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EPIPHYTIC PLANTS ASSOCIATED WITH MANGROVE TREES IN SIMILAJAU NATIONAL PARK MANGROVE FOREST

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EPIPHYTIC PLANTS ASSOCIATED WITH MANGROVE TREES IN SIMILAJAU NATIONAL PARK MANGROVE FOREST

By

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DEDICATION

For my most beloved and respected father, Mustafa Kamal Che Ali and my mother, Ramlah Abd. Ghani and to all my brothers and sisters, Muhammad Ghazali Mustafa Kamal, Siti Qistina Mustafa Kamal and Siti Khairunnisa Mustafa Kamal. Thank you for your support.

May all of you be blessed by ALLAH

ABSTRACT

A study on epiphytic plants in Similajau National Park Mangrove Forest of Bintulu, Sarawak was conducted in August 2006 to March 2007. The aims of this study are (i) to determine the taxonomic distribution of epiphytic plants in a Similajau National Park Mangrove Forest, (ii) to determine epiphytic plants species and (iii) to access epiphytic plants association and distribution. Seventeen (17) in 8 families of epiphytic plants were recorded associated with *R. apiculata* trees in the Similajau National Park Mangrove Forest. They can be categorized into flowering plants (Aspleniaceae-1 species and Orchideceae-7 species) and spore bearing plants (Pteridiophyta-5 species and Bryophyta-3 species). The seventeen (17) species of epiphytes are *Hoya diversifolia, Dendrobium acerosum, D. rosellum, D. rhodostele, Trichotosia velutina, Bulbophyllum* sp., *Bulbophyllum odoratum, Eria ignea, Davallia denticulata, Humata parvula, Asplenium nidus, Drynaria quercifolia, Crypsinus stenophyllus, Calymperes* sp., *C. dozyanum, Thyridium fasciculatum and Lepidolejeunea* sp. All orchids and ferns are frequently associated with mosses, that commobnly grows *Calymperes dozyanum* and commonly growing together with liverworts, *Lepidolejeunea* sp. Epiphytic plants tend to occupy stilt roots rather than branches or trunks of *R. apiculata* trees. There is no definite pattern for the epiphytic plants community with respect to vertical distribution. Their vertical distributions are overlapping. However, bryophytes tend to have a wider range of vertical distribution from low height of 1.62 m to a greater height up to 14.58 m.

ABSTRAK

Satu penyelidikan tentang tumbuhan epifit telah dijalankan di hutan paya bakau di Taman Negara Similajau, Bintulu Sarawak dari Ogos 2006 hingga Mac 2007. Objektif penyelidikan ini adalah untuk (i) untuk mengenalpasti taburan taksonomi tumbuhan epifit di hutan paya bakau Taman Negara Similajau, Bintulu, Sarawak (ii) mengenal pasti spesies tumbuhan epifit dan (iii) membuat penilaian terhadap assosasi dan taburan tumbuhan epifit. Tujuhbelas (17) spesies dalam 8 famili tumbuhan epifit telah direkodkan berasosasi dengan tumbuhan *R. apiculata* di hutan paya bakau Taman Negara Similajau. Tumbuhan epifit di sini dikategorikan kepada tumbuhan berbunga (Asplediaceae-1 spesies and Orchideceae-7 spesies) dan tumbuhan berspora (Pteridiophyta-5 spesies dan Bryophyta-3 spesies). Tujuhbelas (17) spesies tumbuhan epifit tersebut adalah *Hoya diversifolia, Dendrobium acerosum, D. rosellum, D. rhodostele, Trichotosia velutina, Bulbophyllum* sp., *Bulbophyllum odoratum, Eria ignea, Davallia denticulata, Humata parvula, Asplenium nidus, Drynaria quercifolia, Crypsinus stenophyllus, Calymperes* sp., *C. dozyanum, Thyridium fasciculatum* dan *Lepidolejeunea* sp. Orkid dan paku pakis wujud bersama dengan lumut iaitu *C. dozyanum* yang tumbuh bersama dengan *Lepidolejeunea* sp. Tumbuhan epifit menapak lebih kepada bahagian akar sokong jika dibandingkan dengan bahagian dahan dan batang tumbuhan *R. apiculata*. Tidak terdapat taburan menegak yang jelas bagi komuniti tumbuhan epifit. Taburan menegak tumbuhan epifit adalah bertindih antara satu sama lain. Lumut mempunyai taburan menegak yang lebih luas iaitu iaitu dari ketinggian 1.62 m hingga ke ketinggian 4.58 m.

ACKNOWLEDGEMENTS

In the name of ALLAH, Most Gracious, Most Merciful.

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Last but not least, thanks to Mr. Haji Ali bin Yusop, the Controller of Wild Life/Controller of National Parks and Nature Reserves, Forest Department of Sarawak for giving me the permission to conduct this research and to collect samples from Similajau National Park Mangrove Forest.

APPROVAL

I certify that this research project report entitled "Epiphytes Associated with Mangrove Trees at Similajau National Park Mangrove Forest" has been examined and approval as a partial fulfillment of the requirement for the degree of Bachelor of Bioindustry Science in the Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Campus.

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CHAPTER 1

INTRODUCTION

There are a number of definitions for the term mangrove. Mangrove applied to plants which live in muddy, loose, wet soils in the tropical tidal waters (Davis, 1940: In Japar Sidik, 1994). Mangroves refer either to the constituent plants of tropical intertidal forest communities or to the community of mangrove (Tomlinson *et al.*, 1986).

Mangrove forests can only be found at the tropical and subtropical areas. According to Khoo (1989, In: Japar Sidik, 1997) the world's mangroves covered an area of 171,000 km^2. In Malaysia mangroves area cover an area of 6,500 km^2. About 1,100 km^2 is found in Peninsular Malaysia and the rest of the areas in Sabah and Sarawak.

According to the Working Group on Mangrove Ecosystems of the IUCN Commission on Ecology (Saenger *et al.*, 1983), mangrove plants species can be categorized as: (1) the exclusive species which are restricted to the mangrove habitat; (2) the non-exclusive species which may be important in the mangrove habitat, but which are not restricted to it; (3) the associated and correlated biota which include, for example ferns and orchids. Tomlinson *et al.* (1986) also stated that associates to mangroves include cryptogams such as algae, bryophytes and lichens. Most associates are those of vascular epiphytic plants.

In Malaysia, the mangrove plants component has relatively rich resources of trees and shrubs, with at least 35-38 species as exclusive species, 57 non-exclusive and 9 species as associated plant biota (Japar Sidik, 1994). Most mangrove ecosystem studies report on the first two components (Gong *et al.*, 1984; Mohd Lokman and Sulong, 2001) and very little is known on the plant resources of the associated biota. Although this may be the case, the few associated plant biota reported may not reflect all the plants recorded, but rather depend on the extent of available information. In addition, though available in the form of the reports and published papers, these are scattered and quite often are not easily accessible.

This study is conducted to complement those that have been reported by Japar Sidik (1994) and Japar Sidik *et al.*, (1997). The objectives of this study are:

1. To determine the taxonomic distribution of epiphytic plants in a Similajau National Park Mangrove Forest.
2. To determine epiphytic plants and
3. To access epiphytic plants association and distribution. (e.g. supporting plant specificity, habitat and vertical distribution)

CHAPTER 2

LITERATURE REVIEW

2.1 Definition of Epiphytic Plant

Epiphytic plants also termed as epiphytes are those that grow on other plants for support. By using other plants as support to grow above the ground, epiphytes attain favorable light conditions in the dense tropical rainforest. There are about 28,000 species in 84 families of known vascular plants (for examples orchids and ferns) that are categorized as epiphytes. In addition, there are also many species of non-vascular epiphytes, such as algae, bryophytes that outnumbered by species of ferns and orchids (Chung, 1986).

Epiphytes can be herbs or shrubs which are attached by the roots to the trunks or branches of trees. They do not extract nutrients from the live tissues of the trees on which they occupy (Polunin, 1988).

2.2 Epiphytic Plants

Epiphytes such as lichens, bryophytes, ferns, and orchids are found occurring or inhabiting on other plants. Of the many epiphytic plants, ferns and orchids are the conspicuous plants found from lowland, coastal areas including mangroves, limestone to montane areas. Ferns live on the surface of the barks of trees (Piggot, 1988). Ferns roots collect humus which absorb moisture during rain or that form by the night dew. The amount of food from decaying bark, fallen leaves, dust and the debris needed by ferns is

surprisingly small (Holttum, 1968). However, they do not absorb nutrients from the supporting plant (Frahm *et al.*, 1996).

Orchids in Malaysia occur naturally in the jungles, forest, mountains and islands. Species of orchids such as *Bulbophyllum*, *Dendrobium*, and *Coelogyne* are found growing on the tree branches and trunks (Fadelah *et al.*, 2001). Holttum (1954) reported that *Dendrobium callibotrys* was found in the south Peninsular Malaysia as epiphytic plant to old mangrove trees There are 30 species of *Dendrobium* occurring in Borneo (Wood, 1997). About 72% of the epiphytic orchid species of Sarawak are sympodial, i.e. having growth habit in which each shoot has limited growth, with new shoots usually arising from the bases of the older ones. *Dipodium* is unique among Bornean sympodial orchids and can be having life forms as epiphytic, terrestrial and saprophytic (Beaman *et al.*, 2001).

Bulbophyllum is the largest genus of orchids in Borneo. 214 species of *Bulbophyllum* are recorded in which 119 species are present in Sarawak. *Bulbophyllum* are easily found in many habitats in Sarawak, ranging from the sea shore and mangrove communities. *Dendrobium* which is polymorphic polyphyletic genus contains approximately 1400 species and distributed from India to the Pacific islands. It is the second largest orchid genus in Borneo, with approximately 90 named species recorded from Sarawak alone. Sixteen sections of *Dendrobium* have been recognized in Borneo, all which are represented in Sarawak. *Eria* is a large polyphyletic genus represented by over 80 species in Borneo, 59 of which have been recorded in Sarawak. Numerous

species, particularly in sections *Cylindrolobus*, *Hymeneria*, *Mycaranthes*, and *Urostachya* are poorly known (Beaman *et al.*, 2001).

2.3 Epiphytic Plants Association and Distribution

Segregation of epiphytes has been based on many parameters; the nature of adaptation and fidelity to supporting vegetation, growth habits, climatic tolerance, types of substratum, and mechanisms for securing basic resources (Benzing, 1990).

Holttum (1964) stated that epiphytic orchids cannot live in dry areas. Orchids tend to occur in the tropical areas which have plenty of rain. Tukirin and Kuswata (1984) reported that the distribution and composition of epiphytic plants are interrelated or associated with species of supporting plants. Supporting plants or trees with rough skins, dented, huge and has big branches give condition for epiphytic plants growth while smooth and hard supporting trees has small number of epiphytic plants (Tukirin and Kuswata, 1984).

Observations at Kebun Raya Bogor, Sumatera, Indonesia showed that the distribution of epiphytic plants generally occurred at the part of trunks, branches and sticks. Horizontal trunks are areas of attachment for ferns and other angiosperms. Orchids are the biggest epiphytic plants that grow at the branches (Tukirin and Kuswata, 1984).

CHAPTER 3

MATERIALS AND METHODS

3.1 Location of the Sampling Site

The study area was located at Similajau National Park, Bintulu, Sarawak (Lat. 03° 20' 55" N, Long. 113° 09' 30.6" E) along the 300 m trail at Trail 1 (Figure 1).

The study was conducted by repeated visits to the park. On occasions when tides receded, parts of the mangroves trees were exposed that facilitated observations and data collecting.

3.2 Field Surveys and Sampling

Samplings of epiphytic plants were carried out randomly with about 12 of mangroves trees from the species of *Rhizophora apiculata* trees that have the epiphytic plants.

The numbers of the epiphytic plants occurrence were counted on the mangrove tree especially on stilt roots, branches and trunks or stems. At the same time the heights of each epiphytic plant on the stilt roots, branches or trunks were measured from the forest floor. Where epiphytic plants are high up on the branches, the heights were estimated.

Figure 1: Study area in Similajau National Park Mangrove Forest

For record purposes photographs of the epiphytic plants in their habitats and species association were taken and samples were collected. The vertical distribution of epiphytic plants on the supporting trees, stilt roots, trunks and branches were recorded. Samples of the epiphytic plants were packed into the plastics bags, brought back to laboratory for identification.

3.3 Epiphytic Plants Morphological Parameters

Morphological features listed below, of orchids and ferns where appropriate were examined and measurements were recorded.

(a) Morphological parameters measured or examined for orchids included:-

i. Vegetative structures: leaves length and width, length of rhizomes, diameter of pseudobulbs.

ii. Reproductive structures:

Flowers; number of petals, sepals, and lip length and width, colour, pollen and their development.

(b) Morphological parameters measured or examined for ferns included:-

i. Frond size, stipe and sorus in ferns and gametophyte and sporophyte of bryophytes.

3. 4 Leaf Surface Study

This leaf clearing technique is used to observe the leaf surface cells. The specimens were cut into smaller size 2 X 2 cm in various parts of the specimen. First the leaves or fronds of the plant are kept in solution of 15% Natrium hydroxide for 24 hours. Later

the leaves or fronds are soaked in water for 2 minutes and then placed in 15% of clorox for 10 minutes. They were then transferred into solution of 50% alcohol for 10 minutes and later in Safranin solution for another 10 minutes. The sections of leaves or fronds were then washed thoroughly with distilled water. Later they were soaked in series of alcohol solutions of 50%, 70%, 80%, 90% and 95% for 10 minutes each and washed through distilled water each time. The sections of leaves or fronds are soaked in 100% alcohol for 20 minutes and then transferred in clove oil and soaked for 10 minutes. The sections of leaves or fronds were then placed onto the slide using DPX mountant. After 12 hours the slide is ready for observaion under the compound microscope.

Another technique, nail polish technique is very suitable to study leaf and frond surface morphology for orchids and ferns. The adaxial and abaxial leaf surfaces were spread evenly with neutral (transparent) nail polish. After the nail polish had dried, the nail polish was peeled from the leaf or fronds for observation under compound microscope. The shape of the upper and lower epidermal cells and stomata present were determined.

3.5 Identification

Identification on the specimens either in fresh or dried are referred to following the references of Piggot (1988), Holttum (1964, 1968), Johnson (1965), Frahm *et al.* (1996), Schofield (1985), Polunin (1998), Chan *et al.* (1994), Comber (2001) and Segerback (1992) .

3.6 Herbarium and Storage of the Samples

The samples were processed to start a herbarium collection of epiphytic plants from Similajau National Park Magrove Forest, Bintulu. The plants herbarium was prepared following the procedures by Japar Sidik and Muta Harah (1996) where the cleaned samples were arranged and pressed in between sheets of absorbent papers. The pressed samples were then dried either in the oven with temperature of 39°C or in the air. After that the dried samples were transferred and mount onto herbarium papers. Lastly, the specimens were labeled with information onto the herbarium papers.

CHAPTER 4

RESULTS

4.1 Taxonomic Distribution of Epiphytic Plants

The mangrove trees in particular *Rhizophora apiculata* supported a range of epiphytic plants from flowering to spore bearing plants. Table 1 contains a list of the taxonomic groupings and species of associated plant recorded at the Similajau National Park Mangrove Forest. A total of seventeen (17) species in 8 families are recorded as associated plants. The major members of the plants community are orchids and ferns. Mosses and liverworts are low in species number but are dominant as they occur in masses covering the tree stilt roots, branches and trunks of *R. apiculata* trees.

4.2 Epiphytic Plant Descriptions from Similajau National Park Mangrove Forest

The individual description of the epiphytes (field observations and measurement recorded), the references used for identification, their natural habitat as observed in the National Park is given with illustration in the Section 4.2.1 to 4.2.16.

Table 1: Category, family, occurrence of epiphytes associated with *Rhizophora apiculata* trees in Similajau National Park Mangrove Forest

SPECIES	Total number of mangrove trees observed	Occurrence of epiphytes	Percentage of occurrence (%)
FLOWERING PLANTS			
CLASS: DICOTYLEDONEAE			
ASCLEPEDIACEAE			
1. *Hoya diversifolia*	12	71	13.17
CLASS: MONOCOTYLEDONEAE			
ORCHIDACEAE			
2. *Dendrobium acerosum*	12	280	51.94
3. *Dendrobium rosellum*	12	11	2.04
4. *Dendrobium rhodostele*	12	8	1.48
5. *Trichotosia velutina*	12	14	2.60
6. *Bulbophyllum* sp.	12	87	16.14
7. *Bulbophyllum odoratum*	12	7	1.30
8. *Eria ignea*	12	5	0.93
SPORE BEARING PLANTS			
DIVISION: PTERIDIOPHYTA			
DAVALLIACEAE			
9. *Davallia denticulata*	12	14	2.60
10. *Humata parvula*	12	23	4.27
ASPLENIACEAE			
11. *Asplenium nidus***			
POLYPODIACEAE			
12. *Drynaria quercifolia*	12	3	0.57
13. *Crypsinus stenophyllus*	12	3	0.57

DIVISION: BRYOPHYTA			
MOSSES			
CALYMPERACEAE			
14. *Calymperes* sp.	12	5	0.93
15. *Calymperes dozyanum*	12	**	**
SYRRHOPODOTACEAE			
16. *Thyridium fasciculatum*	12	8	1.48
HEPATICAE			
LIVERWORTS LEUJEUNEACEAE			
17. *Lepidolejeunea* sp.	12	**	**
Total occurrence of epiphytic plants		**539**	

Note:

(*) *Asplenium nidus* was found on *R. apiculata* trees that was not sampled
(**) *Calymperes dozyanum* and *Lepidolejeunea* sp. were found dominantly attached to every *R. apiculata*

4.2.1 *Dendrobium acerosum* Lindl.

Family: Orchidaceae

Reference: Comber (2001): p. 662-663

Description:

Small lowland epiphyte forming a small clump, stem occasionally branching, 5-5.5 cm long, zig-zag, thin near the base (Figure 2). Leaves terete, acute, to 11.26 long and 1.87 thick. Leaf surface cells are angular and hexagonal in shape. Stomata on both leaf surfaces are opened, paracytic guards cells is accompanied by one or more subsidiary cells parallel to its long axis and horizontally distributed. Inflorescence one-flowered from the apical leafless part of stems. Flowers 1 cm broad, cream, the sepals and petals yellowish in colour with red veining, the lip yellow patch; dorsal sepal ovate-triangular and lateral sepals obliquely triangular, petal oblong, lip trilobed the centre of the lip yellow in colour.

Habitat:

Inhabits on stilt roots, branches and trunks of *R. apiculata* trees.

Status:

Common

Other observation:

Comber (2001) noted that this particular species is found in lowland and swamp forests distributed in Burma, Thailand, Peninsular Malaysia and Borneo.

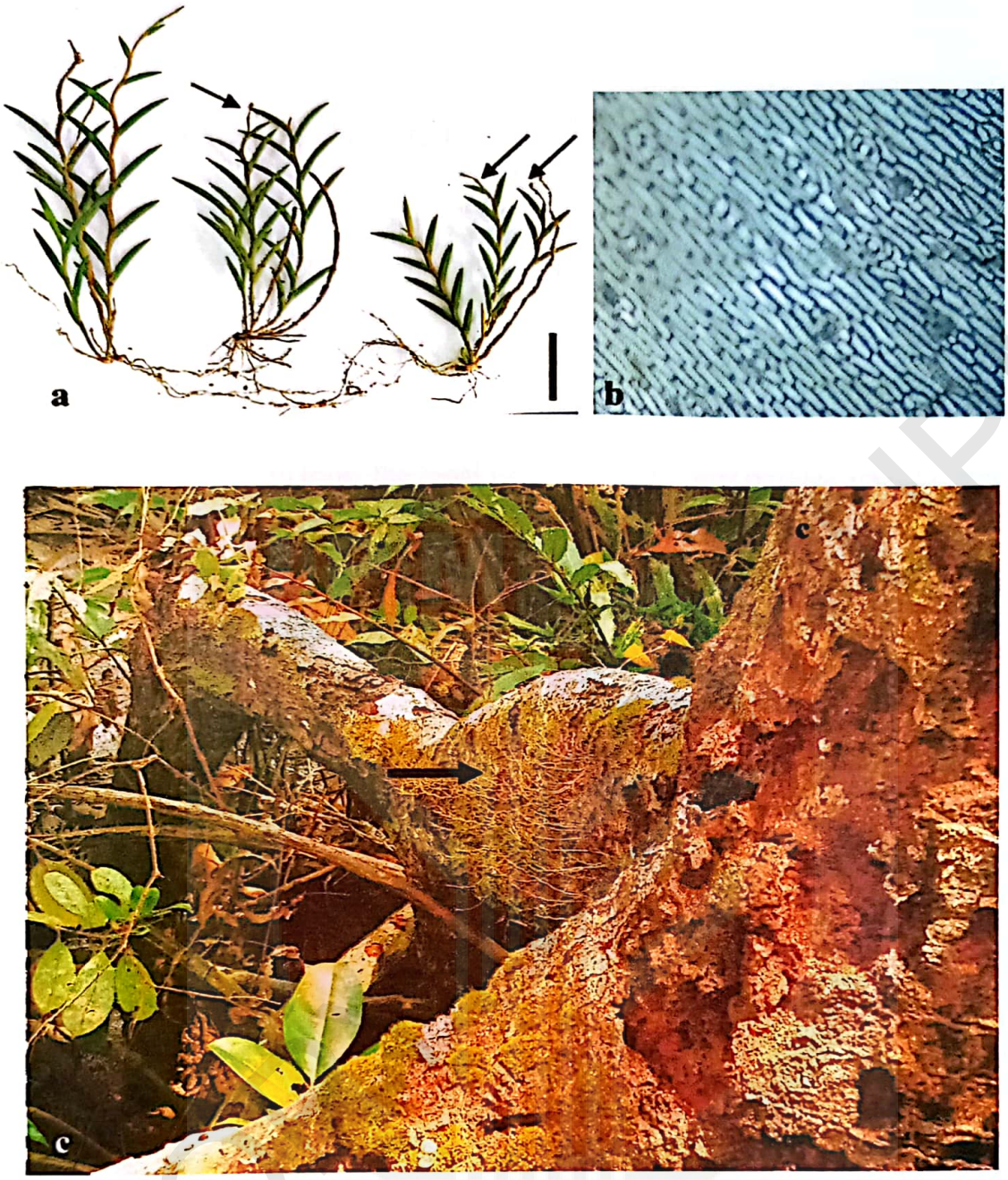

Figure 2: The habit of *Dendrobium acerosum*. (a) cluster of plants with different shoot height of 3 or 4. A shoot normally has an extension of a leafless part (arrow).Scale bar, 2 cm. (b) surface of leaf showing the surface cell morphology and the distribution of stomata. (c) *Dendrobiun acerosum* inhabiting one of the stilt root of *R. apiculata* tree shown by an arrow. This orchid is always in association with mosses *Calymperes dozyanum*, *Thyridium fasciculatum* and liverwort *Lepidolejeunea* sp.

4.2.2 *Dendrobium rosellum* Ridl.

Family: Orchidaceae

Reference: Comber (2001): p. 649-650, Figure. p. 650.

Description:

Similar to *Dendrobium aloifolium* in vegetative characteristics. Stems rarely branching up to 60 cm long, the basal part leafy, the apical part leafless. Leaves 2.4 cm long along the lower margin by 1.4 cm broad at the base, ovate, elliptic, close together, usually green but reddish when exposed to sunlight (Figure 3). Leaf surface cell are non symmetrical square shape, stomata on both leaf surfaces opened, paracytic the stomata are horizontally distributed. Flowers 9 mm wide from the leafless part of the stem, white with purple flushing, the lip is white with purple streaky and a yellow callus. Dorsal sepal broadly oblong. obtuse; lateral sepal broadly ovate, obtuse; petals shortly clawed, broadly lanceolate, curved over the column, acuminate.

Habitat:

Attaches to the stilt roots of *R. apiculata* trees.

Ecological status:

Rare

Other observation:

Occurs in lowland, often near water as reported by Wood *et al.* (1994).

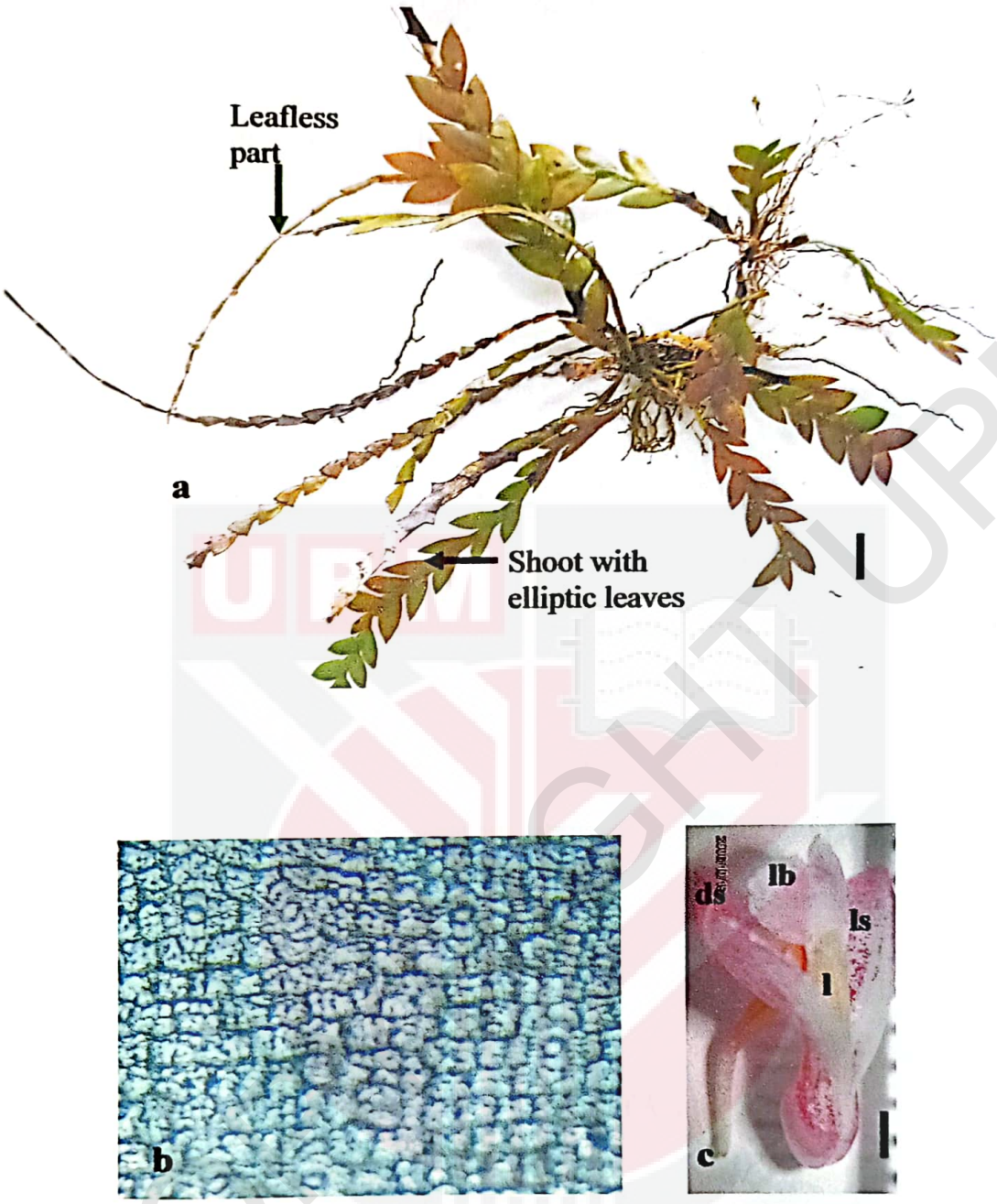

Figure 3: The habit of *Dendrobium rosellum*. The plant is usually in a cluster consisting of shoots with green ovate elliptic leaves and leafless part that bear flowers. Scale bar, 2 cm. (b) surface of leaf showing the surface cell morphology and the distribution of stomata. (c) a flower of *D. rosellum* with the various components; lobe (lb), lateral sepal (ls), dorsal sepal (ds) and lip (l). Scale bar, 1 mm

4.2.3 *Dendrobium rhodostele* Ridl.

Synonym: *Aporum rhodostele* (Ridl.) S. Rauschert in Repert.

Family: Orchidaceae

Reference: Comber (2001): p. 653, Figure p. 653.

Description:

Stems 20 cm long, sometimes longer, the internodes near the base 5 mm long. Leaves medium sized, reddish green (Figure 4). Leaf surface cells are angular to hexagonal in shape, stomata on both leaf surface opened, paracytic, found on abaxial leaf surface, horizontally distributed. Flowers appear from the apical leafless part of the bundles of bracts, white but sepals and petals are flushed pink and the column is purple, about 3 mm long and 5 mm broad; sepals ovate, obtuse, laterals forming a brad, short, obtuse mentum; petals linear, acute; lip oblong in outline narrow, bilobed and rounded; column pink, long and broad.

Habitat:

Usually in a shady spot, attaches to the stilt roots of *R. apiculata* trees.

Ecological status:

Rare

Other observation:

Occurs in Thailand, Peninsular Malaysia and Borneo according to Comber (2001).

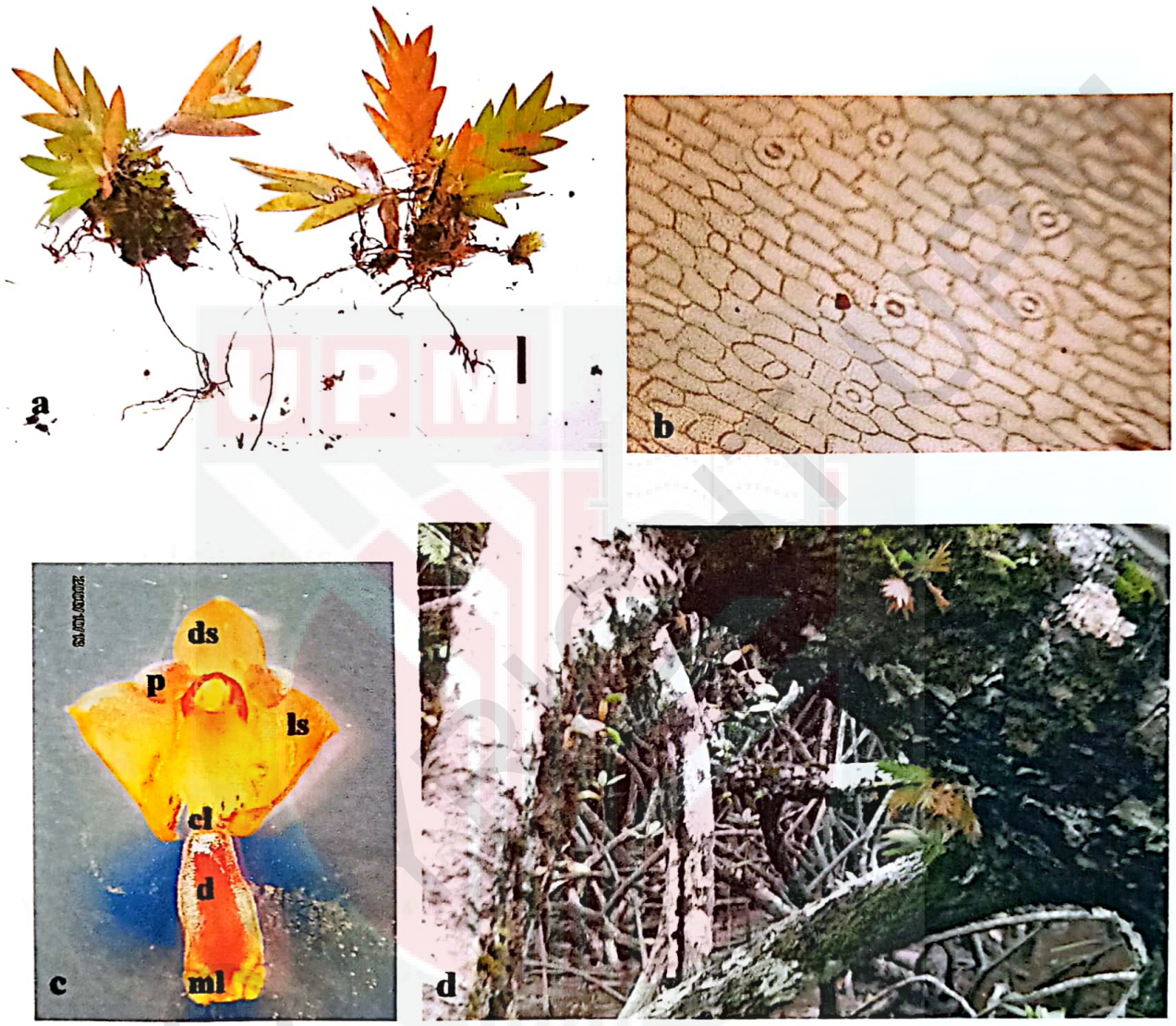

Figure 4: The habit of *Dendrobium rhodostele* (a) the plant is usually in a cluster, rather short with leaves overlapping leaves. Scale bar, 2 cm. (b) surface of leaf showing the surface cell morphology and the distribution of stomata. (c) the haemaphrodite flower of *D. rhodostele* comprising dorsal sepal (ds), petal (p), disc (d), mid-lobe (ml), claw (cl), lateral sepal (ls). (d) *D. rhodostele* is found attached to the stilt root of *R. apiculata* tree

4.2.4 *Trichotosia velutina* (Lodd ex Lindl.) Kranzl.

Family: Orchidaceae

Synonym: *Eria velutina* Lodd ex Lindl

Pinalia velutina (Lodd ex Lindl.) Kranzl.

Dendrobium sessile Gagnep.

Reference: Comber (2001): p. 519-520, Plate p. 519

Description:

Stems more than 20 cm long, pendulous with upturned apices, bearing leaves. Leaves lanceolate, acute, sessile, about 16 mm width, covered all over with long, brown hairs (Figure 5). Leaf surface cells are not conspicuous, Stomata on both leaf surface cell opened, paracytic, found on abaxial leaf surface, horizontally distributed. Inflorescences 24 mm long, with 3 flowers, rachis densely hairy; floral bracts ovate, obtuse. Flowers cream, most parts flushed red towards the base. Dorsal sepal narrowly ovate, obtuse, 8 mm long by 3 mm broad, densely brown hairy on the back. Lateral sepals triangular, obtuse and hairy, long and broad. Petals narrowly oblong, obtuse. Lip entire, spatulate in outline, its apex indented, its apical margins finely erose, 3 ribs which run from the base ending near the apex and broad patch of papillose near the apex. Column straight.

Habitat:

Plant inhabiting the stilt roots of *R. apiculata* trees.

Status:

Rare

Other observation:

Holttum (1964) reported this species occurs in Borneo lowlands as an epiphyte.

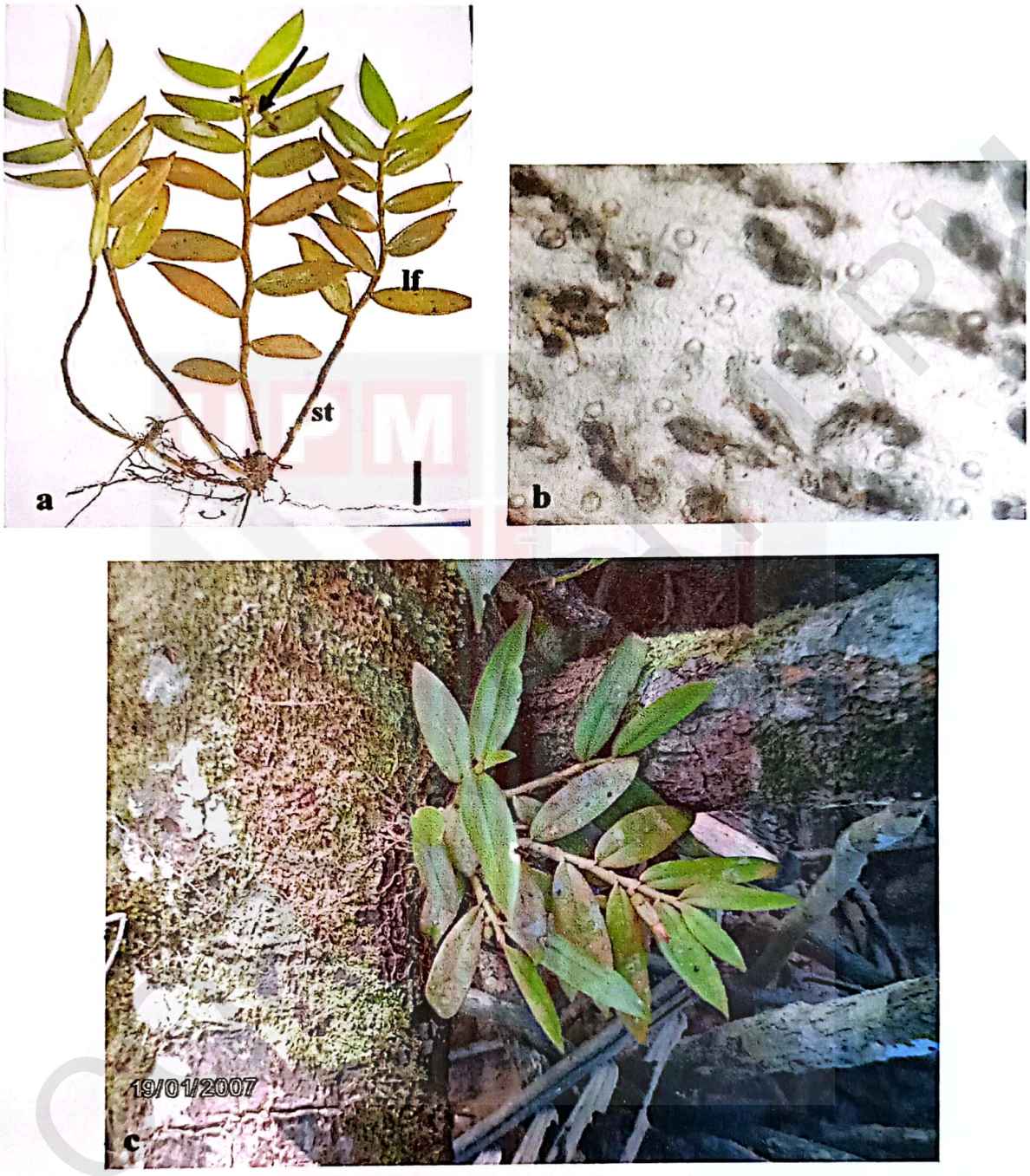

Figure 5: The habit of *Trichotosia velutina* (a) cluster of plants with lanceolate leaves (lf) arranged alternately along the stem (st). Arrow shows the presence of flowers in an inflorescence. Scale bar, 2 cm. (b) surface of leaf showing the surface cell morphology and the distribution of stomata. (c) *T. velutina* is usually attached horizontally to the stilt roots of *R. apiculata* tree

4.2.5 *Bulbophyllum* sp.

Family: Orchidaceae

Reference: Comber (2001): p. 789-790

Description:

Medium-sized epiphytic herb. Rhizome short, stout. Roots wiry, densely clustered on the rhizome. Pseudobulb, 24 mm long and 8.8 mm broad and ovoid in shape (Figure 6). Leaves, 69 mm long and 22.95 mm width, oblong-elliptic. A pseudobulb bears a single leaf. Flower could not be observed during the study in the field or laboratory.

Habitat:

Inhabits the stilt roots and trunks of *R. apiculata* trees.

Ecological status:

Rare

Other observation:

Prefers light condition, occurs in Burma, Vietnam, Thailand, Peninsular Malaysia, Java, Borneo, Sulawesi and Philippines. Also found in West Sumatera and North Sumatera between elevation of 600-1460 m (Comber, 2001).

Figure 6: The habit of *Bulbophyllum* sp. (a) a plant with a single oblong and elliptic leaf (lf) that is attached to a pseudobulb (pb) and its roots tend to cluster on the *R. apiculata* stilt root (b) *Bulbophyllum* sp. growing horizontally on the upper part of the stilt root of *R. apiculata* tree

4.2.6 *Bulbophyllum odoratum* (Bl.) Lindl.

Synonym: *Diphyes adorata* Bl.

Bulbophyllum pàngerangii Rchb.f.

B. elatius Ridl.

B. niveum (J.J Sm.) J.J Sm

B. poolyarachne Ridl.

Family: Orchidaceae

Reference: Comber (2001): p. 720-721, Figure p. 721.

Description:

Rhizomes creeping, bearing pseudobulbs 2.5-4.4 cm apart. Pseudobulbs is disc-shaped, 0.5-1.5 cm broad. Leaves oblong 33-40 mm long, leaf surface is rough (Figure 7). Leaf surface cells is hexagonal in shape, stomata on both leaf surface opened, anomomytic, found on abaxial leaf surface and horizontally distributed. Flowers were not observed from the field or in the laboratory.

Habitat:

Attaches to the trunks and stilt roots of *R. apiculata* trees at a height of about 1.62-3.24 m from the mangrove forest floor.

Ecological status:

Rare

Other observation:

Comber (2001) found this species at the medium elevations.

Figure 7: The habit *Bulbophyllum odoratum*. (a) showing a single leaf (lf) that is attached to a pseudobulb (pb) with creeping roots (rt), spreading on the trunk of *R. apiculata* tree. Scale bar, 2 cm. (b) surface of leaf showing the surface cell morphology and the distribution of stomata

4.2.7 *Eria ignea* Rchb. f.

Synonym: *Eria cinnabarina* Rolfe

Family: Orchidaceae

Reference: Chan *et al.* (1994): p. 158-159, Figure 39.

Description:

Epiphytic herb. Pseudobulbs 37 x 10 mm, ovoid to oblong, clustered, 2-3 leaved, enclosed by several imbricate sheaths at base. Leaves 10 x 15 mm, oblong-ligulate. Leaf surface cells are angular, irregular square to hexagonal in shape, stomata on both leaf surface opened, paracytic, found on abaxial leaf surface, horizontally distributed. Inflorescences were not observed from the field or in the laboratory plantings (Figure 8).

Habitat:

The species inhabits the stilt roots of *R. apiculata* trees at a height of 1.62 m from the forest floor.

Status:

Rare

Other observation:

Chan *et al.* (1994) reported that this species occurs on small trees in podsolic heath forest and in the light open crowns of trees.

Figure 8: *Eria ignea* (a) grown in the laboratory also does not produce flowers or inflorescences (b) surface of leaf showing the surface cell morphology and the distribution of stomata

4.2.8 *Davallia denticulata* (Burm.) Mett.

Synonym: *Adiantum denticulatum* Burm

Davallia elegans Sw.

Family: Davalliaceae

Common name: Rabbit's foot fern

Local name: Paku tertutup

References: Holttum (1968): p. 358-359, Figure 206; Piggot (1988): p. 392-393, Figure 1199-1201.

Description:

Rhizome stout, wide, densely covered with scales when young; scales light brown, long narrowed gradually from the peltate (Figure 9). Frond about 40 cm long. Frond surface cells are jigsaw puzzle in shape, stomata closed on abaxial surface anomomytic where the guard cells are surrounded by cells indistinguishable from other epidermal cell (no subsidiary cells are present) and horizontally distributed. Main rachis flexuous, bearing well-spaced alternate pinnea in 45˚, towards the base almost circular in section like stipe, towards the apex with a narrow flange. Sporangium develop in cup-shaped indusia, with the lamina extending beyond its opening as a curved tooth.

Habitat:

Davallia denticulata inhabits the stilt roots and trunks of *R. apiculata* trees.

Status:

Rare

Other observation:

Piggot (1988) reported that this species commonly occurs in lowland, in exposed places and attaches to the trunks of oil palms.

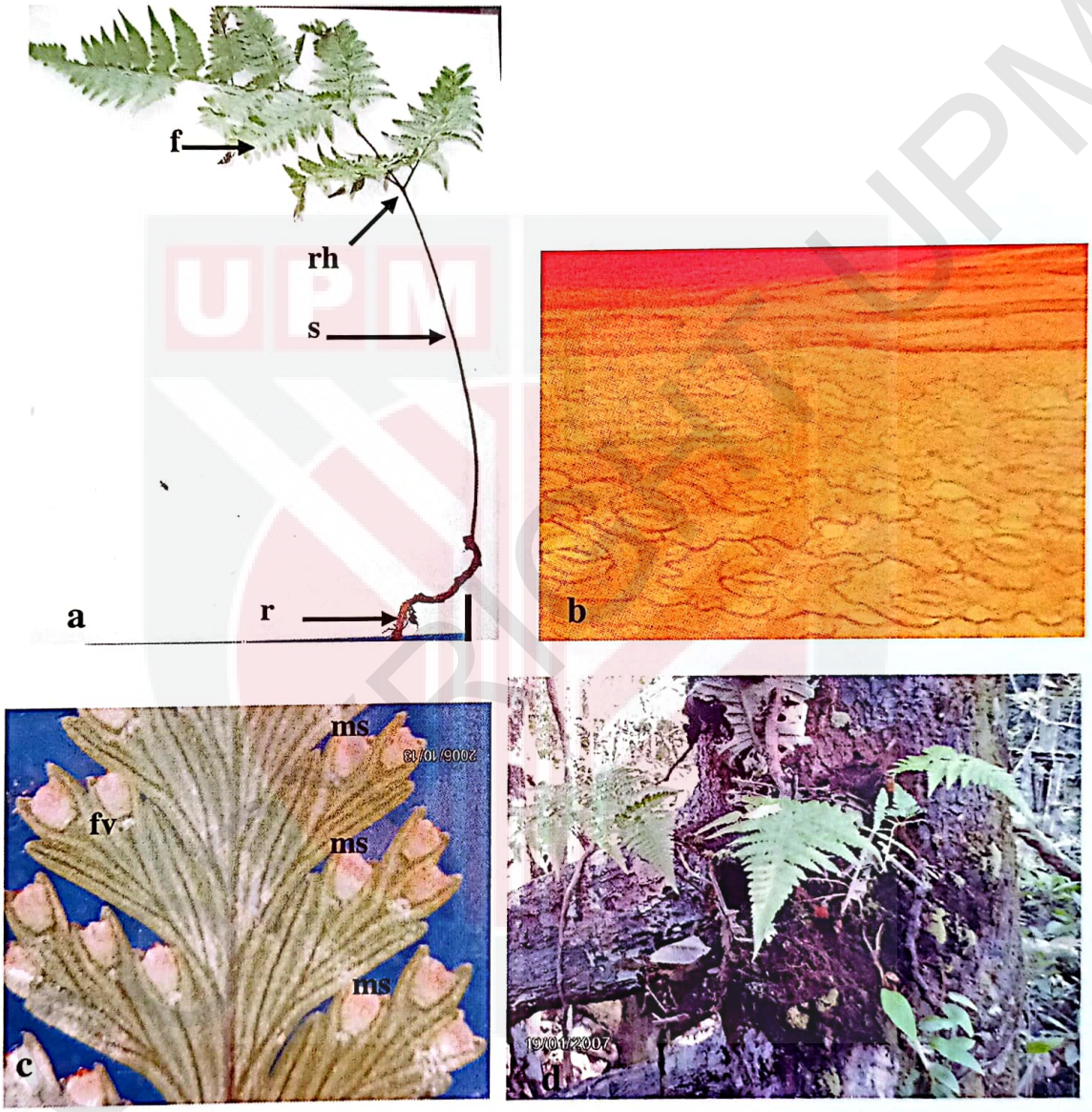

Figure 9: The habit of *Davallia denticulata* (a) the whole plant exhibiting the frond (f), rachis (rh), stipe (s), rhizome (r). Scale bar, 2 cm. (b) the frond surface showing the surface cell morphology and the distribution of stomata. (c) the lower surface of fertile lobes of frond, showing false veins, (fv) and mature sori (ms), a characteristic that is used to confirm the identification of this species. (d) *Davallia denticulata* grows on the trunk of the *R. apiculata* tree

4.2.9 *Drynaria quercifolia* (L.) J. Sm.

Synonym: *Polypodium quercifolium* Linn.

Family: Polypodiaceae

Local name: Daun kepala tupai, Sakat laipang

References: Holttum (1968): p. 182-184, Figure 88; Piggot (1988): p. 134-135, Figure, 392-395.

Description:

Rhizome thick, the young parts densely scaly; scales very dark brown about 2 cm, long narrowed from the peltate base to the very narrow apex, not stiff and finely toothed (Figure 10). Frond surface cells are jigsaw puzzle in shape, stomata closed on abaxial leaf surface, anomomytic and horizontally distributed. Stipes of frond is deciduous, splitting away from the midrib in old fronds or under adverse conditions. Sori in a rather regular row on each side of each main vein, usually round, wide at maturity, and slightly oblong.

Habitat:

Distributed along stilt roots and trunks of *R. apiculata* trees up to 8.1 m from the forest floor.

Status:

Rare

Other observation:

Holttum (1968) reported that this is a common fern on old trees in the lowland on roadside or village trees and also in the crowns of forest trees.

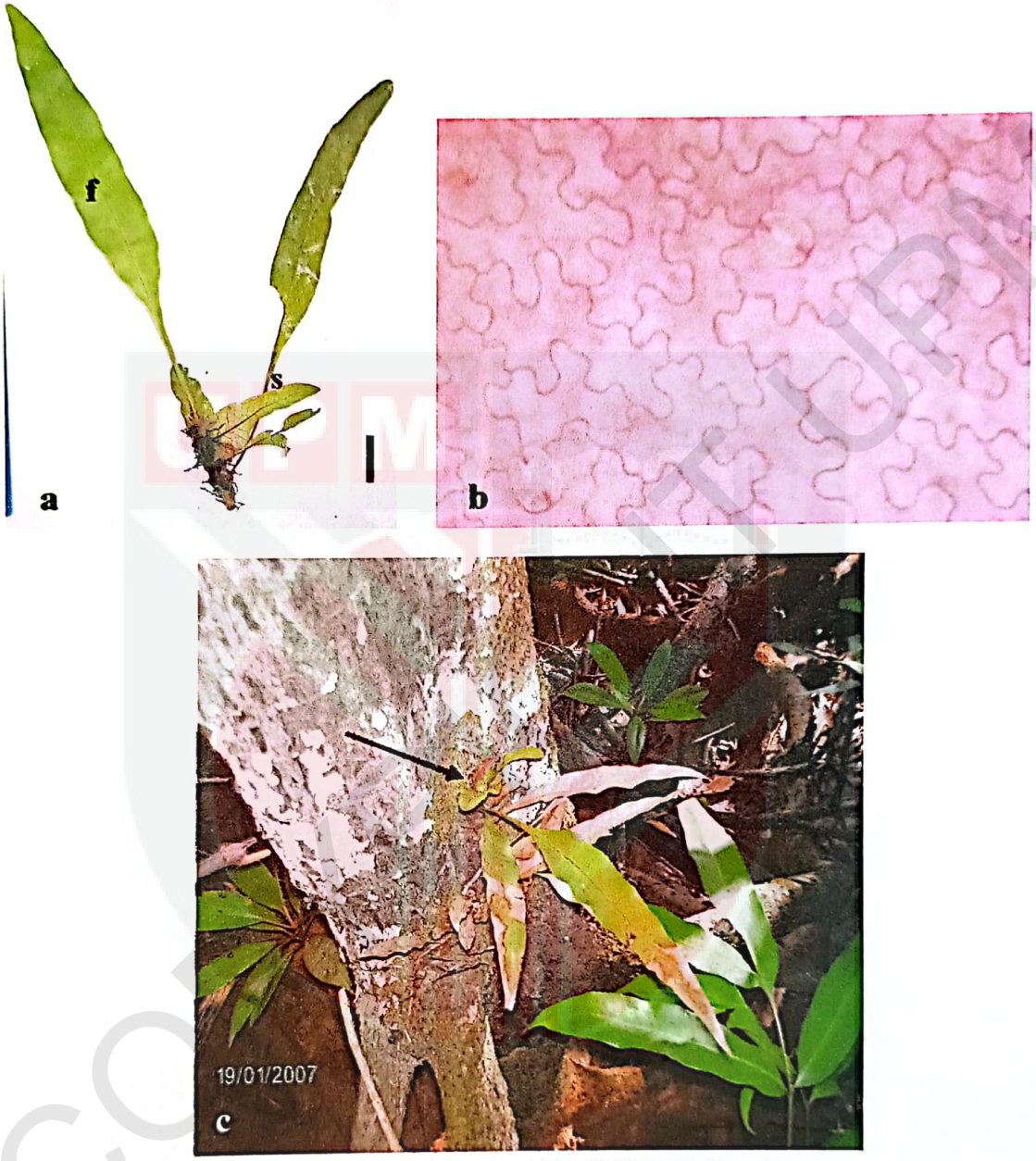

Figure 10: The habit of *Drynaria quercifolia* (a) a plant with a frond (f) attached to the rhizome (r) by the stipe (s). Scale bar, 2 cm. (b) the frond surface showing the surface cell morphology and the distribution of stomata. (c) a young *D. quercifolia* plants (arrow) growing on the stem or trunk of *R. apiculata* tree

Figure 11: *Drynaria quercifolia* (a) in association with *Davallia denticulata* at the lower part of *Rhizophora apiculata* stem (b) a mature plant inhabiting the trunk of *R. apiculata* at a height of 8.1 m from the forest floor

4.2.10 *Asplenium nidus* Linn.

Synonym: *Thamnopteris nidus* Presl.

Family: Aspleniaceae

Common name: Bird's nest fern

Local name: Paku langsuyer, paku pandan, daun semun, Rumah langsuyar, selimbar

References: Holttum (1968): p. 419; Piggot (1988): p. 267-268, Figure 815-819.

Description:

Fronds are simple and entire with broad bases, and form an efficient 'nest' for trapping falling leaves and other debris. Linear indusiate sori develop along the lower two-thirds of all veins branches in the apical part of the fronds. Spores light brown in colour, transculent when fresh, opaque when old, and the wing thickened, irregular (Figure 12).

Habitat:

The plant grows up to 8.1 m on the branch of *R. apiculata* tree

Status:

Rare

Other observation:

A common epiphyte in the lowlands and mountains, on rocks and grows on the ground after falling from the trees (Piggot, 1988).

Figure 12: *Asplenium nidus* growing on the branch of *R. apiculata* tree in Similajau National Park Mangrove Forest

4.2.11 *Crypsinus stenophyllus* (Bl.) Holtt.

Synonym: *Polypodium stenophyllum* Bl.

Ploepeltis stenophylla Moore

Phymatodes sinuosa

Family: Polypodiaceae

References: Holttum (1968): p. 199-201, Figure 101; Piggot (1988): p. 151, Figure 443-445; Polunin (1998): p. 136-137, Figure 137

Description:

Rhizome long creeping, about 1 cm diameter, bearing fronds. The young parts densely covered with scales. Stipes 7 cm long. Frond simple, elongated, unlobed and leathery in texture bearing two rows of large, brown patches which are the spore producing organs with small sori deeply sunk into the lamina and is raised on the upper surface. No veins visible except the midrib. Sterile fronds broader and shorter than fertile, with rounded apex; sori in the upper ½ and ¾ of the frond, in a single row on each side of the midrib, deeply immersed in sharply-defined cavities about 1 mm (Figure 13). Frond surface cells are jigsaw puzzle in shape. Stomata on abaxial frond closed, anomomytic and horizontally distributed. This epiphyte has thick, hallow creeping stems covered by scales and are often inhabited by ants.

Habitat distribution:

Inhabits the stilt roots of *R. apiculata* trees.

Status: Rare

Other observation:

This species occurs from the lowlands as an epiphyte usually on the upper branches of trees in primary forest according to Piggot (1988).

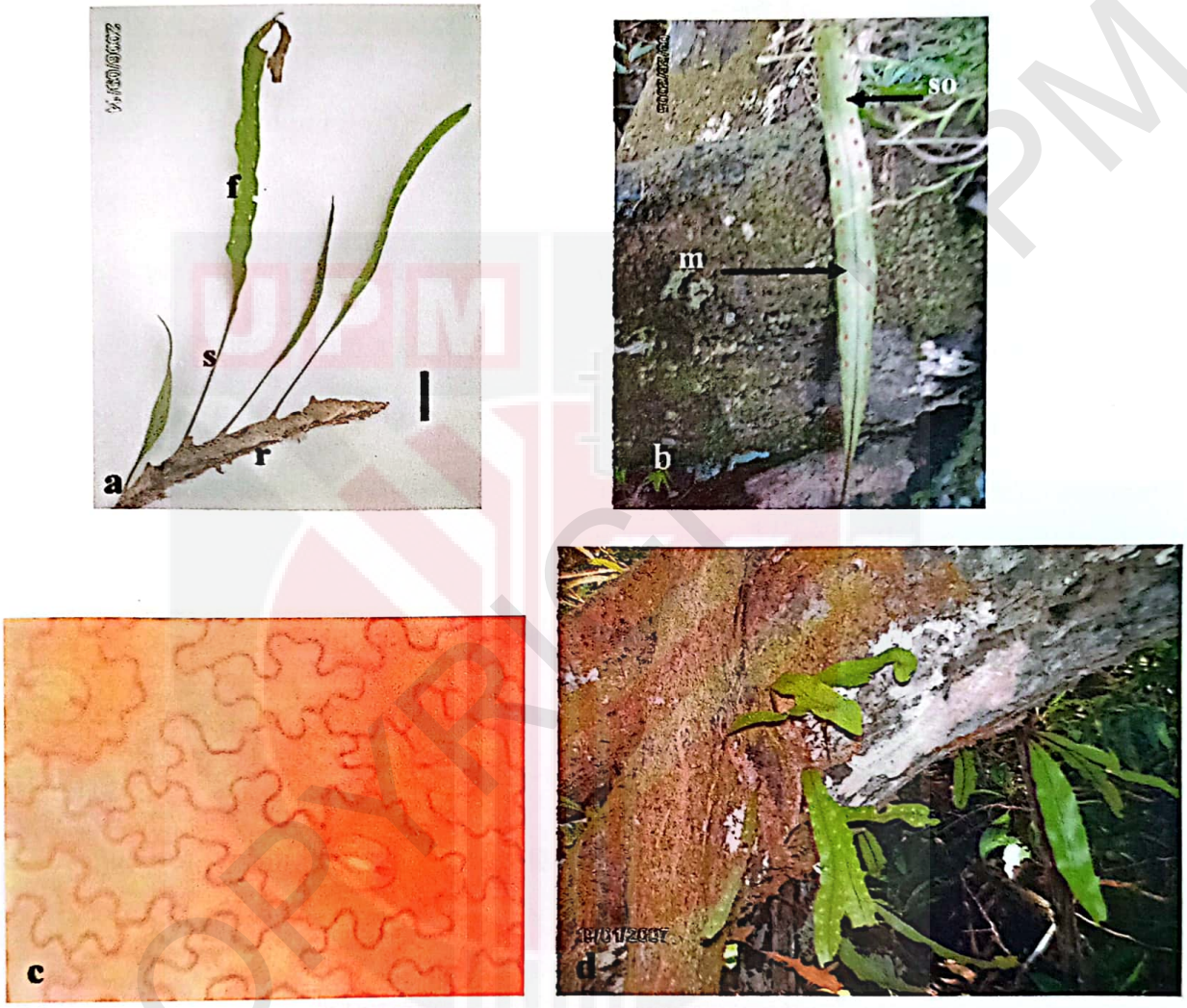

Figure 13: The habit of *Crypsinus stenophyllus*. (a) the plant consists of a rhizome (r), bearing a stipe (s) with a frond (f). Scale bar, 2 cm. (b) the frond having a row of sori (so) and mid-rib (m) (c) the frond surface showing the surface cell morphology and the distribution of stomata (d) *C. stenophyllus*, with hanging fronds carrying the spores, growing attached to the stilt root of *Rhizophora apiculata*

4.2.12 *Humata parvula* (Wall.) Mett.

Synonym: *Davallia parvula* Wall. Cat

Leucostegia parvula J. Sm.

Family: Davalliaceae

Reference: Holttum (1968): p. 368-369, Figure 213.

Description:

Rhizome very slender, 1 mm in diameter without scales. Fronds 5 cm apart. Scales spreading, castaneous with a slightly paler entire edge, long narrowed from peltate base to acute apex (Figure 14). Frond surface cells are jigsaw puzzle in shape. Stomata on abaxial surface closed, anomomytic, vertically distributed. Stipes very slender 4-6 mm long. The lamina deeply dissected as to leave only a narrow wing through each vein, the segments formed uniform width, sori borne at the base of an ultimate fork in the lamina. Indusium firm, dark and circular.

Habitat:

Growing on stilt roots and trunks of mangrove trees.

Status:

Rare

Other observation:

Occurs in the south of Peninsular Malaysia, Borneo, on old mossy mangrove trees as reported by Holttum (1968).

Figure 14: The habit of *Humata parvula* (a) the plant usually form dense creeping masses among the cleavages in the bark of *R. apiculata* tree (b) the frond surface showing the surface cell morphology and the distribution of stomata (c) sori (so) distribution at the base of an ultimate fork in the lamina as observed under dissecting microscope (45X magnification)

4.2.13 *Calymperes* sp.

Group: Musci

Family: Calymperaceae

References: Johnson (1980): p. 49-53, Figure 31-33

Description:

Plant, moderate in height of 4.5 cm. The leaf has of an ovate-lanceolate base. Leaf is narrowed from the base to the tip. The surface cells were jigsaw in shape and the arrangement of stomata are not uniformly distributed (Figure 15).

Habitat:

Grows on stilt roots of *R. apiculata* trees.

Ecological status:

Rare

Other observation:

Johnson (1980) reported that this species occurrs on trees in Singapore and Malaysia.

4.2.14 *Calymperes dozyanum*

Group: Musci

Family: Pouched Hood Moss (Calymperaceae)

Reference: Johnson (1980): p. 50, Figure 28. Frahm *et al.* (1996): p. 5, Figure 6.

Description:

This moss is a creeping plant, bearing upright branches occurs in open and shady situations on trees. Dull dark in colour. The stem is upright up to 11 mm high. The leaves are curled up when dry and form spreading rosette towards the top of the stem.

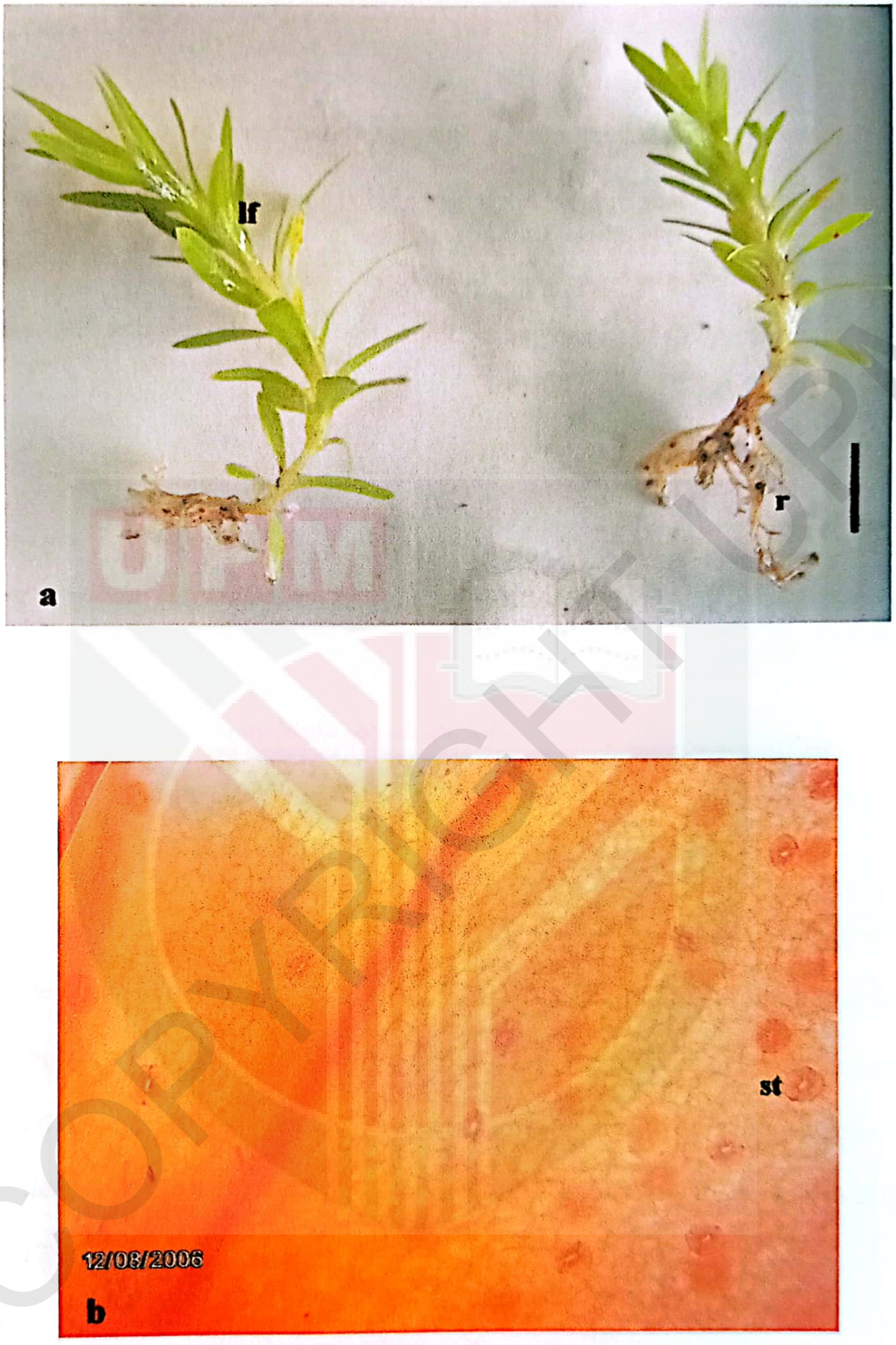

Figure 15: The habit of *Calymperes* sp. (a) showing the rhizome (r) and "leaves" (lf). Scale bar, 1 cm (b) eaf surface comprises irregular hexagonal cells with stomata (st) horizontally distributed (100X magnification)

The sporophyte is up to 6 mm and the capsule is 3 mm long. The calyptra is bell shaped, covering the capsule. The capsule is long, and cylindrical in shape (Figure 16).

Habitat:

Attaches as blotch along the stilt roots, branches and trunks of *R. apiculata* trees.

Status:

Dominant

4.2.15 *Thyridium fasciculatum*

Group: Musci

Family: Bundled Gate Moss (Syrrhopodotaceae)

Reference: Johnson (1980): p. 62-63, Figure 46. Frahm *et al.* (1996): p. 5, Figure 6.

Description:

Branches arising in bundles (fascicles), forming small clusters about 10 mm long to the upper side of the horizontal creeping stem. The leaves are about 2-4 mm long and about 0.2 mm broad, a broad lanceolate above (Figure 17a). The prominent border is golden in colour and disappears below the tip. The sporophytes are about 1 cm long and the seta is red in colour, 4-5 mm high, and bears a long ovoid capsule. Calyptra is reddish in colour (Figure 17b).

Habitat:

It inhabits the stilt roots and the trunks of *R. apiculata* trees.

Ecological status:

Rare

Figure 16: The habit of *Calymperes dozyanum* (a) usually as masses covering the stilt roots, branches and trunks of *R. apiculata* trees (b) sporophyte of *C. dozyanum* consisting of calyptra (cy), capsule (cp), apophysis (ap) and seta (st). Scale bar, 1 mm

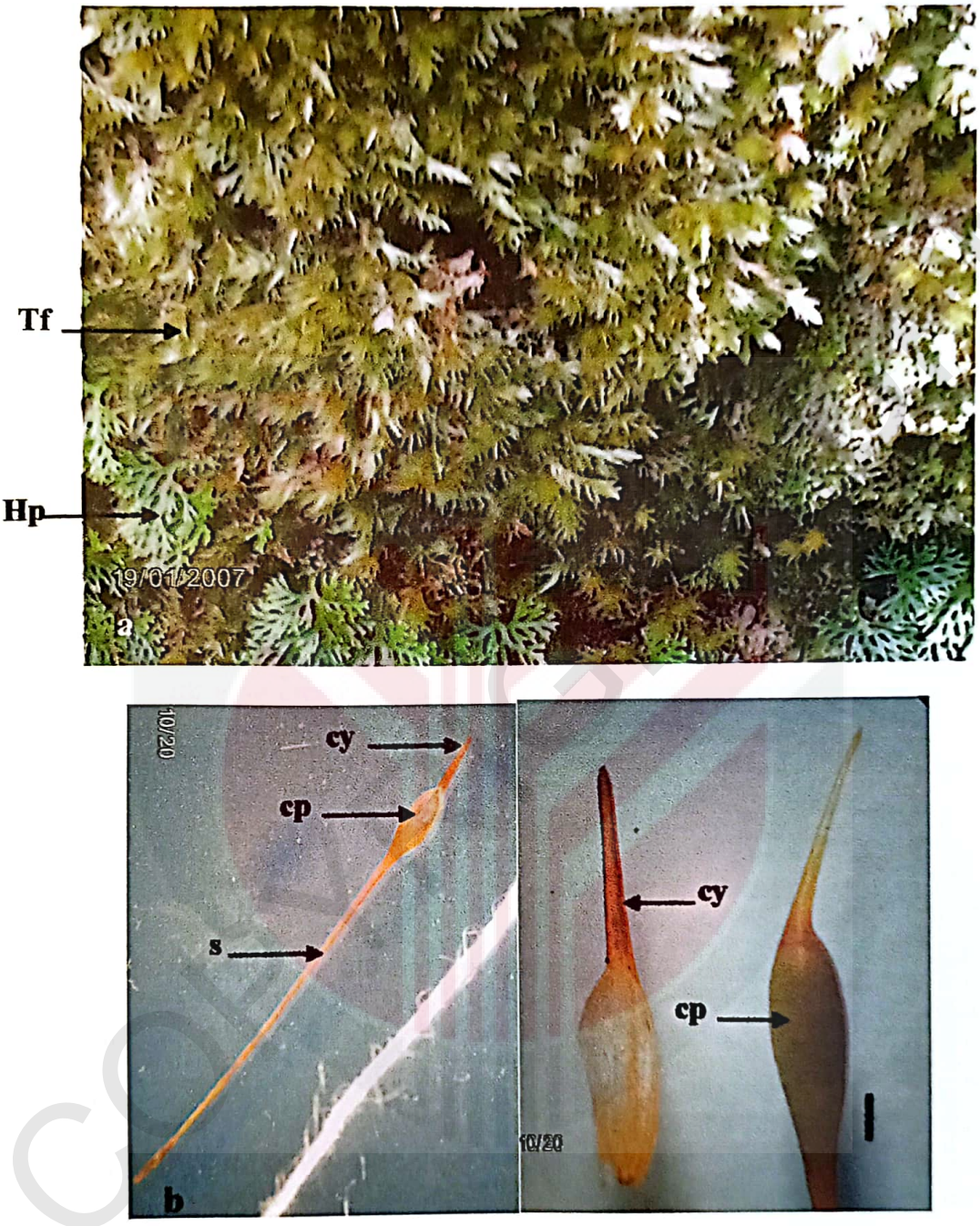

Figure 17: The habit of *Thyridium fasciculatum* (Tf) (a) a fern *Humata parvula* (Hp) is usually associated with *T. fasciculatum* growing on the stilt roots and trunks of *R. apiculata* trees (b) a sporophyte of *T. fasciculatum* comprising calyptra (cy), capsule (cp) and seta (s). Scale bar, 1 mm

Other observation:

Johnson (1980) reported that this species occurs on trees in Singapore, Gunong Pulai, Ginting Simpah and several places outside Malaysia.

4.2.16 *Lepidolejeunea* sp.

Group: Hepaticae

Family: Leujeuneacea

Reference: Johnson (1965): p. 40, 50; Frahm *et al.* (1996): p. 48, 75, Figure 49; Schofield (1985): p. 177.

Description:

A liverwort with long creeping vertically, underleaf bilobed, broadly obtuse, leaf lobe surface is smooth and light green in colour. The lateral leaves are divided making the plant appearing to have five rows of leaves (Figure 18).

Distribution:

Inhabits along the stilt roots and upper part of root *R. apiculata* trees.

Ecological status:

Common

Other observation:

Frahm *et al.* (1996) reported that this species is typical taxa of the lowland forest.

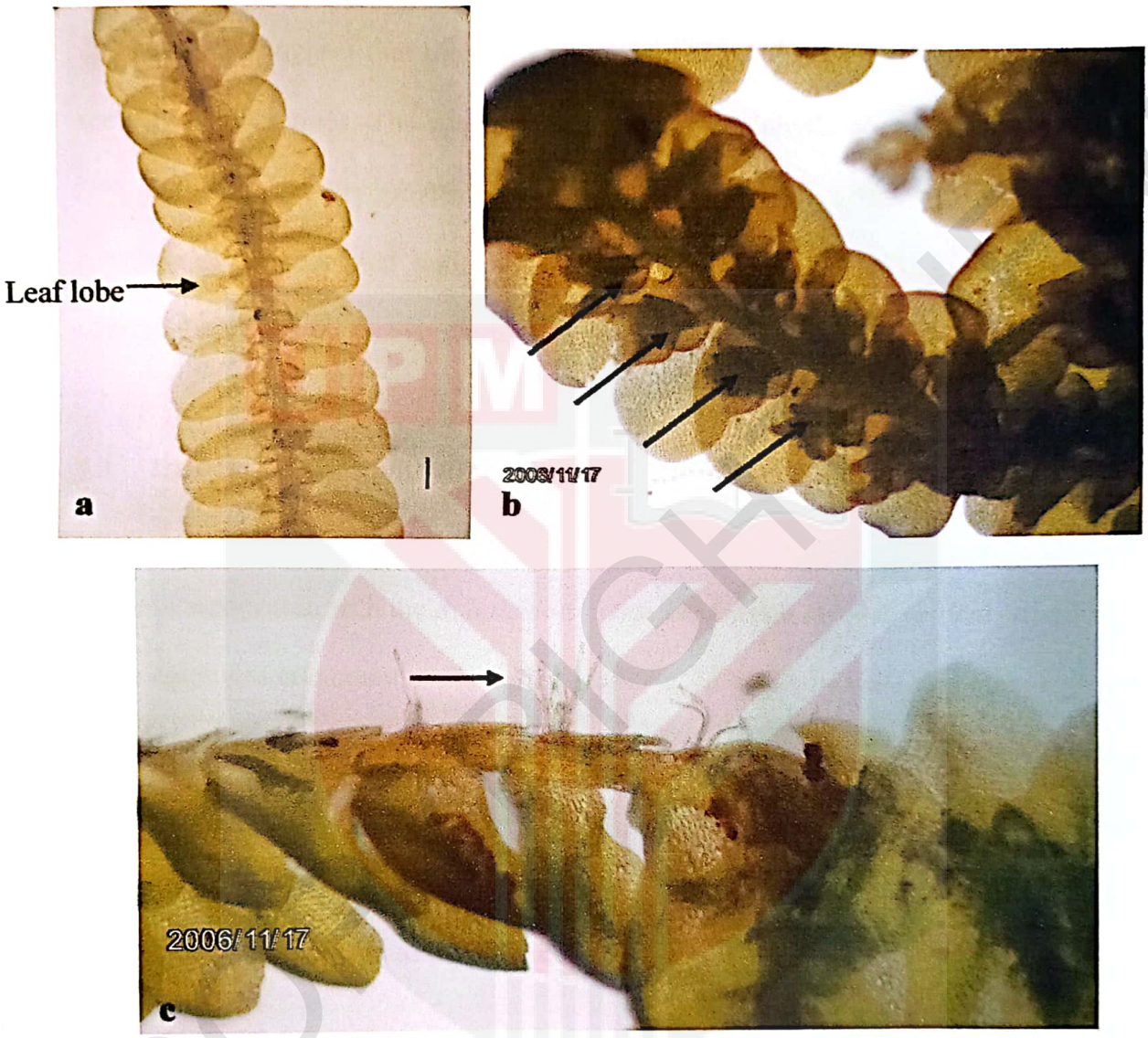

Figure 18: The habit of *Lepidolejeunea* sp. (a) ventral view of the leaves. Scale bar, 1 mm. (c) rows of leaves (arrows) attach along the stem. (c) protonema (arrow) at the branching and leafless axes

4.3 Epiphytic Plants Association

The epiphytic plants occurrence in association with *R. apiculata* trees is shown in Table 2. The results suggest that there are more than 1 to 11 epiphytic plants inhabiting the same individual trees. The association among the epiphytic plants e.g. orchids, ferns (Pteridiophyta) and bryophytes (Bryophyta) is illustrated in Table 3. Orchids and ferns are frequently associated with mosses, *Calymperes dozyanum* (Figures 16) that are commonly growing with liverworts, *Lepidolejeunea* sp. (Figures 18).

4.4 Distribution of Epiphytic Plant

Table 4 and in illustration of Figure 19 showed the vertical distribution of epiphytic plants in association with the *R. apiculata* trees. There is no distinct vertical stratification in the epiphytes community. Flowering plant e.g. *Hoya diversifolia* and orchids tend to occupy heights ranging from 1.62 m to 9.72 m. Similar height distribution was also observed for the ferns (Pteridiophyta) in the range from 1 m to 8.1 m. The mosses and liverworts (Bryophyta) have a wider range of vertical distribution usually inhabiting at low height level of 1.62 m to a greater height of up to 14.58 m (Table 4).

Most of the epiphyte species occurred at the various components of the *R. apiculata* trees e.g. stilt roots, branches and trunks (Table 5). However, the common component of *R. apiculata* trees occupied or inhabited by the 17 species of epiphytic plants is the stilt root as compared to the other components (Figure 20).

Table 2: Epiphytic plants associated with *R. apiculata* trees. E1- *Hoya diversifolia* O1-*Dendrobium acerosum,* O2-*Dendrobium rosellum,* O3-*Trichotosia velutina,* O4-*Bulbophyllum* sp., O5- *Dendrobium rhodostele,* O6- *Bulbophyllum odoratum,* O7-*Eria ignea* , F1-*Davallia denticulata,* F2-*Drynaria quercifolia,* F3-*Crypsinus stenophyllus,* F4-*Humata purvula,* F5*-*Asplenium nidus,* M1-*Calymperes* sp., M2-*Calymperes dozyanum*, M3-*Thyridium fasciculatum*, L1- *Lepidolejeunea* sp.

Rhizophora apiculata trees	Species																Total no of epiphytes per tree
		Orchids							Ferns					Mosses (M) and Liverworts (L)			
	E1	O1	O2	O3	O4	O5	O6	O7	F1	F2	F3	F4	F5	M1	M2	M3	L1	
1	+	+									+				+		+	5
2	+	+				+	+	+	+	+		+			+	+	+	11
3	+	+	+	+	+										+		+	7
4	+	+	+	+	+		+								+		+	8
5	+	+													+		+	4
6	+											+			+		+	4
7	+	+													+		+	4
8	+			+	+										+		+	4
9	+			+	+				+			+			+		+	6
10	+	+								+				+	+	+	+	7
11	+	+			+				+						+		+	6
12	+								+	+		+			+	+	+	7

Note:
**Asplenium nidus* was found outside the observation area
(+) present of epiphytic plants

Table 3: Associations among epiphytic plants associated with *R. apiculata* trees.
O1-*Dendrobium acerosum*, O2-*Dendrobium rosellum*, O3-*Trichotosia velutina*, O4-*Bulbophyllum* sp., O5- *Dendrobium concinnum*, O6- *Bulbophyllum odoratum*, O7-*Eria ignea*, F1- *Drynaria quercifolia*, F2- *Crypsinus stenophyllus*, F3-*Davallia denticulata*, F4-*Humata parvula*, F5-*Hoya diversifolia*, M1-*Calymperes* sp., M2-*Calymperes dozyanum*, M3-*Thyridium fasciculatum*, L1-*Lepidolejeunea* sp.

	Orchids							**Ferns**					**Mosses**			**Liverwort**
SPECIES	O1	O2	O3	O4	O5	O6	O7	F1	F2	F3	F4	F5	M1	M2	M3	L1
O1	+															+
O2		+														+
O3			+													+
O4				+												+
O5					+											+
06						+										+
O7							+									+
F1								+		+						+
F2									+							+
F3								+		+						+
F4											+					+
F5												+				+
M1													+			+
M2										+	+	+	+	+	+	+
M3															+	+
L1	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+

Note:
(+) Present of association between species of epiphytic plants

Table 4: Range of vertical distribution (in meter) of epiphytic plants on the *R. apiculata* trees

FAMILY AND SPECIES	Range (in meter, m)
FLOWERING PLANTS	
CLASS: DICOTYLEDONEAE	
ASCLEPEDIACEAE	
1. *Hoya diversifolia*	1.62-4.86
CLASS: MONOCOTYLEDONEAE	
ORCHIDACEAE	
2. *Dendrobium acerosum*	1.62-9.72
3. *Dendrobium rosellum*	1.62-4.24
4. *Dendrobium rhodostele*	1.62-3.24
5. *Trichotosia velutina*	1.62-4.24
6. *Bulbophyllum* sp.	1.62-4.86
7. *Bulbophyllum odoratum*	1.62-3.24
8. *Eria ignea*	1-1.62
SPORE BEARING PLANTS	
DAVALLIACEAE	
9. *Davallia denticulata*	1.62-4.86
10. *Humata parvula*	1-1.62
ASPLENIACEAE	
11. *Asplenium nidus**	
POLYPODIACEAE	
12. *Drynaria quercifolia*	1.62-8.1
13. *Crypsinus stenophyllus*	2.43
DIVISION:BRYOPHYTA	
MOSSES	
CALYMPERACEAE	
14. *Calymperes* sp.	1-1.62
15. *Calymperes dozyanum*	1-14.58

SYRRHOPODOTACEAE	
16. *Thyridium fasciculatum*	1-1.62
LIVERWORTS	
LEUJEUNEACEA	
17. *Lepidolejeunea* sp.	1-14.58

**Asplenium nidus* was observed growing at a height of 8.1 m on the branch of *R. apiculata*.

Table 5: Distribution of epiphytic plants on the various components of *R. apiculata* trees

FAMILY AND SPECIES	VERTICAL DISRTIBUTION		
	Stilt roots	branches	trunks
FLOWERING PLANT			
ASCLEPIDIACEAE			
1.*Hoya diversifolia*	+	-	+
ORCHIDS			
ORCHIDACEAE			
2. *Dendrodium acerosum*	+	+	+
3. *Dendrobium rosellum*	+	-	-
4. *Dendrobium rhodostele*	+	-	-
5. *Trichotosia velutina*	+	-	-
6. *Bulbophyllum* sp.	+	-	+
7. *Bulbophyllum odoratum*	+	-	+
8. *Eria ignea*	+	-	-
FERNS			
DAVALLIACEAE			
9. *Davallia denticulata*	+	-	+
10. *Humata parvula*	+	-	+
ASPLENIACEAE			
11. *Aplenium nidus**			
POLYPODIACEAE			
12. *Drynaria quercifolia*	+	-	+
13. *Crypsinus stenophyllus*	+	-	-
BRYOPHYTES			
CALYMPERACEAE			
14. *Calymperes* sp.	+	-	-
15. *Calymperes dozyanum*	+	+	+
SYRRHOPODOTACEAE			
16. *Thyridium fasciculatum*	+	-	+

LEUJEUNEACEA 17. *Lepidolejeunea* sp.	+	+	+
Total	17	3	8

Note:
(+) present and (-) absent of epiphytic plants on *R. apiculata* trees

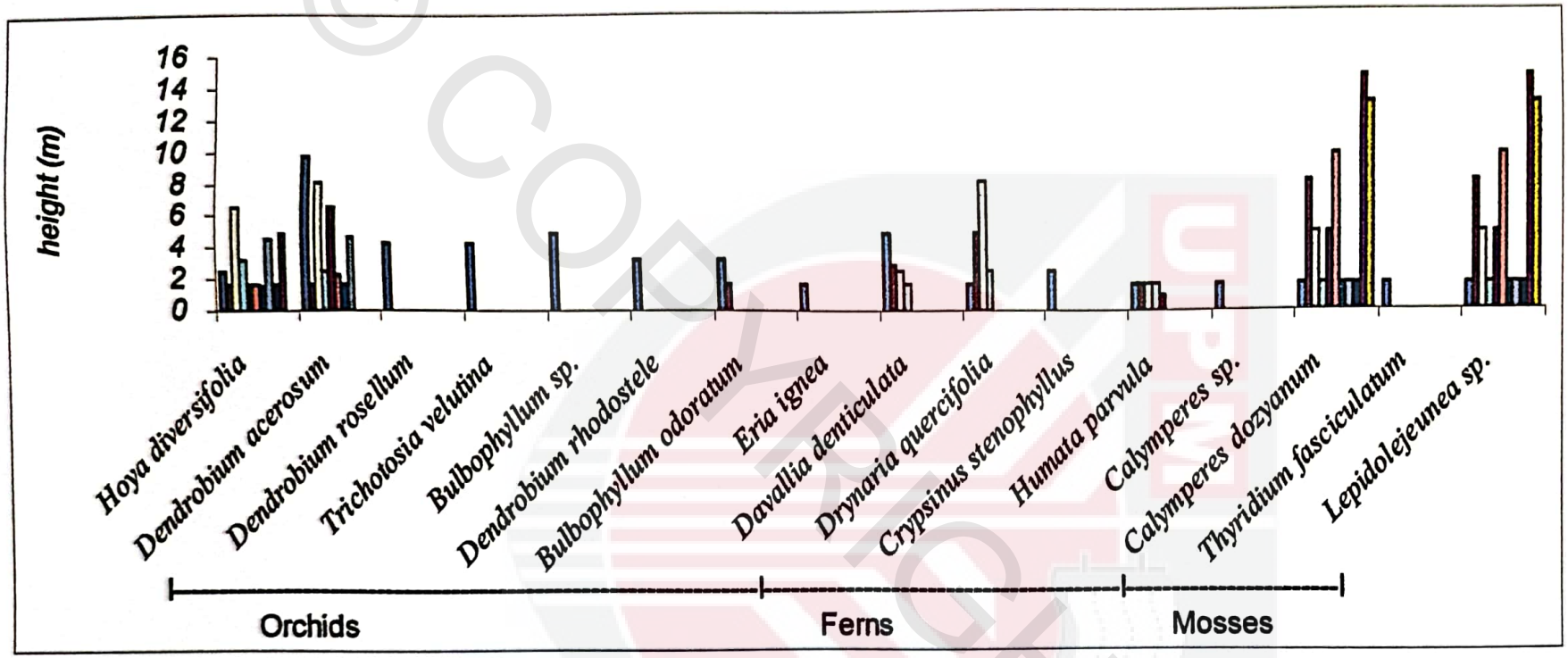

Figure 19: Vertical distribution of epiphytic plants along the *R. apiculata* trees

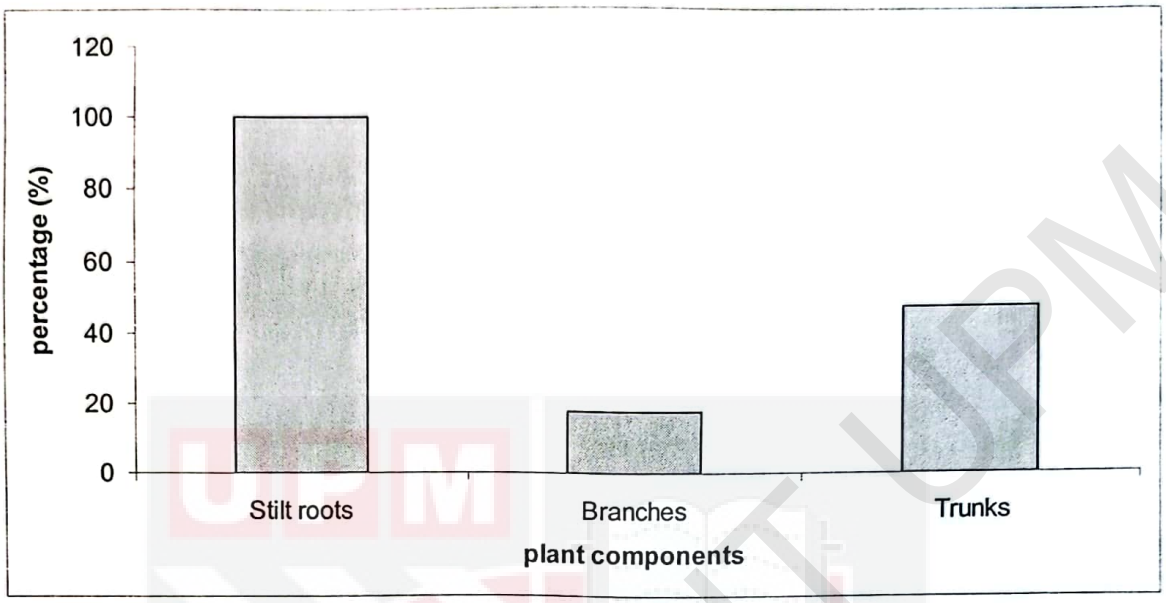

Figure 20: Occurrence (%) of epiphytic plants on the various components of *R. apiculata* trees

CHAPTER 5

DISCUSSION

5.1 Taxonomic Distribution and Epiphytic Plant Species

In this observation, there were 8 families and 17 species of epiphytic plants present in Similajau National Park Mangrove Forest. The families were Asclepideaceae, Orchidaceae, Davalliaceae, Aspleniaceae, Polypodiaceae, Calymperaceae, Syrrhopodotaceae, and Leujeuneaceae (Table 1). It has been reported that in ASEAN countries, Indonesia, and Singapore each have 11 families, while Philippines have 5 families (Japar Sidik, 1994) and 3 families of epiphytic plants discovered in Thailand's mangrove forest by Sahavachrin (1983 In: Japar Sidik, 1997). However, other observation from Indonesia reported that there are 15 species of epiphytes in the Orchidaceae family (Apriliani, 1984). Some of the species such as *Bulbophyllum blumei*, *B. botyphora*, *Dendrobium flexile* that were not found in this observation were reported nearly extinct by Japar Sidik (1994) in the South Johor and Singapore mangrove forests. In Thailand, *Dendrobium crumenatum* and *Grammatophyllum speciosum* were almost extinct. In Singapore *Bulbophyllum avicella* and *Schoenorchis perpusillus* were already extinct (Japar Sidik, 1994). Tomlinson (1986 In: Chai, 1982) reported that Orchidaceae species of *Agrostyphyllum*, *Dendrobium*, *Dipodium*, *Eria*, *Luisia*, *Podochilus*, *Taeniophyllum* and *Trichoglottis* were representative of mangroves in Sarawak. Ferns e.g. *Asplenium nidus*, *A. macrophyllum*, *Humata* cf. *repens*, *Crypsinus* spp., *Drymoglossum piloselloides* and *Platycerium coronarium* were also reported for the Sarawak mangrove forests.

From the present study observations, Orchidaceae has the highest occurrence in distribution, followed by Asclepediaceae with the exception of liverworts which were dominant, forming masses on stilt roots, branches and trunks of *R. apiculata* trees. Low occurrences were observed for ferns and mosses. According to Japar Sidik (1994), in Malaysia, the occurrence of the family Polypodiaceae with 0.09%-1.77%, and Orchidaceae 0.09%-71.11%. In Philippines occurrence of family Polypodiaceae and Orchidaceae both were reported to be in the range of 6.12%-53.06%. However, in Thailand, the occurrence of family Orchidaceae was 78.95%. This suggests that Thailand has more occurrences of epiphytes from Orchidaceae family compared to Philippines and Malaysia.

5.2 Epiphytic Plants Association

Epiphytic plants have no specific preferences for supporting mangrove trees. Epiphytic plants e.g. orchids and ferns are not growing and surviving in isolation but rather in association with other epiphytic plants e.g. mosses and liverworts. The established associations did not particularly indicate there are preferences of species coexistence.

5.3 Distribution of Epiphytic Plants

There is no definite pattern for the epiphytic plant community with respect to vertical distribution. The data suggested that vertical distribution for orchids, ferns, and bryophytes were overlapped. However, bryophytes tend to have a wider range of vertical distribution from low to extreme height up to 14.58 m. Previous studies on epiphytic plants in mangrove in Malaysia, Thailand, Singapore and Indonesia did not report on the vertical distribution of the plant. Most of these studies focused on species distribution,

description, and horizontal distribution e.g. on stilts roots, branches and trunks (Tukurin and Kuswata, 1984; Sahavacharin, 1983). In this present study at Similajau National Park Mangrove Forest, epiphytic plants tend to occupy stilt roots, rather than branches or trunks with the exeption of a fern, *Asplenium nidus*. The liverworts *Lepidolejeunea* sp. grows in masses covering branches and the trunks of *R. apiculata* trees. Tukirin and Kuswata (1984) reported that in Kebun Raya Bogor Sumatera, the epiphytic plants grow from the base up to the sharp end of the branches. In addition, they observed that the composition of epiphytes and vertical distribution are determined by component of the trees such as the stilt roots and branches.

CHAPTER 6

CONCLUSIONS

There are 17 species in 8 families of epiphytic plants found at the Similajau National Park Mangrove Forest that are associated with *R. apiculata* trees. They are *Hoya diversifolia*, *Dendrobium acerosum*, *D. rosellum, D. rhodostele, Trichotosia velutina, Bulbophyllum* sp., *B. odoratum, Eria ignea, Davallia denticulata, Humata parvula, Drynaria quercifolia, Crypsinus stenophyllus, Asplenium nidus, Calymperes* sp., *Calymperes dozyanum, Thyridium fasciculatum* and *Lepidolejeunea* sp.

There are more than 1 to 11 epiphytic plants inhabiting the same individual *R. apiculata* trees. Orchids and ferns are frequently associated with mosses, *Calymperes dozyanum* that are commonly growing together with liverworts, *Lepidolejeunea* sp. The epiphytic plants tend to occupy stilt roots, rather than branches or trunks of *R. apiculata* trees.

There is no definite pattern for the epiphytic plants with respect vertical distribution because the data suggested that vertical distribution of orchids, ferns, and bryophytes are overlapped. However, bryophytes tend to have a wider range of vertical distribution from low height of 1.62 m to a greater height up to 14.58 m.

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PUBLICATION OF THE PROJECT UNDERTAKING

This is to certify that I have no objection to publish the project entitled "Epiphytic Plants Associated With Mangrove Trees In Similajau National Park Mangrove Forest" by the supervisor in a joined authorship. However, it has to be evaluated by the Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Campus and published in the form approved by the Faculty.

Siti Humaira Bt Mustafa Kamal

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