ความหลากหลายของไลเคนเปลือกไม้บนพืชให้อาศัยบางชนิดในป่าเขาหินปูน อำเภอหนองหิน จังหวัดเลย

นายชเนรินทร์ ฟ้าแลบ

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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DIVERSITY OF CORTICOLOUS LICHENS ON SOME HOST PLANTS IN LIMESTONE FOREST, AMPHOE NONG HIN, LOEI PROVINCE

Mr. Shanerin Falab

A Thesis Submitted in Partial Fulfillment of the Requirements
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ชเนรินทร์ ฟ้าแลบ : ความหลากหลายของไลเคนเปลือกไม้บนพืชให้อาศัยบางชนิดในป่าเขาหินปูน อำเภอหนองหิน จังหวัดเลย. (DIVERSITY OF CORTICOLOUS LICHENS ON SOME HOST PLANTS IN LIMESTONE FOREST, AMPHOE NONG HIN, LOEI PROVINCE) อ.ที่ปรึกษาวิทยานิพนธ์หลัก : ผศ.ดร.รสริน พลวัฒน์, อ.ที่ปรึกษาวิทยานิพนธ์ร่วม : รศ.ดร.กัณฑรีย์ บุญประกอบ, 128 หน้า.

การศึกษาอิทธิพลของลักษณะและสมบัติของถิ่นอาศัยบนลำต้นพืชเด่น 3 ชนิด ได้แก่ ปรงเขา (*Cycas pectinata* Griff.) จันทน์ผา (*Dracaena cochinchinensis* (Lour.) S. C. Chen) และจันทน์แดง (*Dracaena jayniana* Wilkin & Suksathan) ต่อความหลากหลายของชนิดไลเคนเปลือกไม้ในป่าเขาหินปูนบริเวณ อ.หนองหิน จ.เลย ภายใต้สมมติฐาน ลักษณะสัณฐานวิทยาและสมบัติบางประการของเปลือกลำต้นพืชเด่นทั้งสามชนิด จะส่งผลต่อความหลากหลายของชนิดไลเคนที่แตกต่างกัน ผลการศึกษาพบตัวอย่างไลเคนทั้งหมด 14 วงศ์ 32 สกุล 57 ชนิด โดยพบบนต้นปรงเขา 14 วงศ์ 23 สกุล 40 ชนิด บนต้นจันทน์ผา 12 วงศ์ 22 สกุล 39 ชนิด และบนต้นจันทน์แดง 9 วงศ์ 17 สกุล 35 ชนิด ดัชนีความหลากชนิด (Shannon-Wiener Index) ของไลเคนบนต้นปรงเขา ต้นจันทน์ผาและจันทน์แดง เท่ากับ 8.70 ± 0.06, 10.71 ± 0.06 และ 8.91 ± 0.08 ตามลำดับ การศึกษาครั้งนี้พบชนิดไลเคนที่ยังไม่เคยรายงานในประเทศไทย 4 ชนิด ได้แก่ *Hyperphyscia syncolla* (Tuck. ex Nyl.) Kalb., *Julella vitrispora* (Cooke & Harkness) M. E. Barr, *Pyrenula interducta* (Nyl.) Zahlbr. และ *Pyrenula leucotrypa* (Nyl.) Upreti. นอกจากนี้พบว่า ค่าสมบัติการอุ้มน้ำของผิวลำต้น ความลึกของรอยแตกบนผิวลำต้น และค่าความเป็นกรด-ด่างไม่มีความสัมพันธ์กับจำนวนชนิดไลเคนต่อต้น

ภาควิชา พฤกษศาสตร์ ลายมือชื่อนิสิต ....

สาขาวิชา พฤกษศาสตร์ ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก ....

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SHANERIN FALAB : DIVERSITY OF CORTICOLOUS LICHENS ON SOME HOST PLANTS IN LIMESTONE FOREST, AMPHOE NONG HIN, LOEI PROVINCE. ADVISOR : ASST. PROF. ROSSARIN POLLAWATN, Dr. rer. nat., CO-ADVISOR : ASSOC. PROF. KANSRI BOONPRAKOB, Ph.D., 128 pp.

The effect of habitat characteristics and properties on corticolous lichen diveristy in three host plants including *Cycas pectinata* Griff., *Dracaena cochinchinensis* (Lour.) S. C. Chen, and *Dracaena jayniana* Wilkin & Suksathan was studied in limestone forest at Amphoe Nong Hin, Loei Province. The hypothesis is that habitat characteristic and properties have the effects on corticolous lichen diversity in the three host plants. This study found a total of 14 families, 32 genera and 57 species of lichens. There are 14 families, 23 genera and 40 species of lichens on *C. pectinata*, 12 families, 22 genera and 39 species on *D. cochinchinensis* and 9 families, 17 genera and 35 species on *D. jayniana*. The species richness (Shannon-Wiener Index) of lichens on *C. pectinata, D. cochinchinensis and D. jayniana* are 8.70 ± 0.06 , 10.71 ± 0.06 and 8.91 ± 0.08 respectively. This study found 4 new lichen species of records including *Hyperphyscia syncolla* (Tuck. ex Nyl.) Kalb., *Julella vitrispora* (Cooke & Harkness) M. E. Barr., *Pyrenula interducta* (Nyl.) Zahlbr. and *Pyrenula leucotrypa* (Nyl.) Upreti. Moreover, bark water-holding capacity, bark crevice depth and bark pH were not correlated with the number of species per plant.

Department : Botany Student's Signature ....

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CHAPTER I

INTRODUCTION

Limestone forest is a unique ecosystem where distributed in the tropics partially located in Central America, Brazil and the Greater Antilles (Tang *et al*., 2011). So far, it is known that there is high environmental heterogeneity caused by edaphic factor variation especially substrate solubility. Therefore, the speciation usually occurs in limestone forests resulting in the important biodiversity pool and endemic species. This is very interesting for entry limestone forest to carry out the biodiversity.

Amphoe Nong Hin is the popular area covering Suan Hin Pha Ngam, located at Loei Province in north eastern Thailand. By the name and physical environment, there are covered by limestone among plant community. Specifically, dominant limestone plant species such as *Dracaena cochinchinensis* (Lour.) S. C. Chen, *Dracaena jayniana* Wilkin & Suksathan and *Cycas pectinata* Griff. have their own bark characteristics and often inhabited by several lichen species. Noticeably, the abundance and density of lichens on their stem surfaces are quite different by observation in the same area. This phenomenon may be affected by the different barks which are lichens substratum.

Barks are the most one of preference habitat where epiphytic lichens form community with the unique conditions. Ecologically, lichens gain the growth requirement from environments through atmosphere and substrate including water and nutrients. Conversely, environmental factors e.g. light intensity, temperature, humidity and pH influence on growth and dispersal of lichen species demonstrating the variable species diversity in different habitats (Adams and Risser, 1971; Cáceres *et al*., 2007; Fritz, 2009; Jüriado *et al*., 2009; Morley and Gibson, 2010).

In addition, many studies indicated that lichens tend to be sensitive or responsive to environmental changes. Thus, barks of different host plants may be the main impact of lichen preference habitats due to physical properties (e.g. crevice depth and water-holding capacity) and chemical properties (e.g. pH and nutrients availability).

Aims of the thesis

The objectives of this study are 2 tolds:

1. To investigate diversity of corticolous lichens found on *Dracaena cochinchinensis*, *Dracaena jayniana* and *Cycas pectinata* in limestone forest, Amphoe Nong Hin, Loei Province.
2. To investigate the correlation between bark properties (Bark crevice depth, water-holding capacity and pH) of the 3 host plants and lichen species diversity.

CHAPTER II

LITERATURE REVIEW

2.1 Lichens

Lichens are the symbiotic association between fungal partner, the mycobiont and one or more photosynthetic partners, the photobiont which may be a green algae or/ and cyanobacterium (Ahmadjian, 1993; Paulsrud and Lindblad, 1998; Dahlkild *et al*., 2001; Nash III, 2008). Overall the lichen symbiosis evolves the successful strategies for surviving in extreme habitats (Nash III, 1996; Garvie *et al*., 2008). They can grow in most terrestrial ecosystems worldwide where are on all kinds of substrata, including rock, soil, bark, bryophytes and even leaves (Nash III, 1996; Cáceres, Lücking, and Rambold, 2007).

2.1.1 Morphology of Lichens (Nash III, 1996; 2008)

The morphology of lichen is strongly influenced by photobiont and its direct contact with the mycobiont. Naturally, a few lichens have same mycobiont but are able to form very different thalli with cyanobacterium and green alga respectively. Generally, there are two types of thalli composed of homoiomerous thallus and heteromerous thallus (Figure 2.2A, B). Homoiomerous thallus is illustrated by the photobiont is distributed more or less uniformly throughout the thallus whereas heteromerous thallus is the stratified that consisting of photobiont layer and mycobiont layer in the thallus. Homoiomerous thallus is often found in thin crustose, gelatinous crustose and folilose lichens e.g. *Caloplaca* and *Collema* but usually found hertomerous thallus in crustose, foliose and fruticose lichens. The main subdivisions of thallus are divided into upper cortex, photobiont layer, medulla and lower cortex (Figure2.2C). Moreover, attachment organs may be developed from lower cortex (e.g. rhizine; Figure 2.2D, holdfast) or rarely on margin or upper cortex (e.g. cilia). On the other hand, reproductive structures occur on mycobiont of symbiosis which are the majority of lichenized ascomycota. The common ascocarps developed in lichenized ascomycota including perithecia and apothecia. Perithecia are globose to flask-shaped which contain open canal called ostiolum (Figure 2.2E) while apothecia are cup- or disc-shaped with two distinguish types. First is lecanorine apothecia which contain margin originating form thallus (Figure 2.2F) and second is lecidiene apothecia which margin developing from apothecia (Figure2.2G). They produce spores in ascus (Figure 2.2H) located in hymenium (hamathecium for perithecia) surrounded by ascocarp walls. In addition, lichens may develop symbiotic propagules on thallus especially isidia and soredia (Figure 2.3A, B). Isidia are simple or brached with cylindrical, warty or coralloid forms scattered on thallus. Although isidia play an important role of dispersal, they increase surface area for photosynthesis. In contrast, soredia contain a few photobiont cells enveloped by loose hyphae. They may be developed on lamina, margin, and fissure in cuff-shaped, labriform or globose.

2.1.2 Lichen growth forms

Lichens are traditionally divided into three main morphological groups such as crustose, foliose and fruticose types based on overall habits. However, the appearance of lichen thallus is determined primarily by the mycobiont but sometimes by photobiont e.g. *Coenogonium* and *Racodium*.

Crustose lichens are closely attached to substrate with penetration so they cannot be removed from substrata without destruction (Figure 2.3C). The thallus may be simple as powdery crusts or complex as squamulose types which became partially free from the substrate. Crustose lichens may be homoiomerous or heteromerous thalli with isidia or soredia-resembling granules.

Foliose lichens are leaf-like, flat and only partially attached to the substrate (Figure 2.3D). They usually have welled organization with distinct upper and lower surfaces with lobed and degree of branching on thallus. There are either homoiomerous (gelatinous lichens; Figure 2.3E) or heteromerous thalli with vegetative propagules and sporocarps. Foliose lichens are divided into two types including laciniate and umbilicate lichens. Lacinate lichens are the high degree branching and lobate foliose covered by rhizines, cilia or tomenum on lower surface for attachment whereas umbilicate lichens consist of central hold fast on upper surface with unbranched lobe or multilobate, circular thalli.

Fruticose lichens are lichens standing out from the surface of substrate. Their lobes are hair-like, strap-shaped or shrubby and flattened or cylindrical with different branching pattern among systematic groups (Figure 2.3F).

2.2 Corticolous Lichens

Nowadays, lichens are threatening species approximately 17,000 species worldwide (Revenga *et al*., 2010). Most of them are corticolous which known as lichens growing specifically on the surface of tree trunks or barks. They are not parasitism but only use the bark for their substrata. Among high moisture in tropical forests, corticolous lichens usually occur together with foliicolous ones on various growth forms (Smith, 1955). Lichens which are closely appressed to bark can be described as crustose. Some of them have protruding leafy lobes form bark called foliose whereas, others have hair-like or strap-like referred to fruticose (Hartman, 2005).

According to their diversity, corticolous lichens contribute to above-ground biomass especially foliose and fruticose species (Ellis, 2012). The variation of this biomass occurred in different vegetation-types of which is important for forest ecosystem dynamics (Boucher and Nash, 1990). Moreover, corticolous lichens may play an important role in water-cycle by enhancing interception of precipitation at forest canopy and nutrient cycling by accumulating Nitrogen in nitrogen fixing cyanolichens (Campbell *et al*., 2010b). Ecologically, they promote the microhabitat complexity facilitating habitats of micro-fauna and many invertebrates (Shorrock *et al*., 1991).

2.2.1 Corticolous lichen diversity at individual tree

Epiphytic lichen diversity has not been analyzed between biogeographic regions such as biomes, latitudinal gradients, energy-water gradients etc. (Ellis, 2012). However, corticolous communities on individual tree and stand level have been more elucidated than broad – scale. The evidences from temperate forests that are high proportion of epiphytic lichens species compared to epiphytic vascular plants (Coote *et al*., 2007; Williams and Sillet, 2007; Affeld *et al*., 2008). In individual trees, species richness of lichens has accessed, for example in the tropical forests, Aptroot (2001) found 173 lichen species on *Eleocarpus* sp. stem surface in Papua New Guinea. In contrast, there were 76 lichens on *Lagarostrobos franklinii* in Tasmanian temperate rainforest (Jarman and Kantvilas, 1995) and 52 lichens on an oak (*Quercus* sp.) in the British Isles

(Rose, 1974). In temperate and boreal forest, there are a few tree species so more than hundred lichens inhabited on individual plant (Coppins and Coppins, 2005, 2006).

In tropical rain forest of Thailand, Boonprakob and Polyiam (2007) reported 31 lichen taxa on *Castanopsis acuminatissima* (Blume) A. DC. and 86 taxa on *Dipterocarpus gracilis* Blume at Khao Yai National Park. Moreover, they found that host tree species was the main factor affecting lichen composition.

2.2.2 Corticolous lichen diversity at stand level

At the stand level, several studies have focused on the species composition combining with effect of environments of habitats. In tropical biomes, In southern Venezuela, 250 lichen species were investigated in sampling plot and species richness depended on vertical gradient of tree trunk (Komposch and Hafellner, 2000). In French Guiana, both the stand plots in tropical lowland cloud forest and lowland rain forest without fog showed 39 taxa with similar macrolichen diversity but they are different in species composition (Normann *et al*., 2010). In this study, diversity patterns were affected by different water availability according to fog and humidity.

In temperate biomes, Andersson and Gradstein (2005) observed lichens on Cacao (*Theobroma cacao* L.) plantation in western Ecuador. They found 61 epiphytic lichen species which were similar to tropical lichens. The species richness was lower in high management than in low management plantation. The study of epiphytes on Sitka spruce (*Picea sitchensis*) plantations in Ireland found 39 lichens and their diversity was affected by edge effect (Coote *et al*., 2007). In redwood stand plots of northwestern California, the number of lichens accounted for 183 species and the species richness correlated with substrate surface areas. (Williams and Sillett, 2007). Moreover, the correlation between tree structure and species indicated that the structural complexity enhanced epiphytic diversity.

In boreal biomes, the comparison of lichen diversity in natural and managed forest was constructed in Sweden. There are total 36 species of lichens but the results indicated that the species richness was higher in natural plots than managed ones. The species diversity correlated factors including stand age, stem density and basal area of the stand plots (Dettki *et al*., 1998). Peterson and McCune (2001) investigated lichens on *Pseudotsuga menziesii* at managed conifer forests in Western Oregon. They found 110 epiphytic macrolichen taxa and lichen community composition patterns had strong correlation with climatic gradients. In consideration effect of forest continuity on epiphytic lichens, there were 51 lichen species in *Fagus sylvatica* stand with continuity but 14 species in forest lacking continuity in southern Sweden (Fritz *et al*., 2008). Focusing on crustose lichens, for example, the species occurrence depended on habitat quality such as bark crevice depth and microclimate on *Quercus robur* trees (Ranius *et al*., 2008b). In broad-leaved forests in Estonia, there were total 104 corticolous lichens which separated in to 70 species on *Fraxinus excelsior*, 50 species on *Ulmus laevis*, 49 species on *Quercus robur* and *Tilia cordata*, and 45 species on *Ulmus glabra*. From this study, the factors influencing species composition, species richness and species abundance were bark acidity, bryophyte cover and circumference of tree stems (Jüriado *et al*., 2009).

2.3 Environment heterogeneity: a control of corticolous lichen diversity

Epiphytic species richness and composition can be explained by ecological process especially in niche theory. Environmental heterogeneity is the one of main factors controlling epiphytic lichen diversity (Figure 2.1). They were explored as the following (Ellis, 2012).

2.3.1 Variation within a single tree

There are 2 systematic gradients of tree structure which shape lichen compositions. First is lateral environmental gradient in different aspects such as light and moisture availability vary on the angle of lean or vertical gradient in radial effects. Second is a strong vertical gradient which encompasses variable structure of the tree and canopy including compositional variation with height on the tree bole and compositional variation which create a canopy. The variation of factors along vertical gradients which affecting on lichen communities composed of time for colonization (different tree part with different age), physical properties and microclimate. For example, bark-pH may differ through the height of tree trunk. In addition, radiation and humidity are responsible for inter-specific difference with in vertical gradient. Light and water are the factors explaining shade-effect and hydration for epiphytic lichens from tree base upward the canopy. These factors may not be detected by physiological responses directly but may be indicated by growth rate and inter-specific competition.

2.3.2 Variation among boles of the same and different tree species

In case of light and humidity, their availability can be controlled by canopy structure directly, from previous studies, lichen communities on the surface of tree trunks usually depended on bark properties. Epiphytic lichens have strongly response to bark-pH and community turnover is explained by bark substratum physical properties. To deplete variation of other factors, several studies have done on intra-specific boles. In same species, bark-pH correlated with tree age and size (diameter at breast height) among trunks but might depend on circumference. Alternatively, tree species identities are important factors to explain lichen community on trunks such as:

a) Bark texture: bark texture among population of species provided intra-specific variation in controlling epiphytic community. This included a species specific relationship between bark roughness and tree age/size.
b) Water-holding capacity and rate of water loss: the fissure depth of bark played an important role in moisture gradients. For example, there was less moisture in deeper bark crevice. Bark thickness was positively correlated with tree age/size and correlated with water-holding capacity.
c) Bark hardness: it is correlated with bark stability and lichens preferred more stable bark for colonization.

2.3.3 Variation controlled by stand- scale factors

Stand- scale environment has determined within the ecological aspect such as forest succession which accumulate the complexity in term of tree species composition, tree age structure, tree density, canopy cover, the volume and quality of dead wood. High structural complexity and long-continuity stand had a positive correlation on abundance and species richness of epiphytic lichens. Stand scale epiphytic composition can be related with comprising of tree-scale factors. The important factor in stand-scale is canopy cover because it creates an availability of light and humidity.

2.4 Limestone forest

2.4.1 Limestone forest

Limestone forests widely covered on tropics, particularly in Southeast Asia, northern Central America, southeastern Brazil and the Greater Antilles (Tang *et al*., 2011). In Southeast Asia, there around 400,000 square kilometer where most distributed to Indonesia, Thailand and Vietnam (Day and Urich, 2000). Geographically, limestone composes of major calcium carbonate derived from sedimentary rocks that formed thin layer and less humid soil (Clements *et al*., 2006). By the time, limestone can be weathering by mechanical and chemical processes that build up tower, cave, cliffs and sinkholes (Clements *et al*., 2006). It is known that limestone forest typically have high environmental heterogeneity due to large scale variability of substrate availability and is the important pool of biodiversity especially endemic flora (Clements *et al*., 2006; Perez-Garcia *et al*., 2009). High flora richness has been reported from Southeast Asia such as in Peninsular Malaysia, there was 14% of total angiosperm species of Malayan from limestone forest areas (Chin, 1977).
Limestone forest vegetation usually inhabited by herbaceous plants and bryophytes. Physical factors strongly affected floral diversity particularly variability of soil layer. For example, soil layer is very thin at the summits but it may be higher depth at the slopes and shallows (Clements *et al*., 2006).

New species were found in limestone biomes such as a new genus and new species of Cyperaceae (*Khaosokia caricoides*) was discovered on limestone cliffs in peninsular Thailand (Simpson *et al*., 2005). In addition, *Smithatris* was also new genus of Zingiberaceae at limestone hills in the Saraburi Province (Kress and Larsen, 2001) and etc.

2.4.2 Corticolous lichens in Limestone forests

There are scarce studies of epiphytic lichens in limestone forests but most of study has done on limestone. In boreal-nemoral forest on North Estonian limestone escarpment, Jüriado and the colleagues (2009) investigated epiphytic lichens on 4 temperate broad-leaved tree species. They found 74 lichen species of 4 tree trunks and species composition was affected by tree level variable including bark-pH, bryophytes cover and host tree species.

In Thailand, there are a few of study corticolous lichens in limestone forest such as In Phu Hin Rong Kla National Park of Phisanulok Province. Dangphui and others (2006) investigated lichen family Usneaceae and they found 2 subgenera and 13 species in every forest types of this area. Moreover, there are 6 genera and 49 species of lichen family Physciaceae and some of them found as new record of Thailand (Meesim *et al*., 2006). For Cladoniaceae, there are 2 genera, 13 species and 3 sections of lichens found in this area (Parnmen *et al*., 2006). Epiphytic foliose lichens composed of 8 families, 20 genera and 61 species which most of them belonged to Parmeliaceae (Buarueng, *et al*., 2006). The results indicated that there are high epiphytic lichen diversity in limestone forest and adjacent areas.

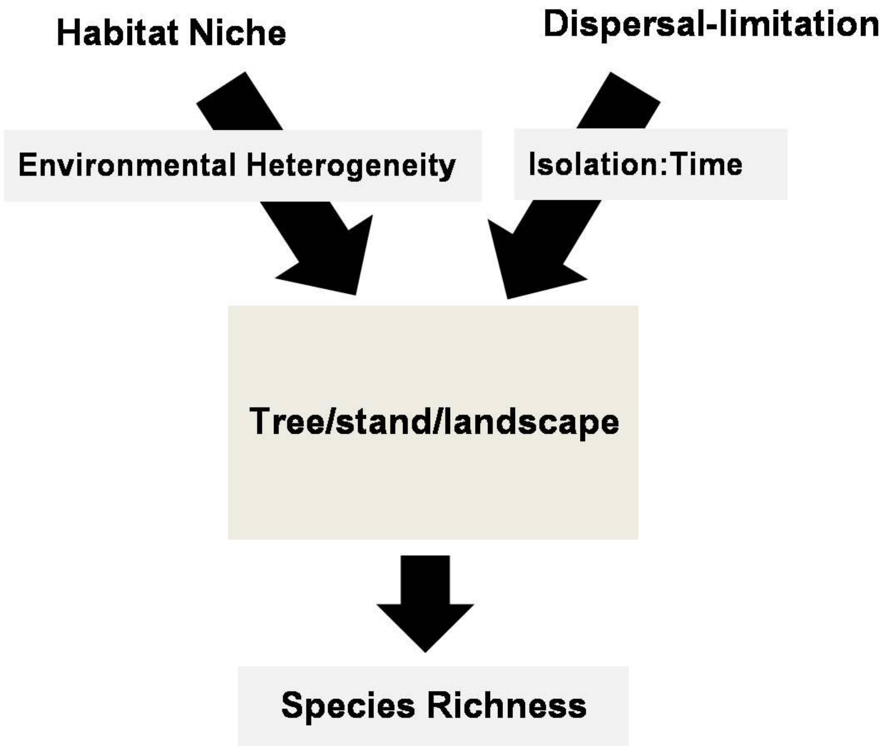

Figure 2.1 A framework for understanding the pattern of lichen epiphyte diversity (retrieved from Ellis, 2012).

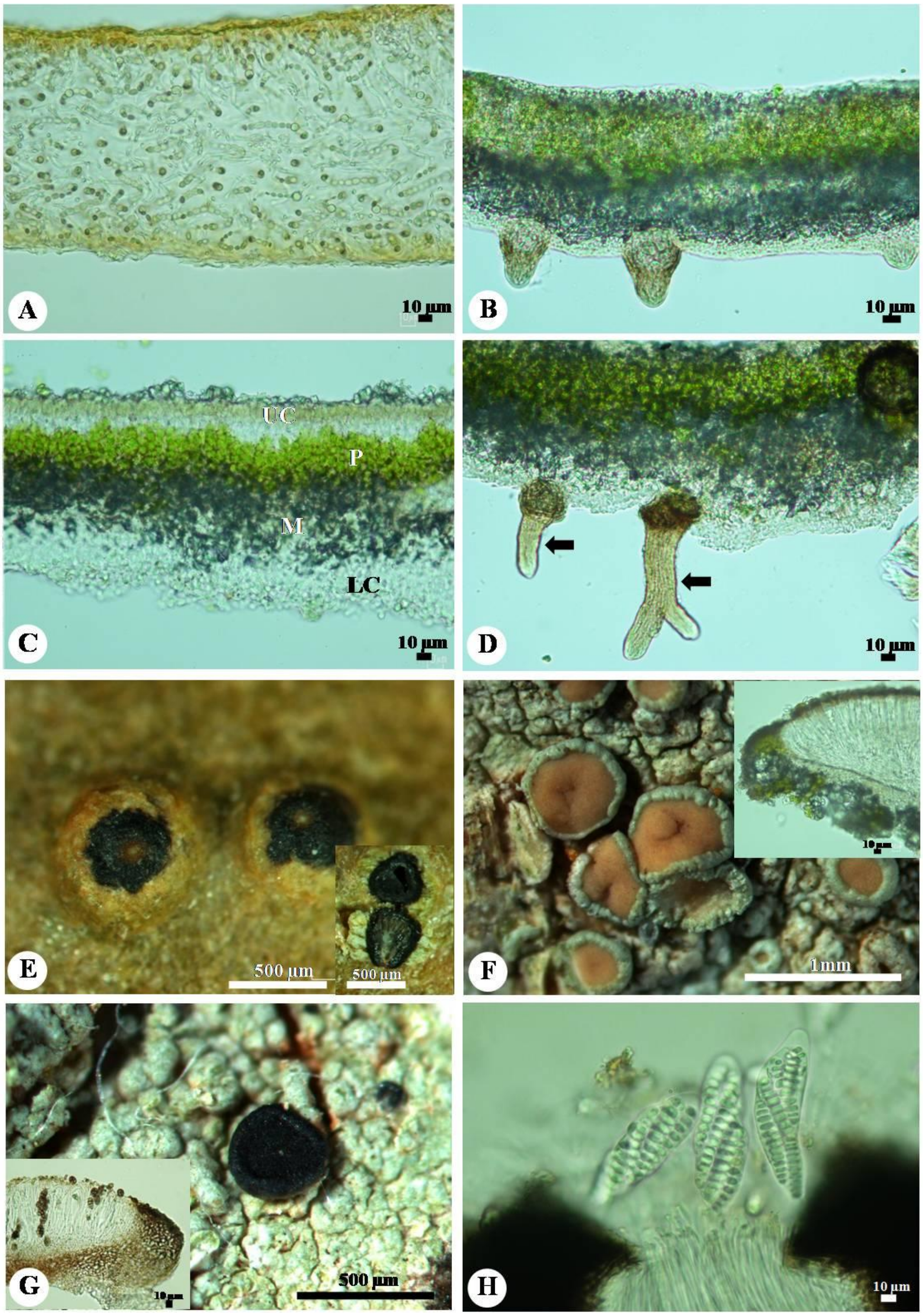

Figure 2.2 Structure of lichens. A. homoiomerous thallus; B. heteromerous thallus; C. X-section of thallus, UC: upper cortex, P: photobiont layer, M: medulla, LC: lower cortex; D. rhizines indicated by black arrows; E. perithecia; F. lecanorine apothecia; G. lecidiene apothecia; H. ascospores in ascus.

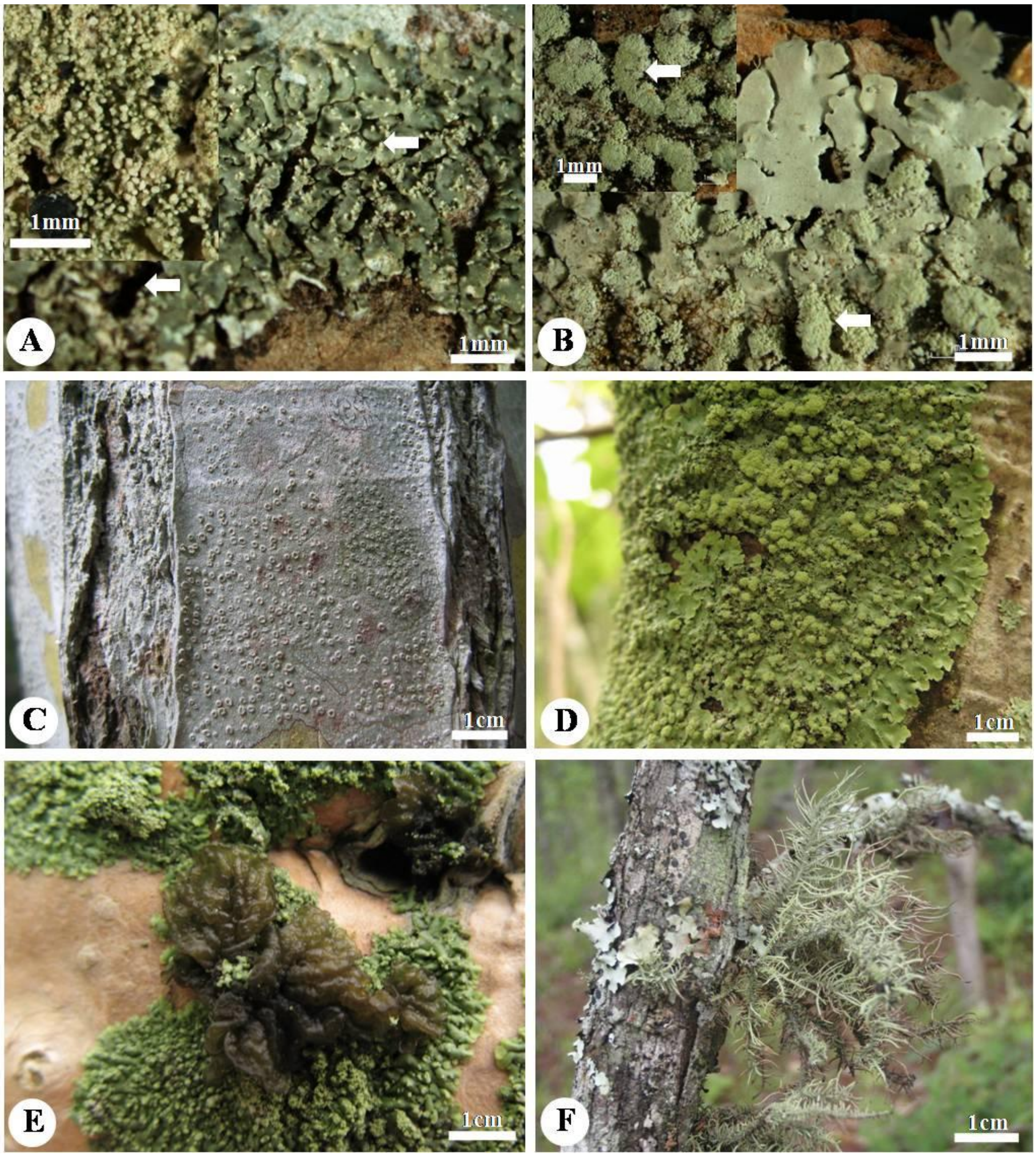

Figure 2.3 Structures and growth forms of lichens. A. isidia; B. soredia; C. crustose lichen; D. foliose lichen; E. gelatinous lichen; F. fruticose lichen.

CHAPTER III

STUDY SITE

3.1 General Landscape

The study was carried out in the Suan Hin Pha Ngam Forest Park area at Amphoe Nong Hin, Loei Province (Figure 3.1A, 3.1B). The elevation range of study site was 400-820 meter. This area was classified into limestone landscape of which soil was derived from sedimentary rock outcrops that mainly composed of calcium carbonate. This landscape type may be called limestone karst or karst where most were derived from calcium-secreting marine organisms for millions of years ago before tectonic movements lifted them above sea level (Clements, 2006). Over the periods, mechanical and chemical processes enhanced forming of the softer sediments covering karsts. Otherwise, these processes usually developed “tower” and “cockpit” karst formations in the tropical regions. The tower and corkpit were classified by degree where 60-90 degree of tower and 30-40 degree of corkpit were dertermined (Clements, 2006). In this area, there are cliffs riddled with caves and sinkholes of tower karsts, and conical shape of corkpit karsts also presented. Among this landscape, thin layer, low humid and low nutrient soils occur all around but, are surrounded by more thickness at the foot of tower. The latter areas are the agricultural area for local farmers for sugar cane or maize production.

3.2 Sampling Points

At the points for collecting specimens, there are four areas including Saun Sa Wan, Suan Hom, Khao Tep Porn and Khao Boon Mee (Figure 3.1C). Suan Sa Wan and Suan Hom are the natural educational trails for ecoturism whereas Khao Tep Porn and Khao Boon Mee are the natural limestone forest without disturbance.

3.2.1 Suan Sa Wan

This area has been usually used by tourists for photographing and plant observation. There are large populations of *Cycas pectinata* and also found some *Dracaena cochinchinensis* and *Dracaena jayniana.* All of plant hosts grow along the limestone shallow and crevice where expose or shade to sun light and low humidity. However, *D. cochinchinensis* usually grow in shaded areas under the tree canopies whereas *C. pectinata* and *D. jayniana* are more exposed to solar radiation. In *C. pectinata* population, some of them die and lean against another or lay down on the floor but none is observed in *D. cochinchinensis* and *D. jayniana* populations (Figure 3.3A, F). Differently, *D. jayniana* grow in clump of stems which each closed to the others.

3.2.2 Suan Hom

This area has been used for camping and surrounded by agricultural areas. There are inhabited by large populations of D. jayniana but are also inhabited by some C. pectinata and D. cochinchinensis. In this area, dense populations of D. jayniana present along the rock crevices near the cliffs where are exposed to sunlight (Figure 3.3E, 3.3F). However, some of them are also under canopies of other tree species along the trails.

3.3.3 Khao Tep Porn

This sampling site is next to Suan Sa Wan and Suan Hom but represent the minor different vegetations. There are covered by *D. cochinchinensis*, *C. pectinata* and a few *D. jayniana* populations. Not only the distributions of two host species, but there are also inhabited by dense herbaceous, *Euphorbia* species and some trees. Thus, light intensity is likely low and quite higher moister content compared to Suan Sa Wan and Khao Tep Porn (Figure 3.3D).

3.3.4 Khao Boon Mee

This sampling area is located far from other ones and near to local road and agricultural areas. There are dense *C. pectinata* populations near the summit of this area, some *D. cochinchinensis* and a few *D. jayniana* along the way to the summit. At the summit, *C. pectinata* population exposes to sun light (Figure 3.3C) and low humidity along cliffs but are more shading under trees in the shallow at lower elevation.

3.3 Climate

The climate of study site is divided into three seasons such as sunny, rainy and winter. From 1971 to 2010, monthly average relative humidity of Loei province range from 62 to 79 percents that highest in rainy on September and lowest in dry season on March (Figure 3.4A). For 40 years average, mean of the relative humidity was 71.7 percent.

Normally, rainfalls have been high in rainy season (May to September) and low in winter and sunny (October to April). It is observed, for example a representative of monthly rainfall in 2010 are shown in Figure 3.4F. The total rainfalls have been fluctuated from around 900 to 1600 mm since 1971 to 2010 (Figure 3.4D.) but average total rainfall for last 40 years was 1242.9 mm.

For air temperature, there is high average temperature in dry season and low in winter which trend is observed in 2010 (Figure 3.4E). The average annual air temperature for last 40 years was 25.7 ºC.

To summary, relative humidity and rainfall are high in averages but fluctuate within different seasons. However, average annual temperature is not high but rich a peak in March to April, then constantly decline in winter.

3.4 Host plants

The three species of host plants were selected for sampling lichens and determination of lichen community. They are dominant species in this limestone forest. Host plants were randomly selected within a range of diameter at breast height (DBH, at 1.3 m above ground level) upper than 8 inches and the host plants which did not have lichen species were excluded from this study. All of the host plants have to erect without or small degree of the damage and inclination. The morphology of the three host plants were described below:

3.4.1 *Cycas pectinata* Griff. (Family Cycadaceae)
(Figure 3.2A, 3.2D)

Plant arborescent; stem erect, often branched, to 12 m tall, 12-25 cm diameter at narrowest point, bark almost smooth, yellowish. **Leaves** 30-60, deep green to grey green, semiglossy, 1.5-2.4 m long, flat, opposing pinnae, rachis consistently terminated by a spine 1-46 mm long. **Petiole** 30-80 cm long, glabrous, spinescent for 30-80% of length. **Basal pinnae** not gradually reducing to spines, pinnae 5 -16 cm long. **Median pinnae** simple, glabrous, strongly discolorous, inserted at 46-60º to rachis, 20-31.5 cm x 7.5-10.5 mm, section flat, margins slightly recurved, decurrent for 4-8 mm, narrowed to 2.5-4 mm at base (to 35-45% of maximum width), 8-13 mm apart on rachis; apex acute, spinescent to not spinescent; midrib raised above, raised below. **Tomentum**

loose and shed early. Cataphylls soft, 5-8 cm long, with closely appressed grey to pale orange brown tomentum. Microspoangiate cones ovoid, yellow or green, 30-55 cm long, 16-22 cm diam. **Microsporophyll** lamina 43- 60 x 19-24 mm, fertile zone 35-57 mm long, sterile zone 3-8 mm long, level, apical spine prominent, sharply upturned, 17-32 mm long. **Megasporophylls** 22-30 cm long, grey-tomentose; ovule 2-4 glabrous; lamina orbicular, 110-180 x 100-130 mm, deeply pectinate, with 40-50 soft lateral spines 26-75 x 2-3 mm wide at base. **Seeds** flattened ovoid, 42-45 x 33-45 mm; sarcotesta yellow, not prunose, 4-7 mm thick; fibrous layer present; sclerotesta smooth; spongy layer absent.

3.4.2 *Dracaena cochinchinensis* (Lour.) S. C. Chen. (Family Asparagaceae) (Figure 3.2C, 3.2F)

Plants treelike, 5-15 m tall. **Stems** branched, sometimes to 1 m thick, reddish apically; internodes much shorter than wide; bark grayish white, becoming grayish brown with age, smooth. **Leave** crowded at apex of branches, sessile, sword-shaped, 30-100 × 2-5 cm, leathery, base reddish, completely covering internode. **Inflorescence** terminal, branched, more than 40 cm; rachis densely papillose-pubescent. **Flowers** in clusters of 2-5; pedicel 3-6 mm, articulate distally. **Perianth** milky white, 6-8 mm; tube 1.5-2 mm; lobes 5-6 mm. **Filaments** flat, 0.5-0.7 mm wide, reddish brown tuberculate distally. **Berry** orange, subglobose, 0.8-1.2 cm in diam., 1-3-seeded.

3.4.3 *Dracaena jayniana* Wilkin & Suksathan (Family Asparagaceae) (Figure 3.2B, 3.2E)

Stems to 5(-8) m tall, woody, basal diam. always basally branched, with usually 3-5 erect stems in a cluster, each sometimes divided into decumbent branches towards apex when axillary buds develop on a shoot following flowering, apical diam. 34-56 mm when unbranched, 28-52 mm branched; leaf scars visible from stem base to apex, apart, grey to grey-brown, epidermis pale brown to grey-brown, texture like thin card, with vertical fissures towards base, peeling away on either side of fissure; where it is damaged, dark red-brown areas of dried sap a few mm in diam. are encountered. **Leaves** in dense clusters at stem apices, coriaceous; sheath 6 x 4 cm, elliptic to ovate, clasping stem 180°, pale green to white, often drying with irregular red pigmentation from sap; 40-75 x 0.5-1.3 cm, not pseudopetiolate (narrowed above sheath), linear-acuminate, dark green, all but the youngest leaves curved near the base, apex pendent, with a weak central to slightly offset costa in basal half of blade, 5 mm wide and 1 mm thick in centre when dry, sometimes paler in colour below, primary venation parallel, dense, sometimes denser in costa than elsewhere, secondary venation not visible, margins with fine translucent denticuli (at least on the sheath and often more densely so there), thickened and opaque. **Inflorescence** terminal on shoot, erect to ascending, more pendent in appearance in fruit but primary axis straight and produced in the direction of shoot growth, not curved towards base; peduncle 10 x 1 cm, fertile 50 cm long, both parts robust and woody at least in fruit, axis compound, with 4 levels of branching, each with reduced diam., partial inflorescences racemose, ultimate axes bearing flowers in glomerules (the 4th level branches), 12-28 cm long, often richly produced to give 1 m; primary axis bracts 15 mm long, ovate, acuminate, scarious, base clasping axis and subtending 1-3 secondary branches, secondary branch bracts 4 mm long, ovate, acute, base and texture as in primary axis bracts. **Flowers** in glomerules of up to 5 flowers, rarely solitary, inter-glomerule distance (5-) 7-20 (-33) mm, not less than 8 mm between basal glomeruli and at least 5 mm apart above or very rarely subopposite on opposite sides of secondary/tertiary axis, not apically crowded; glomerular bracts 2 mm long, broadly ovate or broadly triangular to transversely oblong, membranous, clasping pedicel bases, apex acute to acuminate; floral bracts similar to glomerular bracts in size, often narrower and inserted between pedicel bases; **pedicel** (in flower) 1.9-4.6 × 0.2-0.4 mm below the articulation, filiform, accrescent to 8.8 mm long in fruit; 2.0-3.7 mm long and broader 0.8 mm in diam.) above articulation, accrescent 6 mm long in fruit; flowers often closed with erect tepals (pre and post anthesis), a few at anthesis (which is probably diurnal) with tepals spreading to recurved at about ⅓ of their length. **Tepals** fused at base 0.8-1.2 mm, inserted on a conical receptacle 1.5 x 2.0 mm, **tepals** (free part) 5.0-6.0 x 1.5-2.1 mm, narrowly ovate to oblong, inner whorl slightly broader than outer, dull golden yellow, membranous and translucent towards margins, central vein darker, apices obtuse, cucullate, thickened, minutely scaly. **Filaments** fused to tepals 0.8-1.2 mm at base, free part 2.8-3.9 **x** 0.5-0.7 mm, lanceoloid to narrowly ellipsoid, pale golden yellow, opaque, apex acuminate, bearing a dorsifixed 1.2-1.7 x 0.3-0.4 mm anther, narrowly oblongoid, pale yellow. **Ovary** 3.4-3.6 x 1.3-1.5 mm, fusiformcylindric, dull golden yellow, with 3 spreading apical lobes around the style base; style 2.2-2.4 x 0.5-0.7 mm, cylindric, stigma 0.5 – 0.7 mm in diam., capitate, weakly 3-lobed, style and stigma white. **Fruit** a berry, with 1 – 2 (-3) seeds, 6.0-10.3 x 5.8 -9.0 mm (if 1-seeded), diam. to 12.7 mm in 2- or 3-seeded fruits, (sub) globose to flattened-globose, weakly lobed when 2 or 3 seeds develop, shiny olive green when immature and marked with 3 longitudinal lines which are between lobes in seeds with 2 or 3 seeds, probably dull red when mature but red-black when dry, style base persistent in some immature fruits, with a pale brown 3-lobed scar. **Seeds** c. 6.3 x 5.5 x 3.8 mm and subglobose (1-seeded fruits) or c. 8.5 x 7.9 x 7.5 mm and hemisubglobose (2-seeded fruits), not seen in 3-seeded fruits but probably triquetrous, pale to mid brown, surface rugose when dry, hilum basal, circular.

Table 3.1 The summary of bark morphology in the plant hosts (see also Figure 3.2)

Cycas pectinata	*Dracaena jayniana*	*Dracaena cochinchinensis*
Smooth, fissure present along stem, rectangular unit raised from surface, sometime peeling	Leaf scars visible from stem base to apex; epidermis with vertical fissures and peeling away on either side of fissure	Leaf scars only visible in spical c. 30 cm of braches, fissures present towards base but epidermis corky and not peeling away

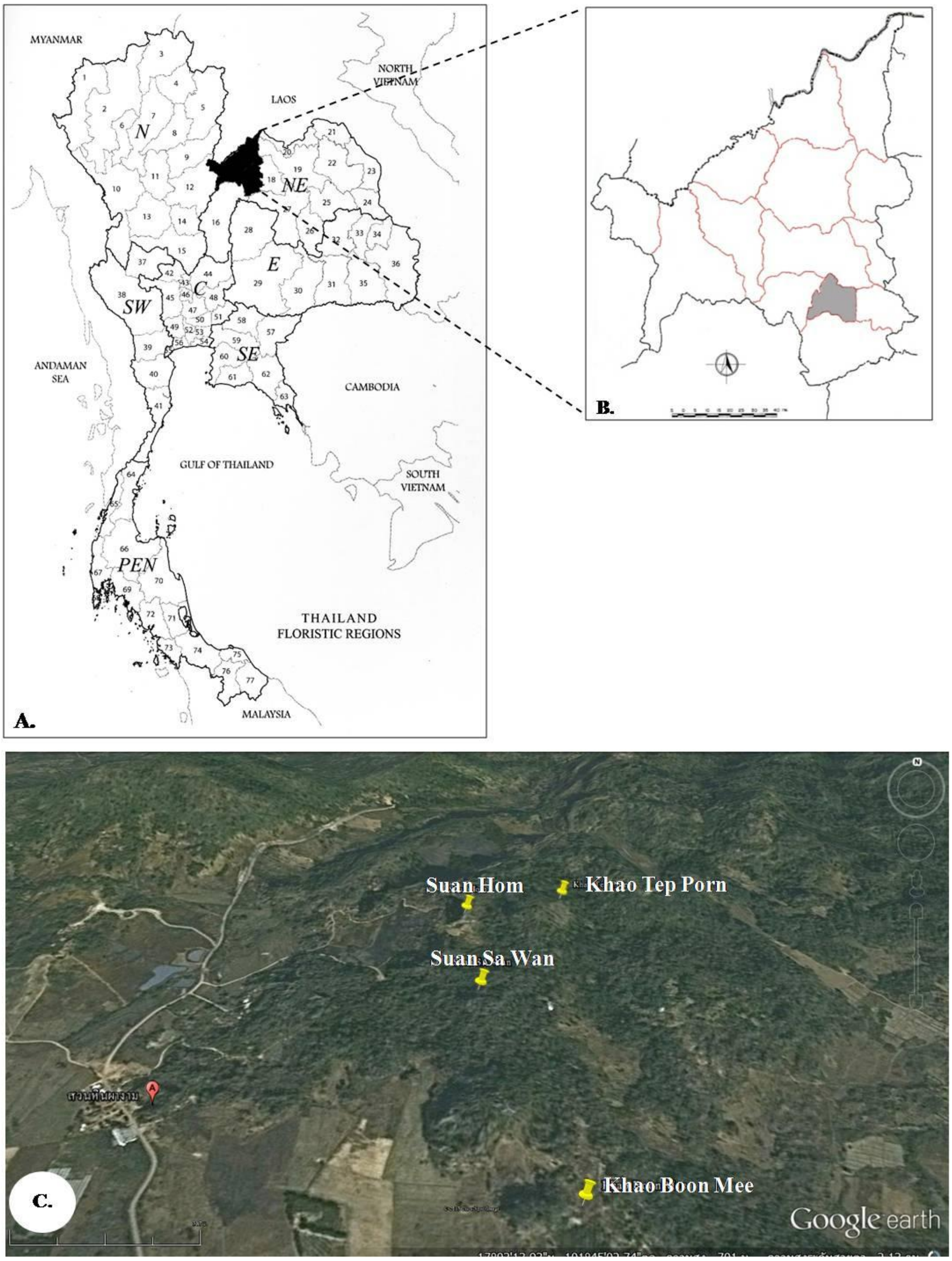

Figure 3.1 Study site. A. map of Thailand indicating Loei Province (black field); B. map of Loei province with grey labeled Amphoe Nong Hin; C. Suan Hin Pha Ngam and the locality for collecting specimens: Suan Hom, Khao Tep Porn, Suan Sa Wan and Khao Boon Mee.

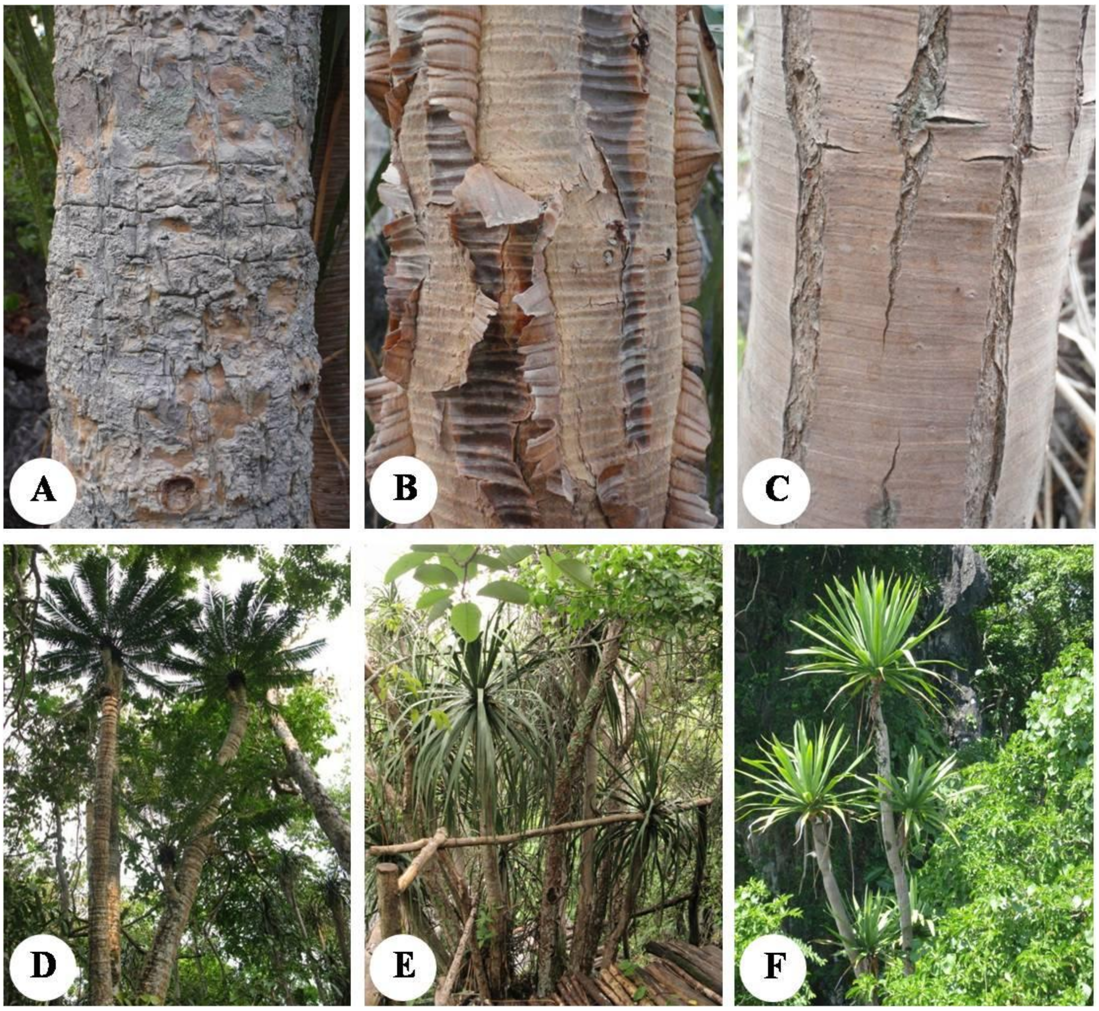

Figure 3.2 Bark Characteristics and habit. A. and D. *Cycas pectinata*; B. and E. *Dracaena jayniana*; C. and F. *Dracaena cochinchinensis*.

Figure 3.3 Specimen sampling areas. A. Suan Sa wan; B. Suan Hom; C. Khao Boon Mee; D. Khao Tep Porn; E. *Cycas pectinata* population; F. *Dracaena cochinchinensis* population.

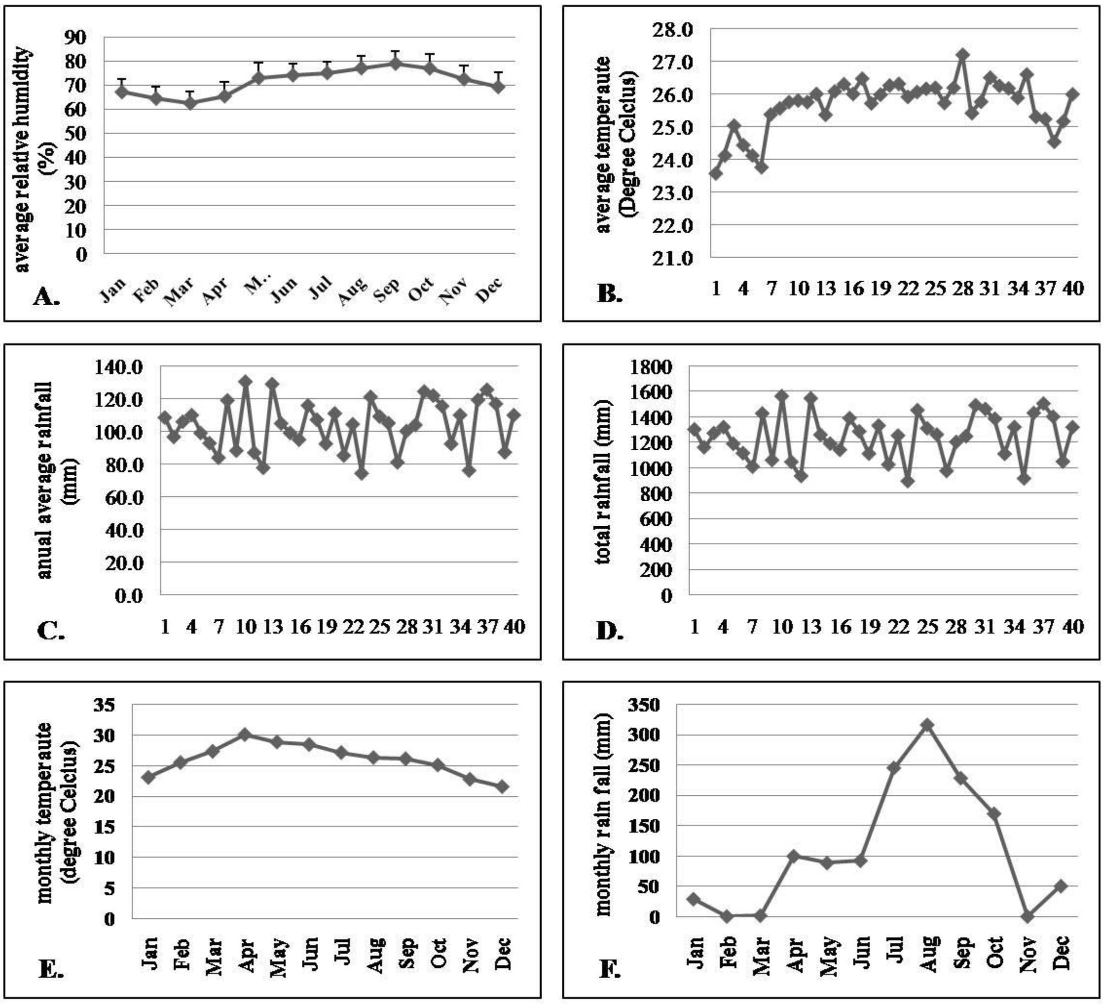

Figure 3.4 Climate of Loei Province. A. monthly relative humidity from 1971-2010; B. average temperature from 1971-2010; C. annual average rainfall from 1971-2010; D. total rainfall from 1971-2010; E. monthly temperature of 2010; F. monthly rainfall of 2010. Note: 1-40 in B., C. D. refer to the year 1971 to 2010 by parallel.

CHAPTER IV

MATERIALS AND METHODS

4.1 Materials

4.1.1 Specimen and data collection equipments

1. Knife
2. Tissue paper
3. Paper bags
4. The Global Position System (GPS) receiver
5. Notes and pencils
6. Diameter tape
7. Vernier caliper
8. Tags
9. Staples

4.1.2 Identification equipments

4.1.2.1 Laboratory equipments

1. Stereomicroscope
2. Light microscope
3. Razor blade (cutter)
4. Forceps
5. Test Tube and Rack
6. Beakers and Stirring Rod
7. Grinder
8. Dropper
9. Glass slides and cover glasses
10. Filter Papers
11. Glass tanks for developed TLC system
12. Silica Plate
13. UV box
14. Hot plate
15. Brush
16. Digital balance

17. Centrifuge rotor
18. pH meter

4.1.2.2 Chemical Substance

1. Potassium hydroxide (KOH)
2. Iodine solution (I_2 in KI)
3. Sodium hypochlorite solution (NaClO)
4. Para-phenylenediamine ($C_6H_8N_2$)
5. Formic acid (HCOOH)
6. Glacial acetic acid (CH_3COOH)
7. Hexane (C_6H_{14})
8. Toluene (C_7H_8)
9. Ethyl acetate ($CH_3COOC_2H_5$)
10. Dioxane ($C_4H_8O_2$)

4.2 Lichen Collections

Lichens were surveyed on each host plant species and were collected systematically. Quadrats were located at the stems of host plant as cylindrical quadrats (Adams and Risser, 1971). The center of quadrat was the point where measured the diameter at breast height: DBH, then extended to upper and lower of stem by 50 cm height (Figure 4.1). All of lichen growth forms and species in quadrats were collected in April, July and November, 2012 which represented the dry, rainy and winter seasons. Complete lichen specimens should include the margins of the thallus and reproductive structures. Crustose lichens should be attached with substratum collected by knife blade that cut below thallus beneath substratum. And foliose lichens should be carefully detached from bark or collected with barks. All lichen specimens had air-dried before placed in paper bags with soft tissue paper. This method facilitated preventing lichen became a small fragment and certain whole specimens. The host plants were tagged with tag labels after collecting lichens. The specimen bags were labeled with the name of collector, collector number, tag number, date of collection and locality. After that, specimens during transportation should not be storage in plastic bags that causes the mould.

4.3 Bark Collections

Barks of three host plants were collected by knife at the same time in lichen sampling within 3 replications. Bark samples which were measured the properties in laboratory should be clear without lichen thallus and other remnants. Barks were not handling and were air dried and stored in paper bags with tissue paper until laboratory analysis. Barks should be air-dried and keep in paper bags as well as lichen specimens for preventing the mould and redrying.

4.4 Lichen identification

The specimens which were not identified in the field were studied in the laboratory. There were morphological, anatomical and chemical characteristic for species determination.

4.4.1 Morphology and Anatomy analysis

Before the identification, lichens were separated in different distinct external morphology such as growth forms or thallus characteristics. To identify lichens to genera, it was indeed to have the investigation the details of ascospores and ascocarp structures under stereomicroscope and a light microscope. The specimens were examined by razor blade and then transfered to slide glasses. The colour, thickness, cell shape and tissue types of epihymenium, hymenium, hypothecium, kind of exciple were determined and noted. In addition, characterize the spores, paraphyses and asci before burst the asci to release the ascospores in order to measure size of the ascospores.

4.4.2 Chemical analysis

4.4.2.1 Chemical spot test

Chemical spot test was requirement for the keys to some genera because lichens produce the unique chemical substance accumulated in form of crystal in medulla or cortex. The chemical tests were carried out on the medullary or cortical tissues that directly show the characteristic colour changes with small area on thallus. As the chemical of each species was constant, the various specimens from different habitat will give the constant result of chemical test (George, 1992).

Chemical spot tests composed of K-test (10 % KOH solution), C-test (Calcium hypochlorite or common bleaching powder), KC-test (K-test followed by C-test) and Pd-test (Orange, James and White, 2001).

4.4.2.2 Thin layer chromatography

Thin layer chromatography technique (TLC) is the simple and rapid method to recognize lichen substances with the accuracy. The thin layer of silica gel on glasses was spotted by acetone extract of lichen fragments. Then, sheets are developed in solvent and continue to the air-dry. After that, colourless lichen substances were observed under short wavelength ultraviolet (UV) and by consequent brushing with 10% sulphuric acid followed by heated at 100 ºC for 10-15 minutes. The UV, colour characteristics and Rf value or mobility were examined to identify lichen substances. Finally, all of data were compared to standard characteristics of thin layer chromatography for finding out the chemical substances (Elix and Ernst-Russell, 1993).

4.4.3 Taxonomic literatures

The morphological, anatomical and chemical information were determined with the taxonomical keys. Firstly, the lichens were classified into the genera level then treated to species level. Secondly, descriptive morphologies were compared to herbarium specimens and literatures. However, confirmations had been done by expert of different lichen groups. Classification and identification of lichen species had been doned based on the lichen studies in Thailand such as Homchantara (1999), Vongshewarat (2002), Sutjaritturakarn (2002) and Noicharoen (2002). The lichen flora were used including Flora of Australia (volume 54, 57 58A), and Macrolichens of East Africa. Moreover, publications or related articles were emphasized the species such as Bliotheca lichenologica (Band 26, 40, 94, 97,102) and the Lichenologist (volume 41, 42).

4.5 Bark Properties Measurements

4.5.1 Bark crevice depth measurement

Bark crevice depth was measured during collecting lichen specimens by using Vernier caliper. The bark crevices were chosen by random in sampling plots up to 20 values. For *D. jayniana*, bark crevices were defined as to top of the wings to the point start peeling whereas bark crevices in *D. cochinchinensis* and *C. pectinata* were referred to the fissures on sampling plots (Figure 3.1A, 3.1B, 3.1C). The averages of bark crevice depth were analyzed and tested the correlation to species per plant.

In the laboratory, the bark samples were air-dried until constant weight and carefully cleaned to remove lichen, mosses or soil particles. It was concerning before collecting that the barks were without remnants if possible. The methodologies of measurement bark pH and bark water-holding capacity were following.

4.5.2 Bark pH

To measure the Bark pH, 2 mm depth from surface of bark collections were weight each sample to 0.5 g before grinding. Then, the dust of barks were soaked in vials with 10 ml deionized water and vigorously shaken by hand. Subsequently, leave the samples for 30 minutes and shake again. The mixers were centrifuged at 4,000 rpm for 5 minutes in order to gain the fluid fraction. Next, fluid fractions were measured pH using pH meter.

4.5.3 Bark water-holding capacity

To measure the bark water-holding capacity, bark specimens were chosen in similar size (1 x 1 cm) and dried in hot air oven at 105 ºC for 24 hours. Five replicates of Barks from each sample were examined and then weighted them with data recording. After that, barks were stored in deionized water for 3 days and weighted again with data recording. Bark water-holding capacities were calculated from percentage of dry weight of the wet weight minus dry weight.

4.6 Data Analysis

4.6.1 Lichen community

To describe the lichen community, several kinds of diversity indices can be applied to study different approach in lichen composition within and between communities. There were described by Whittaker (1972) as shown below:

Alpha diversity (α) is the average of species from several sample units or plots. It is a species richness measurement of community. In this study, the

Shannon-Weiner diversity index (H’) was used to determine the species richness on each species of plant hosts.

$$\mathbf{H}' = \sum_{i=1}^{s} P_i \ln P_i$$

Where **s** is the number of species

p$_i$ is the proportion of individuals of each species belonging to the species of the total number of individuals.

Beta diversity (β) or species turnover is the degree of change in species composition along an environmental gradient or ordination axis, i.e. the different in species composition from one habitat to the next. It is usually measured as the amount of species change between the ecosystems (Whittaker, 1972). In this study, beta diversity was used to indicate different species composition between host plants.

$$\beta = \frac{\gamma}{\alpha}$$

Where α = alpha diversity

β = beta diversity

γ = gamma diversity

Gamma diversity (γ) is the overall diversity within a large region, or the total number of species found is an area.

4.6.2 Similarity of Lichens

Similarity of lichen species composition between host plant species was carried out by Sørensen’s Similarity Index (Sørensen coefficient). In this study, Sørensen coefficient was used to examine the similarity of lichen species among three host plants and then, it was calculated by following equation (Lai, 2001):

$$\text{Sørensen coefficient} = \frac{2C \times 100}{A+B}$$

Where A =total number of species in the plot A

B= total number of species in the plot B

C= total number of species common to both plot A and plot B

4.6.3 Statistical Analysis

The comparisons of the means were examined by one-way ANOVA of SPSS including bark crevice depth bark pH and Bark water-holding capacity. This is the test of significant differences between the means of two or more independent (unrelated) groups. Moreover, correlation coefficients were tested by bivariate correlation in order to indicate the correlation between species per plant and the mean of bark properties in each host plants. To determine the effect of bark factors, multivariate analysis has been done by *Principal component analysis* (PCA). PCA will indicate which factors correlate with species diversity on host plants.

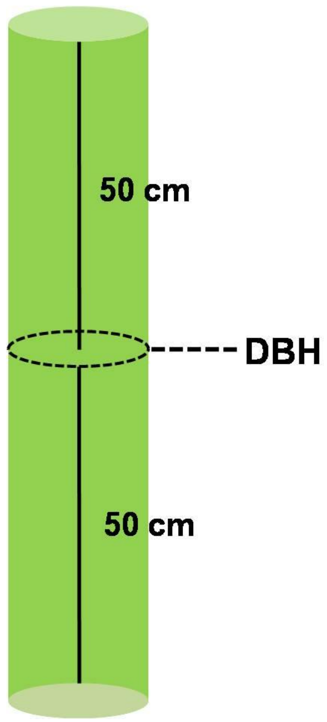

Figure 4.1 Cylindrical quadrat for lichen and bark collection

CHAPTER V

RESULTS

5.1 Lichen diversity

The lichen specimen collections were kept in paper bags with 764 collector numbers. All of corticolous lichens from *C. pectinata*, *D. cochinchinensis* and *D. jayniana* were identified into 17 families, 30 genera and 56 species. There were three lichen growth forms which accounted for 39, 16 and 1 species of crustose, foliose and squamulose respectively. The Physciaceae was the family with largest members found in this study within 6 genera and 10 species whereas the Arthopyreniaceae, Coccocarpiaceae, Monoblastidiaceae, Pertusariaceae and Trypetheliaceae accounted for only 1 species each others. However, Graphidaceae, Lecanoraceae and Pyrenulaceae were the families found 6 lichen species each. According to host plants, there were different lichen families, genera and especially species. Thus, the lichen communities on each plant were likely different (Table 5.2).

Species richness: Alpha diversity (Table 5.3)

Cycas pectinata Griff.

There were 13 families, 23 genera and 39 species of lichens inhabiting on the surface of *C. pectinata*. Crustose lichens were abundant with 28 species while foliose and squamulose were found only 10 and 1 species respectively. Overall, the average lichen species per quadrat was 5.5 ± 2.13 with the 8.79 ± 0.06 species per quadrat for alpha diversity.

Dracaena cochinchinensis (Lour.) S. C. Chen

D. cochinchinensis accounted for the 13 families, 22 genera and 38 species of lichens on stem surfaces. The crustose lichens were dominant group within 24 species and minority of 13 foliose and 1 squamulose lichens. The average lichen species per quadrat was 5.2 ± 2.36 then alpha diversity accounted for 10.71 ± 0.06 species per quadrat.

Dracaena jayniana Wilkin & Suksathan

The totally lichens found on stem surface of *D. jayniana* were 11 families, 19 genera and 36 species. Crustose groups dominated on this habitat for 25 species whilst foliose group accounted for 11 species. Lichen species per quadrat was 4.4 ± 2.79 in average and 8.91 ± 0.08 species per quadrat was alpha diversity.

Differences of lichen species on host plants: Beta diversity

To determine the variation of lichen composition in different habitat, beta diversity was usually demonstrated. If lichen species regularly distributed on each host plant of same species, the beta diversity would be less than the irregularly ones. In this study, beta diversity of lichens on *C. pectinata* (4.78) was highest, followed by *D. jayniana* (3.93) and *D. cochinchinensis* (3.55) respectively (Table 5.3). These indicated that *C. pectinata* represents high variation of species composition compared with *D. jayniana* and *D. cochinchinensis*. Controversially, *D. cochinchinensis* had more lichen species evenness than *D. jayniana* and *C. pectinata* respectively.

5.2 Similarity of lichens (Figure 5.1)

Similarity of lichens between *C. pectinata* and *D. cochinchinensis*

Lichen species on both *C. pectinata* and *D. cochinchinensis* demonstrated 72.7 percent similarity calculating from Sorensen's Similarity Index. There were 28 lichen species found similarly that consisted of abundant crustoses including *Buellia schaereri*, *Coccocarpia rottleri* , *Collema rugosum*, *Cryptothecia monospora, C. aleurodes, Cryptothecia* sp*., Diorygma junghuhnii* , *Dirinaria aegialita*, *D. papillulifera*, *Graphis longispora*, *G. immersella, G. insulana, G. ronglaensis, Hyperphyscia syncolla, Lecanora coronulans, L. ecoronata, L. austrotropica, Leptogium cyanescens*, *Leucodecton albidulum*, *Parmotrema tinctorum, Phyllopsora corallina* (Eschw.) Müll. Arg. var. *coralline*, *Physcia nubila*, *Pyrenula ochraceoflava, P. interducta, P. leucotrypa , P. leucostoma, Pyxine cylindrical* and *Stegobolus crassus*.

Similarity of lichens between *C. pectinata* and *D. jayniana*

Lichen species on both *C. pectinata* and *D. jayniana* showed 69.3 percent similarity according to Sorensen's Similarity Index. The two plant hosts illustrated similar 26 lichen species of which common species including *Buellia schaereri, Collema* *rugosum, C. monospora, C. aleurodes, Cryptothecia* sp.*, Dirinaria aegialita*, *D. papillulifera*, *Graphis longispora, G. immersella, G. insulana, G. ronglaensis, Hyperphyscia syncolla, Lecanora coronulans, L. ecoronata, L. austrotropica, Leptotrema wightii, Leucodecton albidulum, Parmotrema tinctorum*, *Physcia nubila*, *Pyrenula ochraceoflava, P. interducta, P. leucotrypa , P. leucostoma, Pyxine cylindrical*, *P. sorediata*, *Relicinopsis rahengensis* and *Stegobolus crassus*. According to the species richness, crustose species were almost similar lichens on two host plants.

Similarity of lichens between *D. cochinchinensis* and *D. jayniana*

Sorensen's Similarity Index showed 72.9 percent similarity of lichen species between *D. cochinchinensis* and *D. jayniana*. The two host plants shared similar 27 lichen species including *Anisomeridium subprostans*, *Buellia schaereri, Collema rugosum, Cryptothecia monospora, C. aleurodes, Cryptothecia* sp.*, Dirinaria aegialita*, *D. papillulifera*, *Graphis longispora*, *G. immersella, G. insulana, G. ronglaensis, Hyperphyscia adglutinata, H. syncolla*, *Lecanora coronulans, L. ecoronata, L. leprosa*, *L. austrotropica, Leucodecton albidulum*, *Parmotrema tinctorum, Physcia nubila*, *Pyrenula ochraceoflava, P. interducta, P. leucotrypa, P. leucostoma, Pyxine cylindrica* and *Stegobolus crassus*. Crustose lichens were found as the dominant species among *D. cochinchinensis* and *D. jayniana*.

Common species on three host plants

There were 24 lichen species found as common species on three host plants (Figure 5.1). They composed of *Buellia schaereri, Collema rugosum, Cryptothecia monospora, C. aleurodes, Cryptothecia* sp.*, Dirinaria aegialita*, *D. papillulifera*, *Hyperphyscia syncolla*, *Graphis longispora*, *G. immersella, G. insulana, G. ronglaensis, Lecanora coronulans, L. ecoronata, L. austrotropica, Leucodecton albidulum*, *Parmotrema tinctorum, Physcia nubila*, *Pyrenula ochraceoflava, P. interducta, P. leucotrypa , P. leucostoma, Pyxine cylindrical* and *Stegobolus crassus*.

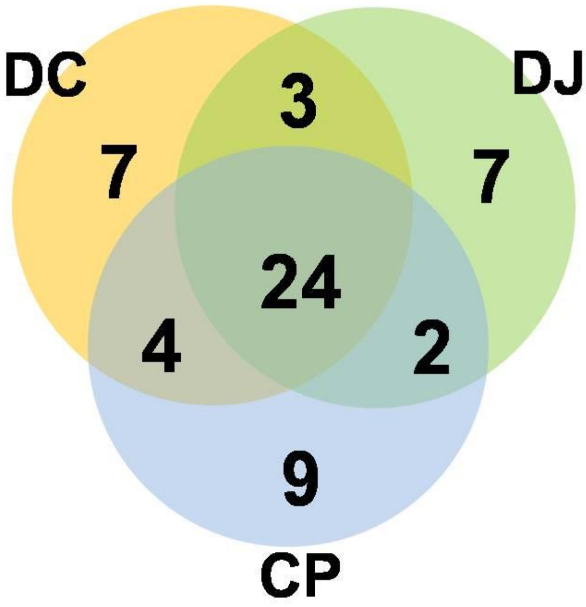

Figure 5.1 Number of similar lichen species between *C. pectinata* : CP, *D. jayniana*: DJ and *D. cochinchinensis* : DC

5.3 Bark Properties

Bark crevice depth

As the peeling of stem surface occur, *D. jayniana* had the deepest of average bark crevice among three host plants. They accounted for 11.46 ± 4.39 mm whereas 2.81 ± 1.36 mm of bark crevice depth occurs in *C. pectinata*. In *D. cochinchinensis*, they perform the small amounted of the depth as 2.03 ± 0.64 mm (Table 5.4, Figure 5.3A). Statistically, there were significantly difference of bark crevice depth between *D. jayniana* and *D. cochinchinensis*, *D. jayniana* and *C. pectinata* but there was no significantly different between *D. cochinchinensis* and *C. pectinata*.

Bark pH

Bark pH is represented by hydrogen ion concentration, however, the trend of pH on plant host was similar and quite acidic (Table 5.4, Figure 5.3B). *D. cochinchinensis* showed the most acidic bark in average pH 3.79 ± 0.36. On the other hand, both *C. pectinata* and *D. jayniana* had more basidic bark recorded to 4.49 ± 0.32 and 4.37 ±

0.38 respectively. It had no significant difference pH between *C. pectinata* and *D. jayniana* but they differed significantly between *D. cochinchinensis* and each other.

Water-holding capacity

Water-holding capacity showed which host could provide more or less water to corticolous lichens. The highest water-holding capacity was 80.8 percents obtained from *C. pectinata*. In *D. cochinchinensis* and *D. jayniana*, the water-holding capacities were 28.9 and 25.4 percents respectively. Notably, the water-holding capacity in *C. pectinata* was greater than the others more than double (Table 5.4, Figure 5.3C).

5.4 Correlation between species per quadrat and bark properties

5.4.1 Correlation coefficient

All of bark properties e.g. bark crevice depth, bark pH (hydrogen ion concentration) and water holding capacity were tested the correlation with the number of lichen species per quadrat. Because there were no significant at the level of 0.05, none was correlated with the number of lichen species per quadrat (Table 5.5).

5.4.2 Principal Component Analysis (PCA)

Principal Component Analysis was used for carrying out the correlation of the multivariate data of lichen species and bark properties. The two set of data matrix between number of species found on each host plant and bark property were used in analysis. The Eigen values illustrated the amount of variation in each data matrix or principal component so that explained the order of importance (Table 5.1). Principal component with an Eigen value at least 1 explained more of the variance than any original variable. Thus, only axis 1 and axis 2 were complied to analyze in PCA with the most importance. The red line indicated correlations of principal axes with bark pH, bark water-holding capacity, bark crevice depth, diameter at breast height (DBH) (Figure 5.2). PCA plot showed that lichen species on each host plants that were not correlated bark properties and DBH. Lichen species were in the center of the plot without the distribution to the host and the bark properties, however, bark pH trended to correlate with *D. cochinchinensis*. Bark crevice depth were likely correlated with *D. jayniana* while DBH and water-holding capacity correlated with *C. pectinata*. It conformed to the correlation coefficient that demonstrating none relationship between bark properties and lichen species occur.

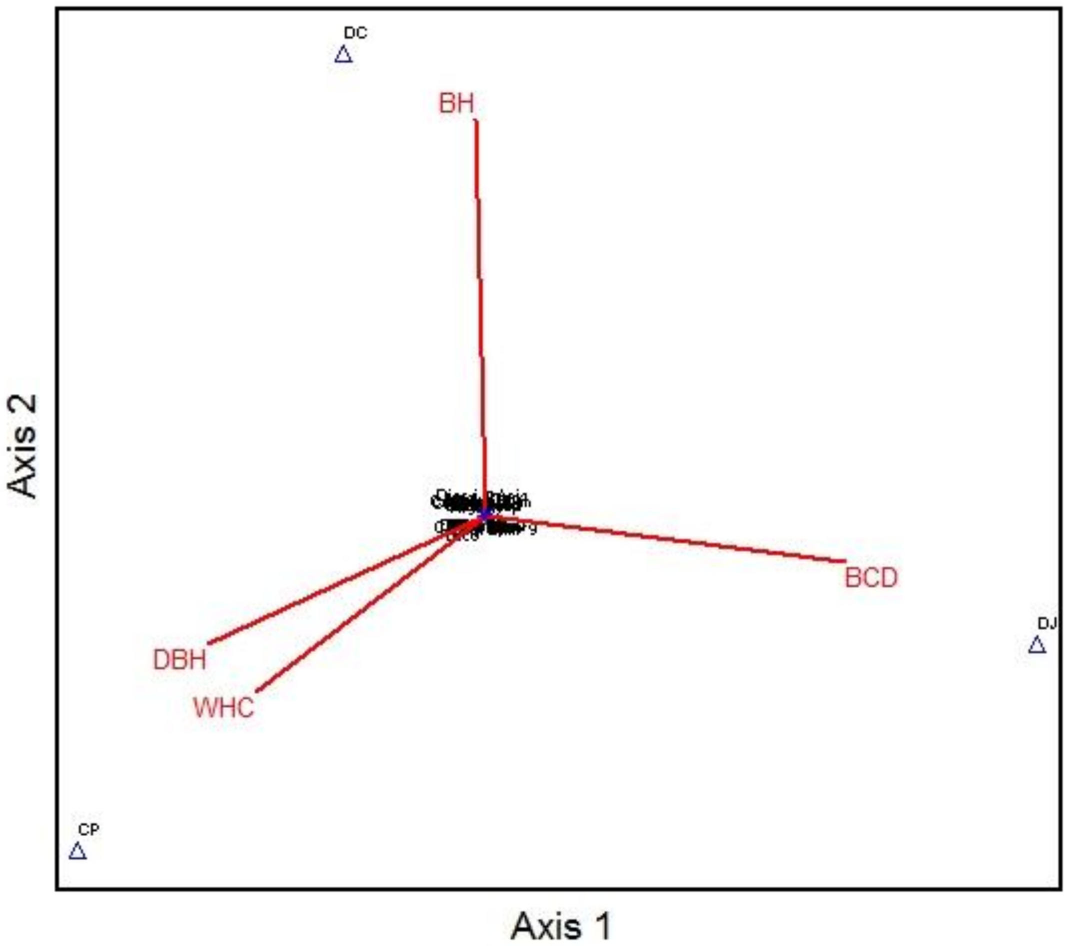

Figure 5.2 Principal Component Analysis (PCA) plot of lichen species and bark properties; Bark water-holding capacity: WHC, Bark crevice depth: BCD, Bark Hydrogen ion concentration: BH and Diameter at breast height: DBH; DC: *D. cochinchinensis*; DJ: *D. jayniana* and CP: *C. pectinata*; lichen species were at center of the plot.

Table 5.1 Eigenvalues from randomizations of Principal Component Analysis

	real data	Eigen value from randomizations			
Axis		Minimum	Average	Maximum	p*
1	794.98	678.04	848.36	1159.8	0.69
2	553.02	188.19	499.64	669.96	0.30
3	0.43×10^{-11}	0.18×10^{-11}	0.39×10^{-11}	0.47×10^{-11}	0.27×10^{-11}
4	0.35×10^{-13}	0.12×10^{-13}	0.42×10^{-13}	0.90×10^{-13}	0.66×10^{-13}
5	0.17×10^{-13}	0.76×10^{-14}	0.23×10^{-13}	0.57×10^{-13}	0.74×10^{-13}

*p-value for an axis is (n+1)/(N+1), where n is the number of randomizations with an eigenvalue for that axis that is equal to or larger than the observed eigenvalue for that axis.

5.5 Diversity of lichens in each sampling sites

Alpha diversity

There were 4 sampling sites for collecting lichen specimens in this study. According to the alpha diversity, there was different diversity of lichens on host plants in each sampling sites.

1. Khao Boon Mee

   There were 20, 14, and only 5 lichen species on *D. cochinchinensis*, *C. pectinata* and *D. jayniana* respecitively at Khao Boon Mee (Table 5.8). Also, alpha diversity of *D. cochinchinensis* and *C. pectinata* showed 3.99 ± 0.07 and 3.69 ± 0.08 respectively. Contrastingly, there was very low alpha diversity on *D. jayniana* (0.96 ± 0.00) compared to *D. cochinchinensis* and *C. pectinata* (Table 5.8). The results illustrated that there were high lichen diversities on *D. cochinchinensis* and *C. pectinata* but very low lichen diversity was on *D. jayniana* at Khao Boon Mee.

2. Khao Tep Porn

There were 25, 24, and only 2 lichen species on *D. cochinchinensis*, *C. pectinata* and *D. jayniana* respecitively at Khao Tep Porn (Table 5.8). Also, alpha diversity of *D. cochinchinensis* and *C. pectinata* showed 5.98 ± 0.11 and 5.18 ± 0.08 respectively. Contrastingly, there was very low alpha diversity on *D. jayniana* (0.69 ± 0.00) compared to *D. cochinchinensis* and *C. pectinata* (Table 5.8). The results illustrated that there were high lichen diversities on *D. cochinchinensis* and *C. pectinata* but very low lichen diversity was on *D. jayniana* at Khao Tep Porn.

3. Suan Sa Wan

There were 20, 21, 24 lichen species on *D. cochinchinensis*, *C. pectinata* and *D. jayniana* respectively. However, alpha diversity was highest on *D. cochinchinensis* (5.04 ± 0.08) followed by on *D. jayniana* (4.69 ± 0.09) and on *C. pectinata* (4.39 ± 0.08) (Table 5.8). Alpha diversities of lichen species on three hosts at these sites were likely higher than Khao Boon Mee and Khao Tep Porn. The results showed that there were quite high alpha diversity on *D. cochinchinensis*, *D. jayniana* and *C. pectinata* at Suan Hom.

4. Suan Hom

The lichen species diversities on host plants at Suan Hom were quite high when compared to other 3 sampling sites. There were 22, 27, 30 lichen species on *D. cochinchinensis*, *D. jayniana* and *C. pectinata* respectively. However, alpha diversity was highest on *D. jayniana* (5.84 ± 0.10) followed by on *C. pectinata* (5.00 ± 0.08) and *D. cochinchinensis* (4.17 ± 0.05) (Table 5.8). Interestingly, the alpha diversity of lichen species at this sampling site was the least on *D. cochinchinensis* when compared to *D. jayniana* and *C. pectinata*. This was different the alpha diversities on host plants from Khao Boon Mee, Khao Tep Porn and Suan Sa Wan. The results showed that there were quite high alpha diversity on *D. cochinchinensis*, *D. jayniana* and *C. pectinata* at Suan Hom.

Beta diversity

The beta diversities indicated that the species turn over on different species of host plants was not similar to each other in each sampling site.

1. Khao Boon Mee

   The beta diversities of lichen species on host plants at Khao Boon Mee were in the same trend of alpha diversity. There were 4.81, 3.97, and 3.85 on *D. cochinchinensis*, *C. pectinata* and *D. jayniana* respectively (Table 5.8). These results indicated that the changes of lichen species on *D. cochinchinensis* were higher than *C. pectinata* and *D. jayniana*.

2. Khao Tep Porn

   The beta diversities of lichen species at Khao Tep Porn were different among host plants. *C. pectinata* contained high beta diversity as 4.69 and 4.17 on *D. cochinchinensis* while there were only 2.90 on *D. jayniana*. The beta diversities among host plants showed the high species changes on *D. cochinchinensis* and *C. pectinata* but low species changes on *D. jayniana*. This was in the same trend as well as alpha diversity on host plants at Khao Tep Porn.

3. Suan Sa Wan

   Differently, there were the highest beta diversities on *D. jayniana* (5.12) and there were 4.87 and 3.97 on *C. pectinata* and *D. cochinchinensis* respectively (Table 5.8). The high beta diversities on host plants in this sampling area indicated that there was high species turn over on each host plants.

4. Suan Hom

   There were highest beta diversities on *C. pectinata* (5.93) and also quite high on *D. cochinchinensis* (5.19) and *D. jayniana* (4.74) (Table 5.8). These results indicated that lichen species had the changes on C*. pectinata* more than on *D. cochinchinensis* and *D. jayniana* respectively. Interestingly, beta diversity in this area was high on *C. pectinata* when compared to other sites.

However, alpha diversity illustrated that *D. cochinchinensis* usually had the highest alpha diversity at 3 sampling sites including Khao Boon Mee, Khao Tep Porn and Suan Sa Wan. For Suan Hom, *D. cochinchinensis* contained the least alpha diversity among plant hosts. However, *D. jayniana* provided the least alpha diversity at Khao Boon Mee and Khao Tep Porn. Controversially, *D. jayniana* had highest alpha diversity at Suan Hom and was also high at Suan Sa Wan.

Overall, *D. cochinchinensis* and *C. pectinata* usually had high alpha diversity at all sampling sites. *D. jayniana* also had high alpha diversity at Suan Sa Wan and Suan Hom but had low alpha diversity at Khao Boon Mee and Khao Tep Porn.

Table 5.2 Corticolous lichens on three host plants in limestone forest Amphoe Nong Hin, Loei Province

No.	Scientific Name	Growth form	No. of Hosts		
			DC	DJ	CP
	Arthoniaceae				
1	*Cryptothecia aleurodes* (Nyl.) Makhija & Patw	crustose	5	3	4
2	*Cryptothecia genuflexa* (Müll. Arg.) R. Sant.	crustose	-	1	-
3	*Cryptothecia monospora* (Vain.) Makhija & Patw.	crustose	6	1	2
4	*Cryptothecia* sp.	crustose	1	1	3
	Arthopyreniaceae				
5	*Mycomicrothelia miculiformis* (Nyl. ex Müll. Arg.) D. Hawksw.	crustose	-	2	-
	Bacidiaceae				
6	*Bacidia incongruens* (Stirt.) Zahlbr.	crustose	-	-	1
7	*Bacidia medialis* (Tuck. ex Nyl.) B. de Lesd.	crustose	-	-	1
8	*Phyllopsora corallina* (Eschw.) Müll. Arg. var. *corallina*	squamulose	1	-	3
	Coccocarpiaceae				
	Coccocarpia rottleri (Ach.) Arv.	foliose	4	-	3
	Collemataceae				
10	*Collema rugosum* Kremp.	foliose	3	1	5
11	*Leptogium cyanescens* (Rabenh.) Korber.	foliose	14	-	10
	Graphidaceae				
12	*Diorygma junghuhnii* (Mont. & Bosch) Kalb	crustose	18	-	9
13	*Diorygma hieroglyphicum* (Pers.) Staiger & Kalb	crustose	-	-	1
14	*Graphis immersella* Müll. Arg.	crustose	4	1	8
15	*Graphis insulana* (Müll. Arg.) Lücking &. Sipman	crustose	7	2	3
16	*Graphis longispora* Awasthi & S. Singh	crustose	11	2	15

Note: DC = *Dracaena cochinchinensis*; DJ = *Dracaena jayniana*; CP = *Dracaena jayniana*;

No. of Hosts = number of host plants inhabited by lichens

Table 5.2 Corticolous lichens on three host plants in limestone forest Amphoe Nong Hin, Loei Province (continued)

No.	Scientific Name	Growth form	No. of Hosts		
			DC	DJ	CP
	Lecanoraceae				
17	*Graphis ronglaensis* Sutjaritturakan	crustose	10	4	8
18	*Lecanora arthothelinella* Lumbsch	crustose	-	1	-
19	*Lecanora austrotropica* Lumbsch	crustose	8	8	6
20	*Lecanora coronulans* Nyl.	crustose	3	6	17
21	*Lecanora ecoronata* Vain.	crustose	1	1	1
22	*Lecanora leprosa* Fée	crustose	2	4	-
23	*Lecanora tropica* Zahlbr.	crustose	1	-	-
	Monoblastidiaceae				
24	*Anisomeridium subprostans* (Nyl.) R. C. Harris.	crustose	17	18	-
	Parmeliaceae				
25	*Bulbothrix queenslandica* (Elix & G.N.Stevens) Elix.	foliose	1	-	-
26	*Bulbothrix goebellii* (Zenker) Hale	foliose	1	-	-
27	*Parmotrema tinctorum* (Despr.ex Nyl) Hale	foliose	14	15	14
28	*Relicinopsis malaccensis* (Nyl.) Elix & Verdon	foliose	1	-	-
29	*Relicinopsis rahengensis* (Vain.) Elix & Verdon	foliose	-	1	-
	Physciaceae				
30	*Buellia schaereri* DeNot.	crustose	22	30	13
31	*Diplotomma venustum* (Körb.) Körb.	crustose	-	-	1
32	*Dirinaria aegialita* (Afzel. ex Ach.) B.J.Moore	crustose	4	11	6
33	*Dirinaria papillulifera* (Nyl.) D. D. Awasthi	foliose	14	12	5
34	*Hyperphyscia adglutinata* (Florke) H. Mayrh. & Poelt.	foliose	1	1	-

Note: DC = *Dracaena cochinchinensis*; DJ = *Dracaena jayniana*; CP = *Dracaena jayniana*;

No. of Hosts = number of host plants inhabited by lichens

Table 5.2 Corticolous lichens on three host plants in limestone forest Amphoe Nong Hin, Loei Province (continued)

No.	Scientific Name	Growth form	No. of Hosts		
			DC	DJ	CP
	Physciaceae				
35	*Hyperphyscia syncolla* (Tuck. ex Nyl.) Kalb.	foliose	4	1	1
36	*Physcia nubila* Moberg.	foliose	1	1	1
37	*Physcia undulata* Moberg.	foliose	-	1	-
38	*Pyxine cylindrica* Kashiw.	foliose	13	12	18
39	*Pyxine sorediata* (Ach.) Mont.	foliose	-	3	1
	Pertusariaceae				
40	*Pertusaria endoxantha* Vain.	crustose	1	-	-
	Porinaceae				
41	*Porina impolita* P.M. McCarthy	crustose	-	-	1
42	*Porina eminentior* (Nyl.) P.M.McCarthy f. *eminentior*	crustose	1	-	-
	Pyrenulaceae				
43	*Pyrenula confinis* (Nyl.) R.C.Harris.	crustose	2	-	-
44	*Pyrenula leucostoma* Ach.	crustose	9	1	5
45	*Pyrenula fetivica* (Krempelh.) Müll. Arg.	crustose	-	-	1
46	*Pyrenula interducta* (Nyl.) Zahlbr.	crustose	1	6	2
47	*Pyrenula leucotrypa* (Nyl.) Upreti.	crustose	7	2	3
48	*Pyrenula ochraceoflava* (Nyl.) R. C. Harris.	crustose	11	5	1
	Rocellaceae				
49	*Enterographa subserialis* (Nyl.) Redinger.	crustose	-	-	1
50	*Enterographa tropica* Sparrius.	crustose	-	-	1
	Thelenellaceae				
51	*Julella vitrispora* (Cooke & Harkness) M. E. Barr.	crustose	-	1	-

Note: DC = *Dracaena cochinchinensis*; DJ = *Dracaena jayniana*; CP = *Dracaena jayniana*;

No. of Hosts = number of host plants inhabited by lichens

Table 5.2 Corticolous lichens on three host plants in limestone forest Amphoe Nong Hin, Loei Province (continued)

No.	**Scientific Name**	**Growth form**	**No. of Hosts**		
			DC	**DJ**	**CP**
	Thelotremataceae				
52	*Leptotrema wightii* (Taylor) Müll. Arg.	crustose	-	1	7
53	*Leucodecton albidulum* (Nyl.) Mangold	crustose	33	16	28
54	*Myriotrema microporum* (Mont.) Hale.	crustose	-	2	-
55	*Stegobolus crassus* (Müll. Arg.) Frisch.	crustose	1	1	7
	Trypetheliaceae				
56	*Polymeridium siamense* comb. Ined.	crustose	-	-	1

Note: DC = *Dracaena cochinchinensis*; DJ = *Dracaena jayniana*; CP = *Dracaena jayniana*;

No. of Hosts = number of host plants inhabited by lichens

Table 5.3 Number of lichen found on three host plants and species richness

	total no. of plant hosts	total no.of lichen species	average (species/quadrat)	Alpha diversity	Beta diversity
C. pectinata	42	39	5.5±2.13	8.79±0.06	4.78
D. cochinchinensis	36	38	5.2±2.36	10.71±0.06	3.55
D. jayniana	34	36	4.4±2.79	8.91±0.08	3.93

Table 5.4 Bark properties of three host plants

Bark Properties	*C. pectinata*	*D. cochinchinensis*	*D. jayniana*	*F*	*P*
Bark Crevice Depth (mm)	2.81 ± 1.36a	2.03 ± 0.64a	11.46 ± 4.39b	144.4	<0.05
Bark pH	4.49 ± 0.32a	3.79 ± 0.36b	4.37 ± 0.38a	13.7	<0.05
Hydrogen ion concentration	4.10 x10 -5 a	2.05 x 10 -4b	5.74 x 10 -5 a	17.1	<0.05
Water-holding capacity (%)	80.8	28.9	25.4		

Note: a, b indicate that the mean difference is significant at the 0.05 level.

Table 5.5 Correlation coefficient between species per quadrat and bark properties

	Number of Species Correlation coefficient	*P*
C. pectinata		
Bark Crevice Depth	0.133	0.461
Hydrogen ion concentration	-0.480	0.135
Water-holding capacity	-0.319	0.601
D. cochinchinensis		
Bark Crevice Depth	0.054	0.745
Hydrogen ion concentration	0.233	0.443
Water-holding capacity	-0.564	0.089
D. jayniana		
Bark Crevice Depth	-0.096	0.577
Hydrogen ion concentration	0.410	0.185
Water-holding capacity	-0.260	0.349

Note: coefficient is significant at 0.05 level.

Table 5.6 Sørensen coefficient of lichen on three host plants

Pair of host plants	Sørensen coefficient (%)
C. pectinata and *D. jayniana*	69.3
D. cochinchinensis and *C. pectinata*	72.7
D. jayniana and *D. cochinchinensis*	72.9

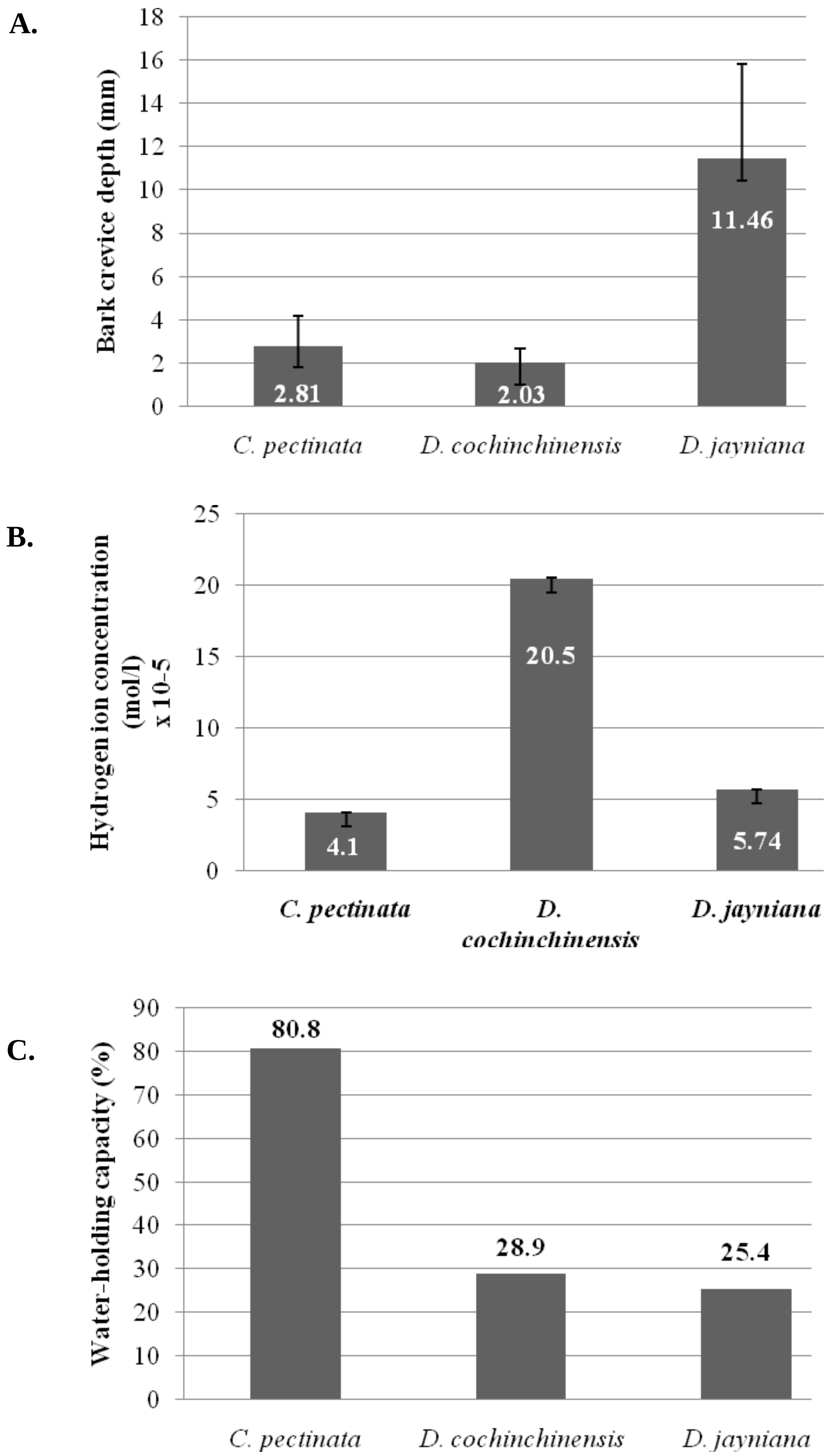

Figure 5.3 Bark properties of three host plants A. bark crevice depth; B. hydrogen ion concentration; C. water-holding capacity.

Table 5.7 Corticolous lichens found on the three host plants in each sampling areas

No.	Scientific Name	*Dracaena cochinchinensis*				*Dracaena jayniana*				*Cycas pectinata*			
		BM	**TP**	**SS**	**SH**	**BM**	**TP**	**SS**	**SH**	**BM**	**TP**	**SS**	**SH**
	Arthoniaceae												
1	*Cryptothecia aleurodes* (Nyl.) Makhija & Patw	1	-	4	-	-	-	2	1	-	-	3	1
2	*Cryptothecia genuflexa* (Müll. Arg.) R. Sant.	-	-	-	-	-	-	-	1	-	-	-	-
3	*Cryptothecia monospora* (Vain.) Makhija & Patw.	-	4	1	1	-	-	1	-	-	-	1	1
4	*Cryptothecia* sp.	-	1	-	-	-	-	-	1	-	1	2	-
	Arthopyreniaceae												
5	*Mycomicrothelia miculiformis* (Nyl. ex Müll. Arg.) D. Hawksw.	-	-	-	-	-	-	1	1	-	-	-	-
	Bacidiaceae												
6	*Bacidia incongruens* (Stirt.) Zahlbr.	-	-	-	-	-	-	-	-	-	-	-	1
7	*Bacidia medialis* (Tuck. ex Nyl.) B. de Lesd.	-	-	-	-	-	-	-	-	-	1	-	-
8	*Phyllopsora corallina* (Eschw.) Müll. Arg. var. *corallina*	-	-	-	1	-	-	-	-	-	-	-	3
	Coccocarpiaceae												
9	*Coccocarpia rottleri* (Ach.) Arv.	1	-	3	-	-	-	-	-	-	-	2	1

Note: the number indicated frequency of host plants inhabited by lichens; BM = Khao Boon Mee; TP = Khao Tep Porn; SS = Suan Sa Wan; SH = Suan Hom.

Table 5.7 Corticolous lichens found on the three host plants in each sampling areas (continued)

No.	Scientific Name	***Dracaena cochinchinensis***				***Dracaena jayniana***				***Cycas pectinata***			
		BM	**TP**	**SS**	**SH**	**BM**	**TP**	**SS**	**SH**	**BM**	**TP**	**SS**	**SH**
	Collemataceae												
10	*Collema rugosum* Kremp.	1	-	-	2	-	-	-	1	1	2	1	1
11	*Leptogium cyanescens* (Rabenh.) Korber.	1	3	8	2	-	-	-	-	1	6	1	2
	Graphidaceae												
12	*Diorygma junghuhnii* (Mont. & Bosch) Kalb	2	11	3	2	-	-	-	-	2	4	2	1
13	*Diorygma hieroglyphicum* (Pers.) Staiger & Kalb	-	-	-	-	-	-	-	-	-	-	-	1
14	*Graphis immersella* Müll. Arg.	-	1	-	3	-	-	1	-	1	4	1	2
15	*Graphis insulana* (Müll. Arg.) Lücking &. Sipman	-	1	5	1	-	-	1	1	-	1	1	1
16	*Graphis longispora* Awasthi & S. Singh	-	1	7	3	-	-	1	1	4	2	8	1
17	*Graphis ronglaensis* Sutjaritturakan	1	6	-	3	-	-	-	4	1	3	1	3
	Lecanoraceae												
18	*Lecanora arthothelinella* Lumbsch	-	-	-	-	-	-	1	-	-	-	-	-
19	*Lecanora austrotropica* Lumbsch	3	4	-	1	-	-	3	5	3	1	-	2

Note: the number indicated frequency of host plants inhabited by lichens; BM = Khao Boon Mee; TP = Khao Tep Porn; SS = Suan Sa Wan; SH = Suan Hom.

Table 5.7 Corticolous lichens found on the three host plants in each sampling areas (continued)

No.	Scientific Name	*Dracaena cochinchinensis*				*Dracaena jayniana*				*Cycas pectinata*			
		BM	TP	SS	SH	BM	TP	SS	SH	BM	TP	SS	SH
20	*Lecanora coronulans* Nyl.	1	-	1	1	-	-	-	6	-	7	5	5
21	*Lecanora ecoronata* Vain.	-	1	-	-	-	-	1	-	-	1	-	-
22	*Lecanora leprosa* Fée	-	1	-	1	1	-	1	2	-	-	-	-
23	*Lecanora tropica* Zahlbr.	1	-	-	-	-	-	-	-	-	-	-	-
	Monoblastidiaceae												
24	*Anisomeridium subprostans* (Nyl.) R. C. Harris.	2	11	3	1	-	-	6	12	-	-	-	-
	Parmeliaceae												
25	*Bulbothrix queenslandica* (Elix & G.N.Stevens) Elix.	1	-	-	-	-	-	-	-	-	-	-	-
26	*Bulbothrix goebellii* (Zenker) Hale	1	-	-	-	-	-	-	-	-	-	-	-
27	*Parmotrema tinctorum* (Despr.ex Nyl) Hale	6	2	4	2	1	-	10	4	4	2	3	5
28	*Relicinopsis malaccensis* (Nyl.) Elix & Verdon	1	-	-	-	-	-	-	-	-	-	-	-
29	*Relicinopsis rahengensis* (Vain.) Elix & Verdon	-	-	-	-	-	-	1	-	-	-	-	-
	Physciaceae												
30	*Buellia schaereri* DeNot.	3	7	11	1	1	-	18	11	6	3	1	3

Note: the number indicated frequency of host plants inhabited by lichens; BM = Khao Boon Mee; TP = Khao Tep Porn; SS = Suan Sa Wan; SH = Suan Hom.

Table 5.7 Corticolous lichens found on the three host plants in each sampling areas (continued)

No.	Scientific Name	***Dracaena cochinchinensis***				***Dracaena jayniana***				***Cycas pectinata***			
		BM	**TP**	**SS**	**SH**	**BM**	**TP**	**SS**	**SH**	**BM**	**TP**	**SS**	**SH**
	Physciaceae												
31	*Diplotomma venustum (*Körb.) Körb.	-	-	-	-	-	-	-	-	-	-	-	1
32	*Dirinaria aegialita* (Afzel. ex Ach.) B.J.Moore	-	1	1	2	-	-	6	5	1	-	1	4
33	*Dirinaria papillulifera* (Nyl.) D. D. Awasthi	3	9	2		2	1	7	2	4	-	-	1
34	*Hyperphyscia adglutinata* (Florke) H. Mayrh. & Poelt.	-	1	-	-	-	-	-	1	-	-	-	-
35	*Hyperphyscia syncolla* (Tuck. ex Nyl.) Kalb.	1	-	3	-	-	-	1	-	-	-	-	1
36	*Physcia nubila* Moberg.	-	-	-	1	-	-	-	1	-	-	-	1
37	*Physcia undulata* Moberg.	-	-	-	-	-	-	1	-	-	-	-	-
38	*Pyxine cylindrica* Kashiw.	2	8	3	-	1	-	6	5	-	4	6	8
39	*Pyxine sorediata* (Ach.) Mont.	-	-	-	-	-	-	-	3	-	-	-	1
	Pertusariaceae												
40	*Pertusaria endoxantha* Vain.	-	-	1	-	-	-	-	-	-	-	-	-
	Porinaceae												
41	*Porina impolita* P.M. McCarthy	-	-	1	-	-	-	-	-	-	-	-	-

Note: the number indicated frequency of host plants inhabited by lichens; BM = Khao Boon Mee; TP = Khao Tep Porn; SS = Suan Sa Wan; SH = Suan Hom.

Table 5.7 Corticolous lichens found on the three host plants in each sampling areas (continued)

No.	Scientific Name	*Dracaena cochinchinensis*				*Dracaena jayniana*				*Cycas pectinata*			
		BM	**TP**	**SS**	**SH**	**BM**	**TP**	**SS**	**SH**	**BM**	**TP**	**SS**	**SH**
	Porinaceae												
42	*Porina eminentior* (Nyl.) P.M.McCarthy f. *eminentior*	-	-	-	-	-	-	-	-	-	1	-	-
	Pyrenulaceae												
43	*Pyrenula confinis* (Nyl.) R.C.Harris.	-	1	-	1	-	-	-	-	-	-	-	-
44	*Pyrenula leucostoma* Ach.	-	5	1	3	-	-	-	1		3	2	-
45	*Pyrenula fetivica (Krempelh.)* Müll. Arg.	-	-	-	-	-	-	-	-	-	-	1	-
46	*Pyrenula interducta* (Nyl.) Zahlbr.	-	1	-	-	-	-	1	5	-	2	-	-
47	*Pyrenula leucotrypa* (Nyl.) Upreti.	1	5	-	1	-	-	-	2	1	1	-	1
48	*Pyrenula ochraceoflava* (Nyl.) R. C. Harris.	-	8	1	2	-	-	-	5	-	-	-	1
	Rocellaceae												
49	*Enterographa subserialis* (Nyl.) Redinger.	-	-	-	-	-	-	-	-	-	1	-	-
50	*Enterographa tropica* Sparrius.	-	-	-	-	-	-	-	-	-	1	-	-
	Thelenellaceae												
51	*Julella vitrispora* (Cooke & Harkness) M. E. Barr.	-	-	-	-	-	-	1	-	-	-	-	-

Note: the number indicated frequency of host plants inhabited by lichens; BM = Khao Boon Mee; TP = Khao Tep Porn; SS = Suan Sa Wan; SH = Suan Hom.

Table 5.7 Corticolous lichens found on the three host plants in each sampling areas (continued)

No.	Scientific Name	*Dracaena cochinchinensis*				*Dracaena jayniana*				*Cycas pectinata*			
		BM	**TP**	**SS**	**SH**	**BM**	**TP**	**SS**	**SH**	**BM**	**TP**	**SS**	**SH**
	Thelotremataceae												
52	*Leptotrema wightii* (Taylor) Müll. Arg.	-	-	-	-	-	-	-	1	-	1	3	3
53	*Leucodecton albidulum* (Nyl.) Mangold	3	11	3	16	-	1	3	12	3	7	1	17
54	*Myriotrema microporum (Mont.) Hale.*	-	-	-	-	-	-	1	1	-	-	-	-
55	*Stegobolus crassus* (Müll. Arg.) Frisch.	-	1	-	-	-	-	1	-	1	3	1	2
	Trypetheliaceae												
56	*Polymeridium siamense* comb. Ined.	-	-	-	-	-	-	-	-	-	-	-	1

Note: the number indicated frequency of host plants inhabited by lichens; BM = Khao Boon Mee; TP = Khao Tep Porn; SS = Suan Sa Wan; SH = Suan Hom.

Table 5.8 Diversity of corticolous lichens found on the three host plants in each sampling areas

Host plants	Alpha diversity				Beta diversity				Gamma diversity			
	BM	**TP**	**SS**	**SH**	**BM**	**TP**	**SS**	**SH**	**BM**	**TP**	**SS**	**SH**
Dracaena cochinchinensis	3.99 ± 0.07	5.98 ± 0.11	5.04 ± 0.08	4.17 ± 0.05	5.01	4.18	3.97	5.28	20	25	20	22
Dracaena jayniana	0.96 ± 0.00	0.69 ± 0.08	4.69 ± 0.09	5.84 ± 0.09	5.21	2.90	5.12	4.62	5	2	24	27
Cycas pectinata	3.69 ± 0.08	5.18 ± 0.08	4.39 ± 0.08	5.00 ± 0.08	3.79	4.63	4.78	6.00	14	24	21	30

Note: BM = Khao Boon Mee; TP = Khao Tep Porn; SS = Suan Sa Wan; SH = Suan Hom.

5.6 Systematic of Lichens on three host plants

1. ARTHONIACEAE

Cryptothecia Stirt.

Thallus crustose, immersed in the substratum or superficial, ecorticate, white to greenish, often byssoid; **globose isidia**-like granules present or absent; **soredia** absent; **prothallus** of interwoven or radiating hyphae. **Photobiont** layer distinct or not; **medulla** usually well defined, white, at least partly amyloid, frequently studded with numerous colourless crystals of calcium oxalate; **thallus** lacking well-defined ascomata; **ascigerous areas** common or rare, restricted to cushions of soft white mycelium immersed in undifferentiated loose medullary tissue, ±spreading over the whole thallus, forming small clusters near the surface of the thallus, or cushion-like structures, usually clearly differentiated from sterile areas; **asci** globose to ovoid, of the *Cryptothecia*-type, bitunicate, thick-walled, often with a dome-shaped extension of the endoascus, with fissitunicate or semi-fissitunicate dehiscence, 1-8-spored, 60-160 x 30-30 cm, enclosed in a cocoon-like layer 5-10 μm thick comprising richly branched and interwoven septate paraphyses c. 1 μm thick; ocular chamber usually only present is asci with mature spores, broad, blunt and non-amyloid; ascus stipe narrow, basal, 10-20 x 3-7 μm; **ascospores** muriform, ellipsoidal and often somewhat curved, oblong or ovoid, colourless, 40-110 x 15-65 μm; **conidiomata** pycnidial, immersed to emergent, globose to ovoid; wall dark brown; conidiogenous cells simple, bacilliform to narrowly clavate, acrogenous or pleurogenous; **conidia** colourless, simple, bacilliform, straight or slightly curved, 3-8 x c. 1 μm, or thread-like, filiform and multiseptate, 110-140 x c. 1.5 μm.

Cryptothecia aleurodes (Nyl.) Makhija & Patw.; Bibl. Lichenol. 99:416. 2009. Figure 5.3A, B.

Thallus corticolous; crustose, up to 10 cm in diameter, 40-55 μm thick, smooth, adnate, pale green to whitish green; **isidia** absent; **prothallus** indistinct white; **photobiont** continuous, 23-30 μm thick; **medulla** distinct white, 26-42 μm thick; **ascigerous area** common, circular in outline, white, slightly raised; **Asci** circular, with 4-8 ascospores; **Ascospores** desely muriform, oblong to slightly elliptic, 19-26 x 51-67 μm.

Chemistry: Lecanoric acid; Cortex: K+ yellow, C+ red turning yellow, KC+ red turning yellow, CK-, PD-; Medulla: K-, C+ red, KC+ red turning yellow, CK+ red turning yellow, PD-; Asci: I-.

Specimen Examined: S. Falab-004

Cryptothecia genuflexa (Müll. Arg.) R. Sant.; Bibl. Lichenol. 99:417. 2009. Figure 5.3C, D.

Thallus corticolous; crustose, 3-5 cm in diameter, c. 80 μm thick, verrucose, matt, white to whitish grey; **isidia** absent; **prothallus** indistinct white; **photobiont** continuous, 37-44 μm thick; **medulla** pale white, densely packed; **ascigerous area** common, circular black dot in outline, immersed; **Asci** pyriform, with 1 ascospores; **Ascospores** desely muriform, oblong to obovate, 17-28 x 52-87 μm.

Chemistry: Lecanoric acid; Cortex: K+ yellow, C+ red, KC+ red turning yellow, CK+ red turning yellow, PD-; Medulla: K+ yellow, C+ red, KC+ red turning yellow, CK+ red turning yellow , PD-; Asci: I-.

Specimen Examined: S. Falab- 002, 003, 159, 160, 161, 162, 167, 168, 173,174, 413.

Cryptothecia monospora (Vain.) Makhija & Patw.; Bibl. Lichenol. 99:417. 2009. Figure 5.3E, F.

Thallus corticolous; crustose, up to10 cm in diameter, c. 90 μm thick, smooth to slightly rugose, white to whitish grey; **isidia** absent; **prothallus** distinct white; **photobiont** continuous, 21- 28μm thick; **medulla** white, densely packed with crystals; **ascigerous area** common, indistinct, immersed; **Asci** cirular, with 1 -6 ascospores; **Ascospores** desely muriform, oblong to slightly ovate, 36-43 x 83-115μm.

Chemistry: Psoromic acid, fatty acid; Cortex: K+ yellow, C-, KC-, CK-, PD+ yellow; Medulla: K+ yellow, C-, KC -, CK-, PD+ orange to golden yellow; Asci: I-.

Specimen Examined: S. Falab-001, 155, 156, 157, 158, 163, 164, 165, 166.

Cryptothecia sp. Figure 5.3G, H.

Thallus corticolous; crustose, up to 4 cm in diameter, slightly rugose or leprose, pale green to white, white circular area scattered on thallus; **isidia** absent; **prothallus**

indistinct white; **photobiont** continuous; **medulla** white, loosely packed; **ascigerous area** absent.

Chemistry: Atranorin, Sphaerophorin, fatty acid; Cortex: K+ yellow, C+ yellow, KC-, CK-, PD+ pale yellow; Medulla: K+ yellow, C+ yellow, KC-, CK-, PD -; Asci: I-.

Specimen Examined: S. Falab-175, 176, 180, 181,182.

2. ARTHOPYRENIACEAE

Mycomicrothelia Keissler

Thallus thin with *Trentepohlia* photobiont; perithecia black; anatomosing paraphyses; **spores** ornamented, brown, 1-septate, relatively thin walled.

Mycomicrothelia miculiformis (Nyl. ex Müll. Arg.) D. Hawksw.; Bibl. Lichenol. 97:77. 2008. Figure 5.4A, B.

Thallus ecorticate, endophloeodal, yellowish white, UV-; **perithecia** solitary, globose, c. 0.40 mm diameter; ostiole apical; **hamathecium filaments** thin, anastomosing above the asci; asci cylindrical, 114-120 µm tall; **ascospores** 8 per ascus, uniseriate, grey brown, 1-septate, clavate, 6.26-9.25 x 16.11-19.70 µm, ornamented, septum submedian, upper cell much wider than lower cell; **coniomata** absent.

Chemistry: no lichen substance detected.

Specimen Examined: S. Falab-061, 272, 273

3. BACIDIACEAE

Bacidia De Not.

Thallus corticolous, grey-green to yellow-green, warted, continuous, 103.5-282.5 mm thick, epruina; **soralia** and **isidia** absent; **prothallus** not visible; **photobiont** chlorococcoid; **apothecia** scattered, entire, sessile; **disc** plane to convex, yellow-orange, reddish-brown to dark brown and persistent, biatorine at margin, epruina, 0.1-0.8 mm diameter, with biatorine (proper exciple), prosoplectenchymatous tissue, composed of radiating branched, anatomosed hyphae; **parathecium** weakly differentiated, composed of thin walled; **epihymenium** hyaline, 0.5-15.0 µm thick; **hymenium** hyaline, 30.0-70.0 µm thick; **subhymenium** indistinct; **hypothecium** hyaline, 70.0-129.5 µm thick; **paraphyses** simple or sparingly branched, apical not conspicurously swollen, 30.5-45.4 µm thick; **asci** clavate, *Bacidia*-type, 8.0-10.9 µm high; **ascospores** 8 per ascus, hyaline, oblong, acicular, bacillary, clavate to straight, curved or sigmoid,transversely 3-5 septate, 21.8-27.8 x (2.4) 2.5-3.4 µm; **pycnidia** and **conidia** absent.

Bacidia incongruens (Stirt.) Zahlbr.; Bibl. Lichenol. 40:56. 1991. Figure 5.4C, D.

Thallus corticolous, yellow-green to olive green, warted to areolate, continuous, c. 1 cm diameter,epruina; **soralia** and **isidia** absent; **prothallus** absent ; **photobiont** chlorococcoid; **apothecia** scattered, entire, orbicular, sessile; **disc** convex, pale orange to old rose, biatorine at margin, epruina, 0.13-0.37 mm diameter, prosoplectenchymatous tissue; **parathecium** weakly differentiated; **epihymenium** hyaline, c. 10 µm thick; **hymenium** hyaline, 47.46-62.38 µm thick, I+ blue; **subhymenium** indistinct; **hypothecium** hyaline, 70.0-129.5 µm thick; **paraphyses** simple, apical not conspicurously swollen, 43.58-47.46 µm thick; **asci** clavate, *Bacidia*-type, 32.23-41.49 µm high; **ascospores** 3-4 per ascus, hyaline, acicular, straight to slightly curved, transversely 2-4 septate, 14.32-21.19 x 2.08-3.28 µm; **pycnidia** and **conidia** absent.

Chemistry: no lichen substance detected; thallus K-, C-, PD-.

Specimen Examined: S. Falab-624, RAMK 003447-K. Noicharoen & R. Noichareon 16378, RAMK 003449-K. Noicharoen 16376, RAMK 34450-N. Osathanon 16379

Bacidia medialis (Tuck. ex Nyl.) B. de Lesd.; Hong Kong Lichens 61. 1988. Figure 5.4E, F.

Thallus corticolous, yellowish green to dark green, appressed to areolate, continuous, up to 3 cm diameter, epruina; **soralia** and **isidia** absent; **prothallus** absent ;**photobiont** chlorococcoid; **apothecia** scattered, entire, orbicular, sessile; **disc** convex, pale orange to old rose, biatorine at margin, epruina, c. 0.1-0.3 mm diameter, prosoplectenchymatous tissue; **parathecium** weakly differentiated; **epihymenium** hyaline, c. 10 µm thick; **hymenium** hyaline, 50.44-66.86 µm thick, I+ blue; **subhymenium** indistinct; **hypothecium** light brown, 66.86-80.29 µm thick; **paraphyses** simple, apical slightly swollen, 40.59-51.34 µm thick; **asci** clavate, *Bacidia*-type, 43.28-51.34 µm high; **ascospores** 4-6 per ascus, hyaline, elliptic to fusiform, with acuminate ends, transversely 3-4 septate, 17.31-24.77 x 1.79-2.98 µm; **pycnidia** and **conidia** absent.

Chemistry: no lichen substance detected; thallus K-, C-, PD-.

Specimen Examined: S. Falab-263, 291, RAMK 003452-K. Noicharoen 17818, RAMK 004354-J. Sutjaritturakarn 17826

Phyllopsora Müll.Arg.

Thallus crustose or squamulose, rarely placodioid or subfoliose; **squamules** 0.1–1.0 mm wide; **isidia** common, sometimes dominating the thallus; lacinules (phyllidia) common; **soredia** absent; **upper cortex** 5–60 µm thick, of types 1, 2 or 1–2; **photobiont** a unicellular green alga, forming a continuous layer; **medulla** usually poorly developed, of loosely woven non-amyloid hyphae, frequently containing lichen substances; **lower cortex** absent; **prothallus** whitish to dark red or purple-black; **apothecia** biatorine, sessile, simple or aggregated, laminal on the squamules; **disc** ±round in outline, plane to convex, yellow, pale brown to dark reddish brown; **proper exciple** composed of conglutinated radially orientated hyphae, pale tan to yellow-brown or dark red, sometimes containing crystals or pigments, K- or K+ red or purple-brown; **epihymenium** indistinct or a thin gelatinous layer with slight pigmentation, K-; **hymenium** colourless to brown or dark reddish brown, 20-60 µm thick, amyloid; **hypothecium** colourless, yellow-brown to brown or dark red, sometimes containing crystals or pigments, K- or K+ red or purple-brown; **paraphyses** 1.5-2.0 µm wide, only slightly thickened at the apex; **asci** elongate-clavate, with a well-developed tholus and a narrow paler conical axial mass; **ascospores** simple or 1-septate, colourless, ellipsoidal to fusiform, rarely acicular, 5-45 x 0.8-5.0 µm, smoothwalled; **conidiomata** pycnidial; **conidia** bacilliform to filiform, straight or bent, 7-15 x 0.5-1.0 µm.

Phyllopsora corallina (Eschw.) Müll. Arg. var. *corallina*; Flora Neotrop. 55: 38. 1991.
Figure 5.4G, H.

Thallus squamulose, 1-2.5 cm diameter; **squamules** round to elongate with digitate lobulate, convex or ascending, PD-, 0.22-0.39 mm wide; **upper surface** pubescent, fibrillose at the margin, grayish green and brownish orange to yellowish green when mature, Type 2 cortex (Swinscow and Krog, 1988), 16.11-23.88 µm thick; **isidia** dense on margin of squamules, cylindrical, richly branched, concolourous with upper surface, sometimes becoming phyllidia; **medulla** loosely organized, white; **prothallus** purple to dark blue; **apothecia** rare, irregular to orbicular, crenulate rim; **disc** orange to red orange, distinct from squamules, 1-2 mm diameter, margin concolourous with disc; exciple, orange to pale tan, K-; **hypothecium** light brown to tan; **hymenium** tan to hyaline, thin, 27.76-35.82 µm thick; **paraphyses** densely packed, simple;**asci** clavate, c. 32 µm high; **ascospore** simple, hyaline, ellipsoid, subglobose to slightly fusiform, 8.96-11.27 x 2.06-2.78 µm; **pycnidia** absent.

Chemistry: no lichen substance detected.

Specimen Examined: S. Falab-056, 057, 058,143, 144, 145, 263, 280, 281, 292

4. COCCOCARPIACEAE

Coccocarpia Pers.

Thallus slate blue to dull leaden grey, grayish fawn, or rarely to yellowish grey; **photobiont** *Scytonema*; **upper cortex** of paraplectenchymatous cells in lines radiaing from centre to periphery, sometimes visible under hand-lens as faint striae; larger species with deeper ridges, curved and concentric with thallus, visible to the naked eye; under side corticated, pale or dark, lower **cortex** often gradually merging into medulla; **rhizines** white to grey or blue to black; **apothecia** without thalline exciple, usually sessile and often appressed to thallus, carneous to reddish or blackish brown, sometimes with white excipular hairs, **spores** globose or ellipsoid to fusiform, simple, often with pseudosepta, 8 per ascus; **pycnoconidia** rod-shaped or with slight swelling at one or both ends, 3-6 x 1-1.5 µm

Coccocarpia rottleri (Ach.) Arv.; Opera Bot. 67: 81 1982; Bibl. Lichenol. 70:77. 1998; Tropical Bryology 18: 192. 2000. Figure 5.5A, B.

Thallus orbicular to irregular, adnate, foliose, 1-6 cm diameter, 69-81 µm thick ; **lobes** bluish-grey to bluish-green when dry, dark bluish when moist, 0.3-0.7 mm wide, contiguous, sublinear, broad rotund at apices, plane or slightly concave, entire or incised, divided into secondary and tertiary lobes; **upper cortex** smooth, matt with a fine whitish pruina, periphery, radiating lines of upper cortex visible, c. 9-12 µm thick; photobiont bluish green, continuous, c. 25-30 µm thick; **lower cortex** pale white to pale brown or cream; **rhizines** whitish, not projecting beyond lobe margins; **isidia** dense on centre of thallus, branched, cylindrical to slightly coralline; **apothecia** absent.

Chemistry: no lichen substance detected.

Specimen Examined: S. Falab-263, 291, 323, 324, 364, 373, 394, 408, 411, 412

5. COLLEMATACEAE

Collema Wigg.

Thallus foliose, homoiomerous, non-corticate above and below, gelatinous when moist;**photobiont** *Nostoc*; **soredia** absent; **apothecia** sessile with both proper and thalline exciples; **spores** 8 per ascus, hyaline, quadrate to ellipsoid to fusiform/acicular, transversely septate or muriform; **pycnidia** bacilliform.

Collema rugosum Kremp.; Bibl. Lichenol. 70:81. 1998; Hong Kong Lichens 87. 1988; Macrolichens of East Africa 73. 1998; Tropical Bryology 18: 193. 2000. Figure 5.5C, D.

Thallus corticolous, orbicular, up to 3.5 cm in diameter, 136-147μm thick, smooth with deep ridge, olive to dark green; **lobe** broad, c. 5 mm width; **isidia** dense on ridges, globular to cylindrical, branched; **apothecia** lecanorine, uncommon on margin of thallus, orbicular, concave, waxy, deep orange disc, with thick paraplectenchymatous base; **proper exciple** subparaplectenchymatous; **hymenium** hyaline, 58-62 μm thick; **asci** cylindrical, 40-63 μm height; **paraphyses** simple with sparsely branched at apex, c.50 μm height; **ascospores** hyaline, fusiform to broadly acicular, transversely septate, 4-6 per ascus, 1.49-2.68 x 30-45 μm.

Chemistry: no lichen substance detected; I+ blue hymenium.

Specimen Examined: S. Falab-146, 147, 148, 149, 244, 245, 254, 286, 295, 302, 340

Leptogium (Ach.) Gray

Thallus foliose, homoiomerous, somewhat gelatinous when moist, in most species with an upper and lower cortex composed of a single layer of more or less isodiametric cells; **photobiont** *Nostoc*; **isidia** often transitional to or replaced by phyllidia; **soredia** absent; **apothecia** with proper and thalline exciple (latter may be inapparent to naked eye); a layer of paraplectenchymatous tissue in the apothecia may be situated basally above the photobiont layer; **spores** usually 8 per ascus, colourless,in most species ellipsoid with acute ends, muriform or submuriform, but in a few species fusiform-acicular and transversely septate, spore wall often ornamented.

Leptogium cyanescens (Rabenh.) Körber; Hong Kong Lichens 117. 1988; Fl. Australia. 54:183. 1992; Bibl. Lichenol. 70:138. 1998. Macrolichens of East Africa 136. 1998. Figure 5.5E, F.

Thallus smooth, loosely attached, bluish green to slate grey, up to 6 cm diameter, c. 55-60 (up to 80) µm thick; **lobes** flabellate, up to 1-2 cm wide; **upper surface** lacking hairs or pruinose; **isidia** dense along margin of thallus, cylindrical, branched to coralline, sometime replaced by phyllidia, concolourous with thallus; **soredia** absent; **apothecia** absent.

Chemistry: no lichen substance detected.

Specimen Examined: S. Falab-146, 147, 148, 149, 150, 151, 152, 153, 154, 253, 297, 300, 301, 314, 353, 355, 387, 423, 470, 484, 489, 490, 514

6. GRAPHIDACEAE

Diorygma Eschw.

Thallus corticolous, cream to greenish grey, surface smooth or slightly tuberculate and dull; **cortex** cream to greenish grey, weakly organized, 4-25 µm thick; **algal layer** 12-41 µm thick; **medulla** whitish grey, 11-47 µm thick, with crystals embedded; **ascomata** lirelliform to roundish, normally numerous, inconspicuous, simple to branched, slightly curved, sometimes aggregated, immersed to erumpent, short to long, 0.5-10.0 mm long and 0.2-0.6 wide, lips white covered by a thin pruina; **disc** usually whitish or brownish, narrow to wide open, often covered by a white pruina; **exciple** uncarbonized to basally carbonized; **labia** entire, convergent to divergent; **hypothecium** indistinct or hyaline to pale brown, 10-50 µm high; **hymenium** clear, 75-210 µm high, I+ weakly violet to blue, especially the upper and lateral parts; **epithecium** hyaline to brownish black, normally developed, 14-35 µm high; **paraphyses** simple to slightly anastomosing and branched at epithecial region; **asci** ellipsoid, 45-210 x 16-70 µm, with 1,2,4 or 8 ascospores; **ascospores** hyaline, transversely septate to densely muriform, peripheral cells of ± equal size as the central ones or peripheral cells smaller than the central ones, rarely fusiform, mostly ellipsoid, thin to thick-walled, 12-200 x 7-60 µm, I+ violet-blue or I-.

Diorygma hieroglyphicum (Pers.) Staiger & Kalb; Fl. Australia. 57: 93. 2009. Figure 5.7A, B.

Thallus corticolous, grayish green, green to pale green; smooth, dull; **cortex** grayish green, slightly pruinose, c. 10 μm thick; **algal layer** continuous, 44.47-62.72 μm thick, with crystals; **medulla** white, with rich crystal, 97.71-114.60 μm thick; **ascomata** lirelliform, numerous, inconspicuous, branched, slightly curved, aggregated, slithly erumpent, short to oblong, c. 1 mm long and 0.14-0.18 wide, with a thin complete thalline margin and white pruina, lip white; **disc** narrow to open; **exciple** uncarbonized; labia entire, divergent; **hypothecium** pale brown, c. 20.29-24.17 μm high; **hymenium** clear, 67.55-86.85 μm high, **I**+ weakly violet at lateral parts; **epithecium** brown, c.10 μm high; **paraphyses** simple and branched at epithecial region; **asci** ellipsoid, c. 70 x c.12 μm, with 1 ascospores; **ascospores** hyaline, densely muriform, peripheral cells of ± equal size as the central ones, 19-22 transverse septa and 5-7 longitudinal septa, ellipsoid to oblong, thin walled, (43.28)15.52-95.82 x 12.53-23.88 μm, **I**+ blue.

Chemistry: Stictic acid; Cortex: K+ yellow, C-, KC-, CK-, PD-; Medulla: K+ yellow, C-, KC-, CK-, PD+ yellow turning red.

Specimen Examined: S. Falab-764

Diorygma junghuhnii (Mont. & Bosch) Kalb; Fl. Australia. 57: 94. 2009. Figure 5.5G, H.

Thallus corticolous, white to whitish grey; smooth, dull; **cortex** white, pruinose, c. 13 μm thick; **algal layer** continuous, c.37 μm thick; **medulla** white, with crystal, 13.7 μm thick; **ascomata** lirelliform, numerous, branched, curved, radiate aggregated, slightly erumpent to erumpent, oblong, 0.76-1.87 mm long and 0.12-0.20 wide, with acomplete thalline margin and white pruina, lip white, raised; **disc** narrow to open; **exciple** uncarbonized; labia entire, divergent; **hypothecium** pale brown, 37.01-46.26 μm high; **hymenium** clear, 143.58-202.66 μm high, **I**+ violet; **epithecium** brown, c. 33.13-37.01 μm high; **paraphyses** simple and branched at epithecial region; **asci** ellipsoid to clavate, 138.80-147.17 x 34.20-38.60 μm, with 1 ascospores; **ascospores** hyaline, densely muriform, peripheral cells of ± equal size as the central ones, 25-31 transverse septa and 6-7 longitudinal septa, ellipsoid to oblong, thin walled, 124.47-161.19 x (25.97)39.10-49.25 μm, **I**+ dark blue.

Chemistry: Norstictic acid; Cortex: K+ yellow turning red, C-, KC -, CK-, PD+ yellow; Medulla: K+ yellow turning red, C-, KC -, CK-, PD+ yellow.

Specimen Examined: S. Falab-671, 672, 688, 689, 690, 691, 692, 730, 669, 670, 687, 686, 702, 703, 707, 708, 709, 710, 711, 712, 724, 725, 726, 727, 728, 729,

Graphis Adans.

Thallus mostly corticolous, whitish, cream to grayish green, smooth to tuberate and dull; **cortex** whitish, cream to grayish green, developed with small crystalline aggregateions, 8-45 µm thick; **algal layer** continuous, often with crystalline masses, 15-42 µm thick; **medulla** whitish grey, sometimes with large crystals, penetrating into the periderm; **ascomata** lirelliform, immersed, erumpent, prominent or sessile, conspicuous, numerous, dispersed, unbranched or irregulary to radiately branched, straight to curved, 0.5-10.0 mm long and 0.1-0.7 mm wide, lips white to green; **disc** almost concealed; **exciple** uncarbonized or apically, laterally to completely carbonized, labia entire or striate, normally convergent; lacking a thalline margin to a complete thalline margin; **hypothecium** indistinct or hyaline to pale brown, 5-25 µm high; **hymenium** inspersed with few to numerous oil globules or clear, 80-250 µm high, I-; **epihymenium** indistinct or grayish black; **paraphyses** simple with a few species have a branched paraphyses at the epithecial region; **asci** ellipsoid to clavate, 70-230 x 25-60 µm with 1-8 ascospores; **ascospores** transversely septate to densely muriform, elongate to ellipsoid, thin to thick walled, 17-180 x 6-47 µm, I+ violet to blue.

Graphis immersella Müll. Arg.; Fl. Australia. 57:133. 2009; The Lichenologist 41: 396. 2009. Figure 5.6C; Figure 5.7C, D

Thallus corticolous, white, smooth, thin, dull; **cortex** off-white, weakly organized, c. 14.32-18.50 µm thick; **algal layer** continuous, c. 80 µm thick; **medulla** light brown, with crystals, 15.52-18.50 µm thick, partly penetrating into the periderm; **ascomata** lirelliform, immersed to erumpent, inconspicuous, simple or sometimes branched, sinuous, curved, 1.41-2.24 mm long x 0.03-0.09 mm wide, without pruina, lips black, closed; **disc** concealed; **exciple** laterally carbonized, labia entire, convergent; **hypothecium** hyaline, c.40 µm high; **hymenium** clear, c.125 µm high, I-; **epihymenium** hyaline to grey, c.10 µm high; **paraphyses** simple; **asci** clavate, 79.10-98.20 x 20.59-

34.62 µm with 6-8 ascospores; **ascospores** hyaline, transversely septate, 8-10 septates, ellipsoid, thin walled, 9.25-12.83 x 43.28-65.97 µm, I+ dark blue.

Chemistry: Stictic acid; Cortex: K+ yellow, C-, KC-, CK-, PD-; Medulla: K-, C-, KC-, CK-, PD-.

Specimen Examined: S. Falab-716, 717, 721, 722, 723, 732, 733, 734, 735, 736, 737, 738, 741, RAMK 018611-J. Sutjaritturakarn 23330, RAMK 003644-J. Sutjaritturakarn 20180, RAMK 018610-J. Sutjaritturakarn 539, RAMK 022027-J. Sutjaritturakarn 23332

Graphis insulana (Müll. Arg.) Lücking &. Sipman; Fl. Australia. 57:133. 2009; The Lichenologist 41: 403. 2009. Figure 5.6F; Figure 5.7E, F

Thallus corticolous, off-white to cream, smooth, dull; **cortex** off-white, with crystals, c. 9.65-10.440 µm thick; **algal layer** continuous, with crystals, c. 100 µm thick; **medulla** light brown, with crystals, c. 160.44 µm thick, partly penetrating into the periderm; **ascomata** lirelliform, semi-immersed to immersed, inconspicuous, radiately branched, sinuous, straight to curved, 1.93-5.32mm long x 0.18-0.27 mm wide, lips black, closed to slightly open; **disc** concealed; **exciple** laterally carbonized, sometime with weakly basal carbonized, labia entire, convergent; **hypothecium** light brown, c. 104.0 µm high; **hymenium** inspersed, 165.20-231.61µm high, I-; **epihymenium** brown to black, c.20.0-25.0 µm high; **paraphyses** simple; **asci** clavate, 147.76-153.13 x 23.58-48.35 µm with 1-2 ascospores; **ascospores** hyaline, densely muriform, ellipsoid to oblong, thin walled, 16.71-22.68 x 58.80-89.55 µm, I+ dark blue.

Chemistry: Norstictic acid, Salazinic acid, Connorstictic acid, fatty acid; Cortex: K+ yellow turning red, C-, KC+ yellow turning red, CK-, PD+ yellow; Medulla: K-, C-, KC-, CK-, PD + yellow.

Specimen Examined: S. Falab-626, 637, 638, 639, 645, 646, 647, 648, 649, 650, 651, 652

Graphis longispora D. D. Awasthi & S. R. Singh;The Lichenologist 41: 392. 2009. Figure 5.6E; Figure 5.7G, H

Thallus corticolous, pale grey, grey to white, smooth, dull; **cortex** grayish green, pale grey to white, weakly organized, 9.25-10.74 µm thick; **algal layer** continuous, 71.17-79.61 µm thick; **medulla** white to cream, with crystals, c.168 µm thick, partly penetrating into the periderm; **ascomata** lirelliform, prominent, conspicuous, irregularly branched, straight or curved, 289.06-997.82 µm long x 92.70-134.89 µm wide, with a thin pruina, lips with a white pruina; **disc** concealed; **exciple** laterally carbonized to weakly carbonized at base, thin completely thalline margin, labia entire, convergent; **hypothecium** pale brown, 37.39-44.63 µm high; **hymenium** clear, 185.77-195.42 µm high, I-; **epihymenium** grayish black, 22.92-33.77 µm high; **paraphyses** simple; **asci** clavate, 190.44-238.80 x 23.88-42.68 µm with 8 ascospores; **ascospores** hyaline, transversely septate, 9-15 septates, ellipsoid, thin walled, 13.73-18.20 x 70.14-122.38 µm, I+ dark blue.

Chemistry: Norstictic acid, Salazinic acid, fatty acid; Cortex: K+ yellow turning red, C-, KC-, CK-, PD+ yellow; Medulla: K+ yellow turning red, C-, KC-, CK-, PD+ yellow.

Specimen Examined: S. Falab-625, 660, 661, 632, 633, 664, 665, 666, 667, 668, 673, 674, 675, 681, 682, 683, 684, 685, 693, 694, 695, 669, 697, 699, 700, 701, 704, 705, RAMK 020480- C. Phaphuchamnong 269

Graphis rongklaensis Sutjaritturakan; The Lichenologist 41: 450. 2009. Figure 5.6A, B

Thallus corticolous, white to pale grey, smooth, dull to waxy; **cortex** grayish white, 13.26-14.47 µm thick; **algal layer** continuous, 41.01-76.61 µm thick; **medulla** cream, with crystals, 153.20-164.06 µm thick, partly penetrating into the periderm; **ascomata** lirelliform, prominent, inconspicuous, simple, rarely branched, straight or curved, 0.35-1.35 µm long x 0.24-1.28 µm wide, lips without pruina; **disc** concealed; **exciple** laterally carbonized, with crystals, completely thalline margin, labia entire, convergent; **hypothecium** pale brown, 16.88-18.09 µm high; **hymenium** inspersed, 244.88-285.90 µm high, I-; **epihymenium** hyaline, c.10 µm high; **paraphyses** simple; **asci** clavate, 94.02-146.56 x 48.35-53.13 µm with 1 ascospores; **ascospores** hyaline, densely muriform, oblong, thin walled, 36.71-57.90 x 159.40-207.16 µm, I+ dark blue.

Chemistry: Norstictic acid, Salazinic acid, Connorstictic acid, fatty acid; Cortex: K+ yellow turning red, C-,KC -, CK-, PD+ yellow; Medulla: K-, C-, KC-, CK-, PD+ yellow.

Specimen Examined: S. Falab-627, 628, 629, 630, 634, 635, 636, 640, 641, 642, 643, 644, 653,654, 655, 656, 657, 658, 662, 663, 676, 677, 678, 679, 680

7. LECANORACEAE

Lecanora Ach.

Thallus crustose, granular, areolate, or placodioid, rarely immersed; **sorediate** or not, isidia and cephalodia absent; **photobiont** *Trebouxia* and perhaps other chlorococcoid algae; **ascomata** apothecia, sessile or shortly stipitate, rarely immersed; **thalline exciple** present, generally conspicuous and concolorous with the thallus, in some species disappearing at an early stage or becoming excluded; **true exciple** poorly differentiated in most species; **epithecium** greenish brown to dark brown or reddish brown, sometime granular; **hymenium** ±colourless, I+ blue; **hypothecium** hyaline or pale; **hamathecium** of paraphyses, simple, sparsely branched or anastomosed, septate, apices slightly swollen to capitates, often pigmented (never "Aspicilia-green"); **asci** elongate-clavate, *Lecanora*-type or *Bacidia* type, apex strongly thickened with an I+ blue apical dome and a broad I- apical cushion, outermost gelatinous coat I+ blue, 8-(32) spored; **ascospores** ellipsoid to subglobose, usually rounded at the apices, rarely apiculate, hyaline, simple, sometimes with a central protoplasmic strand, walls thin or thick, lacking a distinct perispore, smooth-walled; **conidiomata** pycnidia, immersed, walls hyaline but brown around the ostiole; **conidiogenous** cells sessile or borne on short, branched conidiophores, elongate-ampulliform, enteroblastic with broad collarettes; **conidia** acrogenous, bacilliform, filamentous, arc-like or broadly falcate, colourless, simple.

Lecanora arthothelinella Lumbsch; The Lecanoraceae in Thaliand 10. 2011. Figure 5.6G, H

Thallus corticolous, deep green to yellowish green, rugose to verruculose, continuous, epruina; **soralia** and **isidia** absent; **prothallus** distinct white, more than 0.5 mm long; **photobiont** chlorococcoid; **apothecia** rare, circular shape, entire, sessile; **disc** plane, pale orange to yellowish orange, epruina, 0.17-0.38 mm diameter; **thalline exciple** present, white to pale green, distinctly different with the thallus; **amphithecium** with large crystals insoluble in KOH (*Pulicaris*-type); **parathecium** hyaline, with numerous small crystal soluble in KOH, **epithecium** brown to deep orange, with crystals soluble in KOH (*Chlarotera*-type), 5.97-10.44 µm thick; **hymenium** hyaline, 27.46-35.22 µm thick, I+ blue; **hypothecium** hyaline; **paraphyses** simple, sparsely branched at apices, apices not swollen; **asci** clavate, *Lecanora*-type, apex strongly thickened with an I+ blue; **ascospores** subglobose, elliptic to globose, hyaline, simple, walls thin, smooth-walled, 8 per ascus, 3.88- 6.26 x 8.35-13.73 µm; **conidiomata** absent.

Chemistry: Atranorin, Athothelin, fatty acid; thallus: K+ yellow, C+ pale yellow, KC -, CK-, PD -.

Specimen Examined: S. Falab-558.

Lecanora austrotropica Lumbsch; Bibl. Lichenol. 70:123. 1998; The Lecanoraceae in Thaliand 11. 2011. Figure 5.8A, B

Thallus corticolous, whitish green to pale green, verrucose to verruculose, continuous, epruina; **soralia** and **isidia** absent; **prothallus** indistinct white; **photobiont** chlorococcoid, 115.80-158.02 µm thick; **apothecia** common, dispersed all of thallus, circular to irregular shape, verrucose crenulated, sessile; **disc** plane to slightly concave, pale orange to yellowish brown, epruina, 0.16-0.38 mm diameter; **thalline exciple** present, concolorous with the thallus; **amphithecium** with large crystals insoluble in KOH (*Pulicaris*-type); **parathecium** hyaline, with numerous small crystal soluble in KOH, **epithecium** brown, 14.62-20.29 µm thick; **hymenium** hyaline, 56.69-68.05 µm thick, I+ blue; **hypothecium** hyaline; **paraphyses** sparsely branched, apices not swollen; **asci** clavate, *Lecanora*-type, apex strongly thickened with an I+ blue; **ascospores** subglobose to globose, hyaline, simple, walls thin, smooth-walled, 8 per ascus,11.04-18.80 x 9.25-11.34 µm; **conidiomata** absent.

Chemistry: Atranorin, Salazinic acid, Norstictic acid, Athothelin, fatty acid; thallus: K+ yellow, C-, KC-, CK-, PD+ yellow.

Specimen Examined: S. Falab-034, 035, 036, 037, 038, 040, 041, 042, 043, 044, 046, 560, 561, 562, 568, 569, 574, 579, 582, 598, 599, 603, 604, 605.

Lecanora coronulans Nyl.; The Lecanoraceae in Thaliand 13. 2011. Figure 5.8C, D

Thallus corticolous, white, grey to grayish green, rugose to verruculose, continuous, epruina; **soralia** and **isidia** absent; **prothallus** distinct white; **photobiont** chlorococcoid; **apothecia** common, densely in central of thallus, circular to ellipsoid or irregular shape, verrucose crenulated, sessile; **disc** plane to concave, red brown to dark brown, epruina, 0.16-0.47 mm diameter; **thalline exciple** present, concolorous with the thallus;

amphithecium with large crystals insoluble in KOH (*Pulicaris*-type); **parathecium** hyaline, with small crystal soluble in KOH, **epithecium** brown, 13.26-21.71 µm thick; **hymenium** hyaline, 72.37-94.09 µm thick, I+ blue; **hypothecium** light brown to brown, 44.63-50.66 µm thick ; **paraphyses** sparsely branched, apices not swollen; **asci** clavate, *Lecanora*-type, apex strongly thickened with an I+ blue; **ascospores** ellipsoid to subglobose, hyaline, simple, walls thin, smooth-walled, 8 per ascus,5.67-9.85 x 12.83-16.11 µm; **conidiomata** absent.

Chemistry: Atranorin; thallus: K+ yellow, C+ pale yellow, KC -, CK-, PD+ yellow.

Specimen Examined: S. Falab-025, 026, 027, 028, 029, 030, 031, 032,033, 568, 563, 577, 578, 589, 590, 600, 606, 607, 608, 609, 611, 612

Lecanora ecoronata Vain.; Tropical Bryology 18: 194. 2000; The Lecanoraceae in Thaliand 14. 2011. Figure 5.8E, F

Thallus corticolous, deep green to pale green, rugose to verruculose, continuous, epruina; **soralia** and **isidia** absent; **prothallus** distinct white; **photobiont** chlorococcoid; **apothecia** common, dispersed in central of thallus, circular shape, entire, sessile; **disc** plane to slightly concave, red brown to dark brown, epruina, 0.15-0.27 mm diameter; **thalline exciple** present, pale green, different with the thallus; **amphithecium** with large crystals insoluble in KOH (*Pulicaris*-type); **parathecium** hyaline, with small crystal soluble in KOH, **epithecium** light brown, 5.37-11.34 µm thick; **hymenium** pale yellow, 62.83-74.92 µm thick, I+ blue; **hypothecium** light brown to brown, 37.61-58.80 µm thick ; **paraphyses** simple, rarely anatomosed, sparsely branched, apices not swollen; **asci** clavate, *Lecanora*-type, apex strongly thickened with an I+ blue; **ascospores** ellipsoid, hyaline, simple, walls thin, smooth-walled, 8 per ascus,4.47-6.56 x 9.25-15.52 µm; **conidiomata** absent.

Chemistry: Atranorin, Salazinic acid, Norstictic acid, Athothelin, fatty acid; thallus: K+ yellow, C+ pale yellow, KC-, CK-, PD -.

Specimen Examined: S. Falab-597, 601, 602.

Lecanora leprosa Fée; Hong Kong Lichens 111. 1988; Bibl. Lichenol. 70:126. 1998; The Lecanoraceae in Thaliand 21. 2011. Figure 5.8G, H

Thallus corticolous, whitish, grayish white to pale green, verrucose to verruculose, continuous, epruina; **soralia** and **isidia** absent; **prothallus** distinct white; **photobiont** chlorococcoid, with crystal; **apothecia** common, numerous, dispersed all of thallus, circular to ellipsoid shape, verrucose, sessile; **disc** plane, pale orange to deep orange, epruina, 0.15-0.26 mm diameter; **thalline exciple** present, concolorous with the thallus; **amphithecium** with large crystals insoluble in KOH (*Pulicaris*-type); **parathecium** hyaline, with small crystal soluble in KOH, **epithecium** brown, 14.62-20.29 µm thick; **hymenium** hyaline, 52.53-88.05 µm thick, I+ blue at apices; **hypothecium** hyaline, 25.37-53.73 µm thick; **paraphyses** sparsely branched, apices not conspicuously swollen; **asci** clavate, *Lecanora*-type, apex strongly thickened with an I+ blue; **ascospores** subglobose to globose, round ends, hyaline, simple, walls thin, smooth-walled, 8 per ascus,4.17-6.86 x 9.85-12.53 µm; **conidiomata** absent.

Chemistry: Atranorin; thallus: K + yellow, C-, KC-, CK-, PD-.

Specimen Examined: S. Falab-039, 045, 552, 566, 567, 584.

Lecanora tropica Zahlbr. ; Bibl. Lichenol. 70:129. 1998; Tropical Bryology 18: 194. 2000; Fungal Divers. 24: 82. 2007; The Lecanoraceae in Thaliand 30. 2011. Figure 5.9A, B

Thallus corticolous, green, grayish green to olive green, rugose to verruculose, continuous, epruina; **soralia** absent; **isidia** cylindrical, branched; **prothallus** indistinct white; **photobiont** chlorococcoid; **apothecia** common in central of thallus, circular to irregular shape, verrucose crenulated, sessile; **disc** plane to slightly concave, red brown to dark brown, epruina, 0.22-0.33 mm diameter; **thalline exciple** present, concolorous with the thallus; **amphithecium** with large and small crystals (*Melacarpella*-type); **parathecium** hyaline, with small crystal soluble in KOH, **epithecium** brown to orange, 3.28-10.44 µm thick; **hymenium** hyaline, 47.16-64.17 µm thick , I+ blue; **hypothecium** hyaline; **paraphyses** sparsely branched, apices not swollen; **asci** clavate, *Lecanora*-type, apex strongly thickened with an I+ blue; **ascospores** absent; **conidiomata** absent.

Chemistry: fatty acid; thallus: K+ yellow, C-, KC -, CK-, PD-.

Specimen Examined: S. Falab-559.

8. MONOBLASTIDIACEAE

Anisomeridium (Müll. Arg.) Choisy

Thallus thin, ecoticate, with *Trentepohlia* photobiont; perithecia black; anatomosing paraphyses; **spores** not ornamented, hyaline, relatively broad, ovoid 1-3 septate, relatively thin walled.

Anisomeridium subprostans (Nyl.) R. C. Harris.; Fungal Divers. 24: 85. 2007. Figure 5.9C, D

Thallus ecorticate, endophloeodal, greyish white, UV-; **perithecia** solitary, globose, 0.50-0.60 mm diameter; ostiole apical; **hamathecium filaments** thin, anastomosing and branched above the asci; asci cylindrical, 90-98 µm tall; **ascospores** 8 per ascus, uniseriate, hyaline, 1-septate with 2 triangular cells, ellipsoidal, 6.50-8.95 x 18.50-25.67 µm, not ornamented, septum median; **coniomata** absent.

Chemistry: no lichen substance detected.

Specimen Examined: S. Falab-065, 066, 067, 068, 069, 070, 071, 072, 073, 238, 239, 240, 267, 268, 269, 270, 289, 318, 319, 325, 326, 329, 365, 391, 393, 407, 474, 480, 551, 552, 553, 554, 620, 621, 622

9. PARMELIACEAE

Bulbothrix Hale

Thallus foliose, corticated above and below, adnate or loosely attached to substrate; **photobiont** green; **lobes** pale grey, often with a narrow black rim at the margin, under side pale brown to black; **rhizines** concolorous with under side, simple or branched; marginal cilia bulbate, sometimes no more than black nodules**; apothecia** substipitate, with imperforate disc, the thalline exciple of some species with numerous black nodules; **spores** 8 per ascus, simple, ellipsoid; **pycnoconidia** weakly bifusiform, 6-10 µm long.

Bulbothrix queenslandica (Elix & G.N.Stevens) Elix.; Fl. Australia. 55: 17. 1994. Figure 5.9E

Thallus, corticolous, 3-5 cm diameter, adnate attached to substrate, pale grey, 82-103 µm thick; **photobiont** green, continuous, (18)21-39 µm thick; **lobes** pale grey, sublinear, 0.19-0.55 mm wide, upper cortex slightly pruinose, waxy, marginal densely bulbate cilia, medulla white, loosely packed, 32-41 µm thick, lower cortex pale brown to dark brown; **isidia** laminal, shortly cylindrical to globose, black at apices, c. 100 µm long; **rhizines** black, shiny, simple to sparsely branched, c. 80 µm long; **apothecia** absent; **pycnoconidia** not seen.

Chemistry: Atranorin; Cortex: K+ yellow, C-, KC-, CK-, PD-; Medulla: K-, C-, KC-, CK-, PD-.

Specimen Examined: S. Falab-555, RAMK 006679-W. Polyiam 17193, RAMK 008438-R. Noicharoen 14270, 008444- W. Polyiam18899, RAMK 008446-R. Noicharoen 14626, RAMK

Bulbothrix goebellii (Zenker) Hale; Smithsonian Contrib. Bot. 32:14. 1976; Macrolichens of East Africa 25. 1998; Mycosystema 28: 93. 2009. Figure 5.9F

Thallus, corticolous, 3-4 cm diameter, adnate attached to substrate, pale grey, 100-180 µm thick; **photobiont** green, continuous, 32-61 µm thick; **lobes** pale grey, short 0.19-0.81 mm wide, upper cortex slightly pruinose to waxy, marginal clearly bulbate cilia, scattering pycnidia, medulla white, loosely packed,23-32 µm thick lower cortex pale brown to dark brown; **isidia** laminal, densely on central of thallus, shortly cylindrical, with pycnidia, (63)131-166 µm long; **rhizines** black, shiny, simple, sparsely branched, (58)75-104 µm long; **apothecia** absent; **pycnoconidia** bifusiform, 5-7 µm long.

Chemistry: Lecanoric acid, Atranorin; Cortex: K+ yellow, C-, KC-, CK-, PD-; Medulla: K-, C+ rose, KC-, CK-, PD -.

Specimen Examined: S. Falab-554, RAMK 003156-K. Boonprakob 14181, RAMK 003157-W. Polyiam 19324, RAMK 006870-N. Osathanon 15781, RAMK 008140-T. Pooprang 8146

Parmotrema Massal.

Thallus foliose, corticated above and below, usually loosely attached to substrate; **photobiont** green; **lobes** in most species widely rotund apically, pale grey or pale yellow above, pale to dark brown to black below, with a brown, white, or mottled marginal zone; marginal cilia present or absent; **rhizines** unbranched or rarely bifurcated or squarrose, generally sparse or absent towards periphery of lobes, rarely dimorphous ; **apothecia** subsitpitate to stipitate, with thalline exciple, disc perforate or imperforate; **spores** 8 per ascus, colourless, simple, ellipsoid; pycnoconidia sublageniform or filiform.

Parmotrema tinctorum (Despr.ex Nyl) Hale; Hong Kong Lichens 131.1988; Macrolichens of East Africa 194. 1998. Figure 5.9G

Thallus coriaceous, smooth, loosely attached, pale grey to grey-green, 2-8 cm diameter; **lobes** imbricate, broad, round, entire, eciliate, 5-6 mm wide; **upper side** emaculate, shiny, becoming dull toward the centre, upper cortex sometime cracking and flaking, c. 10 µm thick; **medulla** white, loosely packed, c. 100-150 µm thick; **under side** black, shiny, with a wide, brown, naked marginal zone, lower cortex c. 8-10 µm thick; **photobiont** green, continuous, c. 15-20 µm thick; **rhizines** fairly coarse, in scattered groups; **isidia** abundant on lamina, confluent, and cylindrical or irregulary inflated, c. 90-130 mm high; **apothecia** absent.

Chemistry: Lecanoric acid, Atranorin; cortex K+ yellow, C+ yellow, KC+ yellow turning red, PD-, UV-; medulla K-, C+red, KC+ yellow, PD-.

Specimen Examined: S. Falab-128, 129, 130, 131, 132, 246, 283, 294, 313, 337, 338, 339, 352, 357, 386, 430, 439, 458, 469, 479, 483, 488, 494, 501, 513, 517, 518, 521, 522, 528, 529, 534, 535, 536, 539, 540, 541, 542, 618

Relicinopsis Elix & Verdon

Thallus foliose, adnate to tightly adnate, to 1.5-10 cm wide; **lobes** contiguous at centre, contiguous to separate at periphery, irregular or sublinear to linear-elongate, dichotomously to subirregularly branched, 0.5-2 (-3) mm wide; **margins** eciliate or with simple cilia; **upper** surface yellow-green (usnic acid), smooth, maculate or not, lacking pseudocyphellae and soredia, with or without isidia; **upper cortex** consisting of basic palisade plectenchyma with pored epicortex; cell walls containing isolichenan; **medulla** loosely packed, white; **lower surface** pale tan to brown; **rhizines** extending to lobe margins, moderately dense to dense, simple or sparsely to densely branched and agglutinated, usually concolorous; **ascomata** apothecial, laminal, sessile; **disc** ±flat to concave, imperforate, pale brown to red-brown or cinnamon-brown; **ascospores**

ellipsoidal, 8 per ascus, 5-9 x 3-6 µm; **conidiomata** pycnidial, marginal, rarely laminal, sometimes emergent; **conidia** bacilliform or fusiform, 5-7 x 1 µm.

Relicinopsis malaccensis (Nyl.) Elix & Verdon; Fl. Australia. 55: 183. 1994. Figure 5.9H

Thallus closely adnate, yellowish green to pale yellow, 2-3 cm diameter, c.100 µm thick; **lobes** imbricate, sublinear, irregularly branched to subdichotomously branched, 0.10-0.30 mm wide, eciliate; **upper surface** shiny, convex, white-maculate at central thallus, transversely cracked, upper cortex c. 10 µm thick; **isidia** simple, granular to cylindrical, laminal; **medulla** white, loosely packed, c.80 µm thick; **rhizines** simple to sparsely branched, dense, dark brown, shiny; **lower surface** brown to black, shiny, lower cortex c.9.0 µm thick; **apothecia** absent.

Chemistry: Usnic acid, fatty acid; Cortex: K+ yellow, C-, KC-, CK-, PD-; Medulla: K-, C+ pale yellow, KC-, CK-, PD+ pale orange.

Specimen Examined: S. Falab-572

Relicinopsis rahengensis (Vain.) Elix & Verdon; Fl. Australia. 55: 184. 1994. Figure 5.16G, H

Thallus closely adnate, yellowish green to pale yellow, 3-4 cm diameter, 123.88-177.33 µm thick; **lobes** imbricate, sublinear, irregularly branched to subdichotomously branched, 0.15-0.35 mm wide, eciliate; **upper surface** shiny, convex, white-maculate at central thallus, transversely cracked, upper cortex 11.34-21.19 µm thick; **isidia** simple, granular to cylindrical, laminal; **medulla** white, loosely packed, 68.35-98.72 µm thick; **rhizines** simple to sparsely branched, dense, dark brown, shiny; **lower surface** brown to black, shiny, lower cortex (4.17)7.16-16.11 µm thick; **apothecia** absent.

Chemistry: Usnic acid, Barbatic acid, fatty acid, unknown1; Cortex: K+ yellow, C-, KC-, CK-, PD-; Medulla: K-, C + pale yellow, KC-, CK-, PD+ orange.

Specimen Examined: S. Falab-556, 573

10. PHYSCIACEAE

Buellia De Not.

Thallus crustose, plane, firmly attached to substratum, white greenish-grey and white to yellow, shiny to dull, ecorticate or phenocortex, epruinose, rimose, smooth to rugose and aereolate to verrucose; **prothallus** black; **isidia** and **soralia** absent; **apothecia** numerous, single to 2-3 aggregated, sessile, disc concave, black, epruinose; proper exiple, lecidiene, uncarbonized or carbonized; **epiphymenium** black to brown; **hymenium** hyaline, with oil drops or without oil drops; **paraphyses** colourless, simple or branced, with brown or black caps at swollen tips; **hypothecium** pale brown; **asci** clavate, *Physcia*-type; **ascospores** 8 or 12 per ascus, biseriate, brown, ellipsoid, with or without median spore wall thickening, smooth, *Buellia*-type, 14-18 x 6.5-8.0 µm; **pycnidia** laminal to subterminal, immersed on upper surface, pale to black ostiole; **pycnidiospores** hyaline, bacilliform, 0.20-.27 µm long; **photobiont** *Chlorococcoid*.

Buellia schaereri De Not.; Australian Physciaceae:18. 2011. Figure 5.10A, B

Thallus crustose, plane, thin, firmly attached to substratum, greenish-grey, greenish grey to whitish green, dull, phenocortex, epruinose, smooth, slightly rugose to aereolate; **prothallus** black; **isidia** and **soralia** absent; **apothecia** numerous, single to 2-3 aggregated, sessile, disc concave, black, epruinose; proper exiple, lecidiene, uncarbonized; **epiphymenium** black to brown; **hymenium** hyaline, without oil drops, 35.52-51.04 µm thick ; **paraphyses** hyaline, simple or branched at apices, with black caps at swollen tips; **hypothecium** brown, 65.37-71.34 µm thick ; **asci** clavate, *Physcia*-type, 33.73-40.89 µm high ; **ascospores** 6-8 per ascus, biseriate, dark brown to greyish brown, ellipsoid, with median spore wall thickening, smooth, *Buellia*-type, 3.28-4.47 x 11.34-14.62 µm; **pycnidia** absent; **photobiont** *Chlorococcoid*.

Chemistry: no lichen substance detected; thallus: K+ yellow, C+ orange, PD-, UV+ dark orange.

Specimen Examined: S. Falab-047, 048, 049, 050, 051, 052, 053,054, 055, 134,135, 136, 137, 138, 139, 140, 141, 142, 208, 209, 210, 211, 212, 213, 214, 215, 234, 235, 237, 330, 332, 333, 334, 343, 344, 345, 346, 453, 457, 414, 415, 434, 435, 436, 444, 445, 452, 453, 457, 466, 467, 477, 478, 485, 495, 496, 497, 506, 509, 514, 515, 516, 523, 524, 530, 531, 532, 533, 537, 538, 543, 544, 610.

Diplotomma Flotow

Thallus crustose, saxicoulous, plane, firmly attached to substratum, pale to dark grey, dull, ecorticate, epruinose, rimose or smooth; **prothallus** absent; **isidia** and **soralia** absent; **apothecia** sparsely or numerous, single to 2-3 aggregated, sessile, disc convex, black, epruinose, proper exciple, lecidiene, *dispersa*-type, carbonized; **epihymenium** brown to black; **hymenium** colourless, without oil drops; **paraphyses** colourless, branched with brown caps at swollen tips; **hypothecium** dark to brown; asci clavate, *Physciaceae*-type; **ascospores** 8 per ascus, brown, ellipsoid, submuriform, 14.20-16.50-18.91 x 7.49-8.58-9.22 µm; **pycnidia** not seen; photobiont *Chlorococcoid*.

*Diplotomma venustum (*Körb.) Körb.; Australian Physciaceae: 3. 2011. Figure 5.10C, D

Thallus crustose, corticolous, plane, firmly attached to substratum, greenish grey to whish green, dull, ecorticate, epruinose, areolate to verrucose, c. 1 cm diameter, c. 100-110 µm thick ; **prothallus** black; **isidia** and **soridia** absent; **apothecia** numerous, single to 2-3 aggregated, sessile, disc concave, black, epruinose, 0.25-0.30 mm diameter; **proper exciple**, lecideine, *aethalea*-type, cabonized, c. 70 µm thick; **epihymenium** brown to black, 8.05-9.25 µm thick, K-; **hymenium** colourless, without oil drops, 77.91-87.76 µm high; **paraphyses** colourless, simple, with black caps at swollen tips, c. 80 µm high; **hypothecium** pale brown, c. 20 µm high; asci clavate, *Physciaceae*-type, 72.83-82.62 µm high; **ascospores** 8 per ascus, biseriate, dark brown, ellipsoid, submuriform, 8.05-10.75 (11.04) x 21.19-25.37 µm; **pycnidia** not seen; photobiont *Chlorococcoid*.

Chemistry: Atranorin; cortex K+ yellow, C-, PD-; medulla K+ yellow, C-, PD-.

Specimen Examined: S. Falab-024

Dirinaria (Tuck.) Clements

Thallus foliose, of radiating lobes, corticated above and below**; photobiont** green; **lobes** white or rarely stramineous to ochraceous yellow above, often with grayish tinge at periphery, black or rarely pale below; **upper cortex** of anticlinal phyphae; **lower cortex** of periclinal hyphae; **medulla** usually white, but containing red pigment in two species; in most species an ochraceous pigment is unevenly distributed near the lower cortex; **rhizines** absent; **apothecia** with thalline exciple, tips of paraphyses K-, subhymenial layers brown; **spores** brown, thick walled, with one septum, locules presenting hourglass apparence.

Dirinaria aegialita (Afzel. ex Ach.) B.J.Moore; Bibl. Lichenol. 70:90. 1998. Fl. Australia. 57:510. 2009. Figure 5.10E, F

Thallus closely adnate, whitish grey to grey, 1-6 cm diameter, 107.36-147.17 µm thick; **photobiont** green, continuous, 27.76-43.58 µm thick; **lobes** contiguous, white, grayish white to ochraceous yellow, with grayish tinge at periphery, 0.28-0.40 mm wide; **dactyl** clavate, sometime sorediate; **upper cortex** white, slightly pruinose, 12.23-15.52 µm thick; **lower cortex** thin, brown; **medulla** white, 77.61-106.56 µm thick ; **rhizines** absent; **apothecia** rare, with thalline exciple, concolourous, sessile; **disc** black to dark brown, grey pruinose; **subhymenial** layers dark brown, lentiform, 97.71-125.45 µm thick; **epihymenium** brown to light brown, 9.65-17.91 µm thick; **hymenium** hyaline, 82.68-121.83 µm thick; **paraphyses** branched, anatomosing; **spores** dark brown, thick walled, with one septum, locules presenting hourglass apparence, 7.39-9.69 x 18.90-22.06 µm.

Chemistry: Atranorin, Divaricatic acid, fatty acid; cortex K+ yellow, C-, PD+ yellow; medulla K+ pale yellow, C+ pale yellow, PD-.

Specimen Examined: S. Falab-122, 123, 124, 125, 126, 127, 249, 253, 277, 304, 359, 362, 363, 382, 389, 390, 418, 424, 437, 442, 471, RAMK 008164-W. Polyiam 19325

Dirinaria papillulifera (Nyl.) D. D. Awasthi; Bibl. Lichenol. 70:92. 1998. Figure 5.10G, H

Thallus closely adnate, grayish green to whitish grey, 2-4 cm diameter, c.90 µm thick; **photobiont** green, continuous, c.23 µm thick; **lobes** contiguous, pale green to grayish green, dark green periphery, c. 0.2-0.5 mm wide; **isidia** cylindrical, branched; **upper cortex** pale green to grey, epruinose, c.12 µm thick; **lower cortex** thin, brown to dark brown; **medulla** white, c. 80 µm thick; **rhizines** absent; **apothecia** absent.

Chemistry: Atranorin, fatty acid; cortex K+ yellow, C-, PD+ yellow; medulla K-, C-, PD-.

Specimen Examined: S. Falab-111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 247, 257, 264, 278, 279, 303, 309, 310, 311, 416, 419, 420, 438, 441, 451, 463, 499

Hyperphyscia Müll. Arg.

Thallus foliose, orbicular or spreading irregularly; **photobiont** green; **lobes** corticated above and more or less distinctly so below; **upper side** grayish brown to dark brown, sometimes with white to grey pruina; **under side** black centrally, usually paler, peripherally; **rhizines** indistinct or absent; **apothecia** with thalline exciple, **disc** dark brown to black; **spores** 8 per ascus, brown, of *Physcia* or *Pachysporaria* type; **pycnoconidia** filiform, 15-20 x c. 1 μm.

Hyperphyscia adglutinata (Florke) H. Mayrh. & Poelt.; Macrolichens of East Africa 101. 1998. Figure 5.11A, B

Thallus orbicular to irregularly, 2-5 cm diameter, closely adnate, 135.10-168.05 μm thick; **photobiont** continuous, 31.34-40.00 μm thick; **lobes** 0.18-0.37 mm wide, convex, ascending to apex; **upper side** grayish green to blackish green, epruina, black margin, cortex paraplectenchymatous, 15.22-17.01 μm thick; **under side** pale brown to dark brown, white along margin, lower cortex prosoplectenchymatous, 15.22-19.10 μm thick; **medulla** white, 50.14-64.47 μm thick; **isidia** cylindrical to globose, laminal in central of thallus; **soralia** densely at central of thallus, maculiform, **rhizines** absent; **apothecia** absent.

Chemistry: Atranorin, Divaricatic acid, fatty acid; cortex K+yellow, C-, PD-; medulla K-, C-, PD-.

Specimen Examined: S. Falab-570, 571, 624, RAMK 021254-CMSPL 439, RAMK-CMSPL 441, RAMK 021254-CMSPL 443

Hyperphyscia syncolla (Tuck. ex Nyl.) Kalb.; Macrolichens of East Africa 105. 1998. Figure 5.11C, D

Thallus orbicular, up to 5 cm diameter, closely adnate, cracked and rugose at the central of thallus, c. 120 μm thick; **photobiont** continuous, c.50 μm thick; **lobes** 0.19-0.35 mm wide, convex, irregularly; **upper side** grayish green to yellowish grey, epruina, pale at margin, cortex paraplectenchymatous, c. 16 μm thick; **under side** dark brown toward margin, lower cortex prosoplectenchymatous, c. 10 μm thick; **medulla** white, c.50 μm thick; **isidia** and **soralia** absent, **rhizines** absent; **apothecia** numerous, 0.47-0.84 mm diameter, with thalline exciple, subpecicellate, concolourous with thallus; **disc**

dark brown to black, plane to slightly concave, crenulate margin; **epithecium** brown, 7.76-11.94 µm thick; **hymenium** hyaline, 72.88-159.23 µm thick; **hypothecium** light brown to hyaline, 32.85-55.52 µm thick ; **paraphyses** sparsely branched, apices swollen; **asci** clavate; **ascospores** ellipsoid, grayish brown, *Physcia*-type, walls thick, smooth-walled, 8 per ascus, 7.16-9.55 x 17.91-25.97 µm; **pycnoconidia** filiform.

Chemistry: no lichen substance detected; cortex K+ pale yellow, C-, PD-; medulla K-, C-, PD-.

Specimen Examined: S. Falab-261, 262, 280, 281, 290, 336

Physcia (Schreb.) Michx.

Thallus foliose, continuous, lobate, irregular or forming rosettes 2–8 cm wide; **lobes** discrete or contiguous, closely adnate and appressed to ±ascending and loosely attached, sublinear to sublinear-elongate, dichotomously to irregularly branched, ±with marginal cilia; **upper surface** greenish grey or whitish grey to dark grey, occasionally with a whitish pruina, plane to convex, dull to glossy, white-maculate or emaculate; **isidia**, **dactyls**, **pustules**, **soredia** and **lobules** present or absent; **upper cortex** pseudoparenchymatous;**hypothallus** absent; **medulla** well defined, white or partly yellow; **lower surface** corticate, white to whitish grey, pale tan or brown-black; **lower cortex** prosoplectenchymatous or pseudoparenchymatous, rhizinate; **rhizines** white to brown or brown-black, simple to irregularly branched; **ascomata** apothecia, lecanorine, laminal, orbicular, sessile to stipitate; **disc** brown to black, concave to plane or weakly convex, often white-pruinose; **thalline exciple** prominent or reflexed, distinct and persistent, occasionally with a white pruina; hairs absent or present at the base of the apothecia. Epihymenium pale brown; **hymenium** and **hypothecium** colourless; **paraphyses** simple or sparingly branched near the tips, apices clavate, pale brown with a thin dark brown cap; **asci** cylindrical to clavate, *Lecanora*-type, 8-spored, apex wall layers thickened, apex amyloid, with a distinct axial mass; ascospores *Physcia*- or *Pachysporaria*-type, 1-septate, grey-brown to brown or dark brown, ellipsoidal, thick-walled; **conidiomata** pycnidial, immersed in the thallus, with colourless walls except for the dark ostiolar region (appearing as black dots on the lobe surface); **conidiogenous cells** arranged in branched chains, short, cylindrical, enteroblastic, aerogenous or pleurogenous; **conidia** bacilliform.

Physcia nubila Moberg.; Australian Physciaceae :14. 2011. Figure 5.11E, F

Thallus orbicular to irregularly spreading, loosely adnate, 1.0-2.5 cm wide; **lobes** variable, 0.23-0.27 mm wide, discrete to imbricate, irregularly branched, margins incised, or minutely lobulate, apices slightly down-curled; **upper surface** grey-white, occasionally suffused grey-black at lobe apices, emaculate, epruinose; **soralia** marginal, labriform at lobe sinuses; **soredia** coarsely granular, white or grey-white; **lower surface** white to cream; margins often ecorticate; **rhizines** white to light brown, few and robust, usually darker than the underside; **apothecia** absent.

Chemistry:Atranorin ; cortex K+ yellow, C-, PD-; medulla K+ yellow, C-, PD-.

Specimen Examined: S. Falab-096, 101, 102

Physcia undulata Moberg.; Macrolichens of East Africa 231. 1998. Figure 5.11G, H

Thallus orbicular, loosely adnate, 2-5 cm wide; **lobes** 0.52-0.81 mm wide, plane to convex, irregularly branched, imbricate, margins entire to notched, undulate or crenulate, conspicuously sorediate, apices rounded or truncate; **upper surface** grey-white to greenish grey, dull, smooth to shallowly undulate, frosted-pruinose near apices; **soralia** marginal, linear, undulate, eroding the margins; **soredia** coarsely granular, white to greenish; **lower surface** whitish to cream at the margin, pale brown in the centre; **rhizines** white to pale brown or dark brown, denser at the margins, simple with a squarrose tuft at the tip; **apothecia** absent.

Chemistry:Atranorin, Norstictic acid, zeorin, fatty acid, ; cortex K+ golden yellow, C-, PD-; medulla K+ yellow, C+ yellow, PD+ yellow.

Specimen Examined: S. Falab-095

Pyxine Fr.

Thallus foliose, of radiating lobes, corticated above and below, adnate or loosely attached to substrate; **photobiont** green; **lobes** white to pale grey, dark grey, or brownish grey above, often pruinose with pruina farinaceous or in glistening plaques, black below; **pseudocyphellae** generally present on upper side, linear or reticulate, marginal and/or laminal; **upper cortex** of anticlinal hyphae forming a paraplectenchyma; **lower cotex** of periclinal hyphae forming prosoplectenchyma, pale brown to brown-black or black or; medulla pigmented in most species; **rhizines** simple or branched; **apothecia** laminal, rounded, sessile or subpedicellate with thalline exciple, internal stipe connecting subhymenial layer with medulla; disc black, rarely pruinose; epihymenium bluish black, K+ purple; hymenium colourless; hypothecium brown to dark brown; asci of *Bacidia*-type, clavate; paraphyses septate, simple or with short branches near the apices; apices generally capitate, brown-black, K+ purple ;**spores** brown, 1-3-septate, thick-walled, ellipsoidal, (usually *Dirinaria*-type, rarely *Physcia*-type) 8 per ascus.

Pyxine cylindrica Kashiw.; Fl. Australia. 57:523. 2009; Phytotaxa 59: 44. 2012. Figure 5.12A, B

Thallus corticolous, 2.5-4 cm wide, orbicular, loosely to adnate, subdichotomously lobate, 165-199 µm thick; **lobes** radiating, imbricate, slightly convex, 0.21-0.48 mm wide, subrotund to truncate at the apices; **upper surface** greenish grey or whitish green, sparsely pruinose at the lobe tips or epruinose; **dactyls** and **soredia** absent; **pseudocyphellae** distinct, marginal and laminal, irregular; **isidia** laminal, cylindrical, simple or sparingly branched, 0.16-0.26 mm tall; **medulla** white to slightly pale brown, 77.31-89.25 µm thick; **lower surface** black in the centre, paler towards the margin; rhizines ±dense, furcated; **apothecia** groups in the centre, uncommon, *obscurascens*-type, 0.41-0.58 mm wide; **disc** epruinose, concave, black; internal stipe distinct; upper part orange, K+ wine-red, P-; lower part yellow, K-, P-; **ascospores** *Dirinaria*-type, brown, 1-septate, thick walled, ellipsoidal, 8 per ascus, 4.48-7.66 x 15.52-22.90 µm; **pycnidia** not seen.

Chemistry: Atranorin, Norstictic acid; Cortex K+ yellow, C-, KC-, P-, UV-; medulla K+ yellow turning red, C-, P+ orange.

Specimen Examined: S. Falab-103, 104, 105, 106, 107, 108, 109, 110, 248, 255, 284, 285, 312, 385, 421, 422, 429, 432, 433, 455, 459, 460, 464, 475, 476, 486, 487, 503, 508, 511, 512, 519, 520, 525

Pyxine sorediata (Ach.) Mont. ; Bibl. Lichenol. 70:235. 1998; Fl. Australia. 57:531. 2009; Phytotaxa 59: 51. 2012. Figure 5.12C, D

Thallus corticolous, 1.5-5 cm wide, adnate, 170-220 µm thick; **lobes** radiating, contiguous to imbricate, slightly concave, 0.44-0.76 mm wide, subrotund to rotund at the apices; upper surface yellowish grey to greenish grey or blue-grey, distinctly pruinose; pruina punctiform towards lobe apices; isidia absent; **pseudocyphellae** very distinct at the margins, often grey-pruinose ; **soralia** initially marginal, developing from fissures, then laminal and orbicular; soredia granular, dirty white or yellow; **medulla** lemon-yellow above; lower part yellow-brown or yellow-orange; **lower surface** black in the centre, paler towards the margin; rhizines ± dense, black, furcate; **apothecia** absent.

Chemistry: Atranorin, fatty acid; Cortex K+ yellow or K-, C-, KC-, P- or P-, UV-; medulla K+ pale yellow, C-, P-.

Specimen Examined: S. Falab-097, 098, 099, 100

11. PERTUSARIACEAE

Pertusaria DC.

Thallus crustose, white, yellow, grey, green or of intermediate shades, surface smooth, continuous or cracked; **soredia** or **isidia** present or absent; **apothecia** innate within convex, hemispherical or subglobose verrucae that are solitary or confluent, or apothecia disciform; **disc** small or broad and lecanorine; **asci** clavate or cylindrical, 1–8-spored; **ascospores** oval, ellipsoidal, fusiform or, rarely, globose, unicellular, hyaline, c. 20–250 µm long, with a single or double wall; inner ascospore wall smooth or rough; **pycnidia** (rare in Australian species) black, immersed; **conidia** narrowly fusiform to bacilliform, straight or slightly curved.

Pertusaria endoxantha Vain. ; Fl. Australia. 57:133. 2009. Figure 5.12E, F

Thallus pale olive-green, grayish gren to pale grayish green, areolate to slightly rugose, dull; **soredia** and **isidia** absent; **medulla** white, distinct, 151.99-203.86 µm thick; **perithecia** numerous, verruciform, dense, flattened-hemispherical, concolorous with the thallus or paler, sometimes fused more than 1 locules in verruca, 0.57-0.78 mm diameter; **ostioles** apical, black or dark brown, punctiform, inconspicuous in a hyaline zone c. 0.1 mm diam., 1-2 per verruca; **paraphyses** brached, anatosmosing; **ascospores** 4-8 per ascus, hyaline, regularly uniseriate, elongate-ellipsoidal to subfusiform, smooth, halonate, 64.17-92.53 x 24.47-33.73 µm.

Chemistry: Atranorin, Stictic acid, fatty acid; cortex K-, KC-, C-, PD+ pale yellow; medulla K+ yellow, KC-, C-, PD-.

Specimen Examined: S. Falab-617

12. PORINACEAE

Porina Ach.

Thallus corticolous, saxicolous or foliicolous (rarely bryophilous or terricolous); **photobiont** *Trentepohlia* (mainly in corticolous and saxicolous spp.) or *Phycopeltis* (in most foliicolous spp.); **ascomata** perithecia, immersed in the thallus or in thallus-dominated verrucae, or superficial on the thallus; **involucrellum** vestigial to well-developed and almost completely enclosing the exciple, pale to dark orange-brown, red-brown, brown, green-black, purple-black or jet-black, surface smooth to uneven, lacking whorls of stiff subapical setae (rarely with a more uniformly distributed and delicate pilose or ±tomentose covering); **ascospores** with 3 or more transverse septa, or submuriform to muriform.

Porina impolita P.M. McCarthy; Fl. Australia. 58A:132. 2001. Figure 5.12G, H

Thallus epiphloeodal, continuous, grey-green to dark green, shiny, smooth to slightly rugose, corticate, with needle form crystals; **prothallus** distinctly white; **photobiont** *Trentepohlia*, continuos; **perithecia** one-third immersed, semi-prominent, subglobose to globose, 0.25-0.40 mm diameter, dull green to pale green, concolourous with thallus, apex rounded; **ostiole** inconspicuous, dark brown, entire; **involucrellum** contiguous with the exciple, orange to light brown , 102.53-156.82 µm thick, containing algae, K+ red; **asci** obclavate to cylindrical with acuminate apices, 91.34-108.35 µm high; **hymenium** hyaline, inspersed with oil droplets; **paraphyses** simple; **ascospores** 6-8 per ascus, transversely septate, ellipsoid to fusiform, acuminate ends, 6-7 septate, lumina rectangular and conical shape at the ends, 37.31-48.95 x 5.07-8.95 µm; **pycnidia** absent.

Chemistry: no lichen substance detected; Thallus K+ yellow, C-, PD-.

Specimen Examined: S. Falab-203

Porina eminentior (Nyl.) P.M.McCarthy f. *eminentior*; Fl. Australia. 58A:126. 2001. Figure 5.13A, B

Thallus epiphloeodal, continuous, yellowish green, olive brown to pale green, dull, rugose to verruculose, corticate; **prothallus** absent; **photobiont** *Trentepohlia*, continuos; **perithecia** semi-erumpent to prominent, subglobose to globose, 0.27-0.48 mm diameter, concolourous with thallus, apex rounded; **ostiole** inconspicuous, brown, entire; **involucrellum** contiguous with the exciple, light brown, with crystals in clusters, 102.53-156.82 µm thick, containing algae, K+ red; **asci** obclavate to cylindrical with acuminate apices, 91.34-108.35 µm high; **hymenium** hyaline, inspersed with oil droplets; **paraphyses** simple, rarely branched at apices; **ascospores** 8 per ascus, densely muriform, ellipsoid to fusiform, acuminate ends, halonate, with 15-17 transversely septa and 1-4 longitudinal septa, diagonal lumina, 38.50-60.00 x 11.94-23.28 µm; **pycnidia** absent.

Chemistry: no lichen substance detected; Thallus K+ yellow, C-, PD-.

Specimen Examined: S. Falab-199

13. PYRENULACEAE

Pyrenula Ach.

Thallus corticate or not, with or without whitish pseudocyphellae, usually surrounded by a black hypothallus; **ascomata** perithecioid, solitary or with fused walls and/or ostioles; **ascomatal wall** usually completely carbonised, with a distinct clypeus, with or without crystals; **hamathecium** inspersed with oil droplets or not, IKI– or IKI+ blue or orange; **asci** without an ocular chamber; **ascospores** 2–8 per ascus, pale to dark brown or grey, distoseptate but with at least some indication of eusepta in most transverse distosepta, with at least 3 transverse septa, with or without longitudinal septa, if present, the ascospores submuriform to densely muriform; **conidiomata** pycnidial, rare.

Pyrenula confinis (Nyl.) R.C.Harris.; Bibl. Lichenol. 70:226. 1998; Tropical Bryology 18: 195. 2000; Bibl. Lichenol. 97: 97. 2008; Fl. Australia. 57:462. 2009; The lichenologist 44 (1): 2012. Figure 5.13C, D

Thallus ecorticate, endophloeodal, white, UV+ yellow, without pseudocyphellae; **perithecia** solitary, black, globose to subglobose, erumpent from the substratum, side often covered by thallus, c. 0.30-0.60 mm diameter; **perithecial wall** without crystal, c. 100 µm thick; **ostiole** apical, black; **hamathecium** inspersed with oil droplets; **paraphyses** simple and sparsely branched; **asci** cylindrical, 114-120 µm tall; **ascospores** 8 per ascus, uniseriate, grey brown, 1-septate, clavate, 6.26-9.25 x 16.11-19.70 µm, ornamented, septum submedian, upper cell much wider than lower cell; **coniomata** absent.

Chemistry: yellow pigment of lichenxanthone detected with TLC.

Specimen Examined: S. Falab-059, 287

Pyrenula fetivica (Krempelh.) Müll. Arg. The lichenologist 44:27. 2012. Figure 5.13G, H

Thallus ecorticated, greenish white to white, UV-, with pseudocyphellae; **perithecia** numerous, solitary, black, globose, prominent from the substratum, sometimes lay down in irregularly direction; basal partly covered by thallus, c. 0.27-0.32 mm diameter; **perithecial wall** without crystals, 106.15-132.69µm thick; **ostiole** apical, pale white; **hamathecium** not inspersed, hyaline; **paraphyses** simple or rarely branched at apices; **asci** cylindrical, c.130 µm tall; **ascospores** 8 per ascus, uniseriate, grey brown to dark brown, 1-septate, thick -walled, elliptic, with pointed ends, 10.14-12.53 x 20.59-27.46 µm, **coniomata** absent.

Chemistry: no lichen substance detected.

Specimen Examined: S. Falab-372

Pyrenula interducta (Nyl.) Zahlbr. The lichenologist 44:29. 2012. Figure 5.14A, B

Thallus corticated, yellowish green, pale yellow to pale brown, UV-, waxy, without pseudocyphellae; **perithecia** numerous, solitary, black, conical to subglobose, prominent from the substratum, almost completely covered by thallus, c. 0.58-0.84 mm diameter; **perithecial wall** without crystals, 106.15-132.69µm thick; **ostiole** apical, pale brown; **hamathecium** not inspersed, hyaline; **paraphyses** simple; **asci** cylindrical, c.137.31-147.46 µm tall; **ascospores** 8 per ascus, uniseriate, grey brown, 4-5 septate, thick -walled, elliptic, with pointed ends, luminar angular, 15.22-17.31 x 42.08-49.55 µm, **coniomata** absent.

Chemistry: no lichen substance detected; hamathecium K+ red.

Specimen Examined: S. Falab-074, 075, 076, 077, 078, 271, 317, 322, 368

Pyrenula leucostoma Ach.; Bibl. Lichenol. 70:228. 1998; Bibl. Lichenol. 97:106. 2008; The lichenologist 44 (1): 16. 2012. Figure 5.13E, F

Thallus corticated, brownish to greenish brown, UV-, with pseudocyphellae; **perithecia** numerous, solitary, black, globose, semi-immersed from the substratum, side partly covered by thallus, c. 0.30-0.53 mm diameter; **perithecial wall** with crystals, c. 120 µm thick; **ostiole** apical, pale white; **hamathecium** not inspersed, hyaline; **paraphyses** simple; **asci** cylindrical, 108.05-154.02 µm tall; **ascospores** 8 per ascus, biseriate, grey brown, muriform with c. 7-8 rows of c. 3-5 locelli, elliptic, oblong to fusiform with round ends, luminar angular, 11.04-17.31 x 33.43-56.41 µm, **coniomata** absent.

Chemistry: no lichen substance detected.

Specimen Examined: S. Falab-083, 084, 085, 241, 242, 243, 251, 252, 298, 299, 315, 316, 356, 354

Pyrenula leucotrypa (Nyl.) Upreti. The lichenologist 44 : 24. 2012. Figure 5.14C, D

Thallus corticated, pale green or yellowish green, UV-, dull, with pseudocyphellae; **perithecia** numerous, aggregated in group of 3-8, black, globose to subglobose or irregularly shape, semi-erumpent from the substratum, partly completely covered by thallus, c. 0.29-0.77 mm diameter; **perithecial wall** without crystals, c. 70 µm thick; **ostiole** lateral, pale white to black; **hamathecium** not inspersed, hyaline; **paraphyses** simple; **asci** cylindrical, c.123.28-140.29 µm tall; **ascospores** 8 per ascus, uniseriate, hyaline, 3-4 septate, thin -walled, elliptic, with pointed ends, locular lenticular, 7.76-10.14 x 21.49-26.86 µm, **coniomata** absent.

Chemistry: no lichen substance detected.

Specimen Examined: S. Falab- 060, 062, 063, 064, 327, 328, 366, 392, 409, 449, 450, 454, 473, 614, 615, 616

Pyrenula ochraceoflava (Nyl.) R. C. Harris.; Bibl. Lichenol. 70:229. 1998; The lichenologist 44: 13. 2008; Fl. Australia. 57:472. 2009. Figure 5.14E, F

Thallus corticated, yellow to orange or pale orange, with rusty orange patches, without pseudocyphellae, UV+ yellow-orange; **perithecia** numerous, solitary, black, subglobose to globose, erumpent from the substratum, almost completely covered by thallus, c.

0.27-0.65 mm diameter; **perithecial wall** without crystals, c. 130 µm thick; **ostiole** apical, pale brown to brown; **hamathecium** not inspersed, hyaline; **paraphyses** simple; **asci** clavate, 68.05-74.62 µm tall; **ascospores** 8 per ascus, irregularly biseriate, grey brown, submuriform to muriform with c. 4-5 rows of c. 2-3 locelli, oblong to ellipsoid with round ends, luminar rounded, 8.05-11.04 x 16.71-22.08 µm, **coniomata** absent.

Chemistry: Atranorin, fatty acid; thallus K+ red, C+ orange, KC-, P-.

Specimen Examined: S. Falab-086, 087, 088, 089, 090, 091, 092, 093, 094, 269, 270, 274, 275, 321, 369, 406, 410

14. ROCELLACEAE

Enterographa Fée

Thallus crustose growth habit; **photobiont** *Trentepohlia* or *Phycopeltis*; **ascomata** rounded to elongate or punctiform, most usually immersed in the thallus; **exciple** poorly developed; **hamathecium** of branched and anastomosing paraphysoids; **asci** ellipsoid to cylindrical-clavate of the *Opegrapha*-type; **ascospores** usually fusiform with thin septa and perispore, without enlarged terminal cells; **conidiomata** punctiform, and bacilliform or filiform microconidia.

Enterographa subserialis (Nyl.) Redinger.; Bibl. Lichenol. 89:60. 2004. Figure 5.14G, H

Thallus corticated, pale green, olive green to yellowish green, 3-5 cm diameter, 217.13-306.40 µm thick; **photobiont** *Trentepohlia*, with crystals, (66.34) 125.45-165.26 µm thick; **medulla** white, c. 100 µm thick; **ascomata** punctiform, 0.05-0.1 mm diameter, arranged in groups of 8-12 inpseudostromata, visible as punctiform, brownish spots; **pseudostromata** rounded or irregular in outline, convex, c. 0.3 mm diameter, up to 100 µm high, surface grayish green to whitish, not constricted at base; **excipulum** very thin, c. 5 µm wide, pale straw ;**hypothecium** 10-15 µm high, pale straw, K-; **hymenium** hyaline, I+ blue, 50–60 µm high; **hamathecium** of paraphyses branched and anastomosing, not swollen apically; **epithecium** indistinct grey; **asci** of the *Opegrapha*-type, clavate, bitunicate, 68.05-77.61 x 11.34-14.02 µm, with apical KI+ blue ring; **ascospores** 3-4 per ascus, 2-3septate, fusiform, with rounded ends, the median cell slightly enlarged, 36.71-54.92 x 2.08-3.58µm, not constricted at the septa; **conidiomata** absent.

Chemistry: unknown substance 2; thallus K+ yellow, C-, KC-, P-.

Specimen Examined: S. Falab-177

Enterographa tropica Sparrius.; Bibl. Lichenol. 89: 61**.** 2004. Figure 5.15A, B

Thallus corticated, pale grey to greenish grey, grayish hair covered around ascomata, 2-4 cm diameter, c. 200 μm thick; **photobiont** *Trentepohlia*, with crystals, c. 100 μm thick; **medulla** pale white, loosely packed, c. 100 μm thick; **ascomata** punctiform, 0.3-0.5 mm diameter, arranged in groups of 7-10 inpseudostromata, visible as punctiform, brownish spots; **pseudostromata** rounded in outline, convex, hairy, c. 0.5 mm diameter, up to 60 μm high, surface grey to whitish grey, not constricted at base; **excipulum** very thin, c. 5 μm wide, pale straw; **hypothecium** 10–15 μm high, pale straw, K–, I+ blue rapidly turning red, KI-; **hymenium** hyaline, I+ blue rapidly turning red, KI-, 50.74-73.13 μm high; **hamathecium** of paraphyses branched, amatomosing, not swollen apically; **epithecium** indistinct brown; **asci** of the *Opegrapha*-type, clavate, bitunicate, 47.76-51.91 μm high, with apical KI-; **ascospores** 3-5 per ascus, 4 septate, fusiform, with rounded ends, unequal size of two ends, locular larger at one end, 17.31-20.59 x 3.58-5.07 μm, not constricted at the septa; **conidiomata** absent.

Chemistry: Norstictic acid; thallus K+ yellow, C-, KC-, P-.

Specimen Examined: S. Falab-178

15. THELENELLACEAE

Julella Fabre

Thallus thin; perithecia black, immersed; anatomosing paraphyses; **spores** not ornamented, hyaline, muriform, relatively thin walled.

Julella vitrispora (Cooke & Harkness) M. E. Barr.; Sydowia, Annales Mycologici Ser. II. 38:13. 1985. Figure 5.15C, D

Thallus ecorticate, endophloeodal, dull white, UV-; **perithecia** solitary, flat ovoid, immersed, 0.50-1.0 mm diameter; ostiole apical; **hamathecium filaments** thin, not inspersed, anastomosing; asci cylindrical, c. 100 μm tall; **ascospores** 8 per ascus, uniseriate, hyaline, gelatinous coating, muriform, IKI-, ovoid to long clavate or ellipsoidal, 5.97-9.85 x 22.38-30.14 μm ; **coniomata** absent.

Chemistry: no lichen substance detected.

Specimen Examined: S. Falab-179, 197, 198, 200, 201, 265, 206, 207, 266, 288, 320, 372

16. THELOTREMATACEAE

Leptotrema Mont. & Bosch

Thallus thick, epiphloeodal, pale greenish grey, with a protocortex; **photobiont** trentepohlioid; **prothallus** thin to indistinct, pale to rather dark brown; **ascomata** ±rounded, perithecioid or apothecioid, solitary, immersed; **proper exciple** non-amyloid, hyaline internally to yellowish or orange-brown marginally; **hymenium** non-amyloid, not inspersed, conglutinated; **paraphyses** with thickened apices, straight to slightly bent, parallel to somewhat interwoven; lateral paraphyses and true columella absent; **epihymenium** hyaline, egranulose or granulose; **asci** 8 per ascus, clavate, non-amyloid; **ascus** apex and walls uniformly thin; **ascospores** 1–2-seriate, submuriform to muriform, non-halonate, hyaline to brown, non-amyloid to faintly amyloid; **conidiomata** pycnidial, with bacilliform conidia.

Leptotrema wightii (Taylor) Müll. Arg.; Bibl. Lichenol. 70:157. 1998; Fl. Australia. 57: 244. 2009. Figure 5.15E, F

Thallus epiphloeodal, bulging and flaking away from the substratum, pale greenish grey to pale green, dull, smooth, continuous, forming a grainy-speckled pattern, usually not rimose; **protocortex** continuous; **algal layer** continuous, with crystal inclusions, large, clustered; **medulla** with conspicuous bright red anthraquinone crystals, forming a lower cortex-like layer; **vegetative propagules** not seen; **ascomata** inconspicuous, 0.42-0.71mm diameter, rounded to ellipsoid, apothecioid, solitary, immersed; **disc** usually not visible from above, pale to dark brown, epruinose; **pores** small to broad, 0.04-0.08 mm diameter, rounded to slightly irregular, with entire margin; **apical proper exciple** becoming visible from above, free inner pore margin, incurved and usually sunken, off-white; **thalline rim** margin thick, entire, brighter than the thallus, pale green to white; **proper exciple** mainly fused to slightly detached, becoming distinctly free only in old gaping ascomata, thick, hyaline internally to yellowish or orange-brown marginally, non-amyloid; **hymenium** to 185.77-197.83 µm thick, strongly conglutinated; **paraphyses** straight, sparingly branched towards the apical hymenium; **epihymenium** hyaline to fine greyish granules; **ascospores** submuriform to muriform, subglobose to oblong, the ends rounded, red brown to dark brown, amyloid, 24.77-35.52 x 13.43-19.10 µm, with 3–5 x 1–3 locules; locules rounded; septa thin, with distinct a central septum; **pycnidiomata** globose to irregular shape but pycnidia not seen.

Chemistry: Panaric acid, red pigment detected by TLC; Thallus K+ pale yellow, with K+ purple with crystals, C-, PD-; exciple PD+ red.

Specimen Examined: S. Falab-023, 226, 231, 349, 377, 397.

Leucodecton A. Massal.

Thallus endophloeodal to epiphloeodal, usually pale, with shades of grey or green and olive, yellowish or whitish tones, sometimes with a grainy-speckled surface pattern, ecorticate, or with a protocortex, very rarely with true cortex; **photobiont** trentepohlioid; **prothallus** thin to indistinct, brown; **ascomata** ±rounded to slightly irregular, sometimes distinctly irregular or angular, apothecioid or perithecioid, solitary to marginally fused, sometimes also distinctly fused and clustered and forming stroma-like structures; **proper exciple** completely free, rarely fused, non-amyloid, rarely faintly amyloid basally, hyaline to pale yellowish, rarely pale brownish internally, yellowish or brownish, rarely greyish marginally, apically sometimes rather dark brown to slightly carbonized; **hymenium** non-amyloid, not inspersed, conglutinated; **paraphyses** straight to ±bent, distinctly interwoven, sparingly branched towards the margins, the tips thickened; **lateral paraphyses** and **true columella** absent, but columella-like structures sometimes present in fused ascomata; **epihymenium** hyaline, with greyish to brownish granules, often with small crystals; **asci** (1–) 8-spored, clavate, nonamyloid; **ascospores** 1-2-seriate, submuriform to muriform or transversely septate, hyaline or brown, non-amyloid to amyloid; **conidiomata** pycnidial, with obovate to fusiform or bacilliform conidia.

Leucodecton albidulum (Nyl.) Mangold; Fl. Australia. 57:247. 2009. Figure 5.15G, H

Thallus endophloeodal, pale grey to grey green, dull, smooth, pruinose, continuous; **cortex** and **protocortex** absent; **photobion**t continuous, with abundant crystal, clustered; **vegetative propugule** absent; **ascomata** inconspicuous, 0.55-1.44 mm diameter, rounded to irregular, apothecoid, solitary or sometime fused, prominent; **disc** completely visible from above, grayish-pruinose; pores broad, 0.24-0.67 mm diameter, proper exciple, apex of proper visible from above, free, rounded or irregular, entire, white, shrunken, erect; **thalline rim margin** thin, rounded or irregular, entire, concolourous or slightly brighter with thalllus; **proper exciple** free, pale grey, non-amyloid; **hymenium** brown, 128.65-139.40 µm thick, moderately conglutinated; **paraphyses** straight, sparsely branched; **epihymenium** with grayish granules to black; **asci** 8 spore per ascus, thicked tholus, clavate; **ascospores** hyaline, transversely septate, elliptic, oblong to fusiform with acute ends, 12-15 loculate, slightly amyloid, luminar lentiform, septa thin, non-halonate, 42.08-58.20 x 8.65-11.04 µm; **pycnidia** absent.

Chemistry: no lichen substance detected, fatty acid; thallus K+ yellow, C+ pale yellow, PD–; exciple PD+ red.

Specimen Examined: S. Falab-006, 007, 008, 009, 010, 011, 012, 013, 014, 015, 016, 017, 018, 019, 020, 170, 171, 172, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 204, 205, 216, 217, 218, 219, 220, 223, 224, 225, 227, 228, 229, 230, 348, 350, 351,376, 395, 396, 400, 402, 405, 427, 428, 446, 448, 461, 462, 472, 482, 491, 492, 493, 500, 546, 547, 548, 549, 550,

Myriotrema Fée

Thallus endophloeodal to epiphloeodal, usually a shade of olive or grey, with greenish to yellowish or whitish tones; **true cortex** and **protocortex** present; **photobiont** trentepohlioid; **prothallus** thin to indistinct, pale to darkish brown; **ascomata** ±rounded, rarely ±irregular, elongate or lirelliform, perithecioid or apothecioid, solitary to fused, rarely forming stromalike structures; **proper exciple** non-amyloid to amyloid basally, hyaline to pale yellowish, rarely orange internally, yellowish to reddish or greyish to brownish marginally, apically often darkened or covered by granules; **hymenium** non-amyloid, usually not inspersed, rarely inspersed, conglutinated; paraphyses often with ±thickened apices, distinctly or irregularly septate, usually ±bent and interwoven, occasionally parallel, often ±richly branched; **lateral paraphyses** and true columella absent, but fused ascomata often with columella-like structures; **epihymenium** hyaline, with or without granules; **asci** (1–) 8-spored, clavate, wall and apex non-amyloid; **ascospores** 1–2-seriate, transversely septate to submuriform or muriform, hyaline to brown, amyloid or non-amyloid, halonate or not; **conidiomata** pycnidial, with fusiform or bacilliform conidia.

Myriotrema microporum (Mont.) Hale; Bibl. Lichenol. 70:156. 1998; Fl. Australia. 7:269. 2009. Figure 5.16A, B

Thallus endophloeodal pale grey, greenish grey, whitish grey to yellowish brown, dull, smooth, continuous, 176.12-215.93 μm thick; **true cortex** continuous, hyaline, thin, with a very thin protocortex, c.10 μm; **photobiont** continuous, 66.34- 100.12 μm thick with scattered crystals; **medulla** white to pale cream, with crystals, 159.23-205.07 μm thick; **vegetative propagules** absent; **ascomata** apothecioid, abundant, rounded, solitary, immersed, c.0.3 mm diameter; **disc** not visible from above, epruinose; **pores** small, to c. 23.67-48.74 μm diameter, rounded to irregular; **proper exciple** completely visible from above, off-white, shrunken, incurved; **thalline rim** margin becoming rather broad, rounded, thin, entire, planed to slightly raised, whitish or brighter than the thallus; **hymenium** 53.43-73.82 μm thick, not inspersed, moderately conglutinated; **paraphyses** somewhat irregular, ±interwoven, with slightly thickened tips; **lateral paraphyses** lacking; **columella** absent; **epihymenium** hyaline to pale grey, thin; **asci** thin, cylindrical, 73.13-85.67 μm high; **ascospores** 8 per ascus, transversely septate, 3-4 septates, subglobose to ellipsoidal with rounded ends, hyaline, strongly amyloid, 8.65-15.52 × 4.17-5.97 μm, with 3-4 locules; locules lentiform, with hemispherical end cells, septa thin, regular; **pycnidia** absent.

Chemistry: Psoromic acid, Hypostictic acid, fatty acid; cortex K-, C-, PD+ orange; medulla K+ yellow, C-, PD+ orange.

Specimen Examined: S. Falab-005

Stegobolus Mont.

Thallus corticolous, rarely on bryophytes or decomposed bark, corticate, pale to dark oliveg-grey, olve-fawn, olive-brown or olive, continuous to fissured or more rarely fissured-areolate, c. 0.03-0.4 mm thick, with a compact, smooth to strongly verruculose or warty, glossy, cartilaginous or crystalline surface; **prothothallus** line thin, brownish;

photobiont layer 25-80 µm thick, continuous, with scattered to dense photobiont cells, usually few to numerous calcium oxalate crystals, and and often filled with a dense, finely granular gelatinous matrix; **medulla** up to 400 µm thick, epiphloeodal or endophloeodal; **phenocortex** continuous, hyaline to pale brown, 3-55 µm thick, strongly conglutinated,often splitting internally, formed of predominantly periclinal hyphae; **isidia** cylindrical, slightly branched; **soralia** irregular, maculate soralia on thallus and apothecial margin, powdery to subgranular; **apothecia** *Ocellularia*-type, dispersed, rounded, lobate, elongated, long lirelliform or stellate-branched, c. 0.5-4 mm wide and up to 15 mm long, columellate, carbonised or not; **columella** broad stumpshaped, lobate or densely reticulate, in some species replaced or supplemented by a deep radial-fissured hymenium; **columella** and the fused proper exciple pale brown to brown or black, usually with a thin to thick, compact to felty, white, brown; **apothecial disc** (or the partial hymenia) flesh-coloured to dark, covered by a thin white pruina; **proper exciple** *Ocellularia*-type, cupular, fused, pale brown to brown or carbonised, few to numerous small oxalate crystals are usually included in the massive portions of the proper exciple, mostly concentrated in the upper half; **hypothecium** is c. 10-25 µm thick, rarely up to 115 µm thick and then usually layered, hyaline to brown (seldom carbonised) and formed of ± parallel, interwoven, prosoplectenchymatic hyphae that are thinner, c. 1.5-2 µm diam., and less conglutinated than in the lateral exciple; **hymenium** 70-135 µm high, clear, I–; **epihymenium** 7-12 µm high, unpigmented, slightly inspersed by the fine granules adspersed to the tips of the paraphyses and a few small oxalate crystals;**paraphyses** 1.5-2.5 µm diameter, simple, straight, strongly conglutinated, with a single slightly thickened apical cell adspersed with fine greyish to brownish granules;
asci narrowly clavate, 65-130 x 8-15 µm, *Thelotrema*-type, I–; **ascospore** 8 per ascus, 1-2-seriate, small or of moderate size, hyaline or brown, transversely septate to submuriform, 9-37 x 5-11 µm, with acute to subacute or rounded ends, with or without a distinct ornamentation of undulating ridges, **I+** purplish-blue (in brown ascospores observable only in the young stages); **pycnidia** thelotrematacean-type, c. 0.1-0.3 mm diam., with a single, rarely up to three, rounded to seldom elongated pores; **conidia** (3.5-)5-9 x 1-1.2(-1.5) µm, are bacilliform or short bacilliform.

Stegobolus crassus (Müll. Arg.) Frisch.; Molecular phylogeny of the Thelotremataceae 450. 2006. Figure 5.16C, D

Thallus corticolous, corticate, olive-grey, grey-olive to greenish grey, smooth to slightly rugose, compact and glossy; **prothallus** thin, indistinct black; **phenocortex** periclinal hyphae, 14.47-36.18 µm thick; **photobiont** continuous, with crystals, 106.15-143.55 µm thick; **medulla** a thin white, with large oxalate crystals, partly endophloeodal 174.91-212.31 µm thick; **apothecia** emergent, rounded to broad ellipsoid, sometimes fused in group of 2; 0.31-1.14 mm diameter; concolorus to brighter than the thallus,entire, the inner surface brown to black; **pore** rounded to angular, the disc usually visible from above; **collumella** entire, flat, brownish-black, thin toward tip, ; **disc** dark, covered by a thin white pruina; **proper exciple** pale brown to carbonised at the base, laterally 30-100 µm wide, carbonised to the base; **epihymenium** hyaline, 13.26-18.09 µm high; **subhymenium** c. 25.33-34.98 µm high; hymenium 107.36-147.17 µm high, clear; **asci** narrowly clavate, 100 ×15 µm; paraphyses simple, straight, slightly swollen at apices; **ascospores** 8 per ascus ,uniseriate, brown, submuriform, 3-5 x 1-3 loculate, 17.61-27.46 x 10.44-16.41 µm, with rounded ends, I+ blue when young; **pycnidia** absent.

Chemistry: Psoromic acid, fatty acid; cortex K+ yellow, C+yellow, PD+ orange; medulla K+ yellow, C-, PD+ orange.

Specimen Examined: S. Falab-221, 222, 232, 347, 375, 378, 399, 401, 403

17. TRYPETHELIACEAE

Polymeridium (Müll. Arg.) R. C. Harris

Thallus crustose, white to yellowish or grey, ecorticate; **ascomata** perithecia, solitary, black, without pseudostomatic tissues, globose to pyriform, erumpent form the substratum; **ostiole** apical to lateral; **hamathecium** hyaline, occasionally inspersed with oil droplets; **ascospores** 8 per ascus, usually IKI-, rarely IKI+ violet, irregularly biseriate, hyaline, fusiform with subacute ends, symmetrically 3-13 septate, rarely muriform, not constricted at the septa, when immature surrounded by a thin gelatinous sheath, septa not thickened, lumina cylindrical, never becoming rounded or diamond-shaped; **conidiomata** rather rare.

Polymeridium siamense comb. Ined. Figure 5.16E, F

Thallus ecorticate, pale green to olive green; **perithecia** solitary, black, semi-erumpent, partly covered with thallus at base, globose, 0.41-0.52 mm diameter; **ostiole** apical, black; **hamathecium** hyaline, inspersed with oil droplets, branched paraphyses; **ascospores** 8 per ascus, uniseriate, IKI-, hyaline, ellipsoid to fusiform with acute ends, 4 septate or 1 septate when immature, lumina slightly rectangular, 8.05-10.14 x 18.20-25.07 µm; **conidiomata** absent.

Chemistry: no lichen substance detected.

Specimen Examined: S. Falab-079, 080, 081, 082

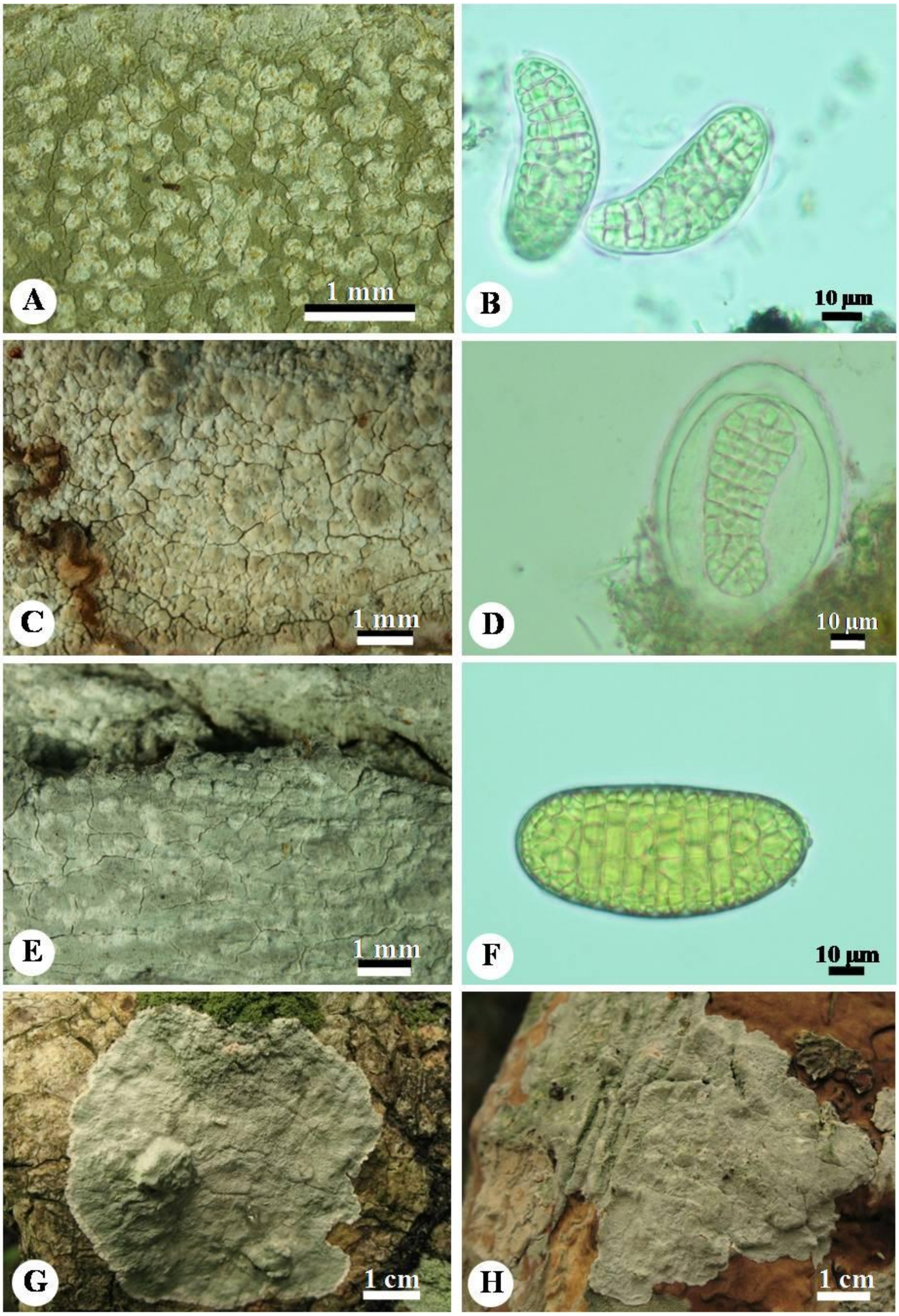

Figure 5.3 lichen species, *Cryptothecia aleurodes*: A. thallus, B. spores; *C. genuflexa*: C. thallus, D. spore; *C. monospora*: E. thallus, F. spore; *Cryptothecia* sp.: G., H. thallus.

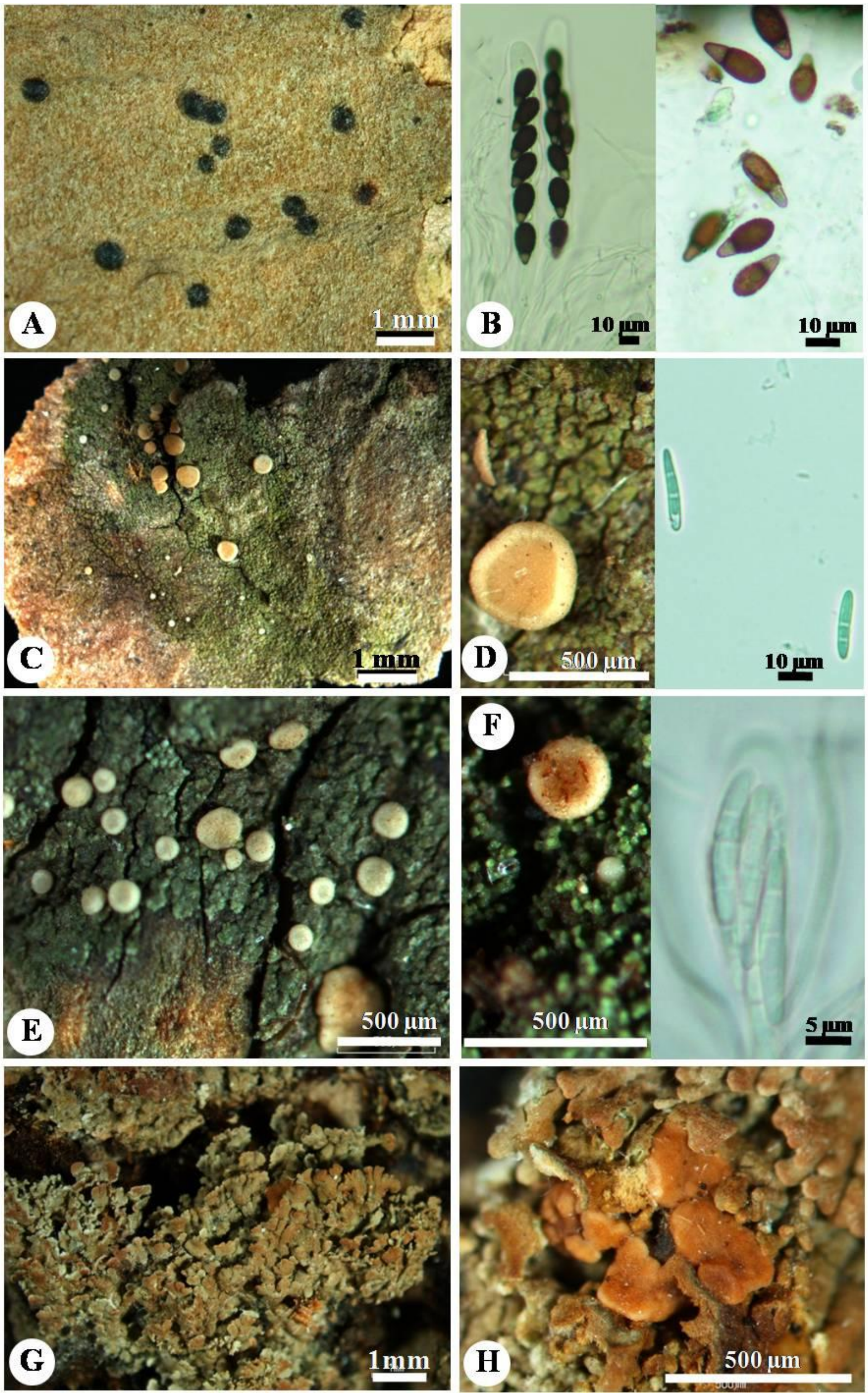

Figure 5.4 Lichen species, *Mycomicrothelia miculiformis*: A. thallus and perithecia, B. spores; *Bacidia incongruens*: C. thallus and apothecia, D. spore; *B. medialis*: E. thallus and apothecia, F. spores; *Phyllopsora corallina* (Eschw.) Müll. Arg. var. *coralline*: G. thallus, H. apothecia.

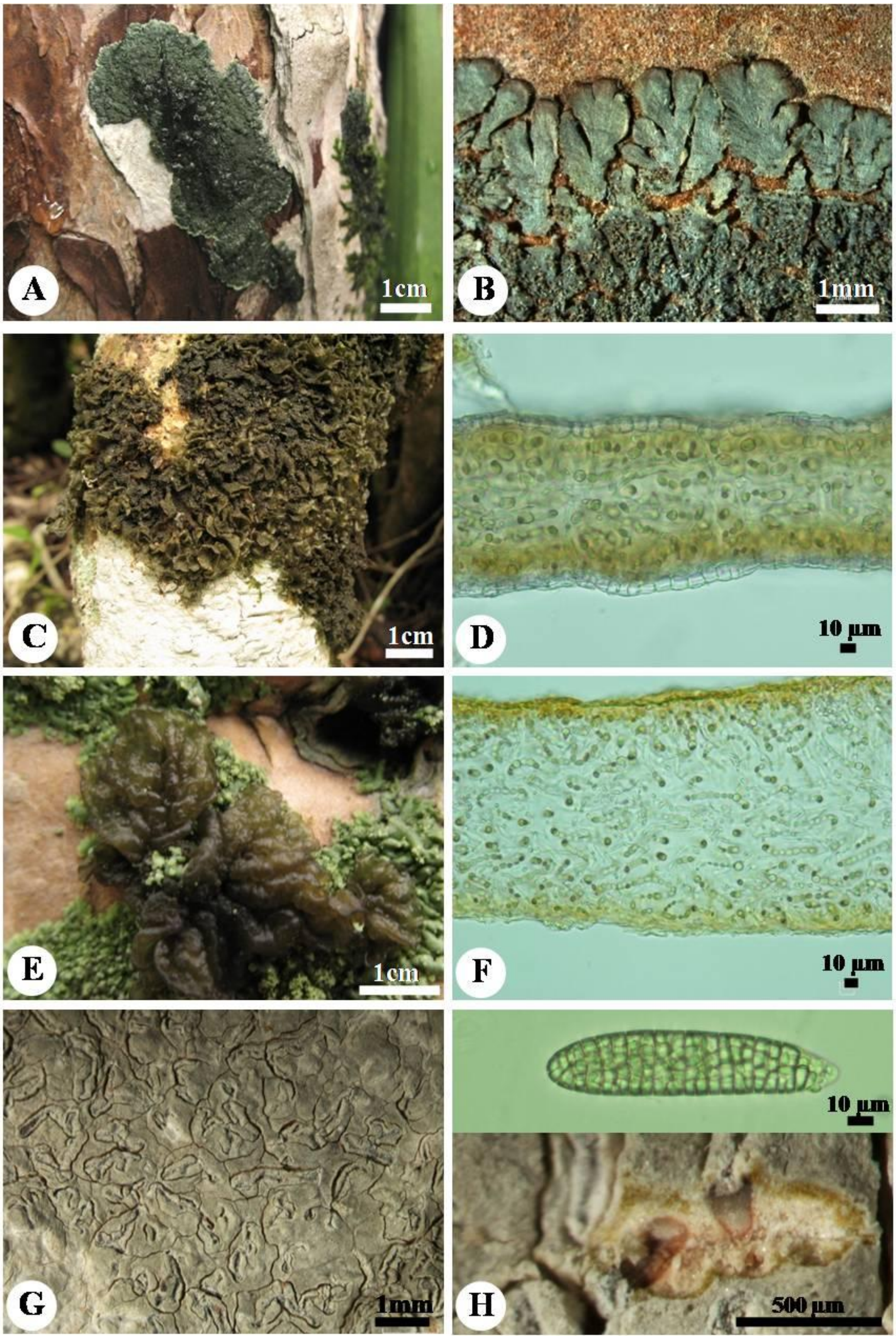

Figure 5.5 Lichen species, *Coccocarpia rottleri*: A. thallus, B. thallus and lobes; *Collema rugosum*: C. thallus, D. X-section of thallus; *Leptogium cyanescens*: E. thallus, F. X-section of thallus; *Diorygma junghuhnii*: G. thallus and apothecia, H. apothecia and spore.

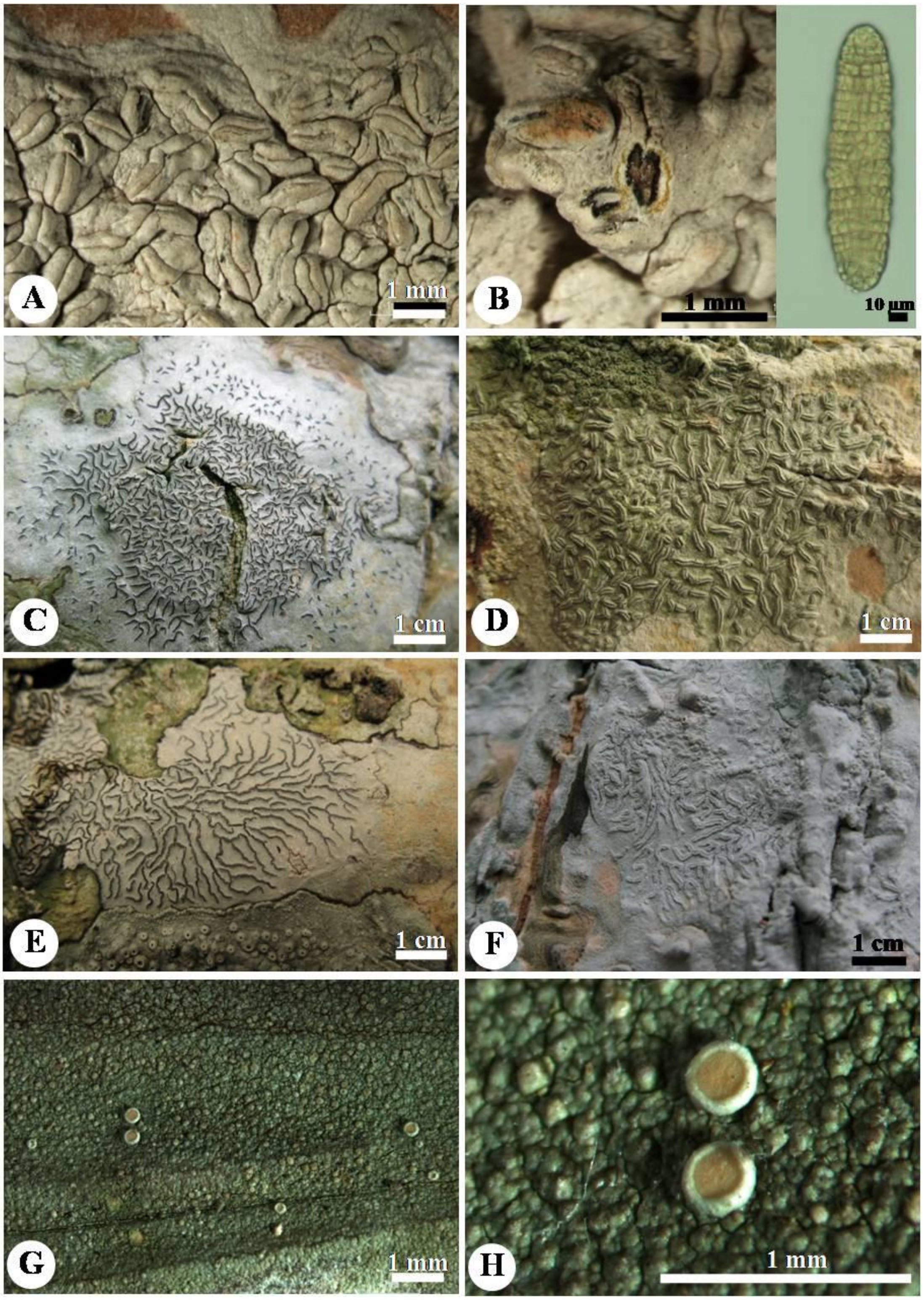

Figure 5.6 Lichen species, *Graphis rongklaensis*: A. thallus and apothecia, B. apothecia and spore; thallus of C. *Graphis immersella*; D. *G.immersella*; E. *G. longispora*; F. *G. insulana* ; *Lecanora arthothelinella* : G. thallus and spothecia, H. apothecia.

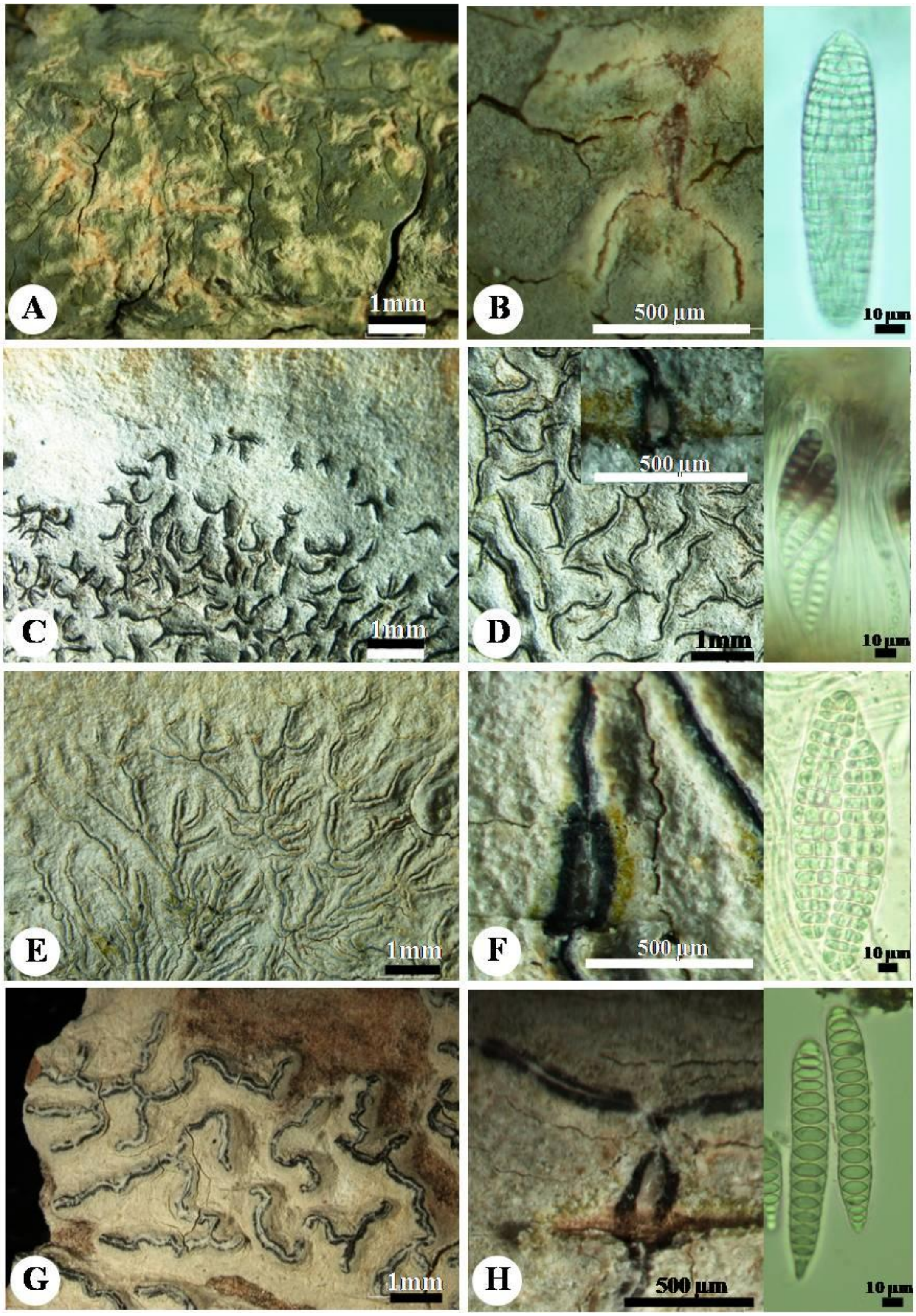

Figure 5.7 Lichen species, *Diorygma hieroglyphicum*: A. thallus, B. lips and spore; *Graphis immersella*: C. thallus and spothecia, D. lips and spores; *G. insulana* : E. thallus, F. lips and spores; *G. longispora*: G. thallus, H. lips and spores.

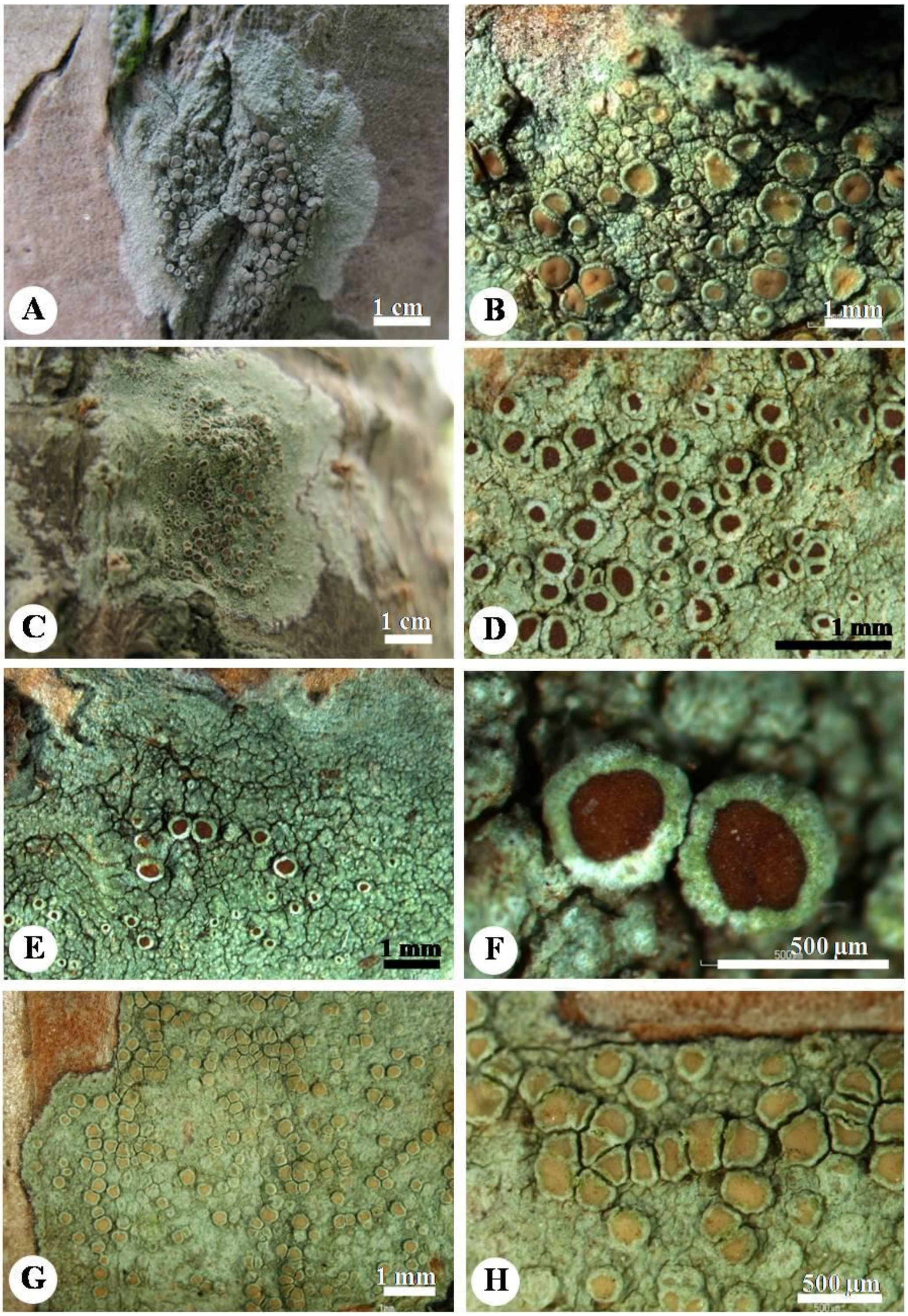

Figure 5.8 lichen species, *Lecanora austrotropica*: A. thallus and apothecia, B. apothecia and disc; *L. coronulans*: C. thallus and apothecia, D. apothecia and disc; *L. ecoronata*: E. thallus and apothecia, F. apothecia and disc; *L. leprosa*: G. apothecia and disc, H. apothecia and disc.

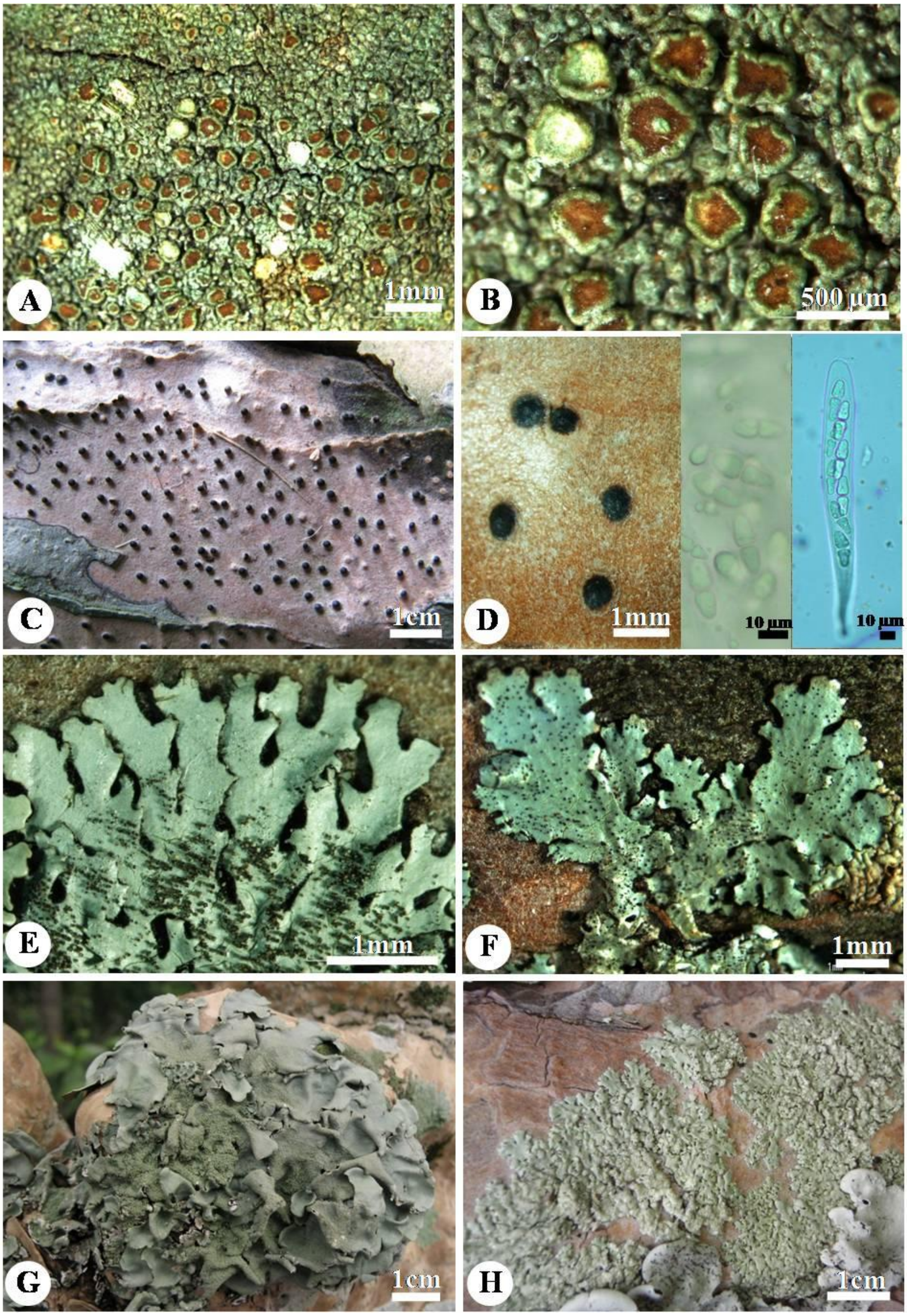

Figure 5.9 Lichen species, *Lecanora tropica*: A. thallus and apothecia, B. apothecia and disc; *Anisomeridium subprostans*: C. thallus and perithecia, D. perithecia and spores; *Bulbothrix queenslandica*: E. thallus and lobes; *B. goebellii*: F. thallus and lobes; *Parmotrema tinctorum*: G. thallus; *Relicinopsis malaccensis*: H. thallus.

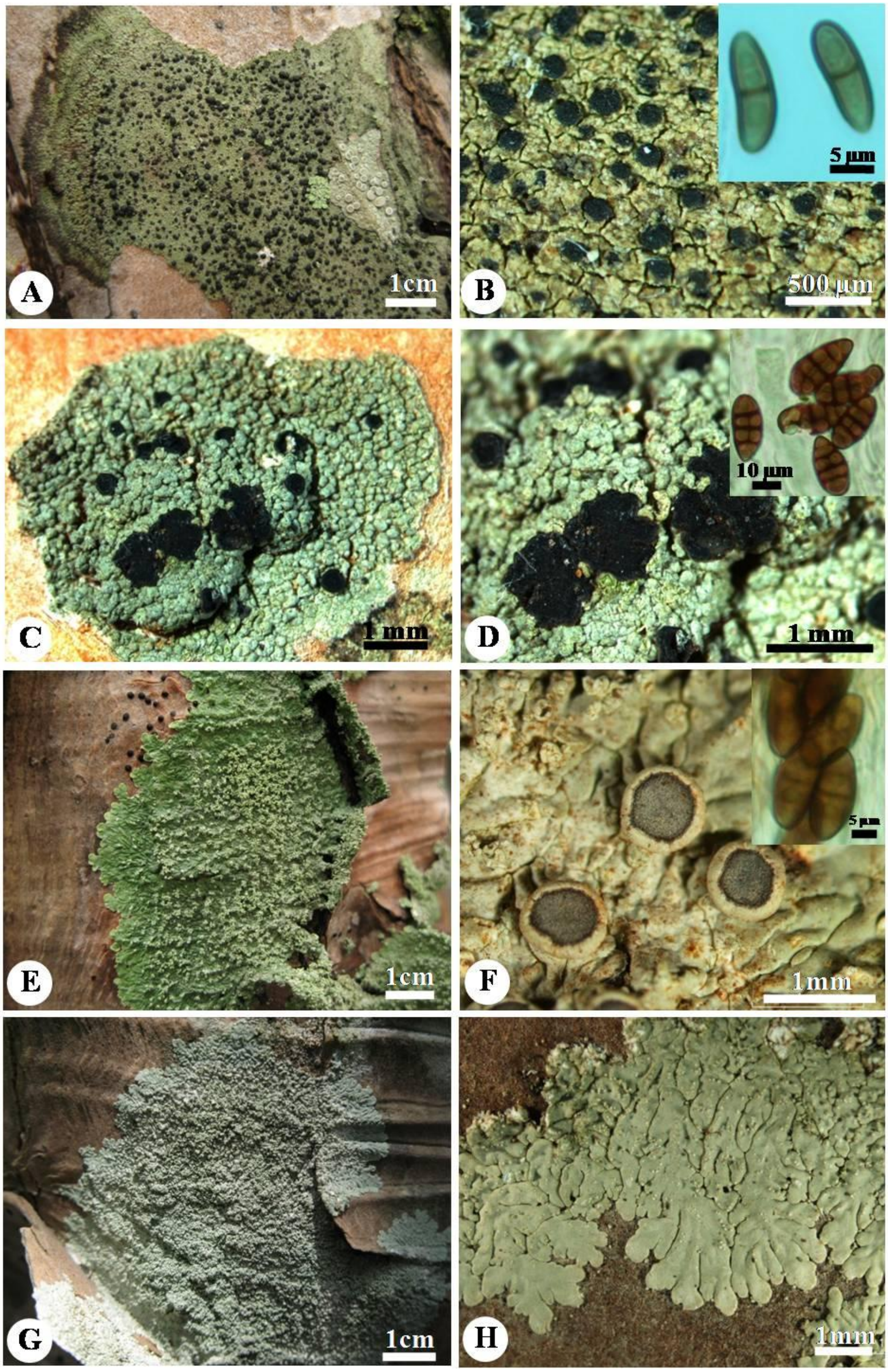

Figure 5.10 Lichen species, *Buellia schaereri*: A. thallus, B. apothecia and spores; *Diplotomma venustum*: C. thallus, D. apothecia and spores; *Dirinaria aegialita*: E. thallus with dactyls, F. apothecia and spores; *D. papillulifera*: G. thallus, H. thallus and lobes.

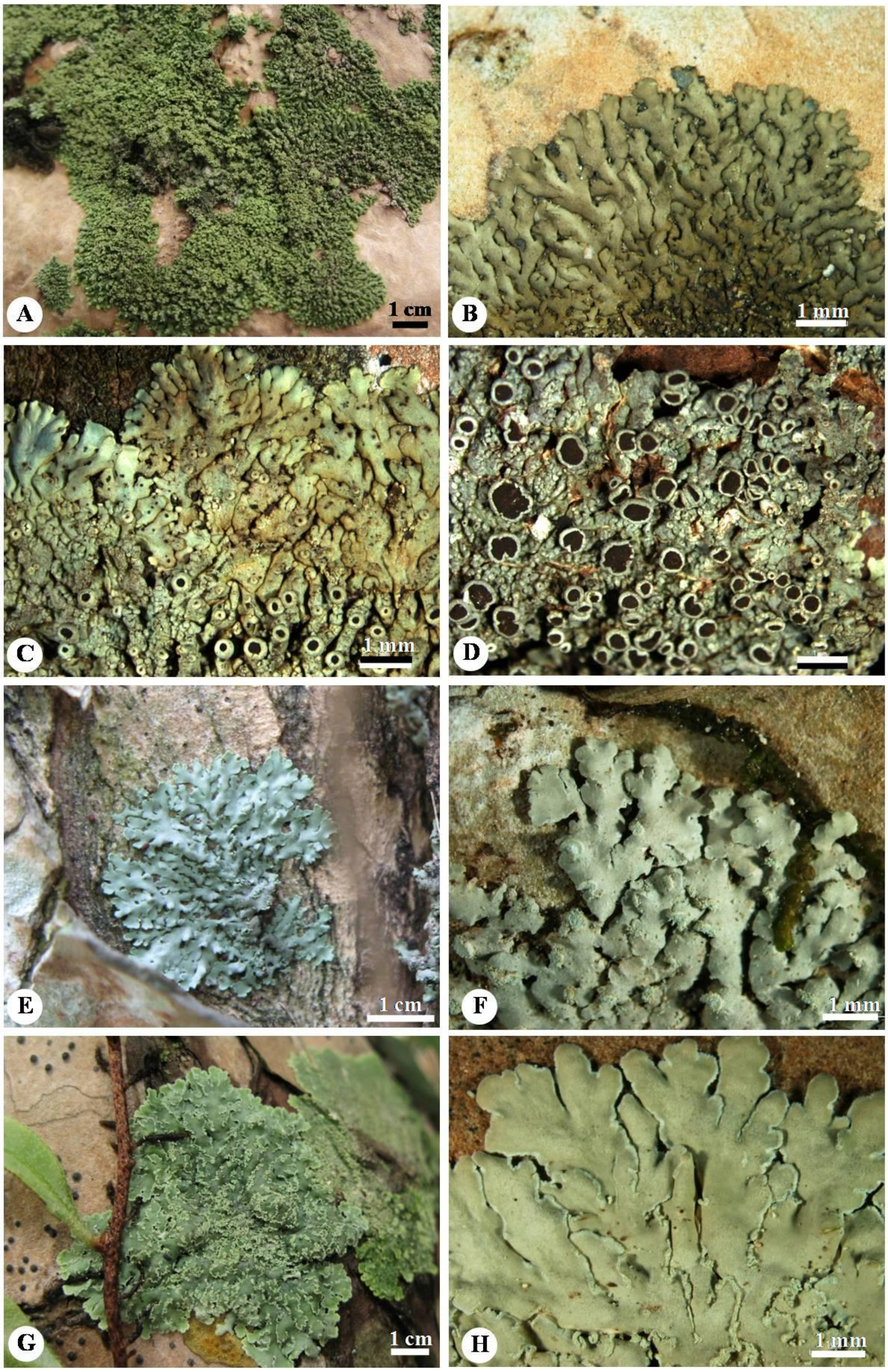

Figure 5.11 lichen species, *Hyperphyscia adglutinata*: A. thallus, B. lobes; *H. syncolla*: C. thallus, D. apothecia and spores; *Physcia nubila*: E. thallus, F. lobes; *Physcia undulata*: G. thallus, H. lobes and solaria.

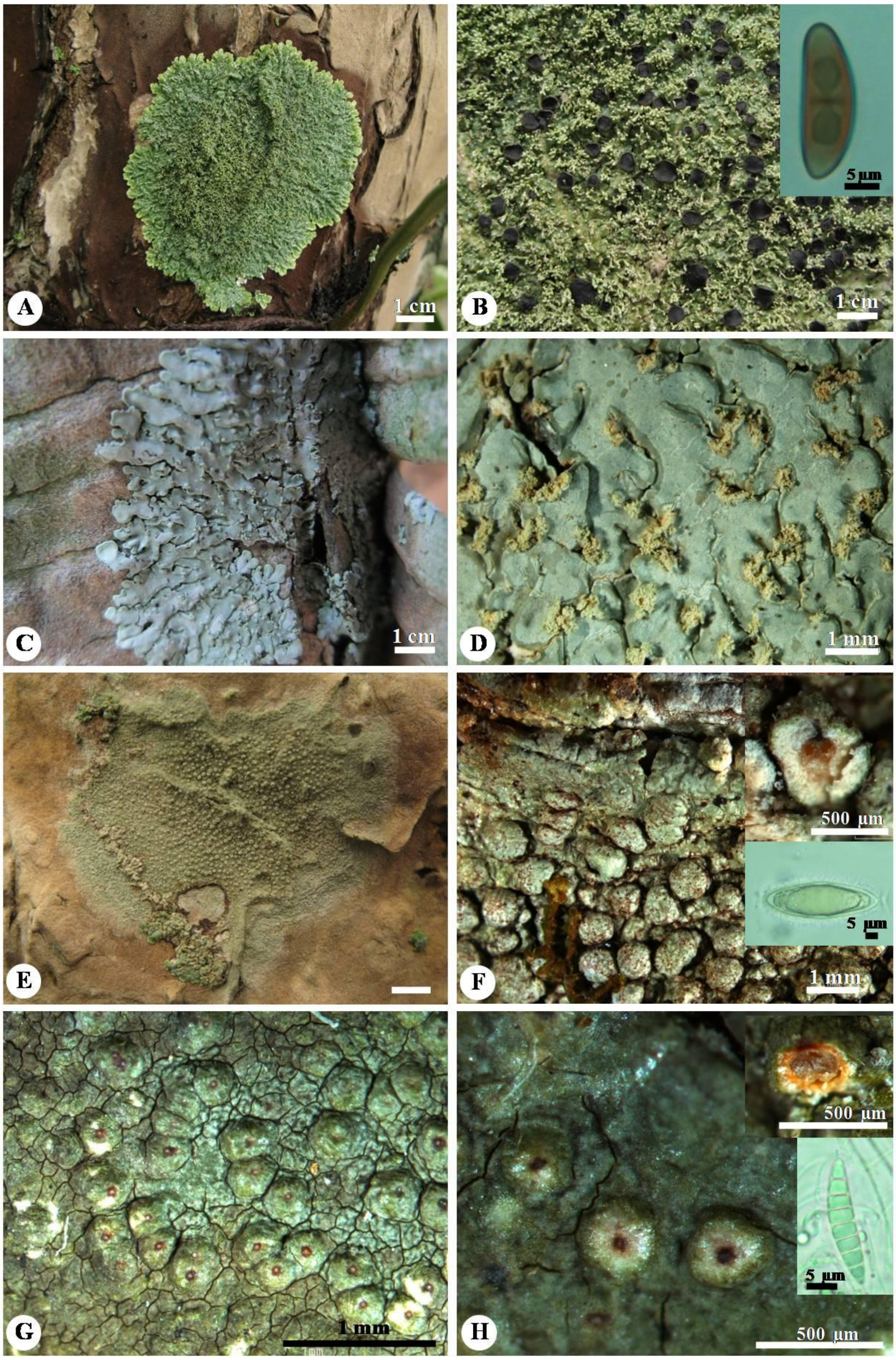

Figure 5.12 Lichen species, *Pyxine cylindrica*: A. thallus, B. apothecia and spores; *P. sorediata*: C. thallus, D. lobes and soralia; *Pertusaria endoxantha*: E. thallus, F. perithecia and spore; *Porina impolita*: G. thallus and perithecia, H. perithecia and spore.

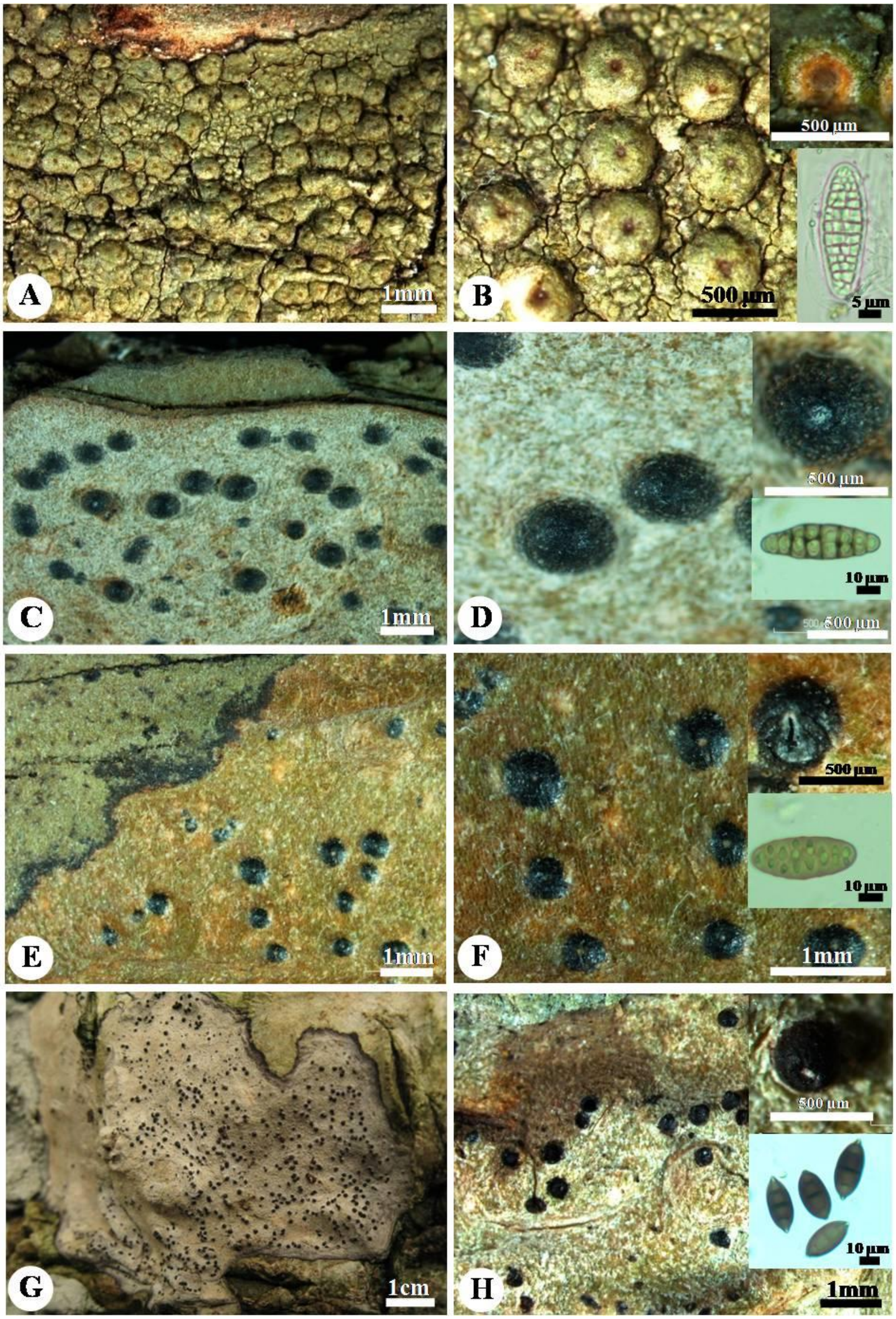

Figure 5.13 Lichen species, *Porina eminentior*: A. thallus, B. perithecia and spore; *Pyrenula confinis*: C. thallus, D. perithecia and spore; *P. leucostoma*: E. thallus, F. perithecia and spore; *P. fetivica*: G. thallus, H. perithecia and spores.

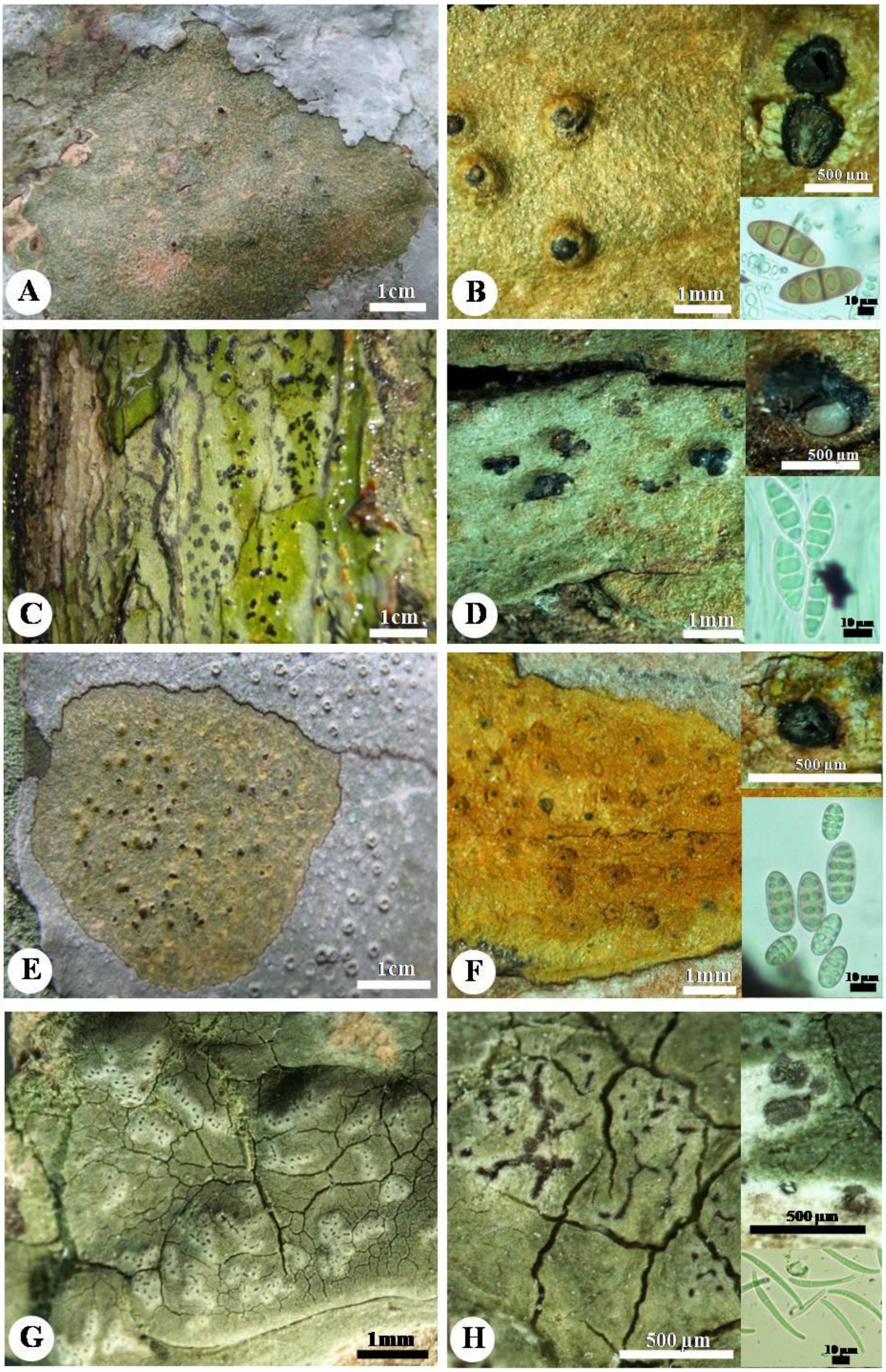

Figure 5.14 lichen species, *Pyrenula interducta*: A. thallus, B. perithecia and spores; *P. leucotrypa*: C. thallus, D. perithecia and spores; *P. ochraceoflava*: E. thallus, F. perithecia and spores; *Enterographa subserialis*: G. thallus, H. apothecia and spores.

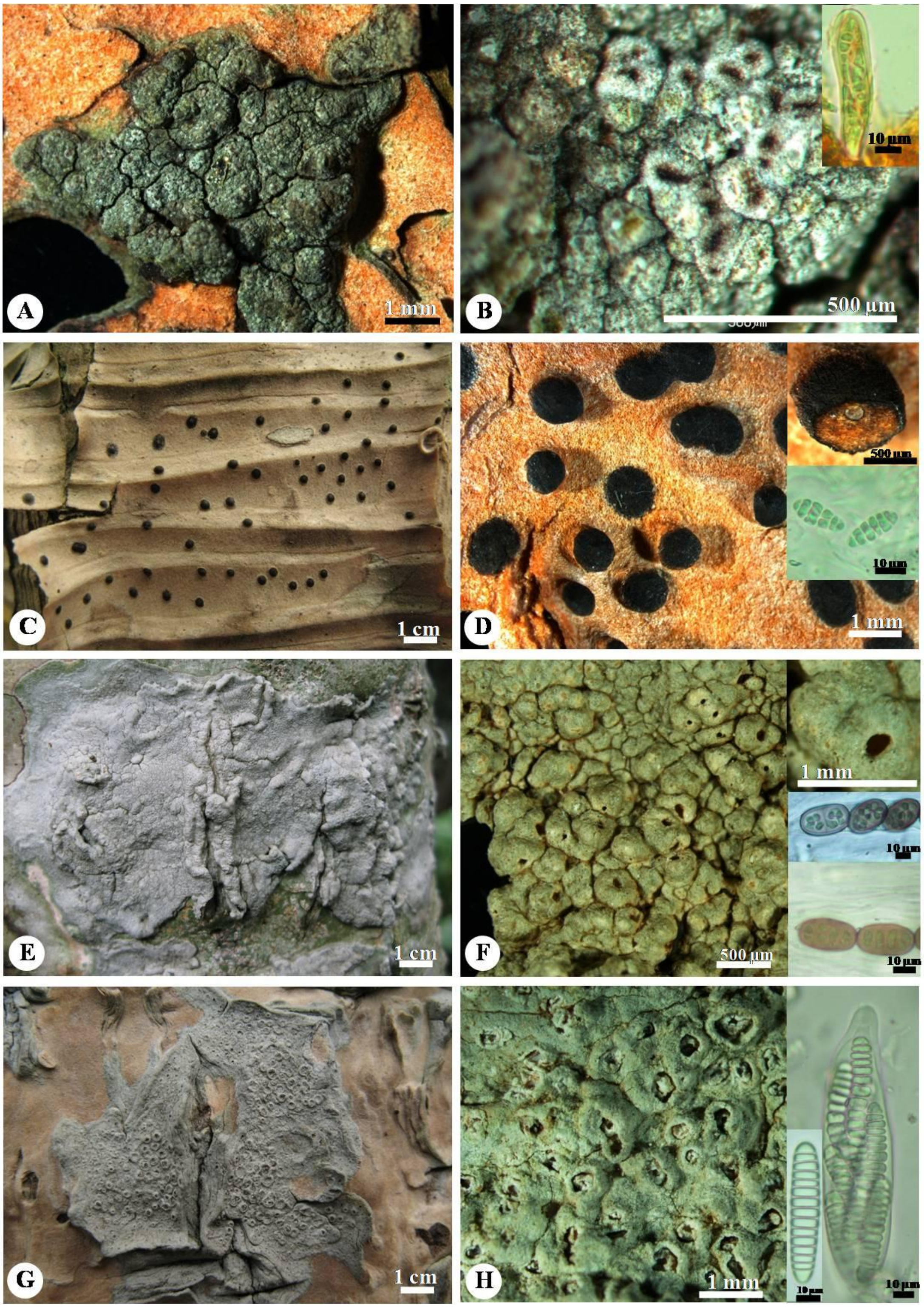

Figure 5.15 Lichen species, *Enterographa tropica*: A. thallus, B. apothecia and spores; *Julella vitrispora*: C. thallus, D. perithecia and spores; *Leptotrema wightii*: E. thallus, F. apothecia and spores; *Leucodecton albidulum*: G. thallus, H. apothecia and spores.

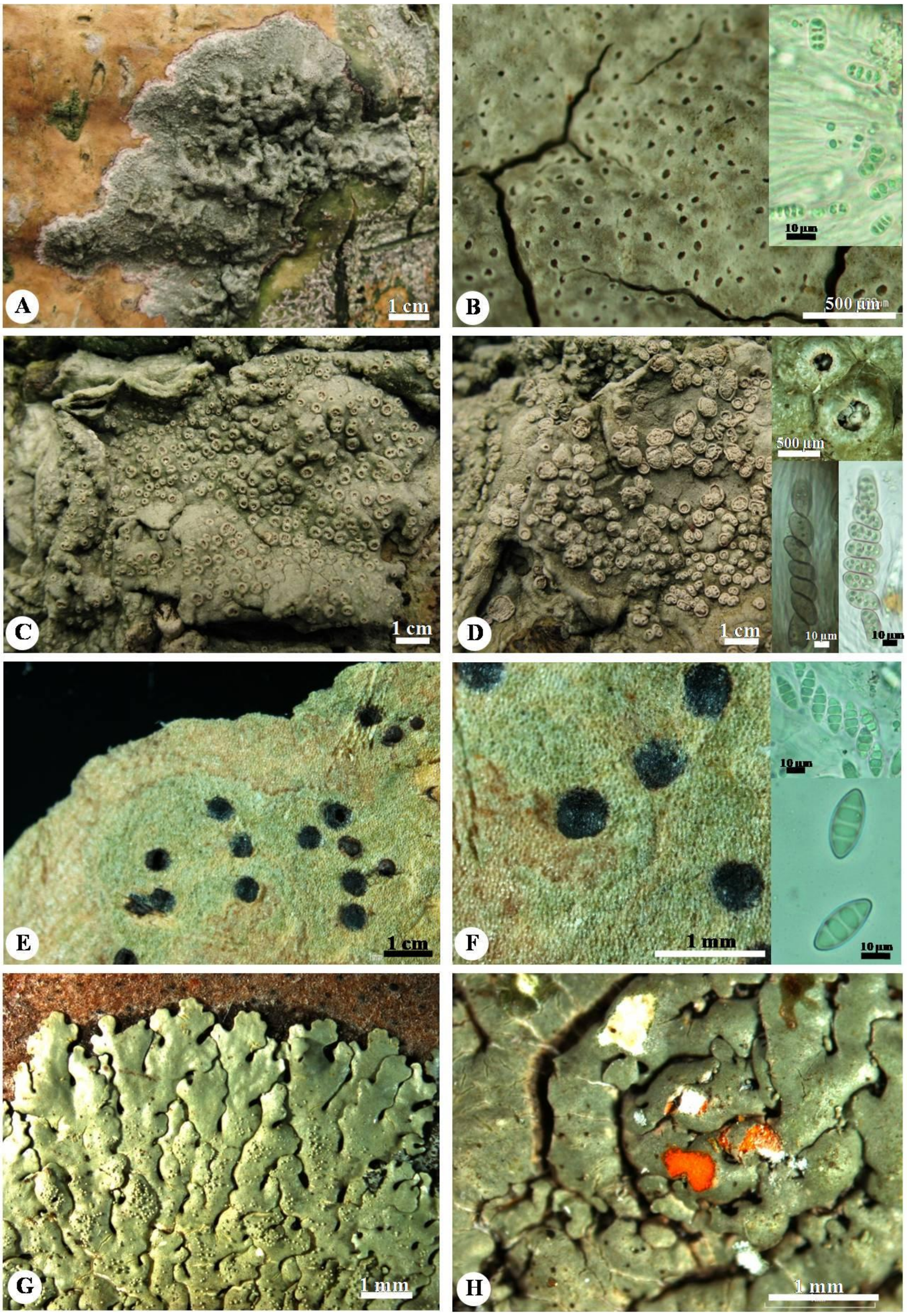

Figure 5.16 lichen species, *Myriotrema microporum*: A. thallus, B. apothecia and spores; *Stegobolus crassus*: C. thallus and apothecia, D. apothecia and spores; *Polymeridium siamense*: E. thallus, F. perithecia and spores; *Relicinopsis rahengensis*: G. thallus and lobes, H. PD+orange-red.

CHAPTER VI

DISCUSSIONS AND CONCLUSION

6.1 Discussions

6.1.1 Lichens Communities on Different Host Plants

Species diversity and species composition

Overall, lichen species were recorded from *Cycas pectinata, Dracaena cochinchinensis* and *Dracaena jayniana* accounting for 39, 38 and 36 species respectively. However, the lichen communities were likely in the same structure in three host plants which were dominated by crustose species and sparsely inhabited by foliose species (Table 6.1). Among crustose group, they prefered *C. pectinata* stem surface for habitats while they had preference in habitats on *D. cochinchinensis* as well as in *D. jayniana.* Thus, the stem surfaces of three host plants were covered by several crustose species with the seldom presence of foliose species (Figure 6.1). The high proportion of crustose lichens in this study was regarding to several research by the reason of requirement of nutrients and water loss (Nash III, 1996). Crustose lichens require less nutrients and water, thus they were easy to develop thallus (Vicol, 2010). Moreover, crustoses had restriction for water loss only on exposed surface and also profited water from surface water flow (Nash III, 1996). Therefore, crustose lichens could tolerate in extreme habitats and dispersed to all substrata. In addition, there were several foliose lichens in three host plants that were quite similar in number of species. Because of the high relative humidity of ambient atmosphere in short periods, foliose lichens could also grow but might be limited dispersal by extreme environments in limestone forest such as high radiation and high temperature (Figure 3.3A, F). Interestingly, young foliose lichens could be in completion with bryophytes and loss the habitat for expands their thalli (Harris, 1971). This had been shown in this study, as the stem of *C. pectinata* contain more water-holding capacity, there were usually primarily inhabited by bryophytes and confront the competition with young foliose lichens. Conversely, bryophytes also provided the habitat with liquid water for cyanolichens (Harris, 1971) that shown in *C. pectinata* and also in *D. cochinchinensis*. Thus, there were more abundant of cyanolichens on both *C. pectinata* and *D. cochinchinensis* than *D. jayniana.* Notably, there were known that habitats containing more humidity were usually more diverse growth forms (Temina, 2009). This study also illustrated that there were more diverse growth forms and species in *C. pectinata* than *D. cochinchinensis* and *D. jayniana* (Table 6.1). Although water availability was important factor controlling epiphytic lichens, bark chemistry such bark pH was also main influence. It was observed in *D. cochinchinensis* of which lichen growths from and species are almost similar to *C. pectinata*. Since lichens prefered pH of substrata moderately acid (Kuusinen and Siitonen, 1998; Jüriado *et al*, 2009b) or vary on host plant identity (Loppi and Frati, 2004), pH might play important role for controlling lichen diversity on *D. cochinchinensis* with low water-holding capacity.

However, these features might cause different and similar in lichen community on different host plant in the same area. They also consisted of the strategies of reproduction such as propagule size, amount, dispersal limitation or the combination of several factors (Bartels, 2012). In this study, due to the similarities of crustose lichens, three host plants showed the similar structure of lichen communities.

Table 6.1 Data of lichen species found on three host plants

	Growth form (species)			
Host plants	crustose	foliose	squamulose	total
C. pectinata	28	10	1	39
D. cochinchinensis	24	13	1	38
D. jayniana	25	11	0	36

Dominant species

The dominant lichen species in this study were defined by the frequently found more than 10 times on at least 2 species of plant hosts. They consisted of two growth forms including 4 foliose and 4 crustose lichen species. The 8 species found such as *Anisomeridium subprostans, Buellia schaereri*, *Dirinaria papillulifera*, *Graphis longispora*, *Leptogium cyanescens*, *Leucodecton albidulum, Parmotrema tinctorum* and *Pyxine cylindrica*. In crustose groups, all of them produced large amount of ascocarps with many spores. For example, *Anisomeridium subprostans* and *Buellia schaereri* produced many perithecia and apothecia respectively with the small size spores (Figure 5.9C, D, 5.10A, B). The spore size was one strategy in dispersal species on far distant habitats (Johansson *et al*, 2007). In addition, *G. longispora* and *L. albidulum* had abundant apothecia covering almost on thallus (Figure 5.7G, H, 5.15G, H). In foliose groups, *L. cyanescens* and *P. tinctorum* had large thallus easily fragmented to disperse. Moreover, *D. papillulifera* and *P. cylindrica* had high production of vegetative propagules including isidia both species (Figure 5.12A, B, 5.10G, H). These reproductive strategies provided the dominance of lichen species.

Similarity of lichens

There was high similarity of lichens on three host plants due to combination with several factors. Because of the *C. pectinata*, *D. cochinchinensis* and *D. jayniana* were in cloud population, lichen species distributed regularly observed by alpha diversity and similarity index (Table 5.6). The combination between reproductive strategies, *D. cochinchinensis* and *D. jayniana* shared most of lichen species with 72.9 percent similarity when compared each to *C. pectinata*. This could be explained by the host identity in the same genus and the same range of bark pH. Besides, reproductive strategies and dispersal limitation also used for illumination the lichen similarity in nearly localities of plant hosts. However, beta diversity was quite not different among host plants so species turnover or variation within host plants was not significant. Crustose lichens dominated on three host plants that contributed the similarity of lichen species, then, they shared common species for 24 species (Figure 5.1). The old host plants usually died and leaned against other plants, so lichens might disperse to new habitats. The environmental in study area such as light intensity, temperature, humidity and edaphic characteristic as limestone soil were the main factors controlling the community and habit of host plants. Thus, host plants might confront same environment that provided effect for growth and dispersal to corticolous lichens. Not only environmental factors affected lichen communities, but the host plant in same genus (*D. cochinchinensis* and *D. jayniana*) could also contribute similar habitats to lichens. However, the characteristics of plant stem surface might provide microhabitats in difference of humidity, pH or light intensity (Ranius, *et al.*, 2008b), so there were a few diverse lichens on each host plants in this study for this reason.

New recorded species of lichens to Thailand

Overall lichen species, the results from this study found four new species recorded to Thailand including *Hyperphyscia syncolla* (Tuck. ex Nyl.) Kalb., *Julella* *vitrispora* (Cooke & Harkness) M. E. Barr., *Pyrenula interducta* (Nyl.) Zahlbr. and *Pyrenula leucotrypa* (Nyl.) Upreti. All of species were corticolous lichens in tropical regions of the world such as *P. leucotrypa* and *P. interducta* were found in eastern palaeotropical (Aptroot, 2012). Moreover, *H. syncolla* were widespread on tree and shrub in open site at 500-2,400 m alt. in Madagascar, Somalia and the Americas (Swinscow and Krog, 1998).

These species might be the indicator species for limestone forests because they had just seen in this area for first time. Actually, the unique climate and vegetation might contribute the species from the speciation (Clements *et al*., 2006). These data would be additional for lichen flora of Thailand.

6.1.2 Reproductive Strategies

Dispersal limitation was directly linked with sexual and asexual processes. The asexual dispersal lichens usually were limited easier than sexual dispersal (Hedenås *et al*., 2003; Löbel *et al*., 2006). In this study, common species often had high production of spores e.g. *Anisomeridium subprostans, Buellia schaereri*, *Graphis longispora* and *Leucodecton albidulum* and have vegetative propagules (isidia) such as *Leptogium cyanescens*, *Parmotrema tinctorum* (isidia) and *Dirinaria papillulifera* (phyllidia) or had both spore and vegetative propagule (isidia) such as *Pyxine cylindrical* (Figure 2.3A). However, linking mechanism could be explained in the common species because of continuous in sources of propagule, landscape level and cloud vegetation of host plants (Bartels, 2012). For the rare species, they usually produced sexual reproductive organs but they might lack of spores such as *Lecanora* spp. Furthermore, some lichens had small diameter of thalli, found only vegetative reproduction or in competition with more abundant species. This study showed that the frequency of sexual species was higher than asexual species. However, they had known that lichen with black structures usually dominate in expose and dry habitats (Temina, 2009). This study also found the dominant lichens with their black ascocarps such as *A. subprostans* had numerous perithecia and *B. schaereri* had dense black apothecia. They contained melanin to protect the reproductive organs from ultraviolet.

6.1.3 Bark Physical and Chemical Properties

Bark Water-Holding Capacity

The evidence indicated moist habitats that are the present of cyanolichens (Foote, 1966). In this study, host plant species such *C. pectinata* was likely most bark water-holding capacity (80.8%) but contained same number species of cyanolichens compared to *D. cochinchinensis*, including *Coccocarpia rottleri*, *Collema rugosum* and *Leptogium cyanescens*. However, there were different in number of *C. pectinata* and *D. cochinchinensis* inhabited by cyanolichens (Table 5.2). Not at all, *Leptogium cyanescens* prefered colonization on *D. cochinchinensis* than *C. pectinata* in spite of there was lower bark water-holding capacity in *D. cochinchinensis* (28.9%). Controversially, there were only a species of cyanolichen on *D. jayniana* with the least amount of bark water-holding capacity (25.4 %). This phenomenon could be explained by the water relation between ambient environment and cyanolichens. They required liquid water for growth and development in high humid site (Harris, 1971; Normann, 2010). Physiologically, higher humidity would reduce evaporation rate that prolonged photosynthetic active time in poikilohydric lichens (Normann, 2010). Moreover, bark fissure depth might control in moisture gradient such as there was drier microclimate in deeper bark crevices (Ranius *et al*., 2008), it was shown in *D. jayniana* for this study. In addition, moisture content played important role in spore germination which provided lichen dispersal and colonization leading to different lichen communities (Armstrong, 1988). The species of lichen in *C. pectinata* and *D. cochinchinensis* might be explained by data of bark pH together.

Bark pH

In this study, the results indicated that lichens had more acidic bark preference. The alpha diversity illustrated the species richness that conformed to bark pH. The alpha diversity accounted for 10.71, 8.91 and 8.79 in *D. cochinchinensis*, *D. jayniana* and *C. pectinata* respectively whereas bark pH were 3.79, 4.37 and 4.49 in *D. cochinchinensis*, *D. jayniana* and *C. pectinata* respectively also. The corticolous lichen communities and community turnover were explained by the pH because it was correlated with availability of mineral nutrients e.g. K, Ca and Mg or limited the species composition (Bates and Brown, 1981; Gauslaa, 1985, 1995; Bates, 1992; Goward and Arseneau, 2000). Coppins and Wolseley (2002) suggested that there were the strong different in cryptogramic epiphytes even though observation had done on same genus of plant hosts. Their results explained in the fluctuation of nutrients and the influence of microclimates. In the same way, there were different corticolous lichen communities on the same genus of plant hosts (*D. cochinchinensis* and *D. jayniana*) of which pH were different in this study. Moreover, among different species of plant hosts (*C. pectinata, D. cochinchinensis* and *D. jayniana*), the lichen community were different by the reason of pH preferences. Due to all host plants were in same locality, the bark pH were in the range of mild acidic. It was discussed that bark chemistry correlated with soil system because different plant species might be prefer different soil types (Gauslaa and Holien, 1998). The beta diversity in this study showed small different between host plants supporting the low variation between them. The previous studies illustrated that epiphytic lichens prefered the acidic bark of *Tilia cordata* in boreo-nemoral vegetation at Latvia (Mezaka, *et al*., 2012).

Morphology of Bark

Bark morphologies in *C. pectinata, D. cochinchinensis* and *D. jayniana* were different (Figure 3.1A, 3.1B, 3.1C). They had effects on microclimate gradient, however, in this study demonstrated in bark crevice depth. *D. cochinchinensis* accounted for high bark crevice depth but it did not contain highest lichen species richness. To explain this occurrence, deeper fissure depth provided drier microhabitats (Ranius *et al*., 2008). Not only bark morphologies accompanied crevice depth, but they also illustrated the stable of bark which related to species identity (Holien, 1977; Aude and Poulsen, 2000; Wannebo- Nilsen *et al*., 2010). Because of high bark crevice depth of *D. jayniana*, they had shown as wings along stems. They were easy to lost stability by mechanical process whereas bark of *C. pectinata* and *D. cochinchinensis* were more stable with small amount of bark crevice depth. In addition, bark morphology might relate with water-holding capacity thereby which winged bark in *D. jayniana* would confront in atmosphere, wind, radiation or high temperature more than not winged barks in *D. cochinchinensis*. To determine the different of bark morphology between C*. pectinata* and *D. jayniana*, they contributed the quite similar alpha diversity. The explanation could not be on the bark morphology alone, but bark pH should be complied. Due to the high water-holding capacity in *C. pectinata* combined with high annual average and total rainfall for long periods in this area (Figure 3.4C, D), lichens had slightly preference in *C. pectinata* than others. Moreover, the exposed habitats for host plants make their barks unstable especially in *D. jayniana* so the habitats would be loss for a while.

6.1.4 Diversity of lichens in each sampling sites

According to the alpha diversity, sampling sites were important for determining the lichen species diversities in term of geomorphology and heterogenous climate (Brunialti and Giordani, 2003). As sampling sites could provide the preference habitats and different environments for host plants, they directly affected to diversity of lichens. In this study, there were different alpha diversities on *D. cochinchinensis*, *D. jayniana* and *C. pectinata* at 4 sampling sites.

The alpha diversities on plant hosts were low at Khao Boon Mee but were high at Khao Tep Porn, Suan Hom and Suan Sa Wan. The distinguish contrast was shown especially in *D. jayniana* among 4 sampling sites (Table 5.8). The reason for explaining these results might be that Khao Boon Mee was surrounded by agricultural areas. Khao Boon Mee was the independent limestone hills from others so it might limit the dispersal of host plants which were lichen habitats. Moreover, high heterogeneity of environment at Khao Boon Mee that exposed to sun light at the summit and covered by high canopy at low elevation might affect host plants community and lichen distribution on *D. cochinchinensis*, *D. jayniana* and *C. pectinata*. As the results, alpha diversities of lichens on all host plant species were low when compared to other sites. Interestingly, most of lichens found on host plants at Khao Boon Mee were the only once in this study. Khao Boon Mee might have special characters or unique environments for some lichens species such as *Lecanora tropica*, *Bulbothrix queenslandica*, *Bulbothrix goebellii* and *Relicinopsis malaccensis.*

In addition, Khao Tep Porn also contained low alpha diversity on only *D. jayniana*. Since Khao Tep Porn was covered by herbaceous, more humid soil, and high degree of canopy cover area, it might not provide suitable habitats for *D. jayniana*. In contrast, Khao Tep Porn was the sampling site where *D. cochinchinensis* and *C. pectinata* provided the highest alpha diversities when compared to the same host species at other sampling sites (Table 5.8). More humidity, low light intensity and slightly different vegetation might influence the distribution of host plants and the species richness of epiphytic lichens.

Although there were slightly different on *D. cochinchinensis*, *D. jayniana* and *C. pectinata* at Suan Sa Wan, they contained high species richness of corticolous lichens, (Table 5.8). Because of the presence of limestone shallow and crevice, Suan Sa Wan was the preference habitats for plant hosts. There seldom occurred tree and shrubs with *D. cochinchinensis* communities but most area exposed to sun light with *D. jayniana* and *C. pectinata*. It might depend on light intensity for plant host distribution. This habitat character might enhance epiphytic lichens inhabiting on plant hosts in this area. Even plant host such *D. jayniana* and *C. pectinata* exposed to solar radiation, they still contained high species richness.

Similarly, the lichen species richness was high on all species host plants at Suan Hom as well as found at Suan Sa Wan. In this area, *D. jayniana* contained the highest alpha diversity which differed from all sampling sites. Lichen preferred *D. jayniana* which grew in limestone crevice along limestone cliff. They directly confronted the wind, sun light and high temperature but not for *D. cochinchinensis* and *C. pectinata*, they grew under canopies.

The main factors affected the lichen species richness in each sampling sites might include light and water for their photosynthesis (Anstett and Coiner, 2010; Nascimbene, *et al*., 2012). It was known that lichens were not limited growth by high light intensities because they had photoprotective mechanisms (Anstett and Coiner, 2010). Therefore, sampling sites in this study such as Suan Sa Wan and Suan Hom where exposed to light still contained high lichen diversity. However, light was also main factor controlling distribution and species richness of epiphytic lichens especially in photobiont part (Marini *et al*., 2011; Nascimbene, *et al*., 2012). Water was the limiting factor for lichen growth especially in photosynthesis and species richness (Anstett and Coiner, 2010; Opdyke, 2011). Nevertheless, it depended on water availability for epiphytic lichens in each area.

Wind was also influence the lichen growth and diversity because it affected in water balance (Anstett and Coiner, 2010). Low water or high rate of water loss reduced photosynthesis so habitats within low water content were inhabited by most crustose lichens (Nash III, 1996) which was similar to this study. All sampling sites and all host plants were dominated by crustose lichens.

However, temperature was not likely affect the lichen habitat selection because they tolerated extreme temperature from -196 °C to 60 °C (Nash III, 2008). It could explain that how lichens can grow and disperse well in all study area with quite high temperature. Sometimes, temperature might be varied through light intensity, humidity and landscape e.g. shallow and cliff, for example, host plants exposed to sun light at Suan Sa Wan and Suan Hom usually confronted high temperature more than which were under canopy at Khao Tep Porn and Khao Boon Mee.

Forest structure was the factors influence the lichen communities because it related with light availability from crown cover and humidity (Moning *et al*., 2009). In this study, canopy areas were the important determination for host plant habitats and lichen diversity. There were different canopy covers at 4 sampling sites. Khao Tep Porn was found more canopy cover area more than other sites and scarcely occurred at Khao Boon Mee, Suan Sa Wan and Suan Hom with different proportions. It might link to light intensity and moisture content for habitat selection and growth. Moreover, changes in lichen diversity were driven by habitat fragmentation and history of land-use (Motiejûnaitë and Faùtynowicz, 2005; Opdyke *et al*., 2011). It was similar to Khao Boon Mee where contained low species diversity. Because of it was not continued to other sites liked habitat fragmentation and was surrounded by agricultural areas.

Due to host plant habitat selection, there was different distribution of different host plant species in several vegetation or habitat types (Knudsen and Magney, 2006). This also occurred in case of *D. jayniana*. They preferred Suan Sawan and Suan Hom for habitats while did not preferred Khao Boon Mee and Khao Tep Porn. Consequently, the distribution and density of host plants might affect the epiphytic lichen diversity in term of habitats.

Overall, corticolous lichen communities might be influenced by sampling sites characters or geomorphology, and environmental heterogeneity e.g. light intensity, moister content, temperature etc. around their habitats. Moreover, biotic factors such as tree directly correlated with light availability. Because of variation of canopy covers, they had impact on light intensity at lichen habitats.

6.2 Conclusion

In summary, host plant species were significant explanatory factors for the different communities and could be concluded as:

1. Host plants were the important factor for structuring the lichen community and individual host plant could be conceptualized as habitat unit that were associated with microhabitats and external factors.
2. According to alpha diversity of lichen, there were higher species richness in *D. cochinchinensis* than *D. jayniana* and C*. pectinata* respectively.
3. There were high similarities of lichen species in *D. cochinchinensis*, *D. jayniana* and C*. pectinata*.
4. Bark crevice depth had major correlation trend with *D. jayniana*.
5. Bark pH had major correlated trend with *D. cochinchinensis*.
6. Bark water-holding capacity had major correlated with *C. pectinata*.
7. Sampling sites for collecting lichen specimens were also main factor to determine plant host habitats of which lichen species diversity occurred.

6.3 More suggestion and future study

The further study might determine the vertical distribution of each host plants and measure the environment factors near the plant host communities. These data may explain some ecological approach for lichen communities. Moreover, the number of host plants can be recorded more amount than this study. The study should be conducted in other limestone forest in Thailand to compare the result in this study.

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