

INVENTORY OF EPIPHYTIC MYRMECOPHYTES IN MUAYA FOREST RESERVE, SIPITANG,  
SABAH

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DISSERTATION SUBMITTED AS PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR  
THE DEGREE OF BACHELOR OF SCIENCE WITH HONORS

CONSERVATION BIOLOGY PROGRAM  
SCHOOL OF SCIENCE AND TECHNOLOGY  
UNIVERSITY MALAYSIA SABAH

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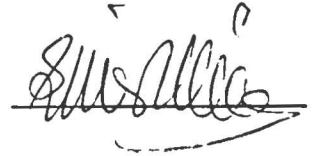
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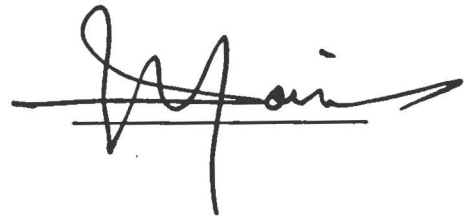
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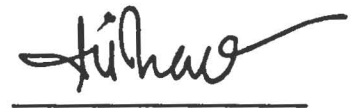
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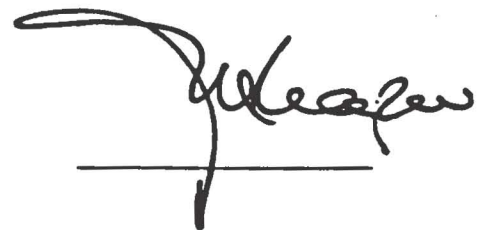
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## **ACKNOWLEDGEMENT**

Bismillahirrahmannirahim. Alhamdulillah. I am very grateful that I have successfully completed my dissertation. First and foremost, I would like to thank Sabah Forest Industry (SFI) for giving me the necessary permission to conduct this study. I also want to express my sincere thanks to Mdm. Luiza Majuakim and Assoc. Prof. Dr. Monica Suleiman for their patient guidances, advices and encouragement.

I would like to extent my appreciation to Dr. Kartini Saibeh and Madam Elia Godoong for their kind advices and guidances. Thanks to my very best friend; Affrensia J. Gibot, plant expertise; Mr. Johny Gisil and Mr. Boni Jaumin for helping me a lot in order to complete the project. I also want to thank SFI staff especially Mr. Daniel who has helped me with the work in the field.

Thanks to all ITBC's staff for necessary logistic support. I wish to express my sincere thanks to my parents for their continuous support and all my friends and whoever involves in completing this dissertation.

## ABSTRACT

In this study, the diversity and distribution of epiphytic myrmecophytes in Muaya Forest Reserve (Muaya FR), Sipitang were determined. Plants of interest were collected together with their colonizing ants. Then, specimens were identified and voucher specimens were prepared. A total of 77 individuals of epiphytic ant-plants were collected of which six species were identified, namely *Myrmecodia tuberosa*, *Hydnophytum formicarum*, *Asplenium nidus*, *Platynerium coronarium*, *Aeschynanthus* sp. and *Hedychium* sp.. Diversity of epiphytic myrmecophytes was found highest at tree trunks and in the secondary. However, epiphytic myrmecophytes were occurred in abundance at fallen logs compare to the tree trunks. In addition, epiphytic myrmecophytes were also found in abundance at lower altitude. Five species of ants were found colonizing the epiphytic ant-plants encountered, namely *Crematogaster* sp., *Myrmecaria* sp., *Dolichoderus* sp., *Polyrachis* sp. and *Parathechina* sp.. Five factors were determined to affect the occurrence of epiphytic myrmecophytes which are habitat (substrate) preferences, altitudinal factors, humidity, light intensity and forest disturbances.

## ABSTRAK

### **Inventori terhadap tumbuhan semut bersifat epifitik di Hutan Simpan Muaya, Sipitang, Sabah**

Dalam kajian ini, kepelbagaian dan taburan tumbuhan semut bersifat epifitik d Hutan Simpan Muaya, Sipitang di kenalpasti. Tumbuhan ini di kumpulkan bersama dengan koloni semut yang menghuni tumbuhan terabit. Kemudian, spesimen melalui proses identifikasi dan spesimen baucar di sediakan. Sebanyak 77 individu tumbuhan semut bersifat epifitik d kumpulan yang mana enam spesies di kenalpasti iaitu *Myrmecodia tuberosa*, *Hydnophytum formicarum*, *Asplenium nidus*, *Platyserium coronarium*, *Aeschynanthus* sp. and *Hedychium* sp.. Kepelbagaian spesies yang paling tinggi berlaku di batang pokok dan pada hutan sekunder. Walaubagaimanapun, kelimpahan spesies yang berlaku di pokok kayu tumbang adalah yang paling tinggi berbanding daripada yang di kutip dari batang pokok. Tambahan lagi, kelimpahan spesies juga tinggi di altitud yang rendah. Lima species semut di kenalpasti iaitu *Crematogaster* sp., *Myrmicaria* sp., *Dolichoderus* sp., *Polyrachis* sp. dan *Parathechina* sp.. Terdapat empat faktor yang di percayai mempengaruhi taburan tumbuhan semut bersifat epifitik iaitu pemilihan tempat tinggal (substrat-dimana tumbuhan di kutip) faktor altitud, kelembapan, kepekatan cahaya dan gangguan yang di alami oleh hutan.

## TABLE OF CONTENT

	Pages
DECLARATION	ii
VERIFICATION	iii
ACKNOWLEDGEMENT	iv
ABSTRACT	v
ABSTRAK	vi
TABLE OF CONTENT	vii
LIST OF TABLE	ix
LIST OF FIGURE	x
LIST OF PHOTO	xi
LIST OF SYMBOL AND ABBREVIATION	xii
 <b>CHAPTER 1 INTRODUCTION</b>	
1.1 Introduction	1
1.2 Problem statement	4
1.3 Objectives	4
 <b>CHAPTER 2 LITERATURE REVIEW</b>	
2.1 Epiphytic myrmecophytes	5
2.2 Relationship: Epiphytic myrmecophytes– Ants	7
2.3 Distribution of epiphytic myrmecophytes	8
2.4 Roles of epiphytic myrmecophytes	9
 <b>CHAPTER 3 METHODOLOGY</b>	12
3.1 Sampling site	13
3.2 Sample collection	14
3.2.1 Materials	14
3.2.2 Sampling methods	14
3.2.3 Voucher Specimens	15
 <b>CHAPTER 4 RESULT</b>	16



<b>CHAPTER 5 DISCUSSION</b>	<b>23</b>
5.1 Species abundance	23
5.2 Number of individuals and number of species collected from different locality	25
5.3 Altitudinal distribution of epiphytic myrmecophytes	26
5.4 Primary forest versus Secondary forest	27
5.5 Species-specificity (Epiphytic myrmecophytes – Ants)	28
5.6 Other species of epiphytes and host tree species	29
 <b>CHAPTER 6 CONCLUSION</b>	 <b>31</b>
6.1 Conclusion	31
6.2 Recommendations	32
 REFERENCE	 33
APPENDIX A	37
APPENDIX B	38
APPENDIX C	39
APPENDIX D	40
APPENDIX E	41
APPENDIX F	42
APPENDIX G	43

**LIST OF TABLE**

No. of Table		Pages
4.1	Epiphytic ant-plants collected with their inhabiting ants	22

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## LIST OF FIGURE

No. of Figure		Pages
4.1	Species of epiphytic myrmecophyte found in Muaya FR, Sipitang	17
4.2	Occurrence of epiphytic ant-plants found in Muaya FR, Sipitang	18
4.3	Number of epiphytic myrmecophytes species found on different places	19
4.4	Distribution of epiphytic ant-plants species based on altitudinal factors	20
4.5	Diversity of epiphytic myrmecophytes in two different two different type of forest in Muaya FR, Sipitang	21

## LIST OF PHOTO

No. of Photo		Pages
3.1	Study site – Muaya Forest Reserve, Sipitang	13





## LIST OF SYMBOL AND ABBREVIATION

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cm	Centimeter
m	Meter
°C	Degree Celsius
%	Percentage
GPS	Global Positioning System
ha	Hectare
a.s.l	Above sea level
DBH	Diameter at breast height

## CHAPTER 1

### INTRODUCTION

#### 1.1 Introduction

Myrmecophyte or so called as ant-plant is a plant that provides shelter, food and nutrient to ants that live in symbiotic relations with it (Feldhaar *et al.*, 2000). The word 'myrmeco' means many ant or plant symbioses which involve the modifications of the structure of the plant itself (Gledhill, 2002) (Appendix A). Myrmecophytes can be divided into three main groups; terrestrial myrmecophyte – species of nutrient-poor highlands; lithophytic myrmecophytes – ant-plants that grow on the rocks; and epiphytic myrmecophytes – ant-plants that use another plant as mechanical support but do not derive nutrients or water from its host (phorophyte). These three groups of myrmecophytes may rely partly or wholly on ants especially for nutritional intake (Itino *et al.*, 2001).

In Asia, the tree genus *Macaranga* from the family of Euphorbiaceae includes many ant plant species that have symbiotic association with *Crematogaster* ants (Feldhaar *et al.*, 2000; Itino *et al.*, 2001). There are a lot of studies which have been done on this genus of *Macaranga* and its associates *Crematogaster* ants. However, only few studies focused on epiphytic myrmecophytes (Appendix B). Basically, ants built their nest in plant cavities and get food supply from it. In return, the resident ants protect their phorophytes against herbivores and clinging vines. Itino and Itioka (2001) named few leaf-eating insects that cause damaged to the plant leaves which

are grasshoppers, chrysomelid and scarabaeid beetles, and lepidopteran larvae. Ant-free plants showed more severe damaged on the leaf compare to those ant-occupied plants (Itino *et al.*, 2001).

Ant-plants such as *Hydnophytum* and *Myrmecodia* can be recognized by their unique features. They possessed specialized organs, large tuberous base where ants inhabit (Itino *et al.*, 2001). It is sometimes up 10 to 12 cm in diameter and besides that the occurrence of spines and ridges on the tubers also can be observed (Itino *et al.*, 2001). These spines and ridges are actually modified roots which developed as to against predators such as herbivores. The tubers of *Hydnophytum* and *Myrmecodia* are tunneled and perforated to allow inhabitant ants to go in and out as well as for ventilation of the cavity system (Lok & Tan, 2009). In this case, Tepe *et al.* (2007) found that the hollow of the tubers might be spontaneously or directly excavated by the resident ants. They also possessed sessile, orange in color flowers and, oblong and fleshy berries containing three to eight seeds (Lok & Tan, 2009).

Some other ant-plants species does not posses specialized organs or preformed cavities which where ants tend to live. According to Kaufmann and Maschwitz (2006), species such as *Dischidia* and *Hoya* did not provide ants with galleried house but they also developed relationship with ant colonies. The ants themselves built their nest on the plants; on the leaves, inside the stems or on the roots (Kaufmann & Maschwitz, 2006). Basically, ants collect seeds, nutrient and debris from the ground and place on the rooting materials of the plant for stronger support of their nest. Different species of ant-plants differ in their leaves shape, stem surface and even habitats. Generally, myrmecophytes that grow in the shadier place tend to have thinner and larger laminae compare to the plants that live in open forest or under full sun (Lok & Tan, 2009).

Myrmecophytes are abundant in heath forest - kind of forest which cannot grow rice. It is a type of tropical moist forest found in Borneo, occurs on acidic sandy soils and is extremely nutrient-poor for the growth of plant. The poor condition of the

soil causes stunted growth of trees like *Shorea* sp. and *Casuarina* sp. (Widodo & Mohamed, 1998). Heath forest also can be characterized by the dominance of *Dacrydium pectinatum* (sempilor) and *Tristaniopsis* (pelawan) growing on sandy podsols with a thin surface layer of humus besides *Syzygium subdecussata*, *Ternstroemia aneura*, and *Vaccinium bancanum* (Widodo & Mohamed, 1998). The height of the canopy of this forest ranges from 15 m to about 25 m. In this context, myrmecophytes such as *Hydnophytum* spp. has managed to survive well on those stunted trees (Widodo & Mohamed, 1998).

In order for the plant to survive in such type of forest, they not only need to rely on the phorophytes for mechanical support which help them to be exposed to sunlight to carry out photosynthesis, but they also need to build a symbiotic relationship with insects such as ants, to obtain nutrients needed for their growth and for seed dispersal mechanism. Myrmecophytes are generally self-dispersed (Lok & Tan, 2009). Hence, existence of residence ants will help dispersing their seeds. Other than heath forest, myrmecophytes are also found in abundance in primary mangrove forest (Lok & Tan, 2009). However, little is known about the distribution of epiphytic myrmecophytes in Sabah or even in Malaysia and factors that influence their occurrences and distribution.

Myrmecophytic plants play several vital roles in nature which indirectly benefited us human. They add to the functions of forest canopy in maintaining the ecosystem in which it increases the level of photosynthesis, nutrient cycling and other processes in order to ensure the survival of other organisms within the ecosystem (Lowman & Rinker, 2004). Besides, myrmecophytes are highly-valued as medicine since they are traditionally used by the indigenous people to heal illnesses. Moreover, they are also valuable as ornamental plants and are currently been introduced to cultivation due to its high economic value.

## **1.1 Problem statement**

There are no checklist ever been published about epiphytic myrmecophytes especially in Muaya FR, Sipitang, and generally in Sabah. This is maybe due to lack of knowledge and awareness about epiphytic myrmecophytes and their importance among researchers, NGOs, government, and students.

Besides, this is also caused by the lack of extensive study on epiphytic myrmecophytes in Sabah and thus, there are less data available. Moreover, there is a dearth of information on the factors that influence the distribution of epiphytic myrmecophytes in Sabah.

## **1.2 Objectives**

There are two main objectives to be carried out in this project, they are;

1. To determine the diversity of epiphytic myrmecophytes in Muaya FR, Sipitang and
2. To determine the factors that influences the distribution of epiphytic myrmecophytes in Muaya FR, Sipitang.



## CHAPTER 2

### LITERATURE REVIEW

#### 1.1 Epiphytic myrmecophytes

Epiphytes are native to the wettest forests and they are often bird-dependent or insect-reliant for seeds dispersal purposes. Epiphytic myrmecophyte is an ant-plant in which relies on another plant for mechanical support but does not take an advantage on their host's nutrients and water (Lowman & Rinker, 2004). Simply speaking, epiphytic myrmecophytes are autotrophic ant plants living symbiotically on phorophytes solely for mechanical support only and at the same time build a relationship with colonies of ants to obtained nutrients provided by the ants. They grow attached to the trunks and branches of trees. In the relationships between epiphytic myrmecophytes and its residence ants, Kaufmann and Maschwitz (2006) found that majority of ants were associated with many epiphyte species, while others were largely restricted to a single epiphyte partner.

A study done by Trager and Bruna (2006) found that the degree of herbivory depends on the tree age, availability of nutrient, ant presence and their interaction. The presence of ant colonies on a plant reduces the probability of being attacked by other herbivorous (Cabrera & Jaffe, 1994; Tepe *et al.*, 2007). In myrmecophytism, nutrients are transferred from ants to plants through the domatia (Cabrera & Jaffe, 1994). Cabrera and Jaffe (1994) also discovered that when resident ants deposited their waste in the domatia of the plants, nutrients are allowed to be directly

transferred to the plants. The nutrient absorption in domatia by the plant required special structure which are formed by the plant itself and this structure must not be excavated (Tepe *et al.*, 2007).

The distribution of epiphytic myrmecophytes is often affected by several environmental factors and microclimatic effects. Three main factors are light exposure, temperature (humidity), and elevation (altitude gradients). Light is very critical for the maximum growth and energy available for reproduction. The change in light conditions would result in a change of the abundance of plants. Sunlight is vital for the plants to carry out photosynthesis. According to Itino (2001), exposure of the sun (light) can be assessed by estimating or calculating the percentage of canopy openness for each tree where the epiphytic ant plants occur.

Humidity is another factor that influence the growth of epiphytes (Lowman & Rinker, 2004). Kaufmann and Maschwitz (2006) found that humidity might be as important as the ant species accessing the epiphyte seeds and providing growth substrate. Temperature is generally lower at higher elevation due to the decrease of atmospheric pressure (Molles, 2010). Extreme temperature basically reduces the rate of photosynthesis in plants. Thus, at higher temperature the growth of epiphytic myrmecophytes will be depleted. However, in terms of elevational distribution, epiphytes are more abundance at higher elevation, from about 1000 m elevation (Beaman *et al.*, 1999). At such elevation, they obtained the maximum sunlight needed and cope with the temperature that helps them to photosynthesize at a maximum rate (Molles, 2010). In addition to microclimatic factors, Cabrera and Jaffe (1994) as well as Lowman and Rinker (2004) believes that epiphytes are affected and enhance by an increased nutrient input.

Occurrence of epiphytic myrmecophytes can also be determined by determining the seed dispersal activity by the residence ants. In this phenomenon, ants carry the seeds of the plants away from the parent plants and leaving them in ant tunnels along the bark of the tree (Lok & Tan, 2009). This is where the seeds

eventually germinate into a new plant. Hence, by looking at the ants' seed-carrying behavior, we can determine the distribution of epiphytic myrmecophytes.

## 2.2 Relationship: Epiphytic myrmecophytes – Ants

Epiphytic myrmecophytes built a relationship with ants to protect them from other herbivory of which this strategy is less expensive. Having a partner that is protecting the leaves would also allow the epiphytes to invest extra energy in reproduction and growth (Aivarez *et al.*, 2001).

Hoya is one example of an Asclepiadaceae that built a relationship with ants. Cardiotonic glycoside, a form of terpenoids (secondary metabolites occur in all plants), synthesized by any members of milkweed family actually provides an effective defense against herbivores (Raven *et al.*, 2005). However, it requires a lot of energy to synthesize terpenoids, and other biotic and abiotic defense of the plants (Nomura *et al.*, 2000).

Two epiphytes species of Bromeliaceae are *Tillandsia usneoides*, Spanish moss used as stuffing material, and *Ananas comosus* (pineapple), a terrestrial plants but are epiphytes in their natural environment. These two species develop mutual relationships with ants.

Fern such as *Platyserium* sp. are mainly found to be associated with ants. Bidin and Jaman (1999) found that ferns in general occurred from lowlands to lower montane forests, hill dipterocarp forests and from light to deep shade areas. Ants found to have a relationship with fern in order to get better place to live.

Melastomes are usually grown on the areas with high humidity. Few are observed to be well developed in water and light saturated of nutrient-poor



substrate. However, species of Melastomataceae which associated with ants are usually found in dry habitats (Cabrera & Jaffe, 1994). Two species of myrmecophytes melastomes found in Primary Rain Forest of Colombia namely *Tococa guianensis* and *T. spadaciflora* were found associated with three ant species which are *Pheidole* sp., *Wasmannia auropunctata*, and *Azteca* sp. (Aivarez *et al.*, 2001).

Orchids discovered to have relationship with ants which help them to obtain nutrients. Myrmecophytic orchid can be found in riverine habitats in the hill forest and lower montane forest, mossy forest on many of the ridges above 1400 m elevation, as well as in heath forest (Beaman *et al.*, 1999).

Two species of the family Rubiaceae which are very well-known for their swollen tubers where ants live are *H. formicarum* and *M. tuberosa*. Kaufmann and Maschwitz (2006) identified *H. formicarum* and *M. tuberosa* as the nest sites for the ant species, *Philidris* sp.. The biologically interesting ant-plant association, myrmecophytism, occurs in 140 of the total 11,000 known species of plants and 22 of the 630 genera of the coffee family (Razafimandimbison *et al.*, 2005).

### **2.3 The distribution of epiphytic myrmecophytes**

For ant-plants species that possessed specialized structures for housing ant colonies, excluding species with ants-constructed nest, there are 415 known species worldwide. In Southeast Asia, epiphytic myrmecophytes are distributed from Sumatera to Borneo, Java, Papua New Guinea, Cape York and Andaman Islands (Lok & Tan, 2009).

According to Lok and Tan (2009), *Myrmecodia tuberosa* probably went extinct owing to deforestation of lowland rainforest and primary mangrove forest, hence it is

now listed as nationally extinct in Singapore. In addition, this particular species do not occur in high densities in closed forest.

There are 84 species of epiphytic myrmecophytes from 16 different families were found distributed in Malaysia, Java and Southern Thailand (Kaufmann & Maschwitz, 2006). They are found at various places comprising pristine dipterocarp lowland forest, hill and montane forest, secondary rain forest, heath forest and even plantations.

## **2.4 Roles of epiphytic myrmecophytes**

Epiphytic myrmecophytes play a crucial role as they provide habitat for a rich fauna and flora which play an important role in the forest ecosystem. Epiphytic ferns for example, collect masses of humus, and become housing sites for lots of arboreal ant species and other obligatory partners like spiders, beetles, lepidopteran larvae, crickets and even stingless social bees (Kaufmann & Maschwitz, 2006). In this context, dissolved chemicals in the rainfall water are trapped by the roots of epiphytic myrmecophytes as water runs down the trunk or bark of the phorophyte. The epiphyte roots block the flow thus reducing erosive ability of the waters and hence allowing accumulation of debris. Eventually, the rooting materials of epiphytic myrmecophytes are best for ants and other invertebrate to build their nests.

In one particular ecosystem where epiphytic myrmecophytes occurs, they actually enhance the carbon sequestering between the plants and the ants colonies (Kaufmann & Maschwitz, 2006). Ant plants also enhance watershed integrity which eventually promote to the erosion control and climate stability besides enhancing the nutrient cycle. Besides, epiphytic ant-plants react sensitively to changes in the ecosystem like certain pollutants in the air. Hence, epiphytic ant-plants are great indicators of environmental quality of an area. When disturbance occur in one area which is caused by urbanization, pollution and so on, the occurrence of epiphytic

myrmecophytes decreases. Another example is when there is change in humidity in one area due to opening up of forest due to logging, the leaves structure and color, as well as the distribution of the plants will be affected.

Importantly, people used epiphytic myrmecophytes (*Myrmecodia* sp.) as a medicine, usually taken by woman after childbirth . Additionally, they are believed to relieve headache, swellings, stomachache and so on. In Cambodia, Laos, Vietnam and Malaysia, a decoction of the leaves of *Hoya diversifolia* mixed with hot water and applied externally to ease the pain of rheumatism (Wiert, 2006). Besides that, *Schefflera* sp. is locally used in primitive medicine of national minorities and in traditional oriental medicine (Averyanov et al., 2003). In Indonesia, the tuber of *Hydnophytum* and *Myrmecodia* as well as the roots of *Pachycentria contricta* were eaten by woman after childbirth. *Hydnophytum formicarum* has a long tradition of use in Thailand traditional medicine as a mixture with other plant extracts for the treatment of diabetes (Prachayasittikul et al., 2008). Currently, *Hydnophytum formicarum* has been identified to possess cardiovascular, anti-inflammatory and anti-parasitic effects, function as neurotonic and used to relief skin rashes, also used as a treatment of headache, hepatitis, rheumatism and diarrhea (Prachayasittikul et al., 2008) (Appendix F).

Researchers use species of epiphytic myrmecophytes to study the relationship of epiphytes with ant colonies and other insects. New findings would probably give us more information about their complex relationship. In addition, by understanding the relationships between epiphytes and ants, we will be able to manage conservation efforts not only for the epiphytic plants but indirectly, we are ensuring the survival of many ants' species that play important roles in one particular ecosystem. Epiphytic myrmecophytes are important not only to the area where they occur but also satisfy many human needs. Traditionally, people eat tuber of *Hydnophytum* sp. as their food alternative when there is less food supply available during rainy seasons or drought where their crops are in a very minimum production. *Hydnophytum* spp. also valued as ornamental plants and has been cultivated commercially. Many growers love to

cultivate *Hydnophytum* and *Myrmecodia* because they are highly valuable compare to other myrmecophytes species.

The occurrence of some epiphytic ant plants which are very unique in their appearance such as orchids attract tourist from all over the world and also used for recreation purposes (Lowman & Rinker, 2004). Recently, epiphytic myrmecophytes like *Hydnophytum* and *Myrmecodia* having great potential for ornamental horticulture because of their bizarre shapes and forms (Lok & Tan, 2009) as well as *Schefflera* and *Hoya* (Averyanov et al., 2003). In addition, the complex relationship between epiphytic plant and their residence ants has inspired human in many field.



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