CHAPTER 4

MORPHOLOGICAL AND ANATOMICAL CHARACTERISTICS OF DISCOLICHENS

The morphological and anatomical characters of discolichens are very important, especially at family and genus level. This group is characterized by disc shaped, that usually colored apothecia, with a margin containing algal cells call and then called a "lecanorine apothecium". In this case, the margin is usually of the same color as the thallus. When apothecia are lacking a thalline margin, they are called a "lecideine or biatorine apothecium". Furthermore, discolichens often have colorless, simple or transeptate to muriform ascospores. Photobiont are usually protococcoid green algae. The characters, which were used for segregating orders, families, genera and species are as follows.

Macroscopic and Microscopic Examination

Hypothallus

The hypothallus is the structure, which forms a layer of woolly and often dark hyphae beneath a thallus or at the margin. The first part of the thallus to grow typically lacks photobionts. Some taxa may produce a distinct, marginal hypothallus (prothallus) (see Figure 5).

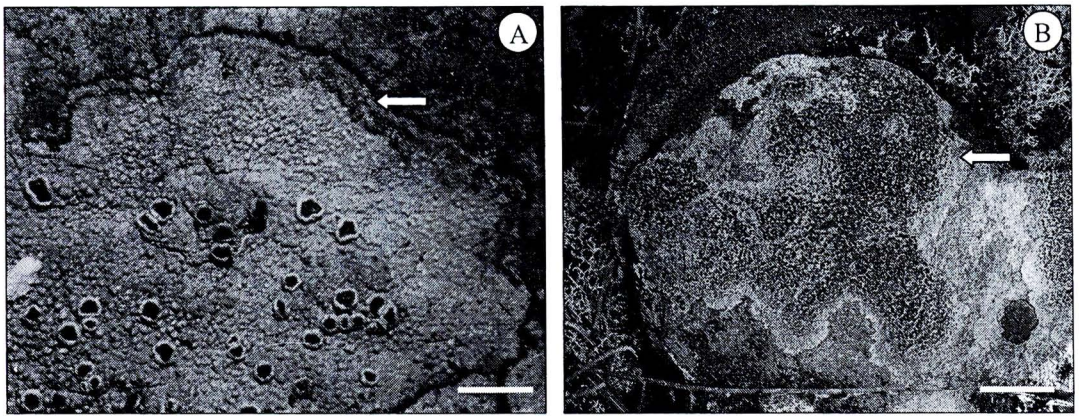

Figure 5 The hypothallus (prothallus) of crustose discolichens

Note. The arrows show the hypothallus (prothallus) of crustose discolichens of

A = *Malmidea eeuuae* Kalb [VC917(RAMK)] (scale = 2 cm)

B = *Ramboldia* sp. (photo from natural habitat at Phu Luang Wildlife Sanctuary) (scale = 2 cm)

Thallus

Crustose discolichens are tightly attached to the substrate and lack a lower cortex and rhizines. They cannot be removed from the substrate without damage. The thallus of crustose discolichens may also be epilithic (on a rock surface) or epiphloeodal (on the bark surface) (see Figure 6).

The texture (smooth, rimose, rough, or warted) as well as the colors (whitish to yellowish to greenish grey or brownish) of the thallus of discolichens can vary greatly. Crystals on the thallus surface might give a verrucose appearance, verrucae can be present (e.g. in *Malmidea coralliformis*), and the surface can be areolate or rimose (see Figure 7). The color of the upper surface is greatly influenced by the nature of chemical constituents. A yellowish white to yellowish grey or brownish grey color may

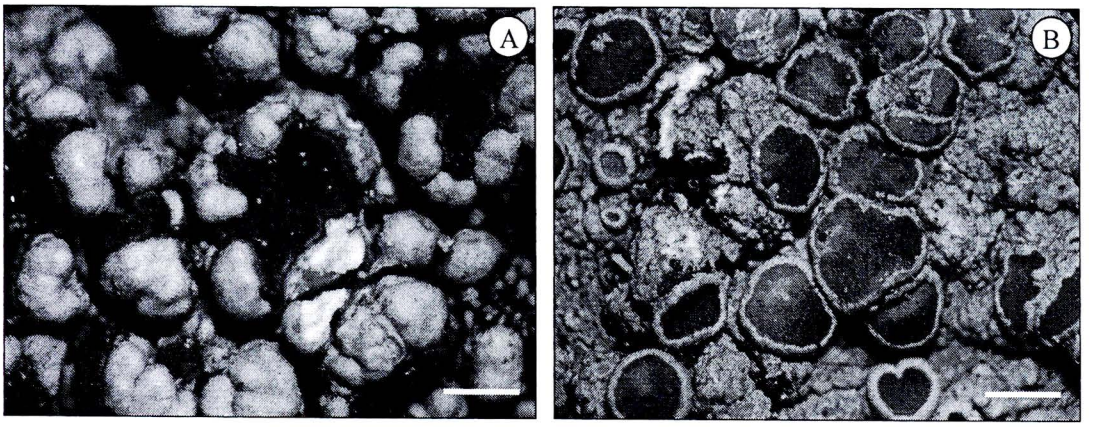

Figure 6 Epilithic or Epiphloeodal of the thallus

Note. A = Epilithic of *Ramboldia* PL.1 [RU010689(RAMK)] (scale = 1 mm)

B = Epiphloeodal of *Lecanora austrotropica* Lumbsch [VC531(RAMK)] (scale = 0.6 mm)

be caused by the presence of atranorin, usnic acid or xanthones. As an example, anthraquinones and particularly parietin in the family Teloschistaceae is responsible for the orange color of many species.

The thallus of crustose discolichens is mostly heteromerous (showing a cortex, an algal layer and a medulla) (e.g. *Lecanora*). Therefore, the thallus consists of 3 layers and they are described as follows.

i). Cortical layer is composed of tightly woven fungal cells (thin, more or less horizontal hyphae, it often appears as parenchyma).

ii). Algal layer consists of loosely woven fungal hyphae with algal cells or filaments interspersed.

iii). Medulla: a layer of fungal hyphae, this area is thought to be the site of water and nutrient storage.

Reproductive Structures

Apothecial characters. Apothecia are cup- or disk-shaped fruits on the surface of the thallus, may be immersed, adnate or sessile, lecanorine or lecideine, round or somewhat irregular. There are two types of apothecia found in discolichens. One with a margin containing algae (lecanorine apothecia); white, cream or pale colored, orange, red to brown, and dark to black (e.g. *Haematomma wattii*), the other without a thalline margin (lecideine apothecia); white, cream or pale colored, orange, red to brown, and dark to black (e.g. *Ramboldia deficiens*) (see Figure 8). Two layers can be distinguished: the inner part is formed by the hymenium, pertaining the asci, the outer layer is called amphithecium, enclosing and protecting the hymenium.

Exciple (Excipulum). The excipulum is a tissue characteristic of the margins adjacent to the hymenium and hypothecium. Without photobiont cells it is called a proper exciple, while a thalline exciple contains photobiont cells. Its structures are diagnostic at family, genus and species level. For example, a paraplectenchymatous excipulum is found in the family Megalosporaceae, in *Bacidia*, and *Lecidella*. An excipulum, which is composed of radiating hyphae, partly with a medullary layer of periclinal hyphae is typical for *Malmidea*, while in some species of *Lecanora* the exciple may soon become excluded.

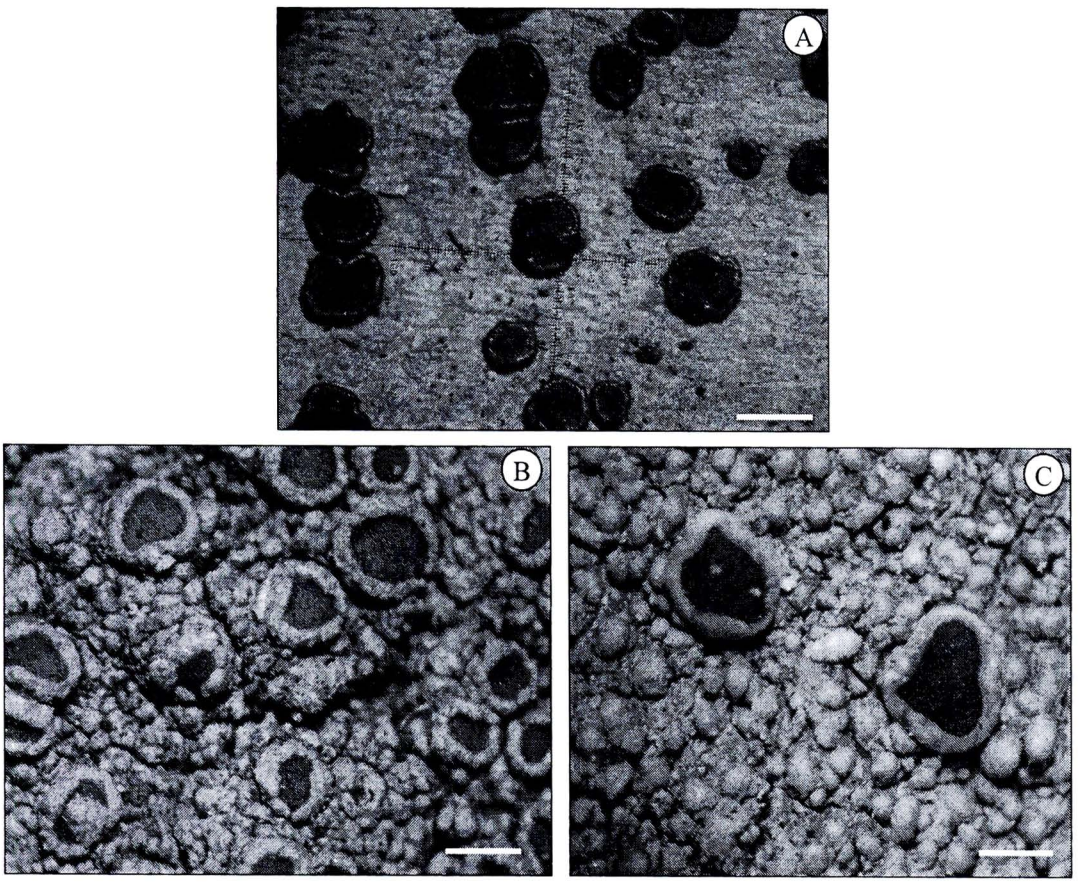

Figure 7 Structure of discolichens thallus

Note. A = Upper surface smooth to rough of *Ramboldia russula* (Ach.) Kalb, Lumbsch & Elix. [RU010519(RAMK)] (scale = 1 mm)

B = Upper surface rimose of *Lecanora achroa* Nyl. [VC851(RAMK)] (scale = 1 mm)

C = Crystals on the thallus surface, verrucae of *Malmidea coralliformis* Kalb [VC820(RAMK)] (scale = 1 mm)

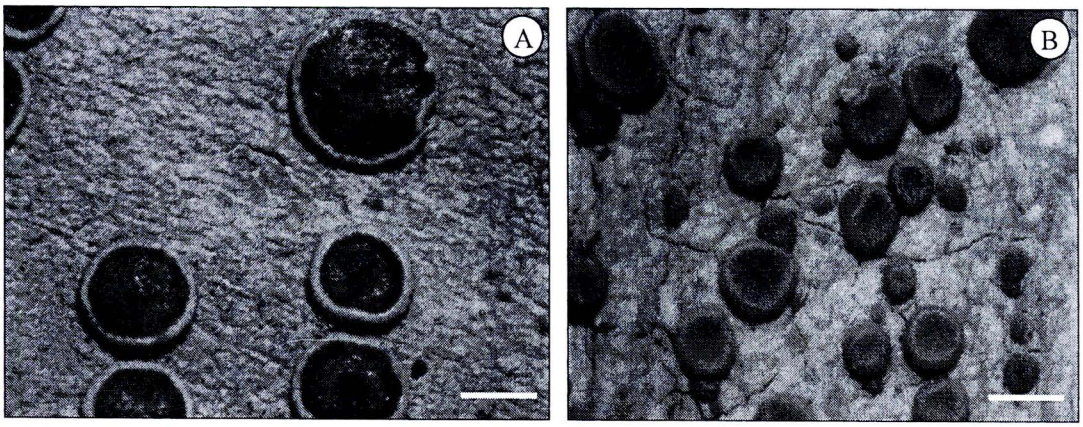

Figure 8 Lecanorine and Lecideine or biatorine apothecium

Note. A = Lecanorine apothecia of *Haematomma wattii* (Stirton) Zahlbr. [VC501(RAMK)] (scale = 1 mm)

B = Lecideine or biatorine apothecia of *Ramboldia deficiens* Sriprang & Kalb [RU010519(RAMK)] (scale = 1 mm)

Amphithecium. The amphithecium is the structure, which forms the ectal and the medullary excipulum together they are called "amphithecium"

The amphithecium has been considered to be all those tissues external to the hypothecium and hymenium, and includes also the cortex. For example, In taxa of *Lecanora sensu stricto* the presence and size of crystals in amphithecium are important diagnostic features (see Figure 9).

Four types of amphithecium can be distinguished in this genus:

i). *allophana*-type with small crystals in the algal-containing and cortical part of the amphithecium.

ii). *campestris*-type with small crystals only in the algal-containing and part of the amphithecium.

iii). *melacarpella*-type with small and large crystals.

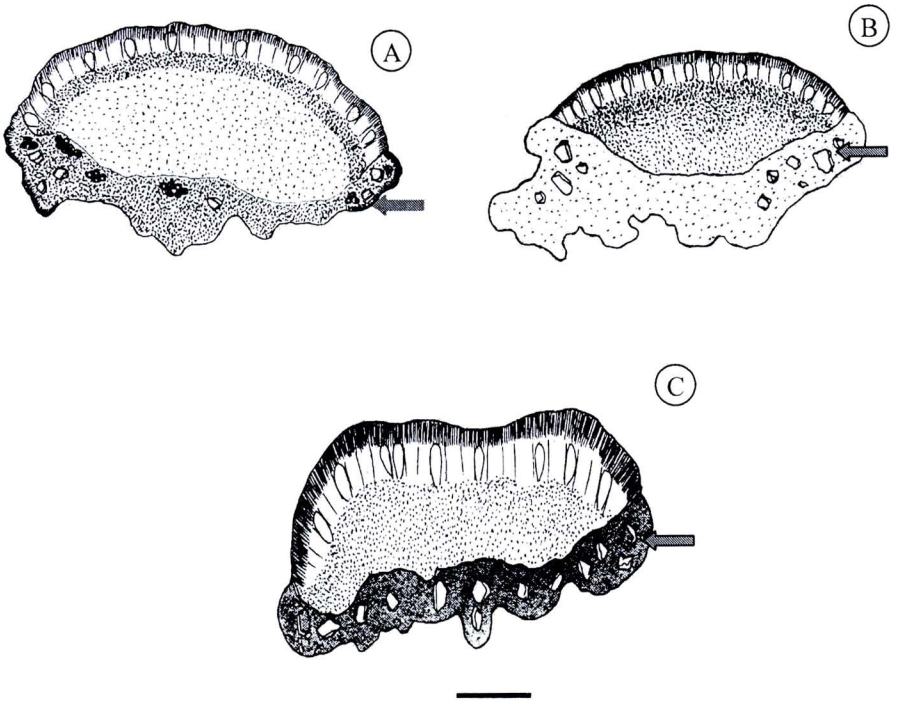

Figure 9 Types of amphithecium of genus *Lecanora*

Note. The arrows show types of amphithecium of *Lecanora*

A = Amphithecium with numerous small crystal (*allophana*-type) of *Lecanora subimmersa* (Fée) Vain. [CP669-1(RAMK)] (scale = 10.57 μm)

B = Amphithecium with small and large crystals (*melacarpella*-type) of *Lecanora flavoviridis* Krempelh. [CP453(RAMK)] (scale = 10.8 μm)

C = Amphithecium with large crystals (*pulicaris*-type) of *Lecanora achroa* Nyl. [VC851(RAMK)] (scale = 11.2 μm)

iv). *pulicaris*-type with large crystals.

Epihymenium. The epihymenium is the structure, which forms the upper layer of the hymenium that is differentiated by pigmentation (within or

between the tips of the paraphyses) and granulation (above or between the tips of the paraphyses). For example, in taxa of *Lecanora sensu stricto* the presence and size of crystals in the epihymenium and pigments are important diagnostic features (see Figure 10).

Three types of epihymenium can be distinguished in the group:

i). *chlarotera*-type with coarse crystals in the epihymenium which are soluble in HNO_3, pigmented or not, if pigmented, pigmentation soluble in KOH (e.g. in *Lecanora achroa* Nyl.).

ii). *glabrata*-type lacking crystals, red-brown-pigmented, pigmentation insoluble in KOH (e.g. in *Lecanora argentata* (Ach.) Degel.).

iii). *pulicaris*-type with small crystals in the epihymenium insoluble in HNO_3, brownish-pigmented with the pigmentation soluble in KOH (e.g. in *Lecanora toroyensis* Zahlbr.).

Epithecium. The epithecium is the uppermost layer of the hymenium. Usually formed by periclinal hyphae originating from the tip of the paraphyses. This structure was not found in the species treated in this thesis.

Parathecium. The parathecium consist of two main layers, the subhymenium and the hypothecium. The parathecium is sometimes very weakly developed and reduced to a ring on the outer margin of the subhymenium or lacking altogether. For example, a composed of thin-walled parathecium is found in the family Megalosporaceae and many other lichens with biatorine or lecideine apothecia, such as *Bacidia, Brigantiaea* and *Letrouitia*. The parathecium is distinct in species with lecanorine apothecia,

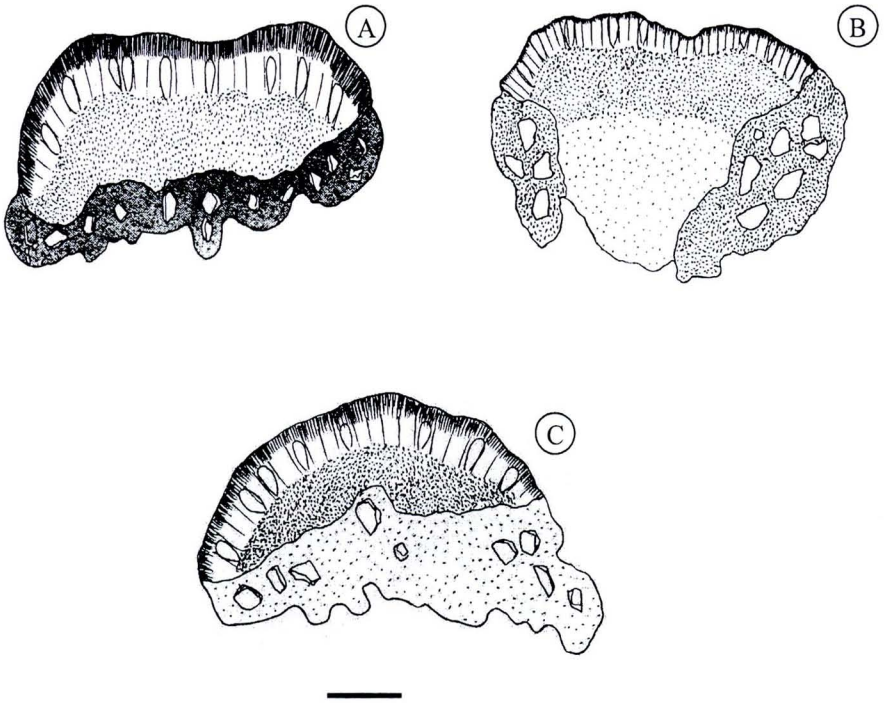

Figure 10 Types of epihymenium of genus *Lecanora*

Note. A = Epihymenium with small crystal (*chlarotera*-type) of *Lecanora achroa* Nyl. [VC851(RAMK)] (scale = 11.2 μm)

B = Epihymenium, K-, without crystals (*glabrata*-type) of *Lecanora argentata* (Ach.) Degel. [VC682(RAMK)] (scale = 11.7 μm)

C = Epihymenium with small crystals (*pulicaris*-type) of *Lecanora toroyensis* Zahlbr. [VC824(RAMK)] (scale = 9.71 μm)

such as *Caloplaca*, and *Lecanora* (see Figure 11-12). It is composed of thick-walled hyphae.

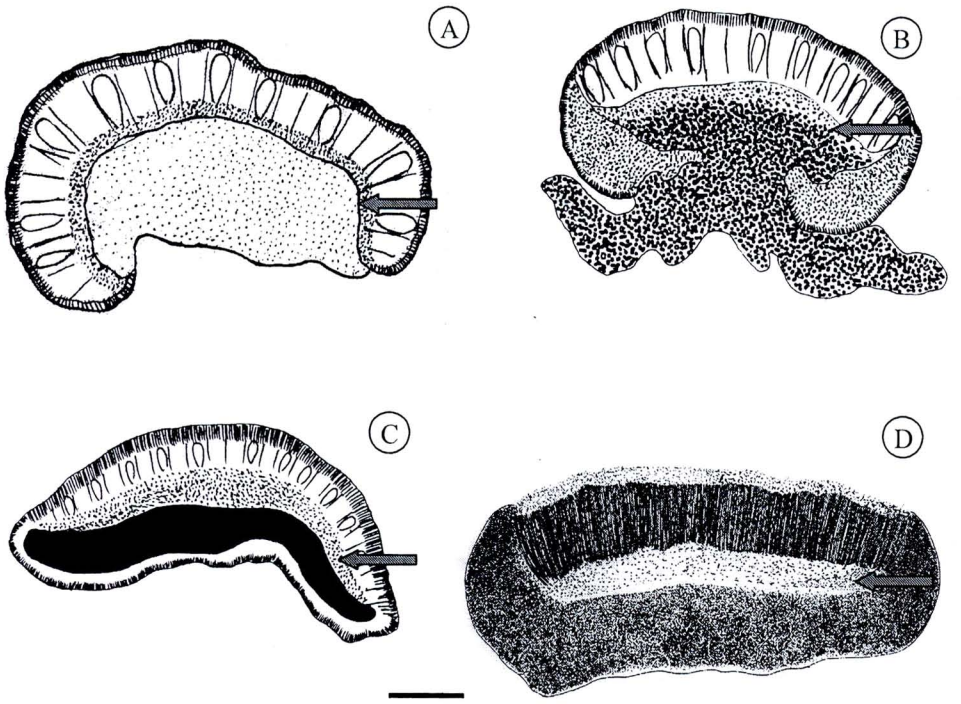

Figure 11 The parathecium of Lecideine or biatorine apothecium with the arrows show the parathecium of Lecideine or biatorine apothecium

Note. A = *Bacidia incongruens* (Stirton) Zahlbr. [VC774(RAMK)] (scale = 10.81 μm)

B = *Brigantiaea leucoxantha* (Spreng.) R.Sant. & Hafellner [RU011817(RAMK)] (scale = 19.7 μm)

C = *Letrouitia vulpina* (Tuck.) Hafellner & Bellem. [VC616(RAMK)] (scale = 11.29 μm)

D = *Megalospora tuberculosa* (Fée) Sipman [VC483(RAMK)] (scale = 11.53 μm)

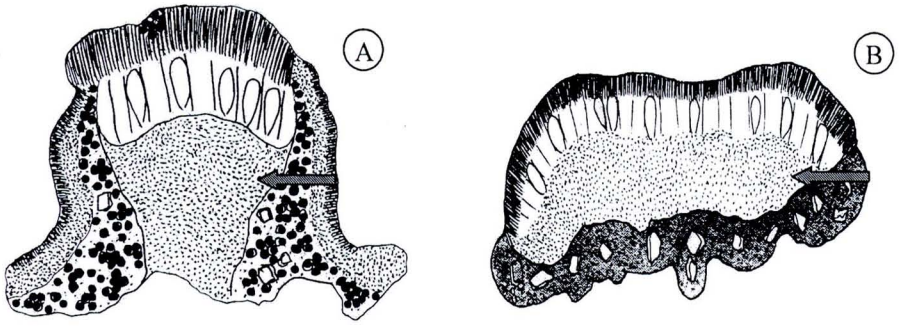

Figure 12 The parathecium of Lecanorine apothecium with the arrows show the parathecium of Lecanorine apothecium

Note. A = *Caloplaca testaceorufa* Vain. [RU010676(RAMK)] (scale = 16.04 μm).

B = *Lecanora achroa* Nyl. [VC851(RAMK)] (scale = 11.2 μm)

Hymenium. The hymenium is the layer which contains the asci and paraphyses in apothecia, usually imbedded in a gelatinous or cartilalagineous matrix. Hymenial characters are length, form, pigmentation and structure of the paraphyses, and of the ascus wall. An important diagnostic feature on species level is the height of the hymenium.

Hypothecium. This is the layer below the hymenium, often colorless or pigmented. Sometimes a hypothecium, underlying the subhymenium, can be developed.

Paraphyses. Paraphyses are the hyphae between the asci in the hymenium, in their totality also called hamathecium. For example, unbranched and not anastomosing paraphyses are typical for Lecanoraceae.

Asci. Asci contain the ascospores, usually 8 in number. In this study, the shape of ascus is clavate and the ascal wall is functionally unitunicate. Its structure is diagnostic at genus level and it is the structure of the ascus apex viewed after staining in iodine which is critical, for example in *Lecanora.*

Ascospores. Ascospores are the most important character for species delimitation. At the species level the size, septation and number of spores in each ascus is often crucial for an identification (see Figure 13).

Pycnidial characters and pycnidiospores. Pycnidia are the main type of anamorph structure and are pear-shaped or globose receptacles within conidia are formed from a conidiogenous cell on a special hyphal type, called conidiophores. Pycnidia are usually immersed or semi-emergent with a colored or pale ostiolar region. For example, conidia which are curved-filiform or bacilliform, simple, colorless are typical for *Haematomma collatum.*

Photobionts. All the species treated here, contain green algae. In most of the species they are chlorococcoid (unicellular and globular).

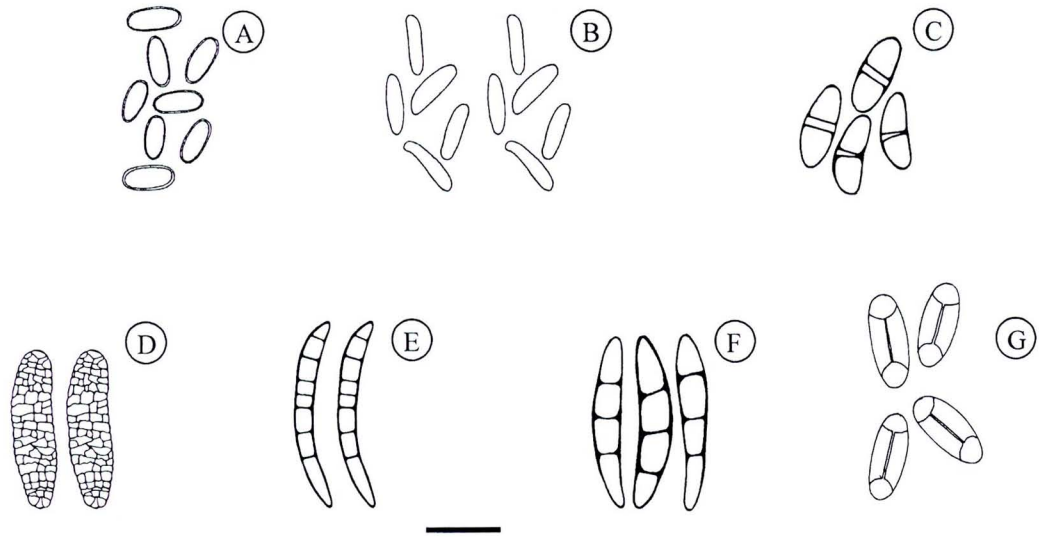

Figure 13 Illustration of ascospores

Note. A = Ascospores simple of *Lecanora phaeocardia* Vain. [VC866(RAMK)] (scale = 3.67 μm)

B = Ascospores simple, non-halonate of *Ramboldia siamensis* Buaruang, Elix & [RU010697(RAMK)] (scale = 5.78 μm)

C = Ascospores 1-septate of *Catillochroma melanotropa* (Nyl.) Kalb [RU010535(RAMK)] (scale = 5.02 μm)

D = Ascospores muriform of *Brigantiaea leucoxantha* (Spreng.) R.Sant. & Hafellner [MSPL049(RAMK)] (scale = 9.54 μm)

E = Ascospores fusiform, 5-7-septate of *Haematomma flexuosum* Hillm. [VC450(RAMK)] (scale = 4.47 μm)

F = Ascospores 3-septate of *Micarea melaena* (Nyl.) Hedl. [CP381 (RAMK)] (scale = 4.13 μm)

G = Ascospores 2-locules of *Caloplaca flavorubescens* (Huds.) J. R. Laundon [VC787(RAMK)] (scale = 16.66 μm)