

## KEY TO LICHEN GENERA IN THAILAND WITH SPECIAL REFERENCE TO EPIPHYTIC TAXA, PART I: MACROLICHENS

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### ABSTRACT

An introduction to lichens and the terminology used to describe them with illustrated plates, is followed by an artificial key to 59 macrolichen genera of Thailand. Key characters and distribution of each genus are described and some common or characteristic species mentioned.

### INTRODUCTION

Lichens are biologically distinct entities composed of an algal or cyanobacterial partner (photobiont) and a fungal (mycobiont) partner living in a symbiotic state. The photobiont may also occur in a free-living state, and the same alga may be found in a wide range of lichens. The photobiont is not known to reproduce sexually in a lichen state. However the fungal partner is specific to the lichen taxon, so that the classification of lichens is based on the sexual characteristics of the fungal partner. However the sexual state is rare in many lichens and vegetative reproduction is widespread in many genera, allowing the algal and fungal partners to be dispersed together. In the field lichen taxa can be circumscribed by a number of morphological characters that are the result of the partnership of both symbionts, and in order to distinguish genera and species these characters are widely used in an artificial key. The photobiont is sensitive to a range of environmental conditions and will determine the distribution of the lichen taxon. In order to protect the photobiont and extend its ecological range the mycobionts have evolved a diversity of chemical substances. Although these have been used as dyeing agents and as medicinal remedies (RICHARDSON, 1975) for a long time, the underlying chemistry has only been studied in the last 120 years, and developed from simple tests for colour reactions to chemical analysis using solvents and chromatography to identify the organic components. These have now become an important taxonomic tool to distinguish genera and species in difficult families such as Parmeliaceae in addition to morphological features.

This generic key uses a combination of morphological characters and simple chemical reactions to identify the component genera. This is however an artificial key and related genera do not necessarily key out near each other.

The range of genera included in this key is based on literature records from South-East Asia (AGUIRRE-HUDSON & WOLSELEY, 1994), our own collections from Thailand, and material collected by the senior author, between 1988–1993. The collections are not

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representative of the geographical or ecological diversity of Thailand, and it is hoped that this preliminary key to macrolichen genera in Thailand and adjacent areas of South–East Asia will stimulate more research in this area. In layout and much of its content the key follows *The Macrolichen Flora of East Africa* (SWINSCOW & KROG, 1988) which has contributed to the identification of some tropical macrolichen genera and species using a combination of morphological, reproductive and chemical characters. A key to the macrolichens of India and Nepal (AWASTHI, 1988) has provided much information from an adjacent geographical region. Generic concepts within part of the Parmeliaceae have been based on the recent publication on generic delimitation of *Parmelia* sensu lato (ELIX, 1993). Descriptions of key characters used, and of ecological distribution, where known, for each genus in Thailand are included in a section at the end of the key. All terminology as bold type in text is illustrated in plates I–IV.

## LICHEN STRUCTURE

### Thallus Morphology

Lichens fall into morphologically distinct groups which provide a basis for most lichen keys.

1. **Fruticose** lichens are shrubby, erect or pendulous, and may be attached by a disc or **holdfast**, or be unattached to a substrate. They may be terete or flattened, hollow or solid and with or without a central cord-like axis. Branching pattern may be **sympodial** or **dichotomous**. **Podetia** are erect cup-like to branched structures bearing fruits and arising from a primary thallus. Found in Cladoniaceae.

2. **Foliose** lichens have erect or horizontally spreading leaf-like lobes, with upper and lower surfaces often differing in colour. Attachment to the substrate may be by **rhizines**, **hapters**, or a holdfast. **Rhizines** may be **simple**, branched (**dichotomous** or **squarrose**) or **fasciculate**. These are distinguished from **cilia** that occur on the margins or the upper surface of the thallus.

3. **Placodioid** lichens with closely attached lobes radiating from a crust-like centre, without distinct organs of attachment e.g. *Dirinaria*.

4. **Squamulose** lichens with scattered or compact, often overlapping leafy outgrowths or peltate discs attached to the substrate by a hypothallus, e.g. *Phyllopsora*.

5. **Filamentous** lichens with the filaments of the phycobiont surrounded by the hyphae of the mycobiont, the whole being found as a loosely arranged matt e.g. *Dictyonema*.

6. **Crustose** lichens are closely appressed to the substrate, and attached to it by the hyphae of the medulla. They may grow in a continuous crust on the substratum, or as rounded or angular areolae. A marginal hypothallus of unlichenised hyphae may or may not be present. If present, this distinguishes the area occupied by each individual thallus. The thalli of crustose lichens may also be endolithic (penetrating a rock surface) or endophloeodal (below the bark surface). These lichens are the subject of a separate key to be published separately as Part II.

Within groups 1–5 a range of structures are used as a basis for the description of lichens, and it is important to be familiar with the terminology used in order to use the key.

**Fruticose**

shrub-like

(*Cladonia furcata*)

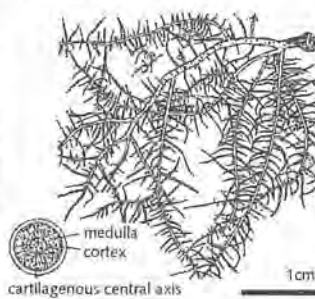


cup-like

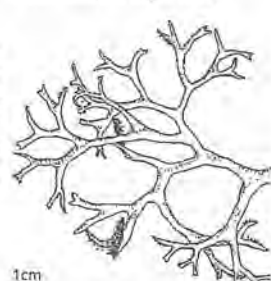
(*Cladonia humilis*)



sympodial branching  
(*Usnea baileyi*)

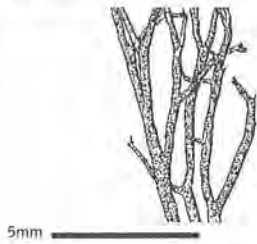


dichotomous branching  
(*Everniastrum nepalense*)



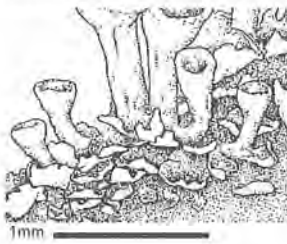
**Foliose**

(*Physconia* sp)



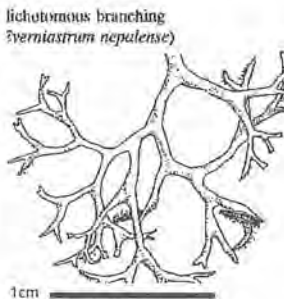
**Placodioid**

(*Dirinaria* sp)



**Cilia**

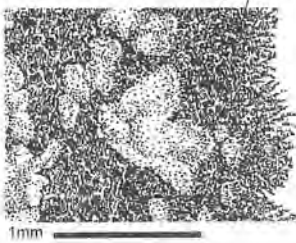
(*Rimelia reticulata*)



lichetuous branching  
(*Everniastrum nepalense*)

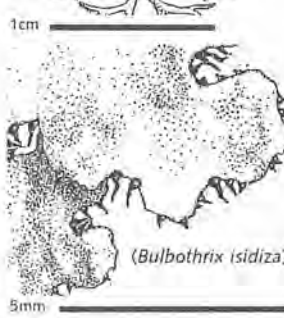
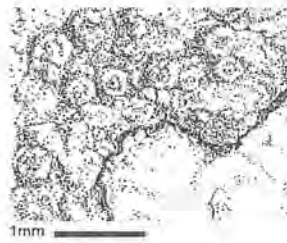
**Squamulose**

(*Phyllopsora furfuracea*)



**Crustose**

(*Ocellularia* sp.)



(*Bulbothrix (sidiza)*)

**Rhizines**



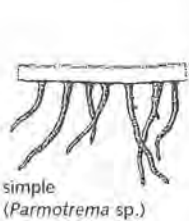
1-branched squarrose  
(*Physconia* sp.)



fasciculate  
(*Peltigera* sp.)



branched dichotomous  
(*Hypotrachyna* sp.)



simple  
(*Parmotrema* sp.)

Plate I. Thallus morphology.

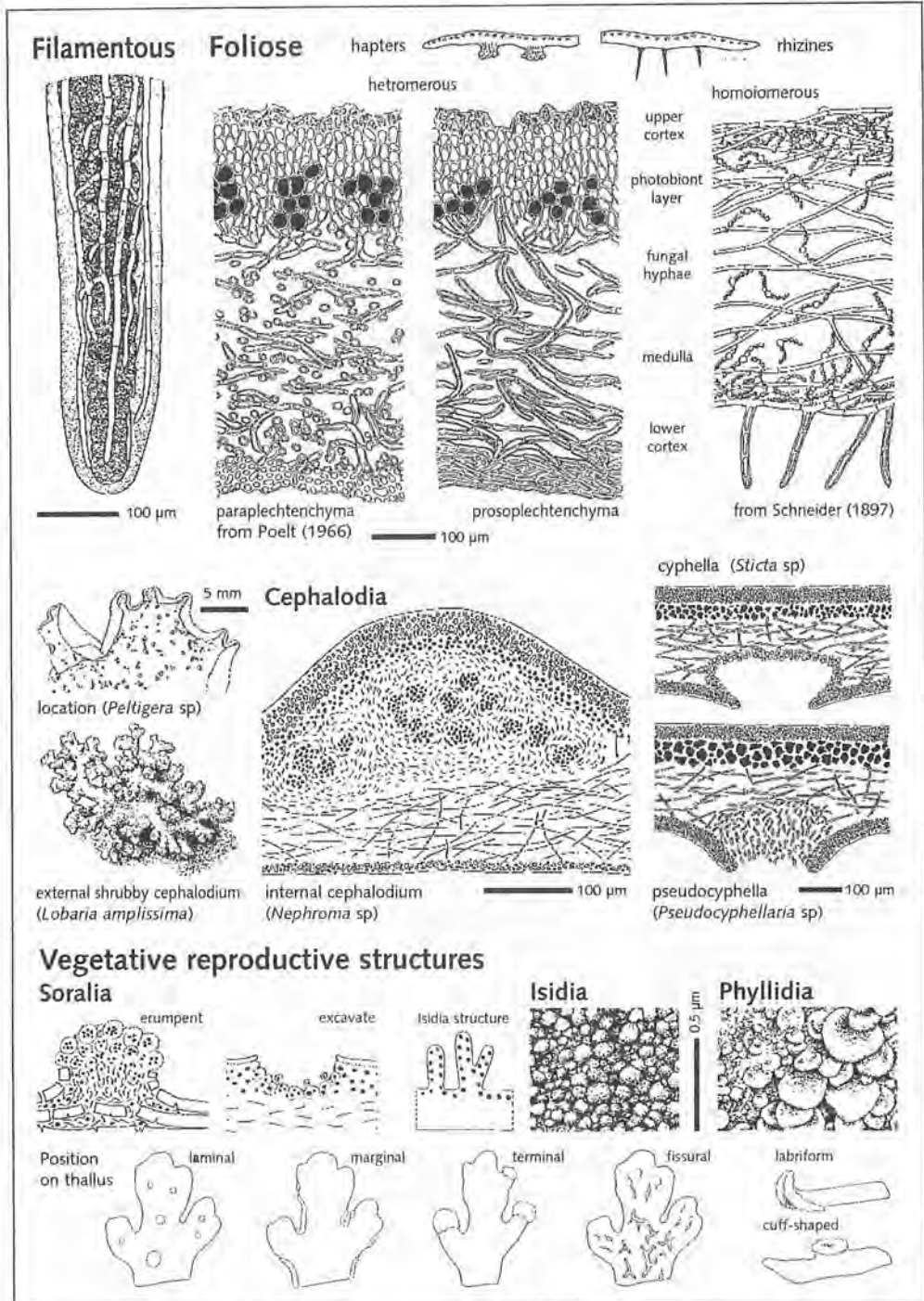


Plate II. Thallus structure.

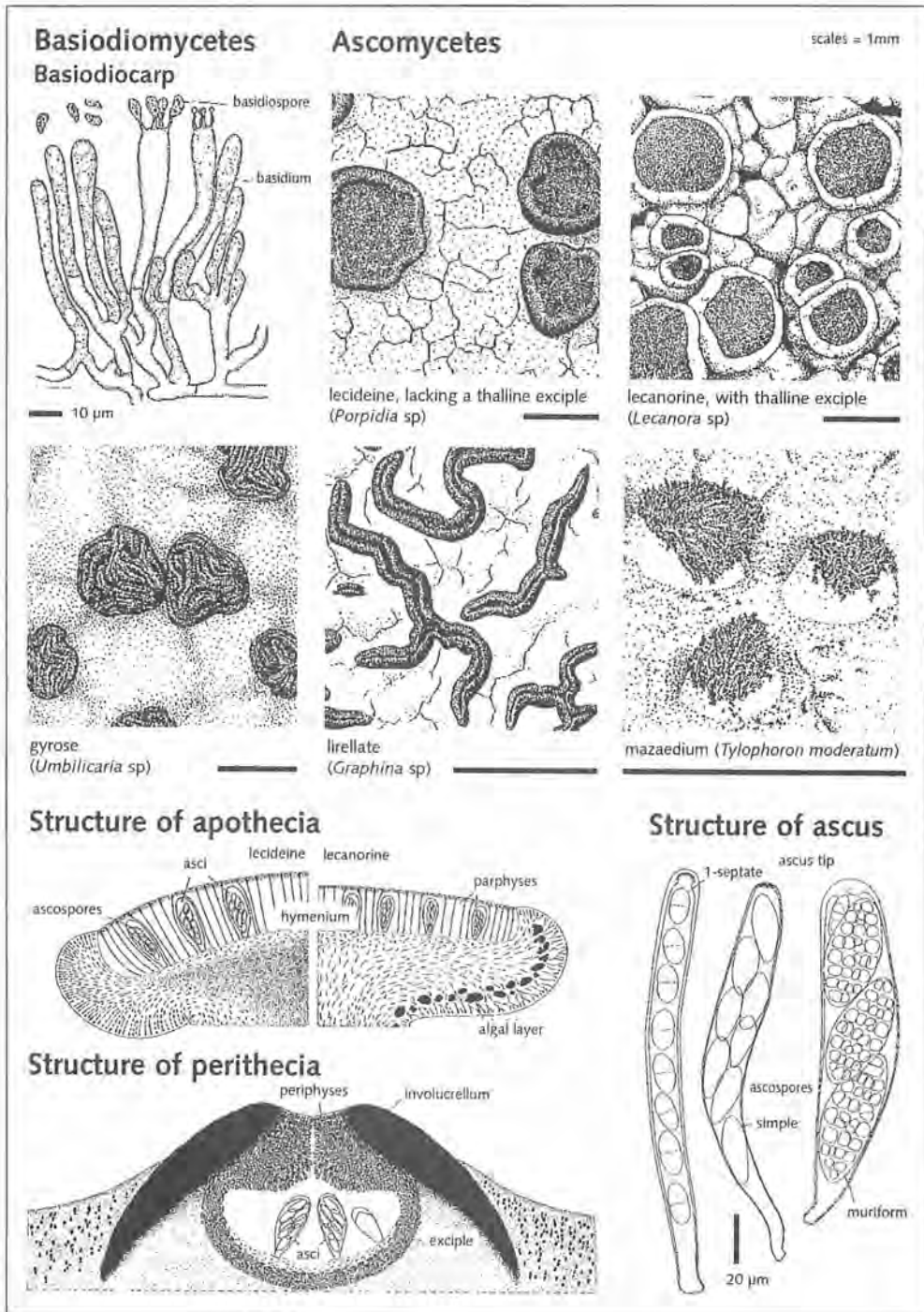


Plate III. Sexual reproduction—the mycobiont.

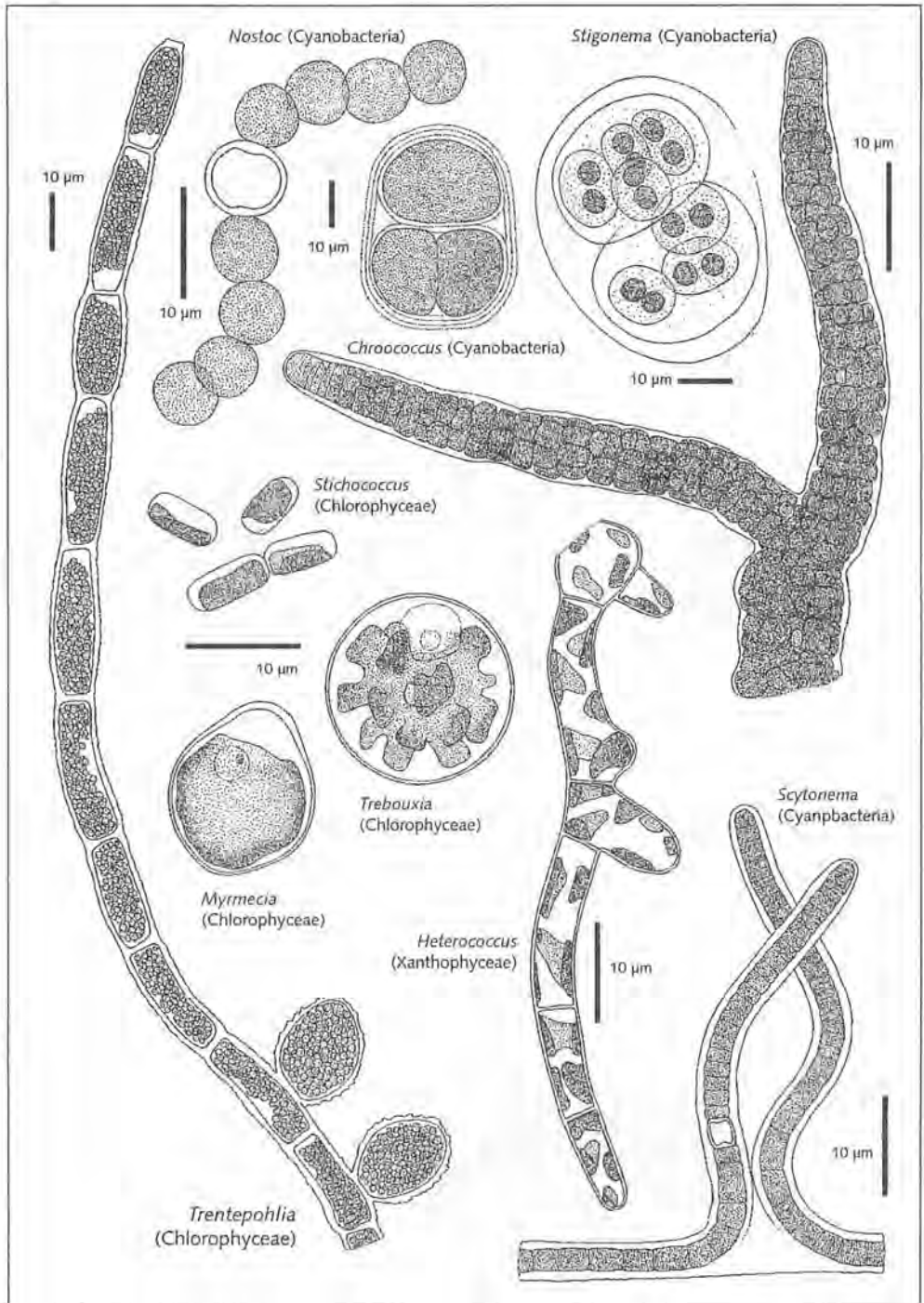


Plate IV. Lichen photobionts.

### Thallus Structure (microscopic)

Thalli may be **heteromerous** and stratified (in section) with differing upper and lower surfaces a distinct dorsiventral structure, or **homoiomerous** with similar upper and lower surfaces, photobiont and mycobiont occurring more or less randomly throughout the thallus.

**Cortex:** consists of tightly packed hyphae which may have a distinct chemistry and colour, occurring in two characteristic tissues; **paraplectenchyma**—as hyphae growing from the inner part of the thallus at right angles to the surface, giving the cortex a cellular appearance in both cross and longitudinal section, or **prosoplectenchyma**— as cortical hyphae parallel to the surface.

**Photobiont layer:** usually lies between the upper cortex and the medulla in foliose and crustose species, and as a layer around the medulla in fruticose species. The contact between the photobiont cells and the mycobiont cells may be developed by haustoria (swollen tip of hyphae).

**Medulla:** a more or less compacted cottony layer of hyphae forming the main body of the lichen. It also contains characteristic lichen compounds. It may be white or coloured.

**Hypothallus** (also known as prothallus by some authors): the initial structure of hyphae without algae from which a lichenised thallus develops is often visible along the margins of the thallus. Found in crustose, squamulose and fruticose genera.

### Thalline Features (use 10x hand lens)

The upper surface of the thallus may be smooth, wrinkled, cracked or reticulate; shiny, pruinose or hairy.

**Cyphellae** are structured perforations through the lower cortex, with a raised rim around a cup-like structure and a distinct membrane bounding the medulla.

**Pseudocyphellae** are shallow, round, long, or effigurate openings in the cortex exposing the medulla. They can occur on upper or lower surface or on the margins of lobes. When on the upper surface maculae and pseudocyphellae may not be easy to distinguish. Irregularities of distribution of algal cells can give a white spotted or reticulate pattern of maculae, which may become fissured and cracked, when they are hard to distinguish from pseudocyphellae.

**Cephalodia** are bodies of cyanobacteria and fungal hyphae growing on the surface or within the thallus of a lichen with a green photobiont. Although the fungal partner is the same, the appearance may be quite different.

### Vegetative Reproductive Structures

**Soralia** are formed by a rupturing of the cortex to expose a powdery or granular mass of soredia, each consisting of photobiont cells loosely enmeshed in fungal hyphae and without any cortical structure. They may be **laminal**, **marginal** or arise from dactyls or pustules, (irregular corticated protuberances, usually eroded), and may vary from fine powder to a granular appearance, and are usually paler in colour than the thallus. **Isidia** have a cortex and originate as extensions of the upper surface of the thallus. They may be pin-like, globose or flattened, branched, coralloid or simple and may be situated laminally or marginally on the upper surface of the thallus, appearing the same colour or darker than the thallus. They may break off from the thallus leaving a pale area, and occasionally become sorediose.

**Phyllidia** are small dorsiventral structures, constricted at base, appearing on the margin or lamina of the lichen thallus. More complicated complanate cortical outgrowths occurring in the genus *Stereocaulon* are called phyllocladia.

## LICHEN MYCOBIONTS

### Sexual Reproductive Structures

Sexual reproduction is only found in the fungal symbiont in lichens so that released spores will only reproduce the fungal partner. Although the fungal partner is found only in the lichenised state, the same algal partner can also occur in a free-living state, and in other lichens in different genera. When a fungal spore germinates it has to incorporate an algal partner in order to form the symbiotic organism, a lichen. Within the fungal kingdom lichenised genera are found in the ascomycetes and basidiomycetes. Ascomycetes are the most frequently occurring group producing characteristic fruiting bodies, **apothecia** and **perithecia**. The most common form of the apothecium is a disk-like structure found on the margins, or usually upper surface of the thallus, it contains the reproductive and accessory tissues which provide important diagnostic features. **Lecideine apothecia** have no thalline margin to the apothecium, the outer edge of the apothecium forming a rim known as the proper exciple, **lecanorine apothecia** have a thalline margin (containing algae) visible around the apothecia. The apothecia may be elongated forming **lirellae**. **Perithecia** are globular or pear-shaped receptacles enclosing the spore bearing hymenium, with the spores released through an ostiole.

The **ascospores** are contained in **asci**, sac-like bodies within the **hymenium** and vary in shape, size, septation and colour. There are usually eight spores, but this may be reduced to one or greater than eight. In some lichens the asci degenerate at maturity leaving the spores in a powdery mass termed a **mazaedium**. Apothecia may also be born on stalked or cup-like **podetia**. Conidia (asexual spores) may develop in a flask-like pycnidium (may appear like small perithecia), which may be immersed, sessile, or pedicillate on the thallus. These are produced by budding off simple or branched hyphae within the pycnidium.

Basidiocarps produce **basidiospores** externally at the apex of the reproductive cell or **basidium**.



## LICHEN PHOTOBIONTS

The photobionts that provide the carbohydrates on which the fungal partner depends belong to two types of algae: the Chlorophyta (green algae) and the Cyanobacteria (formerly called blue-green algae). Within the Chlorophyta the commonest photobionts are unicellular *Trebouxia* and filamentous *Trentepohlia*, the latter occurring more frequently in the tropics. Within the cyanobacteria the commonest photobionts are *Nostoc*, *Scytonema*, and *Stigonema*. These two main groups are readily distinguished in the field by thallus colour when wet. Lichens containing *Trebouxia* turn grass-green when wet, *Trentepohlia* appears orange when the dry lichen surface is scratched, and lichens with cyanobacteria turn or remain blue-grey when wet, when they may also become gelatinous. Lichens with cyanobacteria are able to synthesise nitrates from atmospheric nitrogen, but they are also more sensitive to drought and occur more frequently in wet or moist environments. Within the monsoon climate of Thailand they are more frequent in damp mist-drenched montane communities over 1000 m.

This apparently simple symbiosis is more complex in some cases; a single lichen species may contain more than one photobiont, or may change photobionts and thallus form at different stages of its life or in different habitats (JAMES AND HENSEN, 1976)

## LICHEN CHEMISTRY USED IN THE KEY

Lichens contain many unique compounds which are derived from three major metabolic pathways, and have been used in chemotaxonomy to identify groups of related species. Several techniques of chromatography are used to extract these substances. However, the use of simple readily-obtained chemicals and colour reactions still remains a basis for field identification. As many of the genera in the lichen family Parmeliaceae are distinguished by their chemistry, these tests become important for identification of the genera level.

Three chemicals are commonly used: potassium hydroxide (K), bleach or calcium hypochlorite (C), and paraphenylenediamine (Pd). K is used in a 10–15% aqueous solutions, and Pd is made up freshly in 95% alcohol. K is stable and lasts indefinitely, but C must be fresh and smelling of bleach or it will not produce a colour reaction (test on a known C + lichen e.g. *Parmotrema tinctorum*). All three are corrosive and can ruin paper or clothing. They should be applied with great care to small pieces of the lichen thallus that can be discarded after the test.

Compounds may be found in the cortex or the medulla, so that colour reactions are tested directly on the cortex, and on the medulla by cutting away a small area of the photobiont layer to expose the medulla. Colour reactions and the constituent compounds are indicated in the key. Some lichen compounds fluoresce when exposed to the long-wave UV from an ultraviolet lamp (360  $\mu\text{m}$ ). Fluorescence may be observed in the whole lichen, or following separation of lichen compounds on a chromatographic plate. Only substances which are UV+ in the cortex or medulla of the whole specimen are used in the key. Xanthenes are found in the cortex and may fluoresce various shade of yellow, red and orange (e.g. some species of *Pyxine*), while depsides and depsidones found in the medulla fluoresce blue to white (e.g. *Dirinaria*).

## KEY TO MACROLICHEN GENERA

The key is presented in dichotomous form, where possible using a combination of morphological and sexual characters. However some families that are important and characteristic components of lichen communities in monsoon forests, such as Parmeliaceae and Physciaceae are frequently found in an unfertile state. In order to accommodate these specimens genera are keyed out several times in the key.

Terminology is described in the glossary (see Appendix) and is illustrated in Plates I-IV.

Genera in bold type have been found in Thailand, others are found in adjacent areas and are expected to occur in Thailand.

- 1a. Thallus fruticose or filamentous, erect, pendulous, or prostrate (including podetia and pseudopodetia on a squamulose or crustaceous or filmy base), structure more or less radial to isolateral, although a slight colour difference between the physiological upper and under side may occur ..... 2
- 1b. Thallus foliose, placodioid or squamulose, structure usually clearly dorsiventral ..... 16

**Filamentous Genera**

- 2a. Thallus composed of fine filaments clearly visible with a 10x lens ..... 3
- 2b. Thallus with a cortical structure, not composed of fine filaments ..... 6
- 3a. (2a) Thallus blue-green, sessile, shelf-like, often forming rosettes, sometimes ribbon-like. Texture fibrillose, soft when wet brittle when dry; basidiocarps white or creamish on underside of thallus ..... **Dictyonema**
- 3b. Thallus greyish, green or yellowish-green, forming cushions or sheets or ± foliose-like; soft wet or dry; apothecia scattered on upper surface ..... 4
- 4a. (2b) Thallus whitish-grey and crust-like, texture woolly; apothecia lecanorine, grey to black ..... **Crocynia**
- 4b. Thallus green to black, branched and shrubby or felt-like ..... 5
- 5a. (4b.) Thallus green to yellowish-green, felt-like, apothecia lecideine, orange ..... **Coenogonium**
- 5b. Thallus brown to black, repeatedly dichotomously branched to form small cushions ..... **Polychidium**

**Fruticose genera**

- 6a. (2b). Thallus citrine-yellow to deep orange (K+ purple) or rarely grey; apothecial disc orange (K+ purple) ..... **Teloschistes**
- 6b. Thallus and apothecial disc not citrine yellow or orange ..... 7
- 7a. (6b). Thallus (at least upright parts) with a central axis or cylinder of cartilaginous tissue ..... 8
- 7b. Thallus without central axis of cartilaginous tissue ..... 12
- 8a. (7a). Thallus of branching pseudopodetia covered with leprose ecorticate granules

- ..... **Leprocaulon**
- 8b. Thallus with a well-developed cortical structure on squamules or branches ..... 9
- 9a. (8b). Thallus of upright podetia with a central, hollow, rigid cartilaginous cylinder; squamules often present on podetia or at their base, fibrils absent; apothecia without thalline exciple ..... 10
- 9b. Thallus an erect or pendulous shrub with a hollow or solid central axis of elastic or flexuous cartilaginous tissue; branches bearing few to numerous fibrils, squamules absent; apothecia with thalline exciple and cilia ..... **Usnea**
- 10a. (9a) Thallus simple or sparingly branched, often squamulose, branches tapering or terminated by cups with convex to conglomerate brown or red apothecia  
..... **Cladonia**
- 10b. Thallus repeatedly branched without squamules, apices without cups or conspicuous apothecia ..... 11
- 11a. (10b) Thallus conspicuously and consistently perforate, surface smooth and shiny, paler above and brown in older parts ..... **Cladia aggregata**
- 11b. Thallus imperforate except at the axils of branches, surface uneven, matt or arachnoid ..... **Cladonia** Sect **Cladina**
- 12a. (7b) Thallus dark brown, or dark grey, pendulous with filamentous branches  
..... **Bryoria**
- 12b. Thallus white to purplish, or green to grey, erect or if pendulous with flattened strap-like branches ..... 13
- 13a. (12b) Thallus pale grey to lilac-grey; cortex C + bright red; photobiont (*Trentepohlia*); mainly coastal ..... **Roccella**
- 13b. Thallus pale green-grey, cortex C-; photobiont green ..... 14
- 14a. (13b). Thallus silvery or ash grey; branches bearing phyllocladia and cephalodia; saxicolous or terricolous in montane and alpine regions ..... **Stereocaulon**
- 14b. Thallus shades of green, grey, or straw, lacking phyllocladia, phyllocladioid branchlets, and cephalodia; substrate and distribution various ..... 15
- 15a. (14b). Thallus greenish to brownish grey; apothecia common, disc black powdery; on mossy earth or mossy tree trunks in montane forest ..... **Sphaerophorus**
- 15b. Thallus various, if filamentous, pendulous on tree trunks and branches; usnic acid present, mazaedium absent, distribution and substrate various (widespread)  
..... **Ramalina**

### Foliose and Squamulose Genera

- 16a. (1b). Thallus homoiomerous, colour slate grey, brown, brown-black, or green-black ..... 17
- 16b. Thallus heteromerous, colour green, grey or yellow-orange, various ..... 19
- 17a. (16a). Thallus tough, thick and swollen, cartilaginous and ridged even when wet, spores simple ..... **Physma**
- 17b. Thallus soft, pliant when wet; more or less crisp, fragile when dry, spores muriform or septate ..... 18
- 18a. (17b). Thallus brown-black or green-black, often swollen when wet, without a cellular upper cortex ..... **Collema**

- 18b. Thallus blue-grey, brownish or greyish-black, not usually swollen when wet, cortex present as a single layer of cells ..... **Leptogium**
- 19a. (16b). Thallus of small squamules or lobes > 5 mm long and wide ..... 20
- 19b. Thallus of larger foliose or ribbon-like lobes ..... 28
- 20a. (19a). Thallus citrine- or orange-coloured ..... **Candelaria**
- 20b. Thallus of other colour ..... 21
- 21a. (20b) Thallus with blue-green photobiont (dark grey when wet) ..... 22
- 21b. Thallus with green photobiont (grass green when wet) ..... 23
- 22a. (21a) Thallus without chemistry, apothecia usually without thalline exciple  
..... **Parmeliella**
- 22b. Thallus Pd+orange (pannarin), apothecia with thalline exciple ..... **Pannaria**
- 23a. (21b) Hypothallus present ..... 24
- 23b. Hypothallus absent ..... 25
- 24a. (23a) Thallus squamulose (occasionally crustose), apothecia biatorine .....  
..... **Phyllopsora**
- 24b. Thallus foliose, with overlapping lobes; apothecia with thalline margin .....  
..... **Physcidia wrightii**
- 25a. (23b) Thallus of pale red adjacent squamules with a white rim (montane) .....  
..... **Psora**
- 25b. Thallus of blue-grey to green squamules ..... 26
- 26a. (25b) Thallus of irregular papery thin squamules with cortex 1 cell thick .....  
..... **Eschatagonia**
- 26b. Thallus of regular orbicular or leaf-like squamules with cortex more than 1 cell thick ..... 27
- 27a. (26b) Thallus of bluish- grey or glaucous-grey orbicular squamules with neatly raised rim, often sorediate, upper and lower surfaces concolorous, lower surface pale or white ..... **Normandina**
- 27b. Thallus of overlapping or erect leaf-like squamules ..... **Cladonia**
- 28a. (19b) Thallus attached to substrate only by a central holdfast ..... 29
- 28b. Thallus attached to substrate by rhizines, scattered hapters, the under side, or arising from a basal holdfast ..... 30
- 29a. (28a) Thallus with vesiculate swelling on its upper surface and with corresponding indentations below ..... **Lasallia**
- 29b. Thallus without vesicular swellings ..... **Umbilicaria**
- 30a. (28b) Cyphellae or pseudocyphellae on under side of thallus ..... 31
- 30b. Cyphellae and pseudocyphellae absent from under side of thallus ..... 34
- 31a. (30a) Under side with cyphellae (compounds absent) ..... **Sticta**
- 31b. Under side with pseudocyphellae (compounds present) ..... 32
- 32a. (31b) Lower cortex tomentose, thallus regularly branched lobes .....  
..... **Pseudocyphellaria**
- 32b. Lower cortex naked ..... 33
- 33a. (32b) Lower surface brown, margins with many stalked verruciform pycnidia, apothecia if present, on lower surface ..... **Nephromopsis ornata**
- 33b. Lower surface pale to white, margins without cilia or conidia, apothecia laminal  
..... **Cetrariopsis wallichiana**

- 34a. (30b). Lower cortex absent ..... 35
- 34b. Lower cortex present (look carefully at small firmly appressed species) ..... 42
- 35a. (34a). Lower surface usually distinctly veined, often with projecting rhizines; apothecia partly immersed at apices of lobes ..... **Peltigera**
- 35b. Lower cortex not veined, without projecting rhizines (marginal cilia may be present); apothecia sessile to stalked, laminally or submarginally situated ..... 36
- 36a. (35b). Photobiont a chlorophyte (thallus green when wet) ..... 37
- 36b. Photobiont a cyanobacterium (thallus dark grey when wet) ..... 40
- 37a. (36a) Thallus with marginal cilia; spores brown, 2-celled ..... **Heterodermia**
- 37b. Thallus without marginal cilia; spores colourless, simple ..... 38
- 38b. (37b) Hypothallus absent, apothecia marginal, stalked ..... **Gymnoderma**
- 38a. Hypothallus present; apothecia laminal,  $\pm$  sessile ..... 39
- 39a. (38b). Thallus crustose, squamulose, or foliose, apothecia biatorine .....  
..... **Phyllopsora**
- 39b. Thallus foliose, apothecia with a thalline margin ..... **Physcidia wrightii**
- 40a. (36b). Upper side tomentose; apothecia submarginal, stipitate; hypothallus absent (rhizines may be pigmented bluish grey) ..... **Erioderma**
- 40b. Upper side glabrous or weakly pubescent; apothecia laminal, sessile to substipitate; hypothallus bluish black ..... 41
- 41a. (40b) Thallus without chemistry, apothecia usually without thalline exciple .....  
..... **Parmeliella**
- 41b. Thallus Pd+orange (pannarin), apothecia with thalline exciple ..... **Pannaria**
- 42a. (34b). Photobiont a cyanobacterium (thallus dark grey when wet) ..... 43
- 42b. Photobiont a chlorophyte (thallus bright green when wet) ..... 45
- 43a. (42a). Under side with a coarse dark reticulate pattern of short brown to black hairs, with bare pale areas in reticulations ..... **Lobaria**
- 43b. Under side naked or uniformly finely pubescent, lacking a dark reticulate pattern of hairs ..... 44
- 44a. (43b). Thallus medium to dark brown with short brown to grey tomentum of short hairs on under side; apothecia on the under side of lobe margins .....  
..... **Nephroma**
- 44b. Thallus slate-blue, bluish grey, grey, or yellow, with numerous minute parallel ridges from centre to margins, often with blue-black hypothallus on underside; apothecia adnate to sessile on upper side of thallus ..... **Coccocarpia**
- 45a. (42b). Underside with a tomentum of short hairs which may be evenly distributed or form a reticulate pattern with bare areas in reticulations; internal cephalodia present ..... **Lobaria**
- 45b. Under side naked or with rhizines, without short tomentum of hairs ..... 46
- 46a. (45b) Rhizines absent ..... 47
- 46b. Rhizines present, at least on the margins or in the central parts of the thallus ..  
..... 50
- 47a. (46a) Lobes hollow,  $\pm$  inflated (mainly montane forest species) ..... 48
- 47b. Lobes solid, thallus directly fastened to substrate or by scattered hapters (mainly lowland and savanna species) ..... 49  
[*Anzia* not yet recorded from Thailand has solidly inflated lobes with a spongy

	cushion of anastomosing hyphae on the lower surface]	
48a.	(47a) Hollow lobes with round perforations in upper cortex .....	<b>Menegazzia terebrata</b>
48b.	Hollow lobes without round perforations in the upper cortex .....	<b>Hypogymnia</b>
49a.	(47b) Thallus dark grey to dark brown; atranorin absent, cortex K-, medulla UV .....	<b>Hyperphyscia</b>
49b.	Thallus pale grey or yellow; atranorin usually present, cortex K+, medulla UV+. .....	<b>Dirinaria</b>
50a.	(46b) Upper cortex with pseudocyphellae or maculae (photobiont layer unevenly distributed, or surface cracked exposing medulla) .....	51
50b.	Upper cortex lacking pseudocyphellae or maculae (evenly distributed photobiont layer), surface not cracked .....	57
51a.	(50a) Thallus lobes usually less than 2mm wide; ascospores septate .....	<b>Pyxine</b>
51b.	Thallus lobes usually more than 2mm wide; ascospores simple .....	52
52a.	(51b) Upper surface with linear to reticulate pseudocyphellae or maculae, lower surface black .....	53
52b.	Upper surface with orbicular pseudocyphellae; lower surface pale tan to black .....	55
53a.	(52a) Thallus green to yellow-green, lobes linear, narrow, and transversely cracked .....	<b>Relicinopsis</b>
53b.	Thallus green to grey or buff, lobes rounded and finely reticulately cracked or white-maculate .....	54
54a.	(53b) Cilia simple, rhizines simple or squarrose, fine reticulate pattern of maculae sometimes developing into cracks, conidia sublageniform .....	<b>Rimelia</b>
54b.	At least some cilia sparsely branched, rhizines of two types, maculae effigurate, conidia filiform .....	<b>Rimeliella</b>
55a.	(52b) Thallus yellowish green; rhizines frequent .....	<b>Punctelia</b>
55b.	Thallus grey-green to brown; rhizines sparse or absent .....	56
56a.	(55b) Thallus ridged-rugose, isidiate, caperatic acid present... ..	<b>Platismatia erosa</b>
56b.	Thallus smooth, punctate on lower surface, with or without isidia and soredia, caperatic acid absent .....	<b>Cetrelia</b>
57a.	(50b) Margins of thallus ciliate, sometimes only in lobe axils .....	58
57b.	Margins of thallus without cilia (in some species rhizines are continued to the margins) .....	70
58a.	(59a) Cilia bulbate at base .....	59
58b.	Cilia not bulbate at base .....	60
59a.	(58a) Upper surface grey, cortex K+ yellow (atranorin) .....	<b>Bulbothrix</b>
59b.	Upper surface straw-yellow to yellow green (usnic acid), cortex K- .....	<b>Relicina</b>
60a.	(58b) Lower surface corticate .....	<b>Heterodermia</b>
60b.	Lower surface ecorticate .....	61
61a.	(62a) Upper surface brown, greenish when wet .....	<b>Phaeophyscia</b>
61b.	Upper surface grey to green to straw yellow .....	62
62a.	(63b) Lobes strap-like and canaliculate, ascending and shrub-like, dichotomously branching .....	<b>Everniastrum</b>

- 62b. Lobes of thallus not strap-like or canaliculate ..... 63
- 63a. (62b) Lower cortex white to pale brown ..... 64
- 63b. Lower cortex dark brown to black ..... 65
- 64a. (63a) Thallus matt, usually pruinose at least at lobe tips, upper cortex paraplechtenchymatous ..... **Physcia**
- 64b. Thallus smooth to shiny, not pruinose, upper cortex prosoplechtenchymatous ...  
..... **Heterodermia**
- 65a. (63b) Medulla yellow to orange ..... **Myelochroa**
- 65b. Medulla white ..... 66
- 66a. (65b) Conspicuous conical verruciform pycnidia present along margins of thallus  
..... **Parmelaria**
- 66b. Conical verruciform pycnidia absent from margins of thallus ..... 67
- 67a. (66b) Lobe tips broadly rotund with a broad naked zone on lower surface margin  
..... **Parmotrema**
- 67b. Lobe tips narrow, truncate to sub-rotund, with rhizines to margins ..... 68
- 68a. (67b) Cilia evenly spread on lobe margins; lobes with truncate apices .....  
..... **Parmelinopsis**
- 68b. Cilia mainly in lobe axils; lobes with sub-rotund apices ..... 69
- 69a. (68b) Lobes broad (5–10mm); medulla K+ yellow turning red (salazinic acid) .  
..... **Parmelinella**
- 69b. Lobes narrow (1–6mm); medulla K- ..... **Parmelina**
- 70a. (57b) Thallus straw-yellow to yellow-green ..... 71
- 70b. Thallus grey to green ..... 72
- 71a. (70a) Lower surface rhizinate to margins, occurring on rocks and soil, spores  
5–12  $\mu\text{m}$  long ..... **Xanthoparmelia**
- 71b. Lower surface naked at margins, occurring on bark and rocks, spores 12–18  $\mu\text{m}$   
long ..... **Flavoparmelia**
- 72a. (70b) Rhizines dichotomously branched and prominent, often protruding beyond  
the lobe margin ..... **Hypotrachyna**
- 72b. Rhizines simple, squarrose or reduced to hapters, not protruding beyond lobe  
margin ..... 73
- 73a. (72b) Thallus lobes usually more than 5mm wide, broadly rotund at tips, erect or  
patent but not appressed to substrate; rhizines sparse or absent in a broad naked  
zone near lobe tips ..... **Parmotrema**
- 73b. Thallus lobes usually less than 3mm wide, truncate or linear, appressed to substrate;  
rhizines extending to lobe tips or reduced to hapters ..... 74
- 74a. (73b) Thallus attached by sparse to abundant simple rhizines .....  
..... **Canoparmelia**
- 74b. Thallus attached to substrate by branched rhizines or by hapters ..... 75
- 75a. Upper surface with pseudocyphellae; apothecia lecideine ..... **Pyxine**
- 75b. Upper surface without pseudocyphellae; apothecia lecanorine ..... **Dirinaria**

LICHEN GENERA: KEY CHARACTERS AND DISTRIBUTION IN THAILAND  
(Families according to *Systema Ascomycetum* (ERIKSSON & HAWKSWORTH, 1991)

**BULBOTHRIX** Hale (PARMELIACEAE Zenker)

**Key characters:** thallus foliose, grey, lobes ± adnate, cilia bulbate at base, rhizines simple to dichotomous. Distinguished from *Relicina* with bulbate cilia, by grey colour = absence of usnic acid.

**Distribution:** epiphytic and widespread in deciduous and evergreen forests, c. 7 species recorded in Thailand. Characteristic species of deciduous dipterocarp forests include *B. pigmentacea* (Hale) Hale (K-) and *B. isidiza* (Nyl.) Hale (K+ red), the latter being present but less frequent in evergreen forests.

**CANDELARIA** Massal (CANDELARIACEAE Hakul.)

**Key characters:** thallus squamulose, bright yellow; photobiont *Chlorococcus*; apothecia lecanorine, asci 20–50 spored. Distinguished from other yellow lichens by small crust-like squamules.

**Distribution:** *C. concolor* (Dickson) B. Stein, a new record in Thailand, epiphytic on branches in deciduous dipterocarp forest.

**CANOPARMELIA** Elix & Hale (PARMELIACEAE Zenker)

**Key characters:** thallus foliose, lobes adnate or overlapping, yellowish to grey green, cilia absent (occasionally in lobe axils), rhizines simple; apothecia laminal, eperforate. Distinguished from closely related genera by simple rhizines and absence of cilia.

**Distribution:** epiphytic and frequent in well-lit situations, c. 6 species found in Thailand, *C. ecaperata* (Müll. Arg.) Elix & Hale (thallus yellowish, lower cortex black) being frequent in the dipterocarp forest, and *C. salacinifera* (Hale) Elix & Hale (thallus grey, lower cortex pale tan) being associated with montane forests.

**CETRARIOPSIS** Kurok. (PARMELIACEAE Zenker)

**Key characters:** thallus foliose, erect and lettuce-like, yellow-green above, pale below with pseudocyphellae on the lower surface, rhizines infrequent, only present on the anchored part. Distinguished from other cetrarioid genera by pale lower surface with white punctate pseudocyphellae.

**Distribution:** a monotypic genus, *C. wallichiana* (Taylor) Kurok. is found on twigs in montane forests above 1500 m, known in Thailand from Doi Suthep.



**CETRELIA** W. Culb. & C. Culb. (PARMELIACEAE Zenker)

**Key characters:** thallus foliose, green to grey-brown with punctiform pseudocyphellae on upper surface, rhizines simple usually sparse; apothecia perforate. Distinguished from other cetrarioid genera by black lower surface and pseudocyphellae on upper surface.

**Distribution:** 2 species, epiphytic on twigs and canopy branches, restricted to montane forests above 1500 m in the north of Thailand.

**CLADIA** Filson (CLADIACEAE Filson)

**Key characters:** thallus fruticose, yellow above to pale brown below, of hollow, perforate podetia, with an external cartilaginous layer, fertile podetia larger; apothecia terminal, lecideine. Distinguished by yellow colour and hollow podetia.

**Distribution:** terricolous in montane vegetation above 1500 m, *C. aggregata* (Swartz) Nyl. is recorded in Thailand (AHTI, 1984).

**CLADONIA** Browne (CLADONIACEAE Zenker)

**Key characters:** primary horizontal thallus, green to grey green, with vertical podetia arising from it, primary thallus crustose, soon disappearing (subgenus *Cladina*) or of basal squamules, corticate above, ecorticate below (subgenus *Cladonia*); podetia, simple to richly branched, hollow, with or without squamules, ecorticate (*Cladina*), continuous to discontinuous, apothecia without thalline exciple.

**Distribution:** Epiphytic and terricolous in montane communities over 1000 m. Species recorded in Thailand include *Cladonia siamea* des Abbayes, *C. transindica* Ahti, *C. rangiferina* (L.) Nyl. (subgenus *Cladina*) recorded in adjacent countries of India and China in montane forests.

**COCCOCARPIA** Pers. (COCCOCARPIACEAE (Mont. ex K.Müller) Henssen)

**Key characters:** thallus foliose ± adnate, thallus grey blue turning dark grey on wetting, upper surface frequently with concentric ridges on lobe tips, rhizines squarrose frequently white-tipped; photobiont a cyanobacterium—*Scytonema*; apothecia lecideine, red to dark brown. Distinguished from other genera with cyanobacteria by squarrose rhizines.

**Distribution:** c. 4 species in Thailand, epiphytic and characteristic of evergreen forests at lower and higher altitudes, but persisting into more recently established dipterocarp or pine forests, absent from long established deciduous dipterocarp forest.

**COENOGONIUM** Ehrbg. (GYALECTACEAE Stizenb.)

**Key characters:** thallus filamentous, green to brown-black, threads branched mat-like; photobiont *Trentepohlia*; apothecia lecideine orange, born on the tips of the filaments.

**Distribution:** genus apparently restricted to trunks of moist-barked trees in undisturbed evergreen forests at low altitudes.

**COLLEMA** Wigg. (COLLEMATACEAE Zenker)

**Key characters:** thallus foliose attached to substrate by hapters, olive-green to brown-black, homoiomerous frequently wrinkled or pustulate when dry, gelatinous when wet; photobiont a cyanobacterium—*Nostoc*; apothecia lecanorine, sessile or stipitate, spores muriform (see *Physma*). Distinguished from *Leptogium* by absence of upper and lower cortex and from *Physma* by the absence of a densely short-hairy lower surface.

**Distribution:** mainly epiphytic and found in evergreen forests at lower and higher altitudes, but persisting into recently altered deciduous dipterocarp and pine dipterocarp forests in Thailand.

**CROCYNIA** Nyl. (CROCYNIACEAE M. Choisy ex Hafellner)

**Key characters:** thallus squamulose-placodioid, thick, white, with an abundant dark hypothallus, ecorticate giving a woolly appearance, black pigmentation present in the prothallus and apothecia; apothecia lecideine, grey-black.

**Distribution:** *C. pyxinoides* Nyl. is frequently associated with *Phyllopsora* species on trunks and branches in the lowland and montane evergreen forests.

**DICTYONEMA** Agardh (MERULIACEAE P.Karsten)

**Key characters:** thallus matt-like to foliose, upper side blue- to grey-green, fibrillose; photobiont cyanobacterial filaments surrounded by hyphae.

**Distribution:** a characteristic species of true rain forest, *D. sericeum* (Swartz) Berk. recorded in South Thailand on Kho Tao by PAULSON (1930), not recently recorded.

**DIRINARIA** (Tuck.) Clements (PHYSICIACEAE Zahlbr.)

**Key characters:** thallus foliose, yellow-grey to white, of closely appressed radiating lobes attached by hapters, rhizines absent; apothecia lecanorine, spores brown, thick walled, 1-septate. Distinguished from *Pyxine* and related genera by absence of rhizines and lecanorine apothecia.

**Distribution:** a cosmopolitan genus occurring most frequently in dry, well-lit and open/disturbed sites. Tolerant of disturbance and pollution, so that it is frequently found in urban sites. Common species are *D. consimilis* (Stirton) Awas. (UV-) and *D. picta* (Swartz) Clements & Shear (UV+).

#### ERIODERMA Fée (PANNARIACEAE Tuck.)

**Key characters:** thallus foliose, grey to grey-brown, upper surface with tomentum of hairs. lower surface ecorticate with dense tufts of blue-black rhizines, photobiont cyanobacterial-*Scytonema*; apothecia lecideine. Distinguished from other genera in Thailand with cyanobacteria by naked white lower surface with tufts of blue-black rhizines.

**Distribution:** *E. sorediatum* D.Gallouay & P.M.Jorg. is found locally on twigs and branches in undisturbed montane forests over 1500 m.

#### ESCHATAGONIA Trevisan (family uncertain)

**Key characters:** thallus of thin papery elongated and imbricate squamules usually > 5 mm long, bright green when wet, rhizines lacking. Resembles algal fronds, but contains mycobiont.

**Distribution:** on mossy trunks in moist undisturbed evergreen forests at low altitudes.

#### EVERNIASTRUM Hale ex Sipman (PARMELIACEAE Zenker)

**Key characters:** thallus foliose, grey, lobes narrow, linear, dichotomously divided, canaliculate with dark lower surface and marginal cilia; apothecia lecanorine with hollow stalk. Distinguished from *Heterodermia leucomelos* (L.) Poelt by presence and dark colour of lower cortex.

**Distribution:** a characteristic and abundant genus of twigs in montane evergreen forests over 1000 m, the most common species being *E. nepalense* (Tayl.) Hale ex Sipman. *E. vexans*, an isidiate species, appears above 1600 m in undisturbed forests.

#### FLAVOPARMELIA Hale (PARMELIACEAE Zenker)

**Key characters:** foliose, corticolous or saxicolous, with broad yellow-green subtund lobes, lower cortex with erhizinate zone at margin; apothecia eperforate, spores large (14–20 µm). Distinguished from *Xanthoparmelia* by larger spores.

**Distribution:** *F. caperata* (L.) Hale is recorded frequently in the Himalayas, not recorded in Thailand.

**GYMNODERMA** Nyl. (CLADONIACEAE Zenker)

**Key characters:** thallus foliose, lobate, upper cortex yellow-brown, lower surface ecorticate, white, without rhizines, photobiont chlorococcoid, apothecia marginal, stalked, simple or aggregated, light brown.

**Distribution:** *G.coccocarpum* Nyl. recorded in Thailand (YOSHIMURA & SHARP, 1968) not recently.

**HETERODERMIA** Trevisan (PHYSICIACEAE Zahlbr.)

**Key characters:** thallus foliose closely adpressed or ascending, grey to green-grey, lobes usually ciliate, upper surface with periclinal hyphae, lower surface with or without a cortex; photobiont chlorococcoid; apothecia lecanorine, ascospores brown, thickwalled, 1-septate.

**Distribution:** locally dominant on twigs and trunks in the montane forests, but also occurring on twigs in the lowland evergreen and dipterocarp forests. This genus contains many species in Thailand.

**HYPOGYMNIA** (Nyl.) Nyl. (PARMELIACEAE Zenker)

**Key characters:** thallus foliose, pale grey, attached by adhesive discs below, lobes inflated, hollow, rhizines absent; photobiont chlorococcoid. Distinguished from *Menegazzia* by absence of rounded perforations on upper surface of hollow thallus.

**Distribution:** c.3 species restricted to high altitudes on twigs and branches of trees in forests above 1500 m, the most common species being *H. pseudobitteriana* (Awas.) Awas.

**HYPOTRACHYNA** (Vainio) Hale (PARMELIACEAE Zenker)

**Key characters:** thallus foliose, pale glaucous grey, with truncate lobe ends, lobes without marginal cilia, but with dense dichotomously branched rhizines; photobiont trebouxioid. Distinguished from other Parmeliaceous genera by dense dichotomous rhizines often continued to margins.

**Distribution:** a characteristic and dominant genus in the canopy of montane forests above 900 m, it is rarely found in lowland forests. Common species include *H. formosana* (Zahl.) Hale and *H. orientalis* (Hale) Hale.

**LASALLIA** Merat (UMBILICARIACEAE Chev.)

**Key characters:** thallus foliose, brown, umbilicate, corticated above and below, with pustulate swellings on the upper surface and corresponding indentations below, rhizines

absent, apothecia lecideine.

**Distribution:** saxicolous, occurs in Himalayan regions, Yunnan, and Taiwan; not found in Thailand yet.

**LEPROCAULON** Nyl. (family uncertain)

**Key characters:** thallus fruticose, pale green white, much branched, surface and apices leprose granular.

**Distribution:** 1 species in Thailand, *L. arbusculum* (Nyl.) Nyl., associated with mossy trunks in montane rain forests over 1500 m.

**LEPTOGIUM** (Ach.) Gray (COLLEMATACEAE Zenker)

**Key characters:** thallus foliose, slate grey to brown, homoiomerous, lower cortex with or without hairs; photobiont a cyanobacterium—*Nostoc*; apothecia lecanorine (sometimes not apparent to the naked eye). Section *Mallotium* (Ach.) Vainio with has hairy thalli. Distinguished from *Collema* by presence of upper and lower cortex 1-cell thick.

**Distribution:** widespread and more frequent in evergreen forests at low and high altitudes, species of section *Mallotium* being associated with montane rain forests above 1500 m.

**LOBARIA** (Schreber) Hoffm. (LOBARIACEAE Chev.)

**Key characters:** thallus foliose, broadly lobed, green to grey to brown, lower surface continuously tomentose or in a reticulate pattern in thalline depressions; photobiont a cyanobacteria or green alga; apothecia laminal, infrequent.

**Distribution:** epiphytic on trunks, twigs and branches, restricted to montane fagaceous forests above 1500 m. 3 species recorded in Thailand; *L. retigera* (Bory) Trevisan occurs most frequently.

**MENEGAZZIA** Massal. (PARMELIACEAE Zenker)

**Key characters:** thallus foliose, pale grey green, lobes inflated, hollow, with round perforations on the upper surface, lower surface dark, naked, without rhizines. Distinguished from *Hypogymnia* by round perforations on upper surface.

**Distribution:** *M. terebrata* (Hoffm.) Massal is found on twigs near the summit of Doi Inthanon, a new species for Thailand.

**MYELOCHROA** (Asah.) Elix & Hale (PARMELIACEAE Zenker)

**Key characters:** thallus foliose, grey, with simple cilia, medulla yellow to yellow-orange, rhizines simple or squarrose. Distinguished from other closely related Parmeliaceae with cilia by the coloured medulla.

**Distribution:** locally frequent on trunks and branches in montane forests over 1000 m.

**NEPHROMA** Ach. (NEPHROMATACEAE Wetm.)

**Key characters:** thallus foliose, brownish, lower surface pale, finely pubescent; photobiont a cyanobacterium in Thailand; apothecia on lower surface of lobe apices, reniform, reddish-brown. Distinguished from *Nephromopsis* by the pale lower surface and absence of pseudocyphellae.

**Distribution:** *N. helveticum* Ach. (includes *N. tropicum* (Müll Arg.) Zahlbr.) is restricted to twigs and branches in montane forests over 1000 m.

**NEPHROMOPSIS** (PARMELIACEAE)

**Key characters:** thallus foliose with dark lower surface, with pseudocyphellae on the lower surface; photobiont *Trebouxia*; conidiomata marginal on raised stalks, apothecia on lower surface of lobe apices. Distinguished from *Nephroma* by the dark lower surface with pseudocyphellae.

**Distribution:** *N. ornata* (Müll Arg.) Hue has been recorded occasionally in montane forests above 1000 m.

**NORMANDINA** Nyl. (Family unknown)

**Key characters:** thallus of rounded shell-like squamules 1–2mm diameter, glaucous blue-grey, photobiont trebouxoid, with or without soredia.

**Distribution:** a monotypic genus, *N. pulchella* (Borrer) Nyl. is restricted to undisturbed montane rainforest and usually found on old mossy trees.

**PANNARIA** Delise (PANNARIACEAE Tuck.)

**Key characters:** thallus foliose, squamulose or crustose, pale grey to blue-grey, with or without a conspicuous blue-black hypothallus, photobiont a cyanobacterium—*Nostoc*; apothecia with persistent thalline exciple. Distinguished from *Parmeliella* by the presence of pannarin (Pd + Or).

**Distribution:** reported by Vainio but not recently recorded.

**PARMELARIA** Awas. (PARMELIACEAE Zenker)

**Key characters:** thallus foliose, maculate with black lower surface and few rhizines, margins ciliate with conical black conidia along margin of thallus, apothecia marginal.

**Distribution:** *P. thomsonii* (Stirton) Awas. was collected by Tsuyama at Migothang in Thailand.

**PARMELIA** Ach. (PARMELIACEAE Zenker)

**Key characters:** thallus foliose with linear or effigurate pseudocyphellae on the upper surface, rhizines simple or squarrose usually continuous to the margins.

**Distribution:** many old literature records of this genus have been recently transferred to other genera in Parmeliaceae (ELIX, 1993).

**PARMELIELLA** Ach. (PANNARIACEAE Tuck.)

**Key characters:** thallus squamulose to foliose, greyish brown to lead grey, corticate above ecorticate below; rhizines grey to bluish black; hypothallus usually present, bluish black; photobiont- *Nostoc*; apothecia lecideine; no lichen products detected.

**Distribution:** *P. brisbanensis* (C.Knight) P.M. Jorg. & D. Galloway is frequent on trunks and branches in well-lit open situations in dry evergreen forest and in mangroves.

**PARMELINA** Hale (PARMELIACEAE Zenker)

**Key characters:** thallus foliose, grey, lobes narrow, subrotund apices, maculate upper surface, simple cilia and rhizines, medulla white.

**Distribution:** not recorded from Thailand, but occurs in adjacent countries.

**PARMELINOPSIS** Elix & Hale (PARMELIACEAE Zenker)

**Key characters:** thallus foliose adnate with imbricate lobes and truncate apices, grey, emaculate, cilia simple, often restricted to lobe axils, medulla white, rhizines simple to sparsely dichotomously branched.

Distinguished from *Parmelinella* by presence of at least some dichotomous rhizines and absence of salazinic acid.

**Distribution:** *P. expallida* (Kurok.) Elix has been collected in Thailand in Chiang Mai Province (specimen seen in TNS herbarium in Japan).

**PARMELINELLA** Elix & Hale (PARMELIACEAE Zenker)

**Key characters:** thallus foliose, pale grey green, adnate with imbricate lobes and inconspicuous marginal cilia in the sinuses, medulla white, lower cortex with naked marginal zone, simple white-tipped rhizines, isidia abundant on lamina and on apothecial thalline exciple. Distinguished from *Parmelinopsis* by simple rhizines and presence of salazinic acid.

**Distribution:** *P. wallichiana* (Taylor) Elix & Hale is widespread on trunks and branches in deciduous dipterocarp forests and in open disturbed and modified habitats.

**PELTIGERA** Willd. (PELTIGERACEAE Dumort.)

**Key characters:** thallus foliose, brown, corticate above ecorticate below with network of raised veins and simple to fasciculate rhizines, apothecia without thalline exciple on upper surface of lobe.

**Distribution:** infrequent and only found on earth banks above 2000 m.

**PHAEOPHYSCIA** Moberg (PHYSICIACEAE Tuck.)

**Key characters:** thallus foliose, appressed to substrate, lobes brown-grey without pruina, marginal cilia absent, upper and lower cortex present, rhizines simple; photobiont trebouxoid; cortical substances absent. Distinguished from *Physcia* by brown colour of thallus and absence of lichen substances.

**Distribution:** found infrequently in dry evergreen and montane forests.

**PHYLLOPSORA** Müll. Arg. (BACIDIACEAE W.Watson)

**Key characters:** thallus squamulose, green to white-green, on a red, black or white hypothallus, squamules appressed and placodioid (occasionally appearing crustose) or branching and overlapping appearing foliose, corticate above, non-corticate below; photobiont green; apothecia lecideine. Distinguished from other squamulose genera by green photobiont and presence of a conspicuous felted hypothallus.

**Distribution:** epiphytic, a widespread and variable genus characteristic of the moist evergreen lowland and montane forests, also a rapid coloniser following disturbance, it is found as an indicator of former evergreen status in species-poor deciduous dipterocarp forests that have been fire managed.



**PHYSCIA** (Schreber) Michaux (PHYSCIACEAE Tuck.)

**Key characters:** thallus foliose of radiating appressed to erect lobes, pale white-grey, frequently pruinose; apothecia lecanorine: atranorin and other lichen substances present. Distinguished from *Phaeophyscia* by pale grey thallus and presence of lichen substances.

**Distribution:** infrequent on rocks and trees in deciduous and evergreen forests.

**PHYSCIDIA** Tuck. (PHYSCIACEAE Tuck.)

**Key characters:** thallus foliose of radiating lobes, corticate above, non-corticate below with a white hypothallus, photobiont green, isidia present or absent, apothecia lacking thalline exciple, reddish. Distinguished from *Physcia* which it closely resembles by the absence of a lower cortex and lecideine apothecia, and from *Phyllopsora* by the foliose lobes that are not attached to the substrate by the hypothallus.

**Distribution:** epiphytic, one species *P. wrightii* Tuck. is restricted to relatively undamaged evergreen lowland and montane forests.

**PHYSMA** Massal (COLLEMATACEAE Zenker)

**Key characters:** thallus foliose, lilac grey to brownish grey, homoiomerous, gelatinous when wet, apothecia lecanorine, spores simple. Distinguished from *Collema* and *Leptogium* by the simple spores.

**Distribution:** *P. byrsaeum* (Ach.) Tuck. was found at Huay Kha Khaeng, Uthai Thani Province.

**POLYCHIDIUM** (Ach.) Gray (PLACYNTHIACEAE Dahl)

**Key characters:** thallus fruticose, shining blue-green, densely dichotomously branched with photobiont a cyanobacterium *Scytonema*.

**Distribution:** *P. dendriscum* (Nyl.) Henssen is found on mossy branches near the summit of Doi Inthanon.

**PSEUDOCYPHELLARIA** Vainio (LOBARIACEAE Chev.)

**Key characters:** thallus foliose, grey, corticate above and below, under side pubescent with white or yellow pseudocyphellae; photobiont a cyanobacterium—*Nostoc* or chlorococcoid. Distinguished from *Sticta* by the presence of pseudocyphellae (see plate) on the lower surface and presence of lichen substances.

**Distribution:** epiphytic on twigs and branches, *P. junghuhniana* (Müll. Arg.) Awast. (white medulla, upper surface shiny) and *P. aurata* (Ach.) Vainio (yellow medulla, marginal soralia) are restricted to montane sites in relatively undisturbed fagaceous forest over 1000 m, (a species of the wet tropics is likely to occur in the south; *P. argyrea* (Delise) Vainio (isidiate, white medulla).

**PSORA** Hoffm. (PSORACEAE Zahlbr.)

**Key characters:** thallus squamulose, reddish-brown, corticate above and below, thallus attached to substrate by hyphae, apothecia lecideine brown to black.

**Distribution:** terricolous, *Psora decipiens* (Hedwig) Hoffm. is cosmopolitan and can be expected in Thailand.

**PYXINE** Fr. (PHYSICIACEAE Zahlbr.)

**Key characters:** thallus foliose of radiating lobes, pale grey (to dark grey), lobes truncate, corticate above and below, pseudocyphellae frequently present; photobiont chlorococcoid; rhizines present; apothecia lecideine. Distinguished from *Dirinaria* by presence of rhizines and lecideine apothecia.

**Distribution:** widespread in well-lit situations in lowland forests, *P. coccifera* (Fee) Nyl. (red effigurate pseudocyphellae developing soredia) is frequent in deciduous dipterocarp forests, whereas *P. consocians* Vainio (white effigurate maculae and dactyls) is frequent throughout including secondary, disturbed and urban sites, c. 8 species in Thailand.

**RAMALINA** Ach. (RAMALINACEAE Ag.)

**Key characters:** thallus fruticose, pale green to yellow-green, shrubby or pendulous, photobiont green, branches terete or complanate (flattened), hollow or solid. Distinguished from *Usnea* when branches terete by absence of cartilagenous axis.

**Distribution:** epiphytic on canopy twigs, abundant in exposed sites in montane forest and coastal scrub, elsewhere on coastal rocks but not observed on this survey.

**RELICINA** (Hale & Kurok.) Hale (PARMELIACEAE Zenker)

**Key characters:** thallus foliose, lobes appressed, yellow-green, emaculate, with bulbate cilia, rhizines simple to sparsely branched; apothecia laminal eperforate. Distinguished from *Bulbothrix* by the yellow-green colour of usnic acid.

**Distribution:** *R. sublimata* (Nyl.) Hale is epiphytic on canopy branches and saxicolous above 1000 m.

**RELICINOPSIS** Elix & Verdon (PARMELIACEAE Zenker)

**Key characters:** foliose, lobes narrow, appressed, yellow-green, truncate and simple or agglutinated rhizines, apothecia laminal eperforate. Distinguished from *Relicina* which also has a yellow-green thallus by the absence of cilia.

**Distribution:** epiphytic on well-lit trunks and branches, *R. rahengensis* (Vain.) Elix & Verdon is characteristic of deciduous dipterocarp forests.

**RIMELIA** Hale & Fletcher (PARMELIACEAE Zenker)

**Key characters:** foliose, lobes broad, rounded, ciliate, upper cortex grey green with reticulate maculae becoming cracked and fissured, lower surface rhizinate to margins, rhizines simple to squarrose. Distinguished from *Rimeliella* which also has a cracked and fissured upper cortex by the simple cilia.

**Distribution:** the sorediate species *R. reticulata* (Taylor) Hale & Fletcher occurs on trunks and branches in evergreen lowland and montane forests, but is most abundant and dominant in the montane evergreen forest over 1000 m, especially in disturbed montane rainforest.

**RIMELIELLA** Kurok. (PARMELIACEAE Zenker)

**Key characters:** foliose, lobes broad rounded, cilia frequently branched, upper cortex with effigurate maculae, lower cortex with short marginal rhizines and long agglutinated rhizines. Distinguished from *Rimelia* by at least some cilia being forked.

**Distribution:** epiphytic, a specimen of *R. subsumpta* (Nyl.) Kurok. from Chiang Mai was studied at TNS herbarium in Japan.

**ROCELLA** DC. (ROCELLACEAE Chev.)

**Key characters:** thallus shrubby, tufted, pinkish-grey, attached by basal holdfast, medulla within holdfast orange-yellow; photobiont *Trentepohlia*; apothecia lecanorine, laminal or marginal, subhymenial layers black.

**Distribution:** *R. phycopsis* Ach. recorded in Thailand on rock at Kaw Tao (Koh Tao) (PAULSON, 1930).

**SPHAEROPHORUS** Pers. (SPAHAEROPHORACEAE Fr.)

**Key characters:** thallus fruticose, pale grey to grey-green, much branched, branches usually solid, white to grey-brown; photobiont trebouxoid; apothecia terminal or subterminal on branches. This genus is currently under revision and it is likely that the bulk of the species

belong to the genus *Bunodophoron* Massal.

**Distribution:** saxicolous and terricolous in montane areas over 1500 m in adjacent countries of Vietnam, India and Malaysia. Not recorded in Thailand.

**STICTA** (Schreber) DC. (LOBARIACEAE Chev.)

**Key characters:** thallus foliose, grey to green to brown, loosely adnate or shortly stalked and ascending, corticate above and below, lower surface glabrous or pubescent with distinctly shaped cyphellae, no lichen substances, but thallus often smelling of fish when wet; photobiont a cyanobacterium - *Nostoc* or chlorococcoid; apothecia lecanorine.

**Distribution:** epiphytic on twigs and branches, *S. nylanderiana* Zahlbr. is local and restricted to montane rain forests over 1500 m.

**TELOSCHISTES** Norman (TELOSCHISTACEAE Zahlbr.)

**Key characters:** thallus fruticose with intricate dichotomous branching, yellow to orange, glabrous to pubescent, branches terete to complanate, corticate, photobiont trebouxoid.

**Distribution:** epiphytic on twigs and canopy branches, *T. flavicans* (Swartz) Norman is found in adjacent areas of Vietnam and Yunnan above 1000 m, not recorded in Thailand.

**UMBILICARIA** Hoffm. (UMBILICARIACEAE Chev.)

**Key characters:** thallus foliose, single- or multi-lobed, grey-brown to black, umbilicate and attached by central strand, corticate above and below, photobiont chlorococcoid, rhizines present or absent.

**Distribution:** saxicolous, recorded in temperate areas of the Himalayas, Yunnan, Taiwan and Malaysia, not recorded in Thailand yet.

**USNEA** Adans. (PARMELIACEAE Zenker)

**Key characters:** thallus fruticose, shrubby to pendulous, greenish grey to yellowish, attached to substrate by a basal holdfast, outer cortex present, medulla present and a cartilagenous central axis; photobiont trebouxoid. Distinguished from terete *Ramalina* species by the presence of the cartilagenous central axis.

**Distribution:** widespread and dominant in the upper canopy of montane forests over 1000 m, many species recorded in Thailand.

**XANTHOPARMELIA** (Vainio) Hale (PARMELIACEAE Zenker)

**Key characters:** thallus foliose, lobes narrow, yellow-green, eciliate, rhizines simple. Distinguished from other saxicolous Parmeliaceae by its yellow-green colour and absence of cilia.

**Distribution:** usually saxicolous, frequent on boulders and rock surfaces.

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#### APPENDIX. Glossary of Terms.

- adnate: adjoining the surface (e.g. of the substrate or the thallus).
- anastomose: net-forming.
- anticlinal: of hyphae meeting the surface at right angles.
- apothecioid: apothecia-like.
- apothecium: fruit body of the fungal component of a lichen, often cup-shaped, usually open above, with disc exposed.
- arachnoid: web-like, of a tissue consisting of loosely crisscrossing fungal hyphae.
- ascoma: general denomination for a structure containing asci and ascospores in the ascomycetes.
- ascospore: spore of ascomycetes.
- ascus: sac-like cell, in which after karyogamy and meiosis the ascospores are produced.
- basidiocarp: a basidium producing organ.
- basidiospore: spore of the basidiomycetes.
- basidium: cell or organ of the basidiomycetes from which after karyogamy and meiosis basidiospores are externally produced.
- byssoid: cotton-like; made up of delicate threads.
- cartilaginous: firm and tough, but readily bent (referring to central axis in *Usnea*).
- centrum: general term to describe asci and hamatecium.
- cephalodium: a body composed of blue-green photobiont cells and fungal hyphae growing the surface or within the thallus of lichens with a green photobiont.
- canaliculate: channelled.
- cilia: hair-like outgrowths from the margins or upper surface of the thallus.
- chondroid (axis): the cartilagenous axis occupying the central portion of the medulla.
- clavate: club-like; narrowing in the direction of the base.
- complanate: flattened dorsiventrally, of a thallus.
- conidiomata: hyphal structure where conidia bearing cells and conidia are formed.
- conidium: non-motile asexual spore.
- cortex: a tissue of loose or compacted hyphae, which may appear cellular or fibrous, forming the outer layer of the thallus.
- corticolous: growing on the bark of trees or shrubs.
- corticate: having a cortex.
- crustose: crust-like; i.e. thallus stretching over and firmly fixed to the substratum by the whole lower surface and generally lacking of rhizines.
- cyanobacteria: a blue-green algal cyanobiont.
- dactyl: finger-like protuberance.
- dichotomous: branching into two or more equal arms, usually repeatedly and successively.
- effigurate: having a definite form, not effuse.
- ellipsoidal: (of spore) elliptical in optical section.

- epiphyte: a plant living on another but not as a parasite.
- epithecium: layer of tissue at the surface of an apothecium formed by the branching of the apical cells of the paraphyses.
- exciple: a tissue or tissues containing the hymenium of the apothecium, or forming the walls of a perithecium.
- fibril: a short simple branch perpendicular to the main stem (in *Usnea*).
- filamentous: thread-like, the photobiont forming a filament of cells which is surrounded by the mycobiont, or to fungal hyphae.
- filiform: thread-like (spore).
- foliose: leaf-like, with a distinct upper and lower surface.
- fruticose: shrubby, having an upright or hanging thallus with a radial structure.
- fusiform: spindle-like, narrowing at both ends.
- gelatinous sheath: gelatinous membrane (spore); see perispore.
- glabrous: smooth, not hairy    globose: spherical or almost so.
- hamathecium: neutral term used for all types of hyphae and other tissues between the asci.
- hapter: an organ of attachment (of the thallus to the substrate).
- heteromerous: (of a layered thallus) having the mycobiont and the photobiont in well-marked layers in the thallus.
- holdfast: an expanded often disc-like, attachment of thallus to substrate.
- homoimerous: (of an unlayered thallus) having the mycobiont and the photobiont evenly distributed through the thallus.
- hyaline: transparent (colourless).
- hymenium: the spore-bearing layer of a fruiting body, containing asci, spores and paraphyses.
- hypha: one of the filaments of a fungal mycelium.
- hypothallus: a thick layer of hyphae, white to darkly coloured, on the under side of the thallus and often projecting beyond its margins.
- hypothecium: tissues below the hymenium.
- imbricate: overlapping.
- isidium: a (pin-like) vegetative propagule bounded by a true cortex, comprising both photobiont cells and fungal hyphae; usually concolourous with the upper surface of the thallus.
- leprose: having a loose powdery surface without a cortex.
- lirella: long and narrow apothecium.
- lirellate: lirella-shape.
- maculate: spotted or blotched, due to uneven distribution of photobiont cells.
- mazaedium: a powdery mass of spores together with disintegrating asci and paraphyses.
- medulla: (of lichen thallus) the loose layer of hyphae below the cortex and algal layer.
- muriform: brick wall-like, having transverse and longitudinal septa.
- mycobiont: the fungal partner in the lichen symbiosis    nasse: finger-like protusion of the inner part of a bitunicate ascus into the endotunica or endoascus; internal apical beak or apparatus.
- oblong-ellipsoid: (of spores) having long sides parallel, and ends almost hemispherical.
- ostiole: cavity ending in a pore in the papilla or neck of a perithecium or pycnidium.
- paraphyses: hyphae originating from the base of the cavity, usually unbranched and not anastomosed.

- paraplectenchymatous: a tissue of  $\pm$  isodiametric thin-walled fungal cells.
- periclinal hyphae: of hyphae, lying in the same plane as the surface.
- perithecia: a subglobose or flask-like ascoma.
- perithecioid: perithecia-like.
- phorophyte: the 'host' tree of an epiphyte.
- photobiont: the algal partner in the lichen symbiosis.
- phylloidium: a small corticate, scale-like, dorsiventral structure developed at the margins or the upper surface of the thallus, narrowed or constricted at the point of attachment.
- phyllocladium: a small corticate thalline structure that may be granular, verrucose, coralloid, squamiform, digitate or peltate, containing a green photobiont in *Stereocaulon*.
- placodioid: crustose at the centre, lobed and plicate at the margins of the thallus.
- plectenchyma: a tissue formed of fused and twisted hyphae.
- podetium: lichenised stem-like portion bearing apothecia.
- polarilocular: (of ascospores) bicellular, and the two cells separated by a central perforated septum.
- proper exciple: (of an apothecium) non-lichenized excipular tissue.
- prosoplectenchyma: tissue with elongated longitudinally arranged hyphae (in L.S.).
- pruinose: having a frost-like or flour-like surface covering.
- pseudocyphellae: openings in the cortex of lichens where the medulla is exposed to the air, but lacking specialised cells surrounding the cavity.
- pseudopodetia: a stalk bearing one or more apothecia, developmentally part of the thallus.
- pseudostroma: a stroma formed of thalline tissue and remnants of host tissue.
- pubescent: having soft hairs.
- pycnidium:  $\pm$  flask-shape, ostiolar conidioma, consisting entirely of fungal tissue.
- reticulate: net-like.
- rhizine: root-like hair or thread; the attachment organ of many foliose lichens Plate I.
- saxicolous: growing on rock.
- sessile: having no stem, attached directly to the surface.
- sinuous: having rounded angles, wavy (of a margin).
- soralia: soredia on lamina or margins of thallus in a variety of diffuse or delimited or figurate patterns Plate II.
- soredium: a non-corticate combination of phycobiont cells and fungal hyphae having the appearance of a powdery granule and capable of vegetative reproduction.
- spore: a uni- or multicellular reproductive structure (asexual or sexual) in fungi, bacteria and cryptogams.
- squamule: a small separate thallus scale or lobe (less than 5mm long) with or without a lower cortex.
- squarrose: of rhizines branching at right angles e.g. brush-like.
- subhymenial: generative tissue below the hymenium.
- stipe: a stalk supporting an apothecium.
- stipitate: of an apothecium supported by a stipe.
- stroma: a mass or matrix of vegetative hyphae in or on which spores are produced often covering several ascomata.
- sublageniform: rod shaped with a swelling near but not at one end (of pycnoconidia).



subovate: nearly ovate, or egg-shape.

sympodial: of a thallus with a main axis and a succession of subsidiary lateral branches.

terete:  $\pm$  circular in transverse section.

terricolous: growing on the ground.

thalline exciple: (of an apothecium) lichenized excipular tissue, external to a proper exciple.

thallus: the vegetative body of a lichen.

tomentose: having a dense covering of soft matted hairs; downy.

truncate: ending abruptly, as with the end cut off.

urceolate: pitcher-like.

