



Species Richness and Habitat Suitability of Myrmecophytes in Bengkulu : Host Tree, Coexist Epiphytes and Animals

✉ Safniyeti¹, Sulistijorini², Tatik Chikmawati²

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Department of Biology, Faculty of Mathematics and Natural Sciences, Institut Pertanian Bogor, Indonesia

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Abstract

Myrmecophytes or locally known as *simbagh utak* are common medicinal plants used by locals in Bengkulu, especially in South Bengkulu, for treating various diseases. Despite their potential as medicines, there is no report on biotic factors can be used to indicate of Myrmecophytes species' richness and habitat suitability. The objectives of this research were to analyze the Myrmecophytes' species richness and habitat suitability. This study used the purposive sampling method by exploring the area where Myrmecophytes were commonly found. The biotic factors of Myrmecophytes were analyzed by identifying the tree host, the other epiphyte plant grew around them, and animal occupants on the tuber of the Myrmecophytes. The Myrmecophytes distribution was analyzed by using ArcGIS10.1. The results showed that there were two species of Myrmecophytes, namely *Hydnophytum formicarum* and *Myrmecodia tuberosa* in the study area. The Myrmecophytes attached and hung in 9 species of host trees. The characteristics of host trees are high trees with large diameter, mostly rough-barked; some were cracked and mossy. The highest frequency of host trees included *Hevea brasiliensis* and *Durio zibethinus*. Myrmecophytes coexisted with 12 species of epiphytes. Epiphyte plants like *Dendrobium* sp. and *Drymoglossum piloselloides* can be used to indicate the presence of Myrmecophytes. Ants made up the most predominantly animal found living inside the tubers of Myrmecophytes, with some cockroaches and termites found at the tuber of *Hydnophytum*. Information on species' richness and habitat suitability of Myrmecophytes can serve as supporting data for conservation efforts in Bengkulu to prevent the extinction of this species.

How to Cite

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✉ Correspondence Author:
Dramaga, Bogor, West Java 16680, Indonesia
E-mail: safniyety@gmail.com

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INTRODUCTION

The Myrmecophyte, used by the Indonesian people for traditional medicine, is one group of epiphytes plant that lives attached to a host tree. Myrmecophytes provide a nesting space for ants in their hollow plant parts. Myrmecophytes in Bengkulu province were known as *Simbagh Utak*. *Simbagh* means the plants attached to trees (epiphytes) and *utak* means brain. Epiphytic Myrmecophytes mainly belong to the Rubiaceae family, and only five genera of the group form bulbs, namely *Anthorrhiza*, *Hydnophytum*, *Myrmecodia*, *Myrmephytum* and *Squamellaria* (Huxley & Jebb, 1991). Some of these Myrmecophytes are traditionally used by local people in Indonesia to treat stomachache, cancer (Soekmanto *et al.*, 2013; Senawong *et al.*, 2013), tumors, coronary heart disease, hemorrhoids, tuberculosis, migraines, arthritis, leukemia (Khairudin *et al.*, 2012), hepatitis, headache, diarrhea (Prachayasittikul *et al.*, 2008), liver disease (Tatukude *et al.*, 2014) and diabetes (Sianturi & Kurniawati, 2016). The application of the plants as medicines is performed by boiling the tuber and consuming the boiled water. Another way to use it requires putting pieces of the tuber in the sick body part.

The people of Bengkulu province collect these plants using a wooden pole that makes the young bud fall. This traditional collecting method will accelerate the extinction of this plant if left as it is without any conservation efforts. The conservation could be promoted by breeding the species, which requires Myrmecophyte materials such as seeds and samplings for cultivation (Sutomo & Mukaromah, 2010). However, the data for species cultivation of Myrmecophytes is still unavailable in the Province of Bengkulu, Indonesia.

Cultivation activities can be undertaken by utilizing the autecological data of Myrmecophytes. Autecology is the study of certain plant species in their natural habitat at an early stage effort *in-situ* conservation, and cultivation activities are an attempt of *ex-situ* conservation (Sutomo & Fardila, 2013). The parameters studied in autecology are abiotic and biotic factors of plants. The biotic factors of Myrmecophytes are the host tree, other epiphytes attached on the same host, and the animals that inhabit the tubers of Myrmecophytes. The factors biotic of Myrmecophytes can be used to indicate the species richness and habitat suitability of Myrmecophytes in Bengkulu Province. However, research on those species richness and habitat suitability of Myrmecophytes has never been undertaken in the province of Bengkulu.

Because of the medicinal potential of Myrmecophytes, the factors affecting their existence on the environment need to be further investigated. Therefore, research on the species richness and habitat suitability of Myrmecophytes had been carried out. The purpose of this study is to identify the species and characteristics of the host trees, other epiphytes attached on the same host and the animals that inhabit the tubers of Myrmecophytes. Information on species' richness and habitat suitability of Myrmecophytes can serve as supporting data for conservation efforts in Bengkulu to prevent the extinction of this species.

METHODS

Study area

The research was carried out from July 2015 to May 2016 in the Province of Bengkulu, Sumatera, Indonesia. Sampling was conducted in six districts in the Province of Bengkulu, namely South Bengkulu, Central Bengkulu, Bengkulu City, North Bengkulu, Seluma and Kaur (Figure 1). The samples were identified in the Laboratory of Ecology and Plant Resources, Department of Biology, Faculty of Mathematic and Natural Sciences, Institut Pertanian Bogor, West Java, Indonesia.

Research procedure

The collection of Myrmecophytes was carried out using purposive sampling (Sutomo & Mukaromah 2010) in the six districts in the province of Bengkulu. Sampling for the initial data began with a survey of traditional markets and collection of Myrmecophytes information from the local residents.

As many as 51 plots (10x10 m²) were put on the Myrmecophytes collection spot. The sampling for other epiphytic species was carried out at a 3-6 m growth on the stems of host trees. All host trees, Myrmecophytes, other epiphytic plants on the same host, and animal occupants were collected as wet and dry specimens. The data recorded were collection number, location, date of collection, habitat, local name, morphological characteristics, utilization, and documentation. The plants' specimens were stored as herbarium specimens and identified at Laboratory of Ecology and Plant Resources, Department of Biology, Faculty of Mathematic and Natural Sciences, Institut Pertanian Bogor, West Java, Indonesia.



Figure 1. The sampling locations of Myrmecophytes in six districts of Bengkulu Province, Indonesia. A. North Bengkulu, B. Central Bengkulu, C. Bengkulu City, D. Seluma, E. South Bengkulu, F. Kaur

Data recorded on each plot of observation included the number of Myrmecophytes on a host tree, the height of growth in the host, the number of host trees, species of the host tree, the type of wood surface of the host and other species of epiphytic plants that coexist with Myrmecophytes.

Host trees were identified using Backer and Bakhuizen van den Brink (1965) and the Myrmecophytes using Huxley (1978), Jebb (1985a,b); Huxley and Jebb (1991, 1993). Epiphytic plants were identified using Comber (1990) and Piggott (1996). Ants, the predominant animal occupied Myrmecophytes were identified using Agosti *et al.* (2000) and Hashimoto and Rahman (2003).

RESULTS AND DISCUSSION

Myrmecophytes found in the Province of Bengkulu, Indonesia were *Hydnophytum formicarum* and *Myrmecodia tuberosa*. These plants were distributed in 5 districts out of 6 districts visited in Bengkulu Province, namely North Bengkulu, Central Bengkulu, Seluma, South Bengkulu, and Kaur. The distribution of *H. formicarum* is broader than of *M. tuberosa*. *Hydnophytum formicarum* were scattered in Kaur, Seluma, Central Bengkulu, to North Bengkulu whereas *M. tuberosa* were distributed in South Bengkulu and North Beng-

kulu. *M. tuberosa* scattered in clusters in South Bengkulu district and *H. formicarum* was randomly distributed in four districts in Bengkulu Province (North Bengkulu, Central Bengkulu, Seluma, and Kaur). A previous study of Myrmecophytes occurrence based on their host tree in Bengkulu revealed that 77.8% of the plants spread randomly, and as many as 22.2% spread in groups (Safniyeti *et al.*, 2017). The distribution pattern of Myrmecophytes is influenced by temperature and light intensity in the environment where they grow (Safniyeti *et al.*, 2017).

Myrmecodia tuberosa found in Bengkulu has distinct morphological characteristics from *H. formicarum*. *Myrmecodia tuberosa* has thorns on the surface of its tubers and stems, clypeoli (a wing-shaped structure from the stem surface and considered as the protector of the stem), alveoli (pits on the stem surface where flowers and fruits emerged), pyrene (seed encapsulated by hardened endocarp) of 4-5, and narrow tuber cavities (Figure 2). *Hydnophytum formicarum* has no spines on the surface of its tubers, stems, clypeoli, and alveoli. *H. formicarum* had flowers and fruits that were situated in the plant's leaf axilla, 1-2 pyrene in fruit, and its tuber cavities were larger than that of *M. tuberosa* (Figure 3).

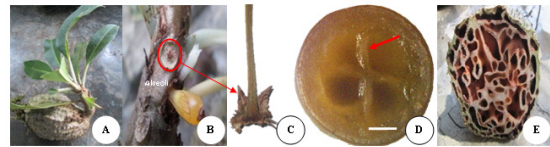


Figure 2. *Myrmecodia tuberosa* found in Bengkulu Province, Indonesia. A. Habits, B. Fruit and flower, C. Clypeoli, D. Pyrene (bar = 1 mm), E. Tuber cavity

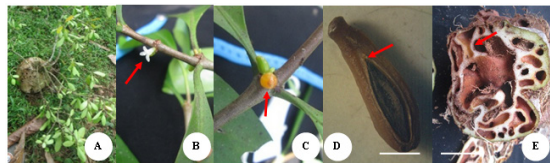


Figure 3. *Hydnophytum formicarum* found in Bengkulu Province, Indonesia. A. Habits, B. Flower; C. Fruit; D. Pyrene (bar = 1 mm), E. Tuber cavity

Host tree of Myrmecophytes

Hydnophytum formicarum and *Myrmecodia tuberosa* found in Bengkulu were found attached to 9 host tree species (Table 1). *Hydnophytum formicarum* and *Myrmecodia tuberosa* grow individually or in groups on a host tree. Both genera *Myrmecodia* and *Hydnophytum* can be found on the same host tree and often occur together with several plants. Previous research reported the presence of

epiphytic plants found only in certain tree species and on the part of certain trees (Febriliani *et al.*, 2013).

Many of the host trees have rough barks (45.1%), while the rest of the trees (54.9%) have either mossy, cracked or slightly rough barks (Figure 4). *Hevea brasiliensis*, *Durio* sp., and *Gmelina arborea* are known to have a rather rough to very rough, mossy, uneven rods, slightly cracked bark texture (Febriliani *et al.*, 2013) with many indentations (Sujalu *et al.*, 2015) and holes (Sujalu 2007). Such trunk characteristics facilitate debris and dusts to accumulate on the tree, allowing the moisture build up on the tree surface (Sadi-li 2015). This tree surface serves as a conducive ground for the growth of Myrmecophytes and their seeds.

Durio sp. and *H. brasiliensis* were the host trees with the highest occupation frequency of the Myrmecophytes (Figure 5). Most of the Myrmecophytes (47.06%) were found on *H. brasiliensis* at the height of between 5 m and 15 m, with the tree condition being at relatively low diameters ranging from 13.69-38.24 cm and at the free branch of tree 3-8 m. *Durio* sp. was the second most frequent host (23.53%) for the Myrmecophytes. *Durio* sp. found in this study has the largest diameter (95.54 cm) among all host trees. *Gmelina arborea* was the highest of all the host trees (23 m) and hosted 7.84% of the Myrmecophytes studied. Most of the Myrmecophytes (22 individuals) found in *G. arborea* grew at the height of up to 16 m. These

results indicate that the Myrmecophytes favor to live higher up on a large-diameter tree (Sujalu *et al.*, 2015), and these plants tend to like the host tree being homogeneous in one environment. Nevertheless, the Myrmecophytes also favor smaller trunk *H. brasiliensis*.

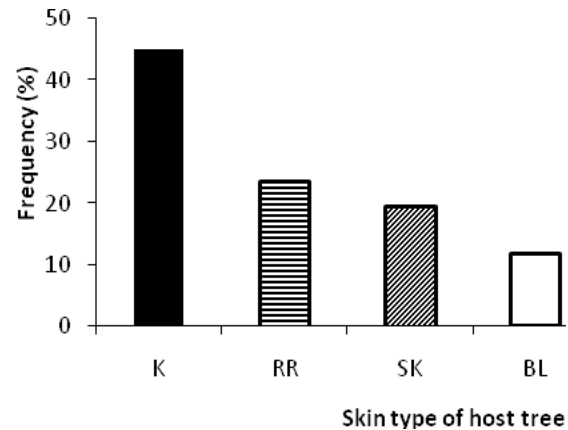


Figure 4. The frequency of host tree skin type. = mossy; = slightly rough; = cracks; = rough

Hevea brasiliensis is a crown-shaped tree with a height ranges from 5 to 15 m. At this height, the Myrmecophytes are able to get maximum sunlight. *Gmelina arborea* and *Durio* sp. have a dense canopy with a tree height ranging from 13 to 23 m and 3 to 16 m, respectively. In such canopies, the Myrmecophytes get enough sunlight, and at the same time still, allow the light to penetrate through and reach the surface of the

Table 1. Characteristics of Myrmecophytes'host trees found in Bengkulu, Indonesia

Species	Σ host tree (ind)	KT (m)	D (cm)	BC (m)	TP (m)	Σ Myr/ host tree (ind)	Genera of Myrmecophytes	Habitat
<i>Hevea brasiliensis</i>	24	3-9	13.69-38.24	3-8	5-15	1-10	HY	Rubber plantation
<i>Durio zibethinus</i>	12	4-12	39.49-95.54	3-11	13-22	1-12	HY, MY	Durio plantation
<i>Gmelina arborea</i>	4	9-16	0.00	14-16	22-23	3-22	HY	Natural tourism forest
<i>Artocarpus integer</i>	3	5-8	45.86-68.15	3-5	10-14	1-3	HY, MY	Durio plantation (mixture plantation)
<i>Archidendron jiringa</i>	2	7	22.29	6	14	1-3	HY, MY	Durio plantation (mixture plantation)
<i>Rhodamnia cinerea</i>	2	10-11	34.71-40.45	7-8	15-17	2	HY	Rubber plantation
<i>Ficus racemosa</i>	2	5-8	30.25-62.10	5-8	13-16	1-7	HY, MY	Natural tourism forest
<i>Artocarpus elasticus</i>	1	8	88.54	8	17	2	MY	Durio plantation
<i>Delonix regia</i>	1	9	0.00	10	16	5	MY	Natural tourism forest (waterfall)

Note: KT = Altitude grow; D = Diameter; BC = free branch of tree; TP = height of tree; Myr = Myrmecophytes; 0.00 = Not measured; HY = *Hydnophytum formicarum*; MY = *Myrmecodia tuberosa*

soil. Myrmecophytes require direct sunlight, as indicated by the way they grow. Myrmecophytes tend to stick and hang on the branches and stems (94%), as well as at the apex of the host tree's canopy (6%) (Figure 6). Myrmecophytes were also found to reside on the main stem of *Delonix regia*, at the height of 9 to 16 m. Despite growing up on the main stem of *Delonix regia*, the Myrmecophytes still receive maximum sunlight. This result is consistent with the results of PCA by Safniyeti *et al.* (2017) that shows the intensity of light is the main component of plant II, which affects the existence of Myrmecophytes.

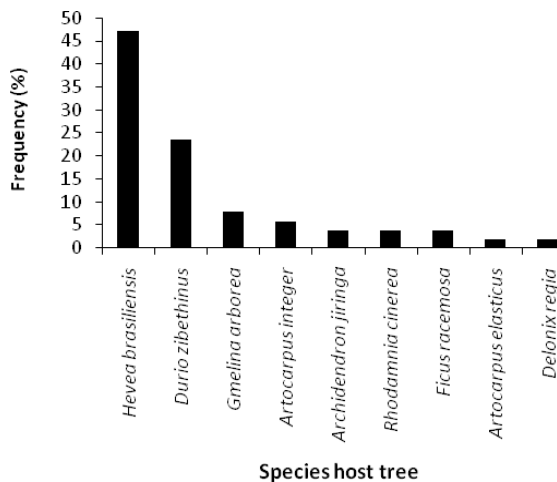


Figure 5. The frequency of Myrmecophyte' host tree species in Bengkulu, Indonesia

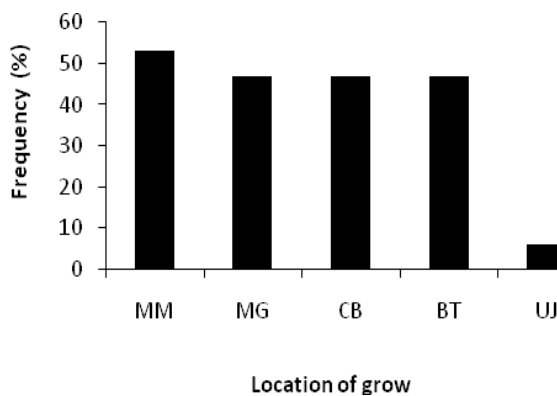


Figure 6. The frequency of the host tree is based on the way and location in which it grows. How to grow: MM = stick of tree; MG = hang of tree. Location grows: CB = branch of tree; BT = stem of tree; UJ = apex of tree

In this present study, Myrmecophytes were found in the trees such as *Archidendron jiringa*, *Artocarpus elasticus*, *Artocarpus integer*, *Durio sp.*, *Delonix regia*, *Ficus racemosa*, *Gmelina arborea*, *Hevea brasiliensis*, and *Rhodamnia cinerea*. Meanwhile, Parinding (2007) reported that Myrmecophytes

grow on trees such as *Melaleuca cajuputi*, *Melaleuca leucadendron*, *Melaleuca symphiocarpa* and *Acacia auriculiformis*. Some Myrmecophytes also coexist with orchids. Both of these epiphytic plants utilize the host only as a place to adhere to (Febriliani *et al.*, 2013). Furthermore, Parinding (2007) also reported that an ant nest could live on plants that have died. In addition to epiphytic plants, *Artocarpus integer* and *Hevea brasiliensis* trees can also be overgrown by parasitic plants (Kartika *et al.*, 2016).

Other epiphytic plants coexist with Myrmecophytes

Other epiphytic species were found to coexist with Myrmecophytes, but that differed in each host species and also for each species of Myrmecophytes. We found as many as 16 individuals of the epiphytic plants in 51 host trees studied. Those epiphytic plants belong to 12 species (Table 2). The most frequent epiphytic plants found are *Simbagh pitis* (*Drymoglossum piloselloides*) and *Simbagh balung* (*Dendrobium sp.*), which favor residing on *Hevea brasiliensis*, *Artocarpus integer*, *Rhodamnia cinerea*, *Durio sp.*, and *Archidendron jiringa* trees. Interestingly, we found that both *Drymoglossum piloselloides* and *Dendrobium sp.*, as well as *Dischidia nummularia*, coexisted with *Hydnophytum* and *Myrmecodia*, whereas the other epiphytic species exclusively coexisted with either one of the Myrmecophytes.

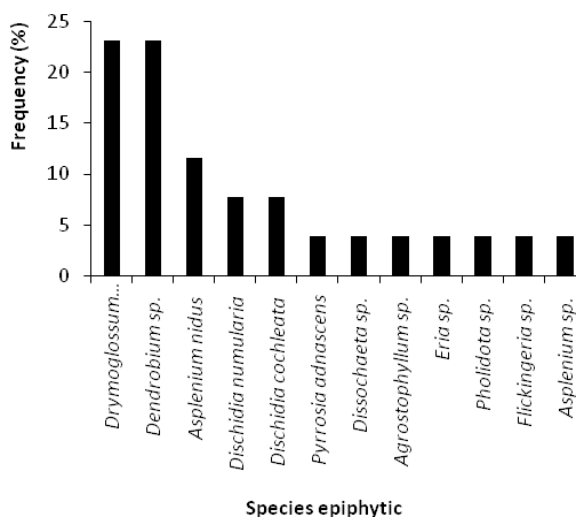
Asplenium nidus is only found in Myrmecophytes of the genus *Hydnophytum* (Table 2). Different epiphytic species found in each of the host trees could be due to environmental factors and the nature of each plant. For example, some epiphytic species have been found in trees that dwell in the shade and are not exposed to direct sunlight (Febriliani *et al.*, 2013).

Dendrobium sp. and *Drymoglossum piloselloides* are the most prevalent epiphytes (21.43%) found in this study, and both coexisted with the two Myrmecophytes. Both of these plants are found in the roots and stems of the Myrmecophytes. *Asplenium nidus* was the next most predominantly found epiphytes with a frequency of 10.71% (Figure 7). In this study, we found that *Asplenium nidus* is coexisted only with *Hydnophytum formicarum* (Table 2) and grew at the bottom and the top of the Myrmecophyte. The fourth most frequent epiphyte plant was *Dischidia nummularia*. The plant was found to reside in the tubers of the two *Hydnophytum formicarum* and *Myrmecodia tuberosa*.

Table 2. Species of epiphytic plants that coexist with Myrmecophytes

Epiphytic species	<i>Hydnophytum formicarum</i>	<i>Myrmecodia tuberosa</i>
<i>Agrostophyllum</i> sp.	√	-
<i>Asplenium nidus</i>	√	-
<i>Asplenium</i> sp.	√	-
<i>Dendrobium</i> sp.	√	√
<i>Dischidia cochleata</i>	-	√
<i>Dischidia nummularia</i>	√	√
<i>Dissochaeta</i> sp.	-	√
<i>Drymoglossum piloselloides</i>	√	√
<i>Eria</i> sp.	√	-
<i>Flickingeria</i> sp.	√	-
<i>Pholidota</i> sp.	√	-
<i>Pyrrosia adnascens</i>	-	√

Note: (-) not found to coexist with Myrmecophytes

**Figure 7.** Frequency of epiphytic species found around the Myrmecophytes

Dendrobium sp., *Agrostophyllum* sp., *Eria* sp., *Pholidota* sp. and *Flickingeria* sp. were the orchid family (*Orchidaceae*) found at the study site. Previous research also reported that the Myrmecophytes and orchids coexist (Parinding 2007). These plants can coexist and do not interfere with each other, even though they reside in and utilize nutrients from the same niche.

Myrmecophytes and other epiphytic plants use tree species as their hosts, and their host preference depends on the climatic conditions of the forest stands (Febriliani *et al.*, 2013), the crown density of the tree and host habitus (Puspitaningtyas, 2007). Epiphytic plants hide among twigs

and branches that grow tightly, sheltered by tall trees and prefer the shade (<50%) (Puspitaningtyas, 2007). Epiphytic plants mostly dwell on branches or twigs that grow relatively flat or tilted (Sujalu *et al.*, 2015); on a tree with stem diameter of > 20 cm. The most common branches dwelled by epiphytic plant is on the lower branch (Sujalu 2007) with thick bark shaded by a canopy (Marilyanti *et al.*, 2015).

Animal occupants in the tuber of Myrmecophytes

The animals found in the tuber of *Myrmecodia* were typically ants with various sizes and colors, while the animals found in the tuber of *Hydnophytum* were termites, cockroaches, and ants (Table 3). Termites *Macrotermes* sp. found in the tubers of *Hydnophytum* that resided at the height of 54 m on *Rhodamnia cinerea* tree. The tuber of the *Hydnophytum* was moist and juicy with large tubers cavity (depth 3.5 cm). A cockroach *Pycnoscelus* sp. found in the tuber of *Hydnophytum* that were attached at the height of 133 m on the host *Hevea brasiliensis* tree.

Table 3. Diversity of occupants in the tuber of two myrmecophytic epiphytes in Bengkulu, Indonesia

Genera of Myrmecophytes	Local names	Freq. (%)	Animal species
<i>Hydnophytum</i>	Termite	1	<i>Macrotermes</i> sp.
	Cockroach	1	<i>Pycnoscelus</i> sp.
	Ants	98	<i>Plagiolepis</i> sp., <i>Crematogaster</i> sp., <i>Monomorium destructor</i> , <i>Anoplolepis gracilipes</i> , <i>Philidris</i> sp., <i>Plagiololepis pygmaea</i>
<i>Myrmecodia</i>	Ants	100	<i>Plagiolepis pygmaea</i> , <i>Philidris</i> sp., <i>Anoplolepis gracilipes</i> , <i>Monomorium destructor</i>

Ants living in the Myrmecophyte' cavity tubers consisted of several genera such as *Crematogaster*, *Monomorium*, *Anoplolepis*, *Plagiolepis*, and *Philidris*. These ants are usually found at an altitude of 25-629 m altitude and in a low-lying area. Previous research reported that Myrmecophytes are predominantly populated by the *Iridomyrmex* ant (Huxley, 1978), but the ant was not found in this present study. The altitude and natural habitat of Myrmecophytes affected the species that

inhabit their tubers. *Iridomyrmex* is commonly found in Myrmecophytes which lives in savanna forests at an altitude of 0-1890 m altitude (Huxley & Jebb 1985).

Hydnophytum has a larger and deeper (\pm 2-7 cm) cavity compared to *Myrmecodia*, so the animals found within *Hydnophytum* tuber were of a diverse variety. Termites, cockroaches, wasps, centipedes, grasshoppers, lizards (Susanti 2016), geckos, frogs (Parinding 2007) and other invertebrates are animals found in the tubers of *Hydnophytum*, but not found in the tubers of *Myrmecodia*. *Hydnophytum* tubers found in this study were \pm 1.5 cm in length, had cavities which were inhabited by ants (Figure 8). Meanwhile, *Myrmecodia* tubers were of a marble-size, hollow, and also inhabited by ants (Parinding 2007).

There were two species of ants, namely *Plagiolepis pygmaea* and *Philidris* sp. found inside the tuber of *Hydnophytum*. Whereas two different ant species, *Monomorium destructor* and *Anoplolepis gracilipes* were found in the tuber of *Myrmecodia*. The cavity and the depth of the Myrmecophytes tubers where those ants found are larger than those of the tubers where the termites were discovered (Figure 9).

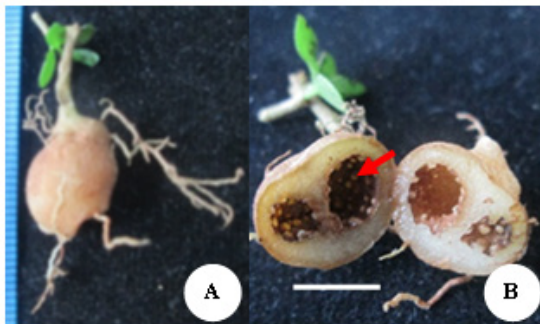


Figure 8. Tuber of young *H. formicarum* found in the Province of Bengkulu, Indonesia. A. tuber; B. tuber cavity (arrow indicates cavity). Bar = 2 cm

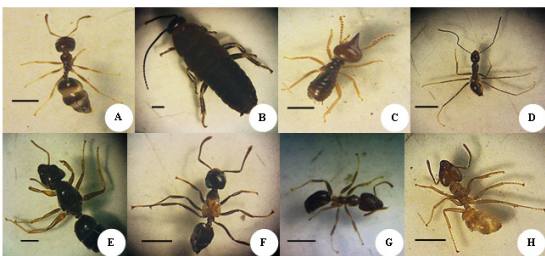


Figure 9. Types of animal occupants on Myrmecophytes tubers. A. *Monomorium destructor*; B. *Pycnoscelus* sp.; C. *Macrotermes* sp.; D. *Anoplolepis gracilipes*; E. *Plagiolepis pygmaea*; F. *Crematogaster* sp.; G. *Philidris* sp.; H. *Plagiolepis* sp. Bar = 1 mm

In this present study, Myrmecophytes found were *Hydnophytum formicarum* and *Myrmecodia tuberosa*. Both species is a medicinal plants used by locals in Bengkulu Province and most of which grew in the gardens belonging to the local community. The benefit of this research is to can be used as basic information to cultivation of Myrmecophytes, in addition the abundance of myrmecophytes is also used as a source of additional income for local people in Bengkulu Province.

CONCLUSIONS

In conclusion, Myrmecophyte species found in Bengkulu Province are *Hydnophytum formicarum* and *Myrmecodia tuberosa*. The Myrmecophytes attached and hung in 9 species of host trees, most of which grew in the gardens belonging to the local community of Bengkulu Province. Myrmecophytes coexisted with 12 species of epiphytes. Among the epiphytes, *Drymoglossum piloselloides* and *Dendrobium* sp. were found to be associated with both Myrmecophytes; thus, their presence can serve as an indicator for the occurrence of the two Myrmecophyte species. The animals found living inside the tuber of *Myrmecodia* were all ants, whereas the animals found in the tuber of *Hydnophytum* were largely ants with a very small number of cockroaches and termites.

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