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Ant species composition in *Macaranga* spp. trees at a conservation forest of palm oil plantation in West Sumatra, Indonesia

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Abstract
This study was aims to investigate the ant species composition in *Macaranga* spp. trees at Conservation Forest of Palm Oil Plantation of Tidar Kerinci Agung Company in West Sumatra Province by using Colony Collections and Hand Collections methods. A total of 28 species of ants that belonging to five subfamilies, 10 tribes, 17 genera and 5277 individuals was collected from five species of *Macaranga* (31 individuals of *Macaranga* trees). Myrmicinae and Formicinae were the highest in number of species (10 species respectively), followed by Ponerinae and Dolichoderinae (three species respectively), meanwhile Dorylinae only one species. *Crematogaster* (*Decacrema*) *borneensis* Andre, 1896 was the species with the most frequently among samples, accounting for 100% of species occurrences. Shannon-Wiener Diversity Index for all samples collected was low (0.94).

Keywords: Ants, *Macaranga* spp., *Crematogaster* spp., Conservation Forest

1. Introduction
Ants are highly eusocial insects that belonging to the family Formicidae of the order Hymenoptera. Approximately about 20.000 ant species living in the world and were classified into 16 subfamilies [2, 3]. Ants are an ideal organism for biodiversity studies since this insect usually high in diversity, numerical and biomass. Ants are dominant in almost every habitat, easy to collect, stationary nesting habits that allow them to be resample over time, sensitive to environmental change and have several interactions with other organism at every tropic level [1].
The research about ants was not just limited to the taxonomy, ecology, diversity, but also on the interactions of ants with plants. Some plant species depend on other organism, mainly animals, for anti-herbivore defenses [6, 24]. In this type of defense system, which is called biotic defense, the plants attract other organism to protect them from the herbivore attacks [21]. Mutual interactions between ants and plants are widespread phenomenon, with plants provided housing or food for ant meanwhile plant will receive the protection from other herbivores [4].
There are three main types of ant-plant association i.e. non-myrmecophytic species, incipient myrmecophytes and obligate myrmecophytes. *Macaranga* (Euphorbiaceae) is the only genus of plant in Asia with a substantial of myrmecophytes [11]. There are approximately 23 of myrmecophytic of *Macaranga* species had known from the Malay Archipelago. The plants have developed a complex set of associations with ants, involving numerous plant and ant species. *Macaranga* comprises a range of species, from those not inhabited by ants to obligate myrmecophytes [13, 14, 16].
The myrmecophytic species are usually associated with specific ants from the genus of *Crematogaster*, which live within the stem internodes of their plant-partners where they cultivate trophobiotic coccids [11, 30]. Myrmecophytic complex is more diverse, and involves a much variation in life types and species diversity, e.g., *Camponotus* ants of the subgenus *Colobopsis* which utilize food bodies but do not keep coccids [15].
The information about ant plant interaction from West Sumatra is very limited except the composition of ants in banana with Banana Bunchy-Top Virus (BBTV) symptom [22]. Palm oil plantation of Tidar Kerinci Agung (TKA) Company has an area that covered of 2400 ha of conservation forest. Conservation forests develop a nursery with 60 kinds of plant seedling to be planted in the forest area [29]. The aims of this research are to analyze the composition of the ant species among *Macaranga* spp. trees as one of mainly pioneer tree species in this conservation forest.

2. Materials and Methods

Study Area: Ants were collected in Conservation Forest of TKA Company that covered the area of Solok Selatan District and Dharmasraya District in West Sumatera Province.

Ant Collection: Ant was collected by using Colony Collections and Hand Collections methods from October 22 to October 27, 2014 in a mixed conservation forest and oil palm plantation of TKA company at two sites (Miniature Forest and IPK4 Forest) (Figure. 1). Ant colonies were collected by cutting about three set of 30 cm branches of *Macaranga* spp., put it into plastic bag (30 x 50 cm) and bring it to laboratory. Ants from each branch was collected by forceps then kept in vial with 96% ethanol. Hand Collections was conducted by using forceps to collect directly the foraging ant from stem and other part of *Macaranga.*

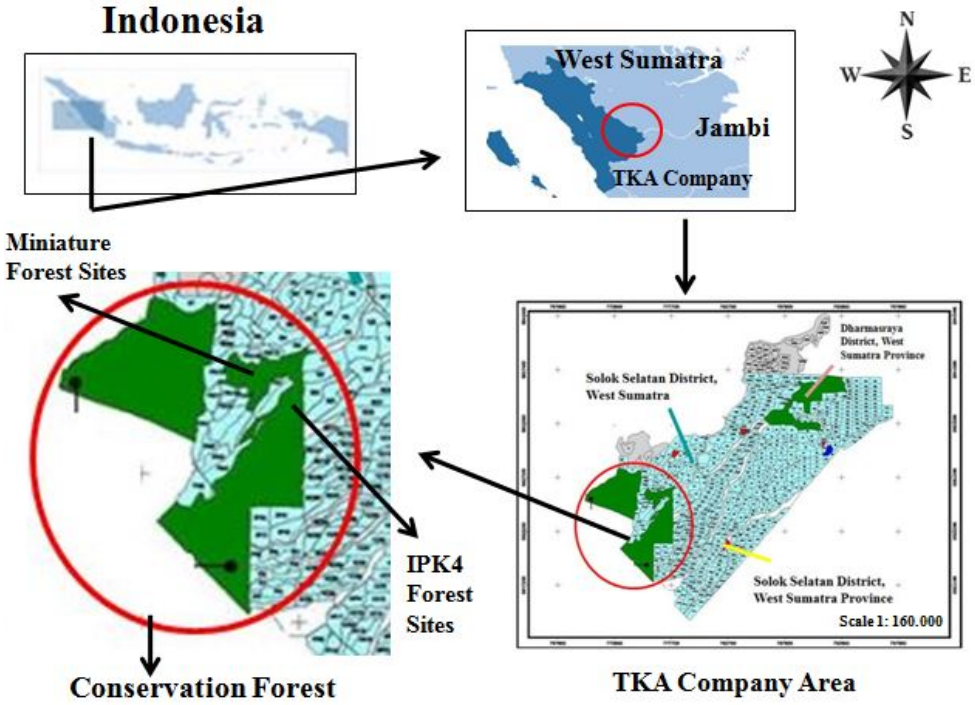

Fig 1: Map of study area at conservation forest of Palm Oil Plantation of TKA Company, West Sumatra Province, Tidar Kerinci Agung Company.

Ant Identification: Ant specimens were identified by using the identification guides [2, 20, 26]. Identification of ant species was also confirmed by direct comparison with reference materials deposited in the Laboratory of Animal Taxonomy, Department of Biology, Andalas University, Padang, West Sumatra. If specimens could not identified to species level by using the identification guides and also difference from the reference materials, we wrote morphospecies with additional code as HH (Henny Herwina) or SKY (Seiki Yamane). The species diversity indices, similarity indices, and cumulative number were counted for ant species among the different *Macaranga* species. The specimen was deposited in Laboratory of Animal Taxonomy of Biology Department, Andalas University, Padang, West Sumatra.

Data Analyses: The list of ant species that found in each *Macaranga* shows in table 1. All ants of one species, which were found in *Macaranga* trees (the proportion of species/*Macaranga* occurrences), were counted as one species occurrence (SOC), whereas a sample comprised all species collected in *Macaranga* trees. The Shannon-Wiener function was used to calculate the species diversity indices of the ants living in each *Macaranga* as follows:

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

H′ = Index of species diversity; pi = Proportion of the total sample belonging to i^{th} species [27].

To measure the similarity between two community samples, the coefficient of Sorensen was calculated as follows:

$$QS = \frac{2C}{A+B} \times 100\%$$

Qs = Sorensen's similarity coefficient; C = number of species in sample A and sample B (joint occurrences); a = number of species in sample A but not in sample B; B = number of species in sample B but not in sample A.

We used Estimate S Vers. 9.0 for the calculation of rarefaction curves of observed and estimated number of ant species among *Macaranga* species [7].

3. Results and Discussion

Ants were collected from 31 individuals of *Macaranga* trees that belonging to five species of *Macaranga* i.e. *M. depresa* (Müll Arg), *M. gigantea* (Reichb.F. & Zoll.), *M. hypoleuca* (Reichb.F. & Zoll.), *M. tanarius* (L.) Müll.Arg and *M. triloba* (BI.) Müll.Arg. *(*Figure 2). A total of 28 species of ants that categorized to five subfamilies, 11 tribes, 17 genera and 5277 individuals were collected. Myrmicinae and Formicinae were the highest in number of species (10 species respectively), followed by Ponerinae and Dolichoderinae (three species respectively), meanwhile Dorylinae only one species (Table 1 and Figure 3).

Camponotus and *Crematogaster* were the genus with the highest in number of species (four species respectively) followed by *Dolichoderus* and *Pheidole* (three species respectively). *Crematogaster* was predicted can build nests in the trunk of *Macaranga*. These ants were found while foraging and making nest in the hollow of tree trunks and branches. About 12 genera of ants were found only one species i.e. *Tapinoma*, *Aenictus*, *Echinopla*, *Anoplolepis*, *Euprenolepis*, *Nylanderia*, *Pheidologeton*, *Meranoplus*, *Paratopula*, *Diacamma*, *Leptogenys* and *Odontoponera*. These genera were predicted as visitor on *Macaranga* tree because of the biology of some genus known as generalized foragers and predator [1] (Table 1).

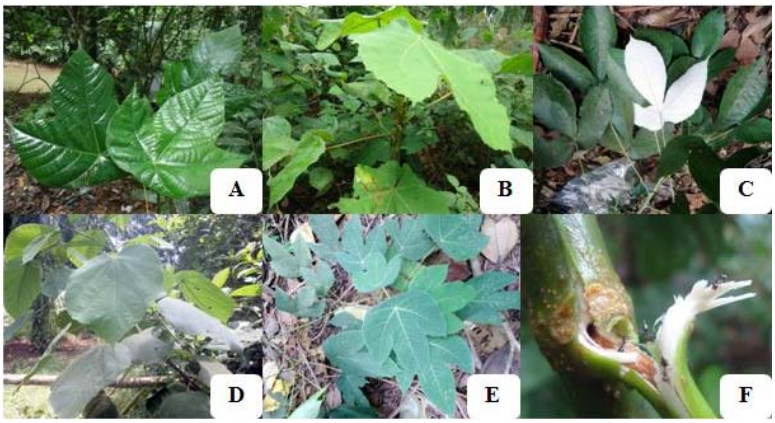

Fig 2: *Macaranga* species that were found at conservation forest of Palm Oil Plantation of TKA Company. A: *Macaranga depresa*, B: *Macaranga gigantea*, C: *Macaranga hypoleuca*, D: *Macaranga tanarius*, E: *Macaranga triloba* and F: Ants that were found in the hollow of *Macaranga* tree.

The highest number of individual of ant species was found in *Macaranga* spp. i.e *Crematogaster* (*Decacrema*) *borneensis* (2941 individuals), followed by *Crematogaster* (*Paracrema*) *modiglani* (2092 individuals) (Figure 4). Species of *Crematogaster* (*Decacrema*) *borneensis* was collected from five species and 31 individual of *Macaranga* trees meanwhile *Crematogaster* (*Paracrema*) *modiglanii* was collected from five species and 20 individual of *Macaranga* trees. The highest number of individual of those species probably because of there was a symbiotic mutualism between *Crematogaster* (*Decacrema*) spp. and *Crematogaster* (*Paracrema*) with *Macaranga* occurred. Previous study only reported about mutualism between *Crematogaster* (*Decacrema*) spp. and *Macaranga* [13, 14, 25, 31].

About 12 species of ant in this study were found only one individual i.e. *Dolichoderus* (*Hypoclinea*) cf. *thoracicus*, *Dolichoderus* sp. 45 of SKY, *Tapinoma melanocephalum*, *Camponotus* (*Myrmamblys*) *bedoti*, *Camponotus* (*Tanaemyrmex*) *festinus*, *Echinopla melanarctos*, *Nylanderia* sp. 1 of HH, *Pheidole* sp. 9 of HH, *Crematogaster* cf. *rogenhoferi*, *Paratopula* sp. of HH, *Diacamma holocericum* and *Leptogenys diminuta* (Figure 5). This trend probably because they just visiting or foraging in *Macaranga* during sampling activities (Hand Collection).

Table 1: List of the ant species (Hymenoptera: Formicidae) in *Macaranga* spp. trees at conservation forest of Palm Oil Plantation of TKA Company (1: *M. depressa*, 2: *M. gigantea*, 3: *M. hypoleuca*, 4: *M. tanarius* and 5: *M. triloba*; N: total number of individuals; SOCs: Species Occurrences; M: mean number of individuals per occurrence; RF: Relative Frequency).

No	Species	1	2	3	4	5	N	SoCs	M	RF (%)
	Dolichoderinae									
	Dolichoderini									
1	*Dolichoderus (Hypoclinea) thoracicus* (F. Smith, 1860)		1		4	92	97	6	16.17	19.35
2	*Dolichoderus (Hypoclinea)* cf. *thoracicus* (F. Smith, 1860)					1	1	1	1	3.23
3	*Dolichoderus* sp. 45 of SKY		1				1	1	1	3.23
	Tapinomini									
4	*Tapinoma melanocephalum* (Fabricius, 1793)				1		1	1	1	3.23
	Dorylinae									
	Aenictini									
5	*Aenictus sundalandensis* Jaitrong and Yamane, 2013					16	16	2	8	6.45
	Formicinae									
	Camponotini									
6	*Camponotus* (*Myrmamblys*) *bedoti* Emery, 1893		1				1	1	1	3.23
7	*Camponotus (Myrmosaulus) camelinus* (F. Smith, 1857)		3			1	4	2	2	6.45
8	*Camponotus (Tanaemyrmex) festinus* (F. Smith, 1857)			1			1	1	1	3.23
9	*Camponotus (Tanaemyrmex) odiosus* (Forel, 1886)	1				2	3	2	1.5	6.45
10	*Echinopla melanarctos* Smith, 1857	1					1	1	1	3.23
11	*Polyrhachis (Myrma) proxima* Roger, 1863				2		2	1	2	3.23
12	*Polyrhachis (Polyrhachis) olybria* Forel, 1912		3				3	1	3	3.23
	Lasiini									
13	*Anoplolepis gracilipes* (F. Smith, 1857)	4			2	7	13	8	1.63	25.81
	Plagiolepidini									
14	*Euprenolepis procera* (Emery, 1900)		1			5	6	4	1.5	12.90
15	*Nylanderia* sp. 1 of HH				1		1	1	1	3.23
	Myrmicinae									
	Attini									
16	*Pheidole* sp. 1 of HH					2	2	1	2	3.23

17	*Pheidole* sp. 3 of HH				15	1	16	2	8	6.45
18	*Pheidole* sp. 9 of HH				1		1	1	1	3.23
	Crematogastrini									
19	*Crematogaster (Decacrema) borneensis* Andre, 1896	651	8	296	38	1948	2941	31	94.87	100
20	*Crematogaster (Paracrema) modiglianii* Emery, 1990	19	18	157	99	1799	2092	20	104.6	64.52
21	*Crematogaster* (*Physocrema*) *sewardi* (Forel, 1901)		2			4	6	2	3	6.45
22	*Crematogaster* cf. *rogenhoferi* Mayr, 1879			1			1	1	1	3.23
23	*Pheidologeton* cf. *affinis* (Jerdon, 1851)			1	34	3	38	3	12.67	9.68
24	*Meranoplus mucronatus* F. Smith, 1857				24		24	2	12	6.45
	Paratopulini									
25	*Paratopula* sp. of HH		1				1	1	1	3.23
	Ponerinae									
	Ponerini									
26	*Diacamma holosericeum* (Roger, 1860)			1			1	1	1	3.23
27	*Leptogenys diminuta* (F. Smith, 1857)		1				1	1	1	3.23
28	*Odontoponera transversa* (F. Smith, 1857)		2				2	1	2	3.23
	Total of Individual	**676**	**42**	**457**	**221**	**3881**	**5277**			
	Total of Species	**5**	**12**	**6**	**11**	**13**	**28**			
	Total of Genus	**4**	**8**	**4**	**9**	**8**	**17**			
	Total of Tribe	**3**	**5**	**3**	**7**	**7**	**10**			
	Total of Subfamily	**2**	**3**	**3**	**3**	**3**	**5**			
	Diversity Indices	**0.19**	**1.88**	**0.71**	**1.61**	**0.87**	**0.94**			

It has been found one species resemblance with the other research i.e. *Crematogaster* (*Decacrema*) *borneensis* that living in the colonies and built nest in the tree branch of *Macaranga* plants [9, 10, 32]. This species was estimated for the ability to associate with *Macaranga* by making a nest for its colony. Myrmecophytic between *Macaranga* and *Crematogaster* also provide their ant partners with domatia and food bodies [8].

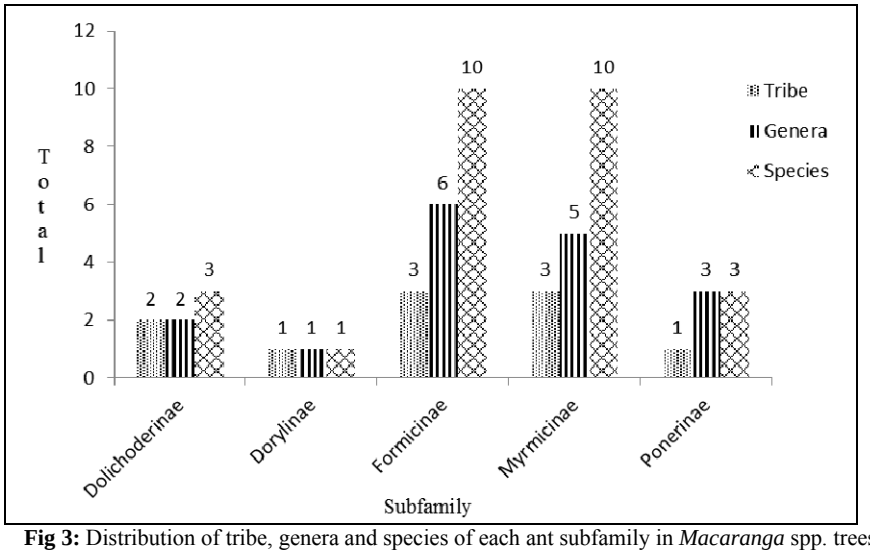

Fig 3: Distribution of tribe, genera and species of each ant subfamily in *Macaranga* spp. trees at Conservation Forest of Palm Oil Plantation of TKA Company.

Fig 4: Ant species with the highest number of individuals that were found in *Macaranga* spp. at Conservation Forest of Palm Oil Plantation of TKA Company. A: Profile of *Crematogaster (Decacrema) borneensis* Andre, 1896, B: Head in full-face view of *C. (Decacrema) borneensis*, C: Profile of *Crematogaster (Paracrema) modiglianii* Emery, 1990, D: Head in full-face view of *C. (Paracrema) modiglianii*.

Macaranga triloba was the plant with the highest in number of ant species (13 species) followed by *M. gigantea* (12 species), *M. tanarius* (11 species), *M. hypoleuca* (six species) and *M. depressa* (five species) (Table 1). *M. triloba* is myrmecophytic species where the ants built nests on the trunk, although the stem does not have hollow like the other myrmecophytic species. *M. triloba* also have extrafloral nectarines liquid that attracting the ants and other insects to visit [11, 13]. *M. gigantea* and *M. tanarius* are non-myrmecophytic species and do not have a vascular tissue [28]. We predicted that the ant visiting *Macaranga* just for foraging activities. The ant species that found in *M. tanarius* was estimated to seek the nectar since this plant has extrafloral nectarines [18].

Fig 5: Ant species that were found only one individual in *Macaranga* spp. at conservation forest of Palm Oil Plantation of TKA Company (A: *Dolichoderus* (*Hypoclinea*) cf. *thoracicus* (F. Smith, 1860), B: *Dolichoderus* sp. 45 of SKY, C: *Tapinoma melanocephalum* (Fabricius, 1793), D: *Camponotus* (*Myrmamblys*) *bedoti* (Emery, 1893), E: *Camponotus* (*Tanaemyrmex*) *festinus* (F. Smith, 1857), F: *Echinopla melanarctos* Smith, 1857, G: *Nylanderia* sp. 1 of HH, H: *Pheidole* sp. 9 of HH, I: *Crematogaster* cf. *rogenhoferi* Mayr, 1879, J: *Paratopula* sp. of HH, K: *Diacamma holosericeum* (Roger, 1860) and L: *Leptogenys diminuta* (F. Smith, 1857).

For species identification as well as confirmation of the colony of *Crematogaster* (*Decacrema*) spp. which is found on the surface of the *Macaranga* tree, the queen is needed. We found *C.* (*Decacrema*) *borneensis* can inhabitants the stems of *Macaranga*. We also found the queen of the species *C.* (*Decacrema*) *borneensis* is polyginy with 16 of queens and *C.* (*Paracrema*) *modiglanii* with 12 of queens. Associations between *Crematogaster* ants of the subgenus *Decacrema* and their *Macaranga* host plants were found to be stable over periods of time, long enough to enable reproduction of the ant colony and (in most cases) the host plants, too [10].

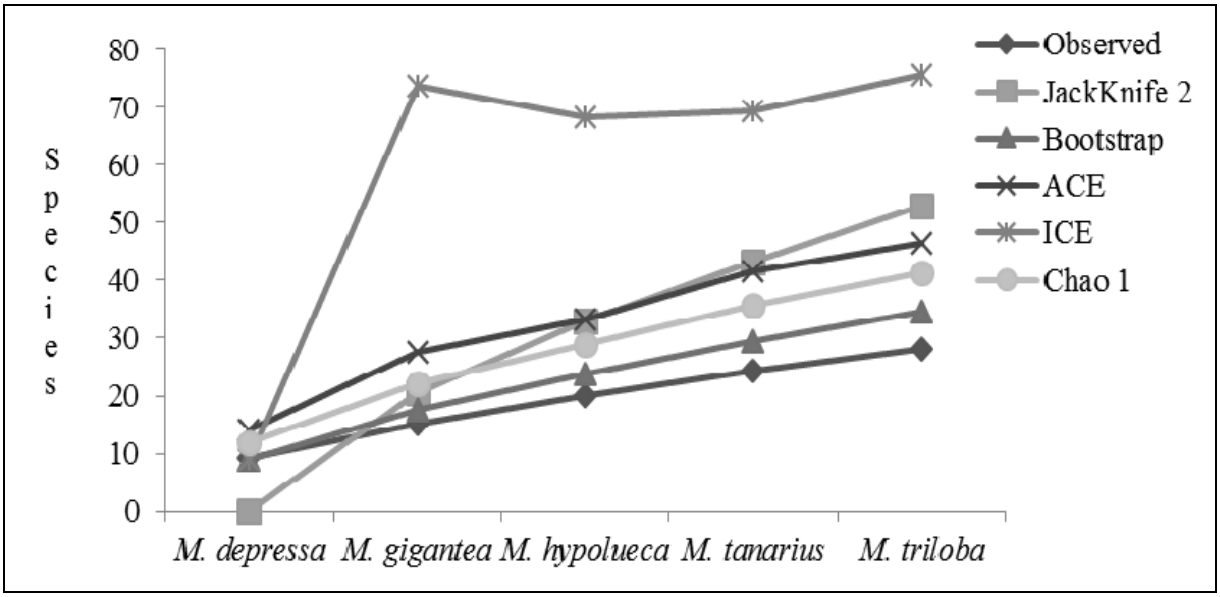

Fig 6: Accumulation curve of observed species JackKnife 2, Bootstrap, ACE, ICE, Chao 1 estimator of ant species collected from five *Macaranga* at Conservation Forest of Palm Oil Plantation of TKA Company.

There is a possibility to collect more species of ant because the observed line and estimated line (with JackKnife 2, Bootstrap, ACE, ICE and Chao 1) were not asymptot yet (Figure 6). This graph shows that the possibility of the ant species will varied with more sampling number. *Macaranga gigantea* had a highest Shannon diversity index with 1.88 and the lowest is *M. depressa* with only 0.19. The diversity index of ants in *Macaranga* spp. at conservation forest of palm oil plantation of TKA Company was categorized as low (0.94) probably because of only specific ant species could have symbiosis relationship with *Macaranga* (Table 1).

Table 2: Similarity index of ants among *Macaranga* species at Conservation Forest of Palm Oil Plantation of TKA Company (M. de: *M. depressa*, M. gi: *M. gigantea*; M. hy: *M. hypoleuca*; M. ta: *M. tanarius* and M. tri: *M. triloba*)

***Macaranga*/Similarity Index (QS)**	**M.de (%)**	**M.gi (%)**	**M.hy (%)**	**M.ta (%)**	**M.tri (%)**
M.de (%)	-				
M.gi (%)	23.53	-			
M.hy (%)	36.36	22.22	-		
M.ta (%)	25.00	26.09	17.65	-	
M.tri (%)	55.56	40.00	15.79	33.33	-

The highest Sorensen's similarity index was found about 55.56% between *M. depressa* and M. *triloba*, followed by *M. gigantea-M. triloba* (40.00%), *M. depressa-M. hypoleuca* (36.36%) and *M. gigantea-M. hypoleuca* is the lowest with 22.22% (Table 2). *Macaranga triloba* was more closely related to *M. depressa* with the following characteristics: solid stems, coriaceous stipules that were not a pressed to the stem and long horns on the mature fruits. *Macaranga triloba* can easily distinguished from the latter by the following characteristics: leaves larger, with a substantially large lamina; the staminate bracteoles are large and have a much more elongated caudate apex; central lobe broad 6-12 (-14) cm wide at the base and narrowing gradually to the apex, lateral lobes usually quite broad 3-6 (-8) cm wide and ascending or spreading [33]. *M. depressa* have more narrow and spreading the leaf lobes if compare with *M. triloba*.

This study shows an association between two ant species of *Crematogaster* (*Decacrema*) *borneensis* and *Crematogaster (Paracrema) modiglianii* with *Macaranga*, meanwhile previous research only reported about association of one species of *Crematogaster* (*Decacrema*) *borneensis* with *Macaranga* [10, 17]. The association of them was depend on a specific characteristic of both partners (ant species and *Macaranga*).

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