/1/luas-tanaman-perkebunan-menurut-jenis-tanaman-.html.

Cao, Q. et al., 2022. Differentiated impacts of the feeding-habits of three ant species on carbon mineralization in tropical forest soils. *European Journal of Soil Biology*, 110. doi: 10.1016/j.ejsobi.2022.103403

Exélis, M.P. et al., 2023. Foraging Behaviour and Population Dynamics of Asian Weaver Ants: Assessing Its Potential as Biological Control Agent of the Invasive Bagworms Metisa plana (Lepidoptera: Psychidae) in Oil Palm Plantations. *Sustainability*, 15(1), pp.780. doi: 10.3390/su15010780

Haneda, N.F. & Yuniar, N., 2015. Komunitas Semut (Hymenoptera: Formicidae) pada Empat Tipe Ekosistem yang Berbeda di Desa Bungku Provinsi Jambi. *Jurnal Silvikultur Tropika*, 6(3), pp.203-209.

Haneda, N.F. & Yuniar, N., 2020. Peranan Semut di Ekosistem Transformasi Hutan Hujan Tropis Dataran Rendah. *Jurnal Ilmu Kehutanan*, 14, pp.16-2. doi: 10.22146/jik.57459

Harwanto, H. et al., 2020. Explorasi Dan Studi Komposisi Botani Gulma Di Perkebunan Karet Ptpn IX Kebun Getas Sebagai Pakan Ternak Ruminansia. In *Prosiding Seminar Nasional Teknologi Agribisnis Peternakan (STAP)*, 7, pp.699-700.doi: 10.46549/jipvet.v11i1.133

Hashimoto, Y. & Rahman, H. 2003. *Manual for Bornean Ant (Formicidae) Identification*. Universitas Malaysia Sabah, Kinabalu.

Hidayat, S. & Yohanes, V.A., 2007. Strategi Pengembangan Kawasan Agroindustri Terintegritas yang Berbasis Ekspor di Provinsi Jambi. *EKO-REGIONAL*, 2(1), pp.1-8. doi: 10.20884/1.erjpe.2007.2.1.384

Krebs, C.J., 2014. *Ecology: The Experimental Analysis of Distribution and Abundance 6th Edition*.

Latumahina, F. et al., 2015. Respon semut terhadap kerusakan antropogenik dalam hutan lindung sirimau ambon (Ants Response to Damage Anthropogenic in Sirimau Forest Ambon). *Jurnal Manusia dan Lingkungan*, 22(2), pp.169-178. doi: 10.22146/jml.18739

Majeed, W., Khawaja, M. & Rana N., 2021. Assessing Fluctuation of Ant Populations in a Distinct Ecological Habitat to Track Climate Change Effects. *BIODIVERSITAS: Journal of Biology Diversity*, 22 (5), pp.2722-2727. doi: 10.13057/biodiv/d220533

Nazarreta, R. et al., 2021. A guide to the ants of Jambi (Sumatra, Indonesia): Identification key to ant genera and images of the EFForTS collection. doi: 10.14203/press.273

Nazarreta, R. et al., 2020. Rainforest conversion to smallholder plantations of rubber or oil palm leads to species loss and community shifts in canopy ants (Hymenoptera: Formicidae). *Myrmecological News*, 30, pp.175-186. doi: 10.25849/myrmecol.news_030:175

Nazarreta. R., 2017. Keanekaragaman dan Identifikasi Semut Arboreal di Lanskap Hutan Harapan dan Taman Nasional Bukit Duabelas, Jambi. Institut Pertanian Bogor.

Nooten, S. et al., 2019. Habitat complexity affects functional traits and diversity of ant assemblages in urban green spaces (Hymenoptera: Formicidae). *Myrmecological News*, 29, pp.67-77. doi: 10.25849/myrmecol.news_029:067

Pawar, S.L., 2014. Formicidae: Occurance and its role in ecosystem functioning. *Flora and Fauna*, 20(1).

Pierre, E.M. & Idris, A.H., 2013. Studies on the predatory activities of *Oecophylla smaragdina* (Hymenoptera: Formicidae) on *Pteroma pendula* (Lepidoptera: Psychidae) in oil palm plantations in Teluk Intan, Perak (Malaysia). *Asian Myrmecology*, 5(1), pp.163-176.

Putra, I.L.I., Setiawan, H. & Suprihatini, N., 2021. Keanekaragaman jenis semut (Hymenoptera: Formicidae) di sekitar kampus 4 Universitas Ahmad Dahlan Yogyakarta. *Biospecies*, 14(2), pp.20-30. doi: 10.22437/biospecies.v14i2.12905

Rawal, D., 2020. A report on various benefical roles of insects. *International Journal of Entomology Research*, 5(1), pp.15-17.

Riyanto., 2007. Kepadatan, pola distribusi dan peranan semut pada tanaman di sekitar lingkungan tempat tinggal. *Jurnal Penelitian Sains*, 10(2), pp.241-253. doi: 10.56064/jps.v10i2.445

Ronque, M.U.V., Fourcassie, V. & Oliveira, P.S., 2018. Ecology and Field Biology of Two Dominant *Camponotus* Ants (Hymenoptera: Formicidae) in the Brazilian Savannah. *Journal of Natural History*, 52(3-4), pp.237-252. doi: /10.1080/00222933.2017.1420833

Roza, S., 2018. Keanekaragaman Semut (Hymenoptera: Formicidae) pada Beberapa Jenis Ekosistem Perkebunan di Dharmasraya. Universitas Andalas Padang.

Rubiana et al., 2015. Agricultural land use alters species composition but not species richness of ant communities. *Asian Myrmecology*, 7(1), pp.73-85. doi: 10.20362/am.007008

Shattuck, S.O., 2000. *Australian ants: their biology and identification* (Vol. 3). CSIRO publishing.

Sholih, M.B. et al., 2019. Pengaruh tipe penggunaan lahan dalam membentuk komunitas semut dan layanan ekosistem yang diberikan. *Jurnal Entomologi Indonesia*, 16(2), pp.83-83. doi: 10.5994/jei.16.2.83

Siriyah, S.L., 2016. Keanekaragaman dan dominansi jenis semut (Formicidae) di hutan musim Taman Nasional Baluran Jawa Timur. *Biota: Jurnal Ilmiah Ilmu-Ilmu Hayati*, 1(2), pp.85-90. doi: 10.24002/biota.v1i2.995

Suin, N.M., 1997. Ekologi Fauna Tanah. *Jakarta: Bumi Aksara.*

Swift, M. & David, B., 2001. *Standard Methods for Assessment of Soil Biodiversity and Land Use Practice.* International Centre for Research in Agroforestry. Bogor, Indonesia.

Ward, P.S. & Boudinot, B.E., 2021. Grappling with homoplasy: taxonomic refinements and reassignments in the ant genera Camponotus and Colobopsis (Hymenoptera: Formicidae). *Arthropod Systematics & Phylogeny*, 79, pp.37-56. doi: 10.3897/asp.79.e66978

Worboys, G., Wendy, L.F., & Michael, L., 2010. Connectivity Conservation Management: A Global Guide (with Particular Reference to Mountain Connectivity Conservation). Britania Raya: Earthscan.

Wielgoss, A. et al., 2010. Temperature and a dominant dolichoderine ant species affect ant diversity in Indonesian cacao plantations. *Agriculture, Ecosystems & Environment*, 135(4), pp.253-259. doi: 10.1016/j.agee.2009.10.003

Yaherwandi et al., 2019. The Influence of Forest Ecosystems to Ant Community on Smallholder Oil Palm Plantations at Dharmasraya Regency, West Sumatera Indonesia. *IOP Conference Series: Earth and Environmental Science*, 347(1). doi: 10.1088/1755-1315/347/1/012104