CHAPTER 4
MORPHOLOGICAL, ANATOMICAL AND CHEMICAL CHARACTERS

Structural Character for generic delimitation

Prominent structures for delimitation of genera in this study were the apothecia, spore wall and the thallus chemistry. *Ochrolechia* does not have verruciform apothecia. Disciform apothecia of *Ochrolechia* (Figure 4.1 A) are distinguished from *Pertusaria* apothecia (Figure 4.1 B) by having a prominent and thick exciple. Verruciform apothecia (Figure 4.1 C) only occur in *Pertusaria.* The ascospore wall of *Ochrolechi*a is constantly thin and smooth, but variable thin to thick and smooth to rough in *Pertusaria* ascospores. In the case of thallus with vegetative-reproductive propagules *e.g*. soralia and isidia, there is little different morphology. The sorediate thallus *Pertusaria* often has a distinct lump of soralia but is scattered in *Ochrolechia*. *Ochrolechia* contains mainly gyrophoric acid; while *Pertusaria* has other chemicals (see in Table 4.5 and 4.6).

Thallus

The thallus surface of Pertusariaceae was variable from smooth to tuberculate. According to Dibben (1980), there was no significant difference in thickness or texture of thallus but colour is variable in *Pertusaria*. The colour of the thallus surface depends on chemicals in the cortex and medulla. It is possible that chemicals in the thalli could depend on geography. In tropical regions, in my observation, few specimens of *Pertusaria* species that contain thiophaninic acid, they have only a light yellow thallus, in contrast with many; clear and strong yellow thallus species in temperate zones. The colour of the *Ochrolechia* thallus is mostly all the same, dull and whitish grey green. Reproductive structures on the thallus could enable easy early identification. There were two separated groups of structures; asexual reproductive propagules; isidia (Figure 4.3) and soredia (Figure 4.4) and sexual reproductive structures, apothecia (Figure 4.1). In the SEM study of the surface of the structures, isidia, soredia (Figure 4.5) and apothecia (Figure 4.2) there were

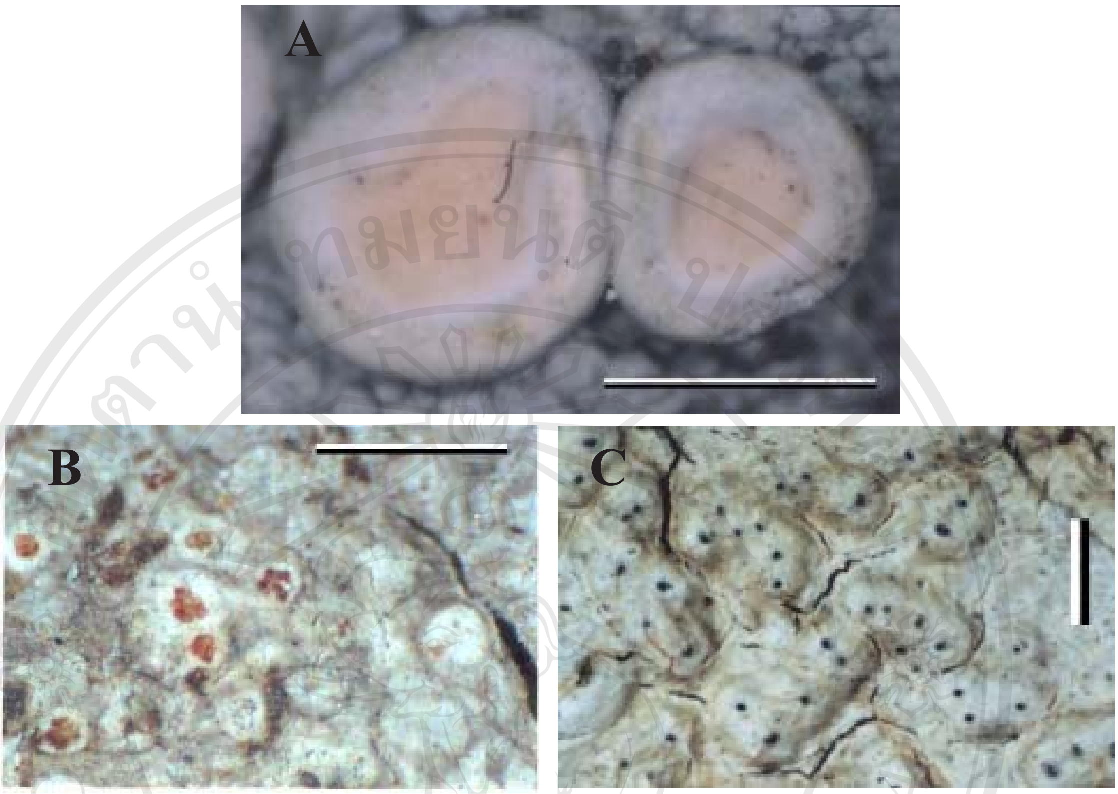


Figure 4.1 Apothecia types of Pertusariaceae
A. Disciform apothecia of *Ochrolechia* sp. 1 (*S. Jariangprasert 3544* QSBG), showing thick exciple
B. Disciform apothecia of *Pertusaria velata* RU 15122 (RAMK), with indistinct exciple
C. Verruciform apothecia of *P. ceylonica F. David 120.1* (PSU)

A-C, scale bar = 1 mm.

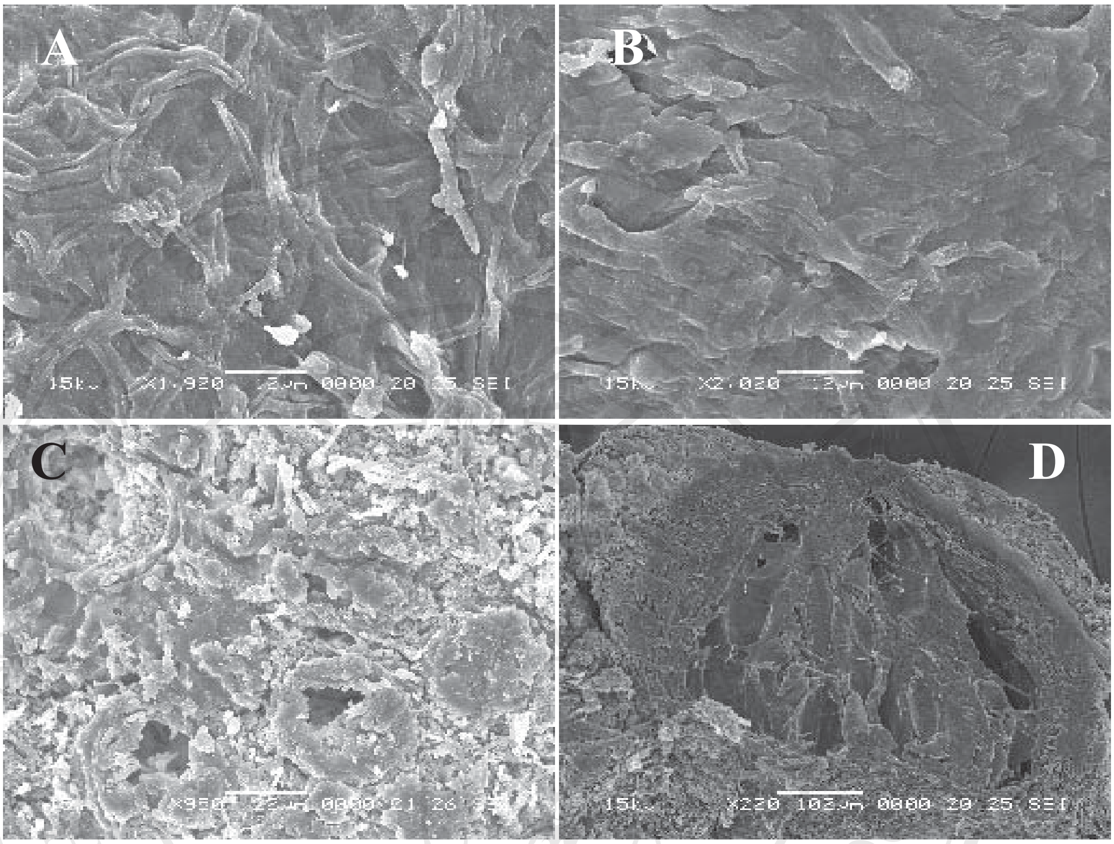


Figure 4.2 Apothecia of Pertusariaceae viewed by SEM

A. *Ochrolechia trochophora,* RU 1803 (RAMK), exciple surface, scale bar = 12 micrometre

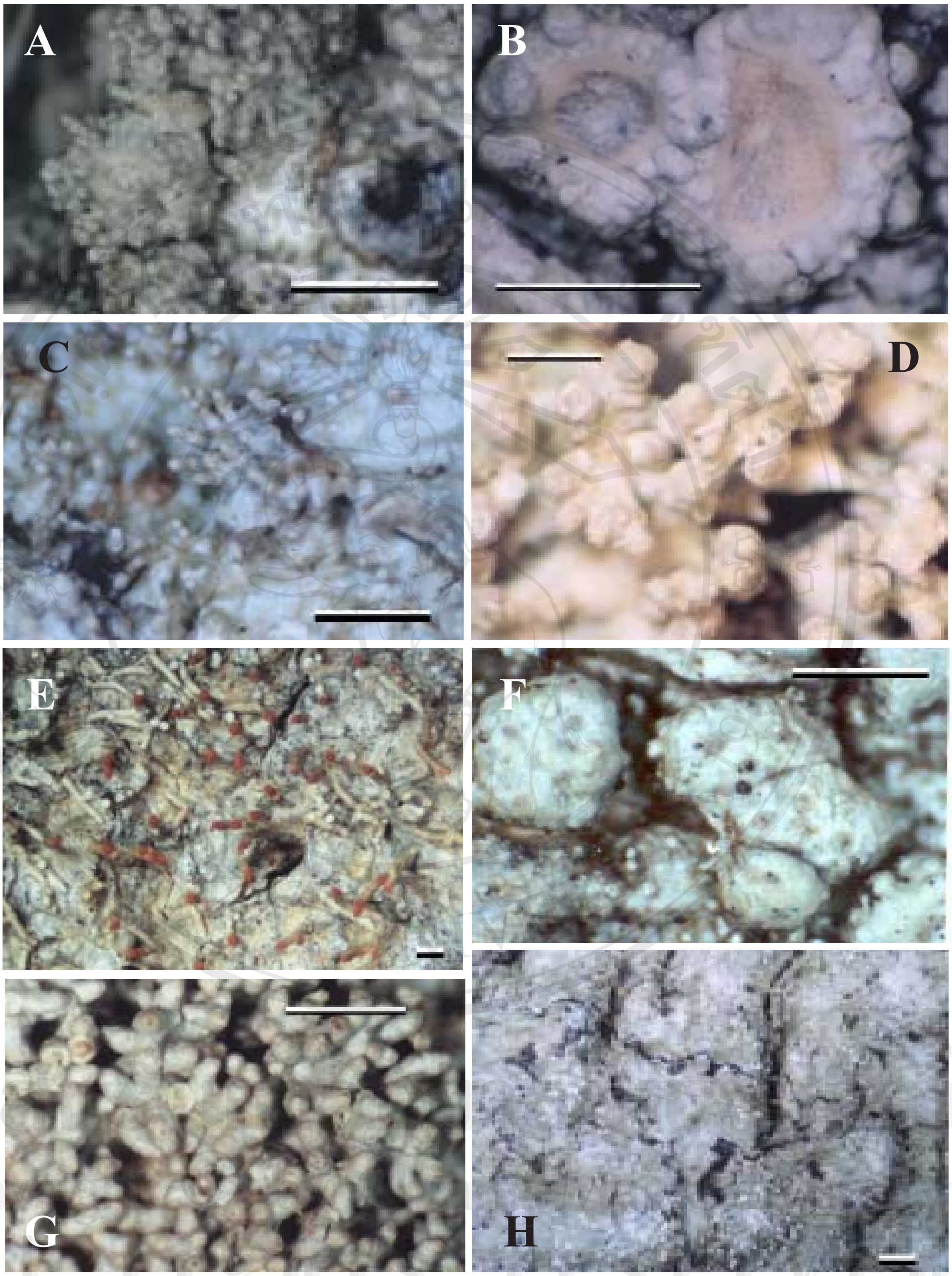
B. *O. yasuda, S. Jariangprasert 3307* (QSBG), dense weaving hypha cortex on exciple surface, scale bar = 12 micrometre

C. *Pertusaria miscella, S. Jariangprasert 1583* (QSBG), disc surface with pruinose and asci, scale bar = 22 micrometre

D. *P. pallida, S. Jariangprasert 1400* (QSBG), section of verruciform apothecia, scale bar = 102 micrometre

Figure 4.3 Isidia reproductive propagules of Pertusariaceae
A. *Ochrolechia yasudae* var. *corallina, S. Jariangprasert 3774* (QSBG), uneven surface, simple and branched isidia
B. *O. yasudae, S. Jariangprasert 3736* (QSBG), global isidia on apothecia exciple
C. *Pertusaria muricata, S. Jariangprasert 3791* (QSBG), even smooth surface and branched isidia
D. *P. pilosula, S. Jariangprasert 3731* (QSBG), uneven surface and branched isidia
E. *P. ramulifera, S. Jariangprasert 2437* (QSBG), red tip with even and smooth surface, large simple isidia
F. *P. takensis, S. Jariangprasert 1319* (QSBG), minute global isidia on apothecia exciple
G. *P. wauensis, S. Jariangprasert 2436* (QSBG), even smooth surface and branched isidia
H. *P. umbricola, S. Jariangprasert 2907* (QSBG), very fine global isidia

A, B, D, E, F scale bar = 1 mm, C scale bar = 0.5 mm



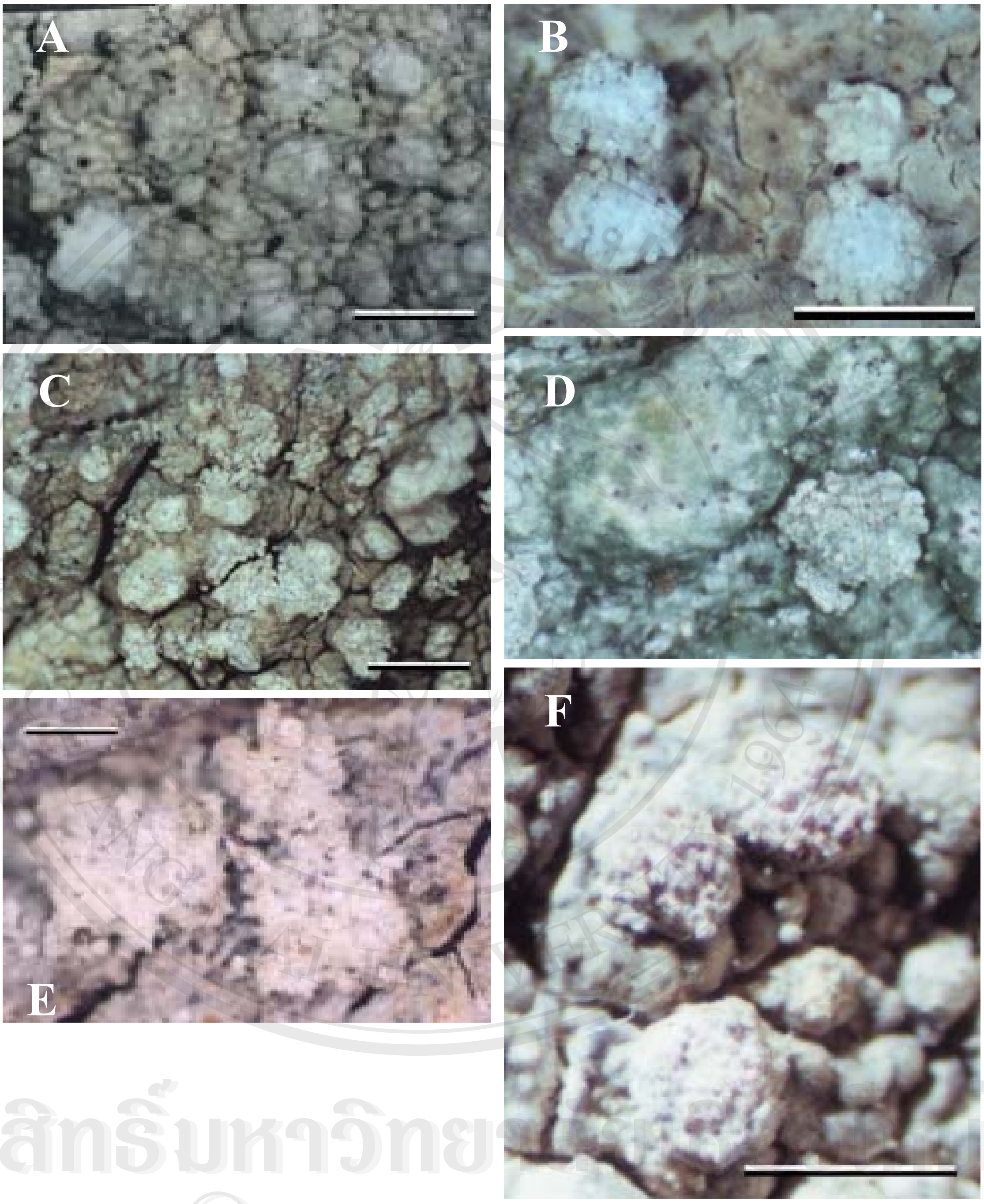


Figure 4.4 Soredia reproductive propagules of Pertusariaceae

A. *Ochrolechia androgyna, S. Jariangprasert 3378* (QSBG)

B. *Pertusaria albescens, K. Papong 20* (QSBG)

C. *P. moreliensis,* RU 1022 (RAMK)

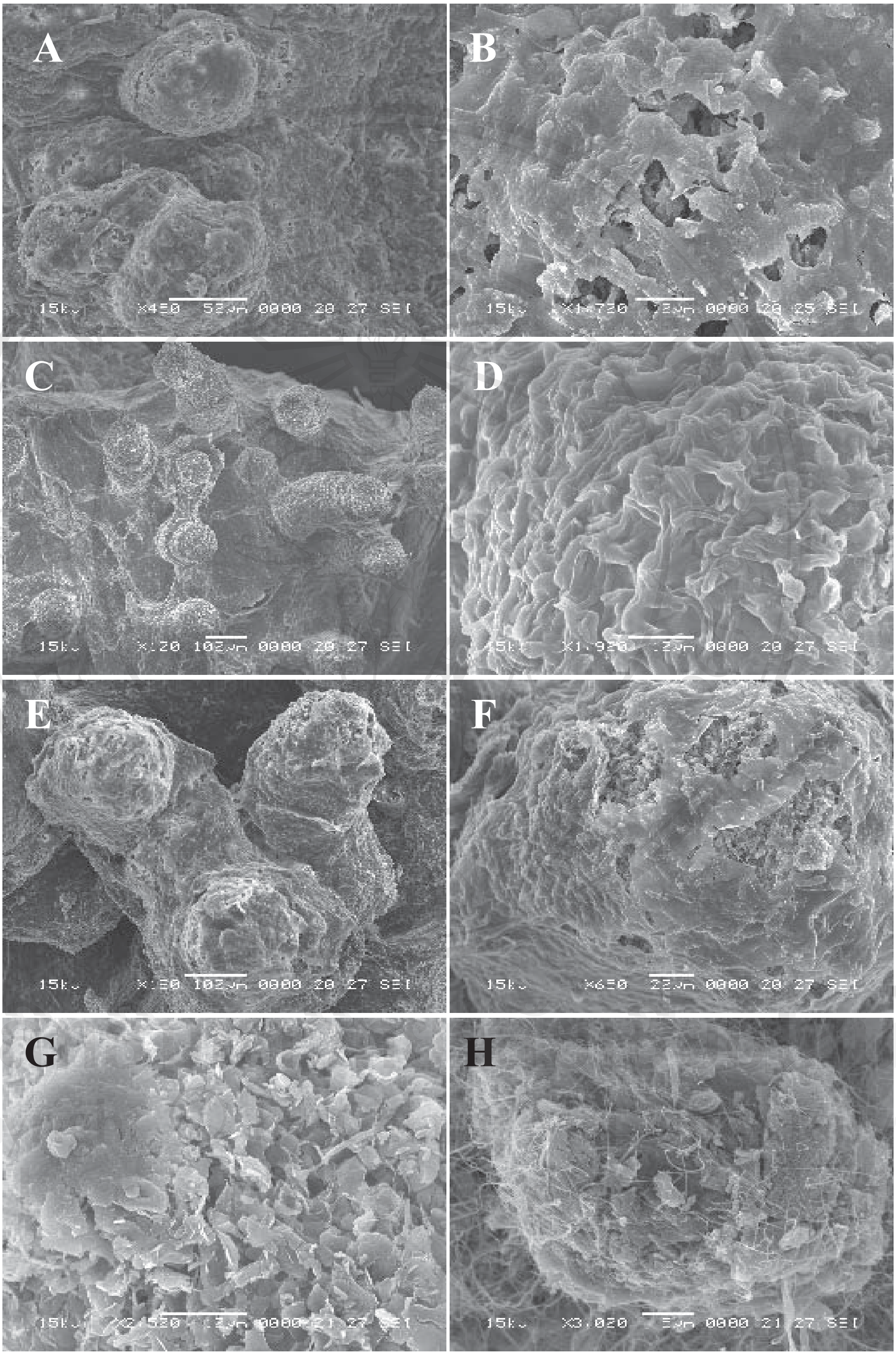
D. *P. lansangensis, S. Jariangprasert 3779* (QSBG)

E. *P. psoromica, S. Jariangprasert 2584* (QSBG)

F. *P. scaberula,* RU 4344 (RAMK)

A-F, scale bar = 1 mm

Figure 4.5 Isidia and soredia of Pertusariaceae viewed by SEM
A. *Ochrolechia yasuda* var. *corallina, S. Jariangprasert 3774* (QSBG), uneven surface isidia, scale bar = 52 micrometre
B. *O. yasuda* var. *corallina, S. Jariangprasert 3774* (QSBG), showing loosed cortex of uneven surface isidia, scale bar = 12 micrometre
C. *Pertusaria muricata, S. Jariangprasert 3791* (QSBG), even surface isidia, scale bar = 102 micrometre
D. *P. muricata, S. Jariangprasert 3791* (QSBG), dense weaving hypha of even surface isidia, scale bar = 12 micrometre
E. *P. pilosula, S. Jariangprasert 3731* (QSBG), uneven isidia, scale bar = 102 micrometre
F. *P. pilosula, S. Jariangprasert 3731* (QSBG), showing loosed cortex of uneven surface isidia, scale bar = 22 micrometre
G. *P. albescens, S. Jariangprasert 1647* (QSBG), soralia without cortex, scale bar = 12 micrometre
H. *P. puffina, S. Jariangprasert 2286* (QSBG), soredia without cortex, scale bar = 5 micrometre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differences among the structures. Isidia with uneven surface had loosed cortex (Figure 4.5 A-B, E-F), as of soredia (Figure 4.5 G-H) without cortex. While as even and smooth isidia had thick and dense cortex composed of woven hypha and also of apothecia (Figure 4.2 A-B, 4.5 C-D).

Apothecia

The sexual reproductive structure of Pertusariaceae was called the apothecia or ascomata. There were two distinct forms, disciform and verruciform as shown in Figure 4.1 and Table 4.1-4.2. More detail of *Pertusaria* and *Ochrolechia* apothecia forms can be found in Dibben (1980; 1982) and Brodo (1987; 1991), respectively.

The fertile disciform apothecia in *Pertusaria* may be pale orange (*P. commutata*), yellowish to reddish (*P. asiana, P. velata*) or black discs (*P. ophthalmiza*). *Pertusaria* disciform sterile apothecia always had a pruina surface or nonfunctional asci. In *Pertusaria* disciform apothecia never had real exciples, some species burst from under the thallus with torn margins (*P. ophthalmiza*). In some species (*P. patellifera*), the apothecia look like cups when the hymenium was being released. In *Ochrolechia*, disciform apothecia were almost thick, smooth and even, prominent exciple but immature biatorine. The disc colour ranged light to dark from yellowish to reddish brown with or without pruina. The apothecia exciple of *Ochrolechia yasudae* had isidia.

Verruciform apothecia were found only in the subgenus *Pertusaria*. They might be dispersed, small (*P. pertusa* and *P. macounii*) or large (*P. mattogrossensis* and *P. norstictica*), conspicuous, constricted at the base (*P. novaeguineae* and *P. pallida*) or not (*P. howeana*), or confluent (*P. allotwaitesii* and *P. twaitesii*), very flattened and inconspicuous and could be only found by ostiole (*P. endochroma*).

Ostioles were present on fertile verruciform apothecia. According to Archer (1997: 15) ostioles were not open and closed by an epithecium. However, they are pore-like under the scanning electron microscope (Figure 4.6). The colour and characters of ostioles were determined for *Pertusaria* species. There were shown in Figure 4.7. Even and small black ostioles were found in many species, such as *P. leucostigma*, *P. nanensis* whereas distinct large black ostioles in *P. bonariensis, P. ceylonica, P. follmaniana, P. glomerata, P. nahaeoensis, , P. novaeguineaea*

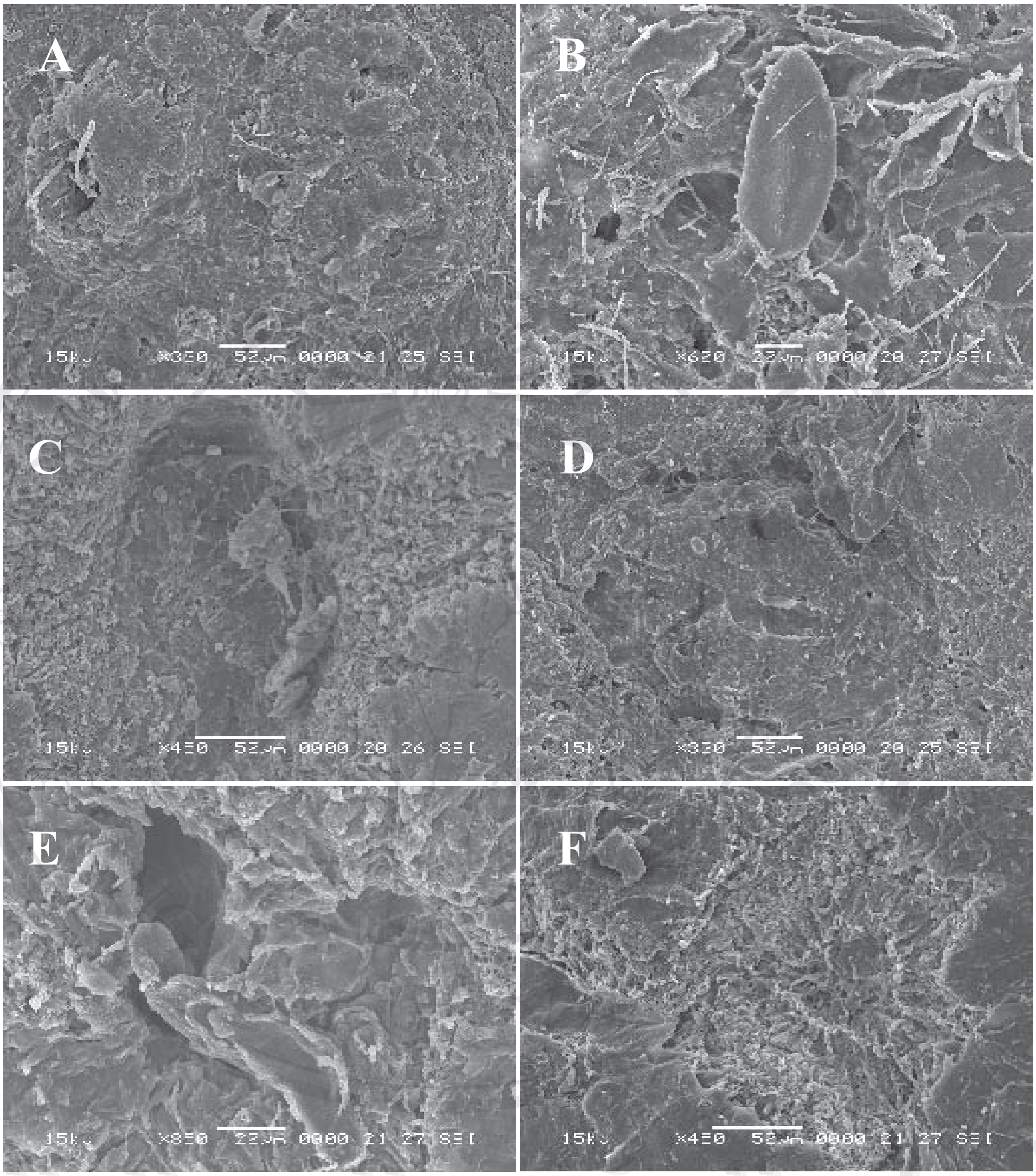
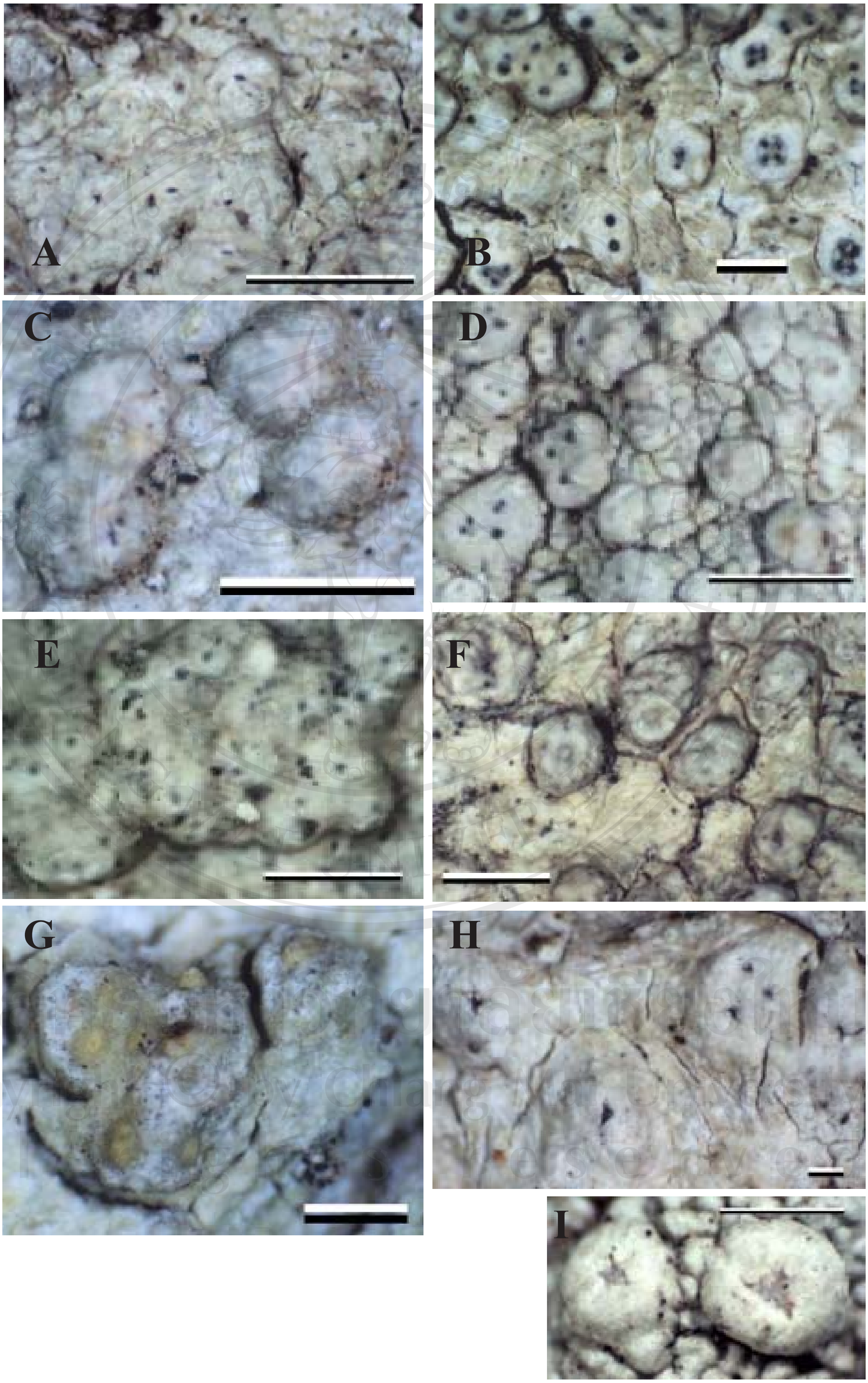


Figure 4.6 Ostioles characters of *Pertusaria* by SEM

A. *P. mattogrossensis, S. Jariangprasert 2513* (QSBG), grey papillate ostiole
B. *P. norstictica, S. Jariangprasert 2306* (QSBG), grey pore ostiole
C. *P. novaeguineae,* RU 5231 (RAMK), black fused and depressed ostiole
D. *P. pallida, S. Jariangprasert 1400* (QSBG), black unfused ostioles
E. *P. pertusa,* RU 8117 (RAMK), black pore ostiole
F. *P. tetrathalamia* var. *plicatula, S. Jariangprasert 1640* (QSBG), inconspicuous ostiole
A, C, D, F, scale bar = 52 micrometre
B, E, scale bar = 22 micrometre

Figure 4.7 Ostioles characters and colours of *Pertusaria*
A. Small and black ostioles of *P. leucostigma, S. Jariangprasert 1522* (QSBG)
B. Large and black ostioles of *P. ceylonica, F. David 120.1* (PSU)
C. Inconspicuous ostioles of *P. pertusella, S. Jariangprasert 3574* (QSBG)
D. Yellowish to black ostioles of *P. alboaspera* var. *deficiens,* holotype (QSBG)
E. Variable ostioles (grey to black, even to protruded) of *P. thwaitesii, S. Jariangprasert 2406* (QSBG)
F. Grey and protruded ostioles of *P. litchicola,* L 166 (CMU)
G. Yellow and protruded ostioles of *P. leioplacella, S. Jariangprasert 4324* (QSBG)
H. Black ostioles under cracked cortex of *P. lordhowensis, S. Jariangprasert 1603* (QSBG)
I. Grey under cracked cortex of *P. subplanaica* var. *tetraspora,* holotype (QSBG)

A-I, scale bar = 1 mm.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P. nebolusa, P. pertusa, P. radiata and *P. sommerfeltii*. Many species had inconspicuous ostioles, *P. pertusella* and *P. ramuensis.* Some species had both black and pale yellowish ostioles; *P. alboaspera* var. *deficiens, P. howeana* and *P. thiophaninica,* while *P. leiocarpella, P. leioplacella* and *P. texana* constantly yellow ostioles. Some species with variable characters of ostioles, such as *P. allowthwaitesii, P. macounii*, *P. mattogrossensis, P. norstictica, P. twaitesii* and *P. xanthonaria* ranged from pale grey to black and even to protrude. The colour depended on the age of apothecia and chemicals; immature ostioles were mostly paler than the older ones. In species which contained thiophaninic acid, yellow ostioles were always present but with more or less colour depending on the chemistry concentration. Although ostioles of *P limbata, P. litchicola, P. paradoxica* and *P. petrophyes* were persistently grey and protruded. In some species, the ostioles were black under cracked cortex, *P. lordhowensis* and *P. stenostoma* but only grey in *P. subplanaica* var. *tetraspora.* Many species had variable ostioles from inconspicuous to black conspicuous such as *P. cicatricosa, P. cinchonae, P. mundula, P. tetrathalamia* and *P. tetrathalamia* var. *plicatula.*

Apothecia of Pertusariaceae were usually filled with clear hymenium layer, cylindrical asci and branched paraphyses. *Pertusaria* ascus character was specific by having ocular, thick and bitunicate wall (Figure 4.8 A). Asci of *Pertusaria* (Figure 4.8 B) had a less blue reaction with I_2 than *Ochrolechia* (Figure 4.8 C). Measurements of asci size were not carried out in this study as there was no significant in size.

Ascospores

Ascospores of this family were hyaline and simple except one with transverse septate in subgenus *Varicellaria* which was not found in Thailand. Ascospores in *Pertusaria ceylonica* and *P. cinchonae* were often yellowish due to the chemical reaction in the bark. It was only found on bark of trees of the Fagaceae and Dipterocapaceae. The spore shape in Pertusariaceae was ellipsoid, long ellipsoid (cylindrical) and subfusiform rarely globular (Figure 4.9). The number, shape, size and including of ascospores arrangement were important taxonomic characters for identification in the genus *Pertusaria*. The shape of *Pertusaria* asci was cylindrical to long cylindrical (Figure 4.11, 4.13) and clavate to cylindrical in *Ochrolechia* (Figure

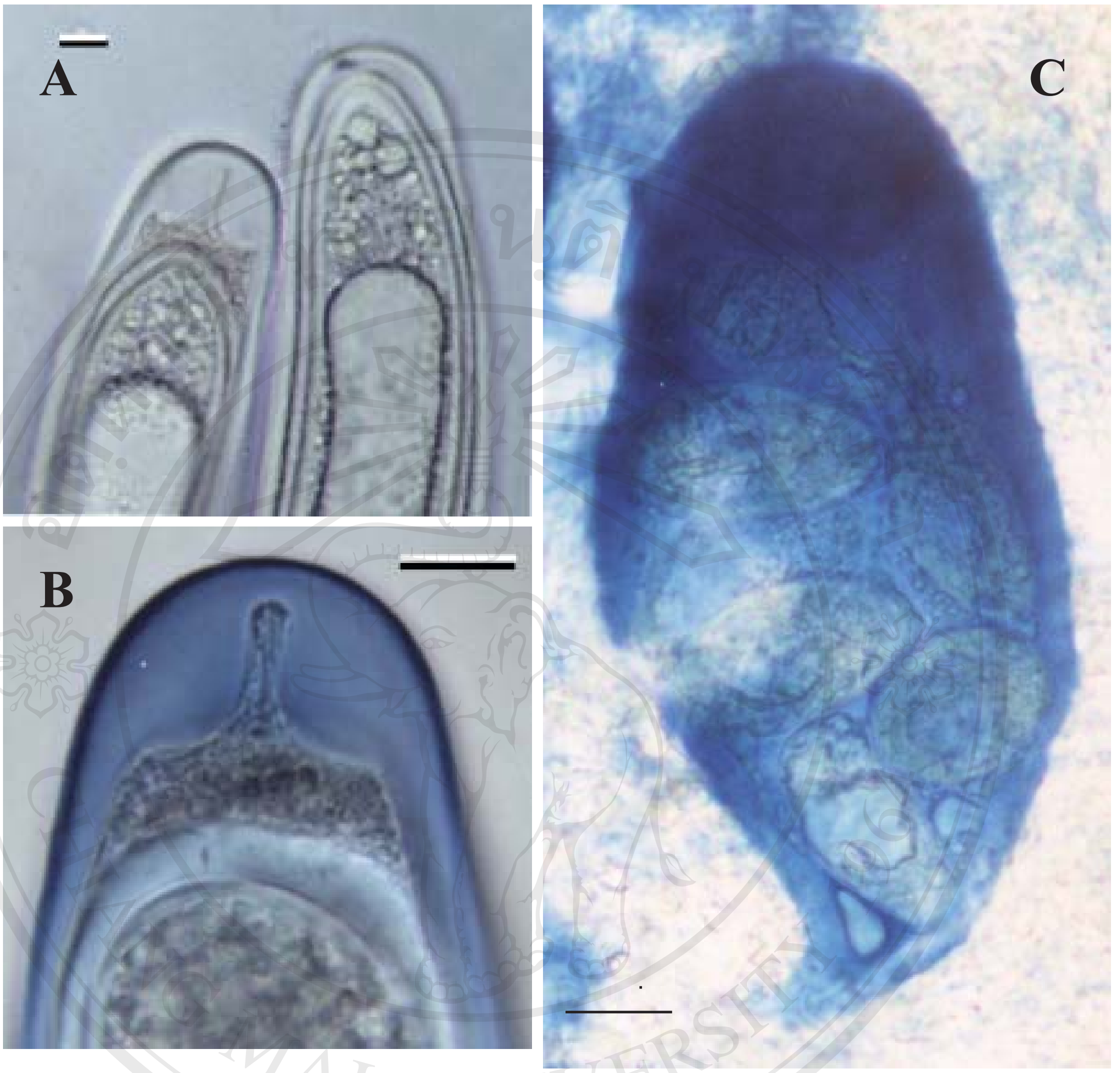

Figure 4.8 Pertusariaceae ocular
A. *Pertusaria inthanonensis, S. Jariangprasert 2676* (QSBG), mounted in water, scale bar = 10 micrometre
B. *P. ceylonica, S. Jariangprasert 2456* (QSBG), stained with iodine solution, scale bar = 20 micrometre
C. *Ochrolechia, S. Jariangprasert 706* (SJ), stained with iodine solution, scale bar = 10 micrometre

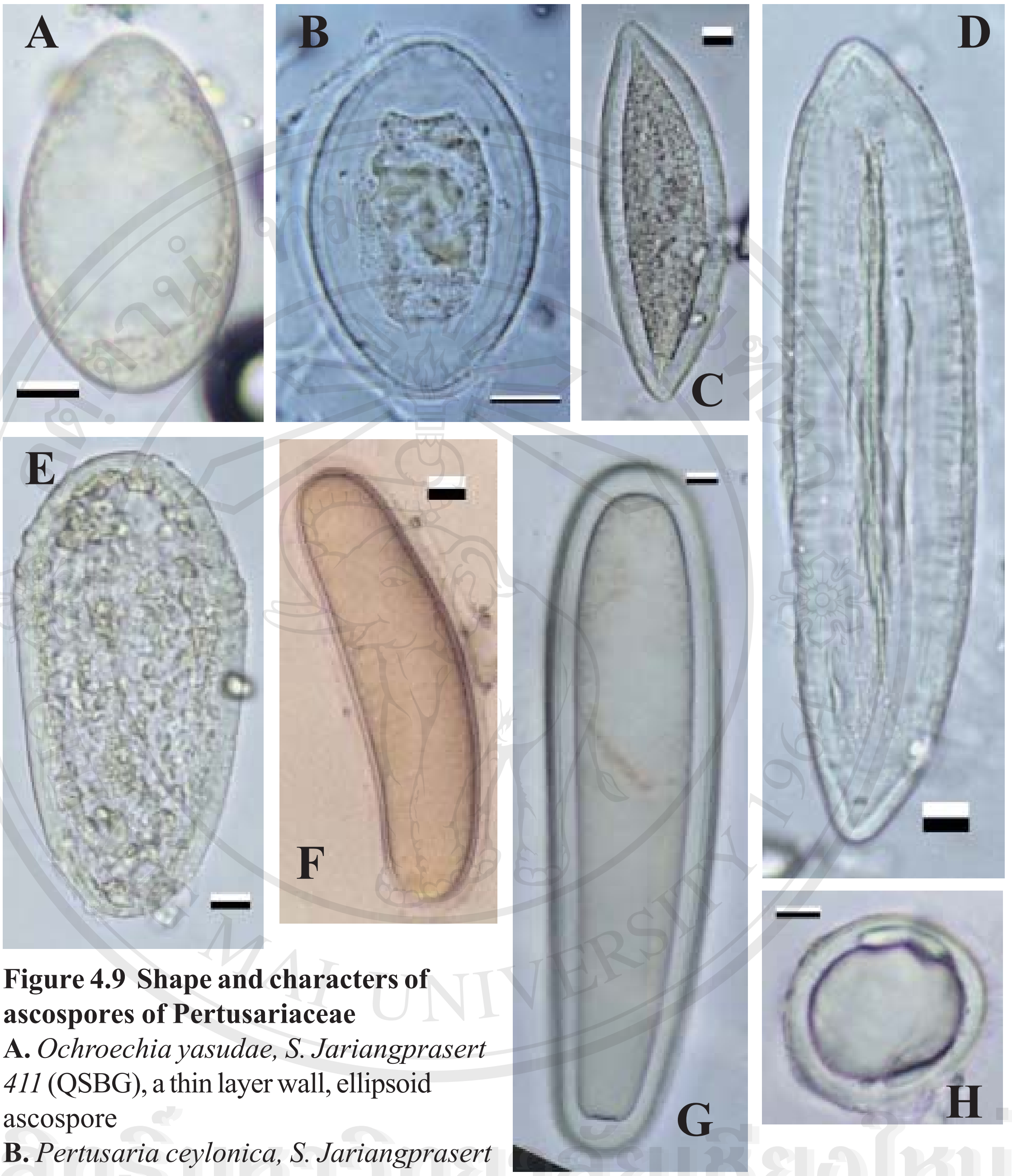

Figure 4.9 Shape and characters of ascospores of Pertusariaceae

A. *Ochroechia yasudae, S. Jariangprasert 411* (QSBG), a thin layer wall, ellipsoid ascospore

B. *Pertusaria ceylonica, S. Jariangprasert 1648* (QSBG), double thick layer and smooth, trimmed ellipsoid ascospore

C. *P. cicatricosa* var. *deficiens,* RU 8637 (RAMK), smooth, subfusiform ascospore

D. *P. irregularis, S. Jariangprasert 3866* (QSBG), double thick layer, smooth, tapering end, cylindrical ascospore

E. *P. clarkeana,* RU 3639 (RAMK), a thick layer, smooth, ellipsoid ascospore

F. *P. scutellifera,* RU 4451 (RAMK), a thin layer,smooth, cylindrical ascospore

G. *P. velata, S. Jariangprasert 1559* (QSBG), double thick layer, smooth, cylindrical ascospore

H. *P. paradoxica, S. Jariangprasert 2073* (QSBG), smooth, globular ascospore

A-H, scale bar = 10 micrometre

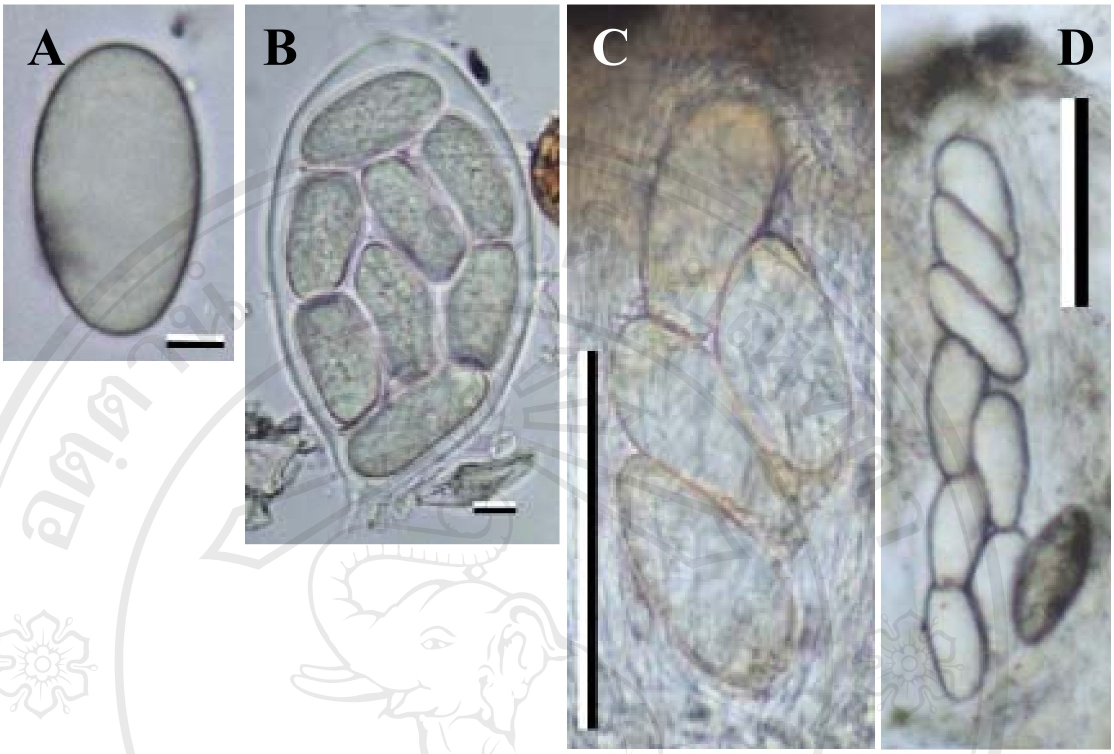

Figure 4.10 Ascospores of *Ochrolechia,* number and arrangement
A. *Ochrolechia* sp. 5, RU 148 (RAMK), ascospore
B. *Ochrolechia* sp. 7, RU 16707 (RAMK), octosporic, clavate ascus
C. *Ochrolechia* sp. 3, *S. Jariangprasert 1551* (QSBG), tetrasporic, cylindrical ascus
D. *O. africana,* RU 1803 (RAMK), octosporic, long cylindrical ascus

A, B. scale bar = 10 micrometre
C, D. scale bar = 100 micrometre

Figure 4.11 Smooth ascospores of *Pertusaria,* number and arrangement
A. *P. ophthalmiza,* RU 4453.1 (RAMK), monosporic ascus
B. *P. inthanonensis, S. Jariangprasert 2492* (QSBG), disporic ascus
C. *P. pertusa*, RU 8657.5 (RAMK), trisporic ascus
D. *P. radiata*, RU 9590.1 (RAMK), tetrasporic ascus
E. *P. ceylonica,* RU 582.1 (RAMK), tetrasporic, uniseriate ascus
F. *P. follmanniana, S. Jariangprasert 1628* (QSBG), hexasporic, uniseriate ascus
G. *P. hylocola, S. Jariangprasert 1612* (QSBG), hexasporic, biseriate ascus
H. *P. alboaspera, S. Jariangprasert 1602* (QSBG), octosporic, irregular uniseriate ascus
I. *P. leucostigma, S. Jariangprasert 1522* (QSBG), octosporic, uniseriate ascus
J. *P. alboaspera* var. *deficiens,* RU 713 (RAMK), octosporic, basically biseriate ascus
K. *P. lordhowensis, S. Jariangprasert 4291.1* (QSBG), octosporic, biseriate ascus

A-K, scale bar = 100 micrometre


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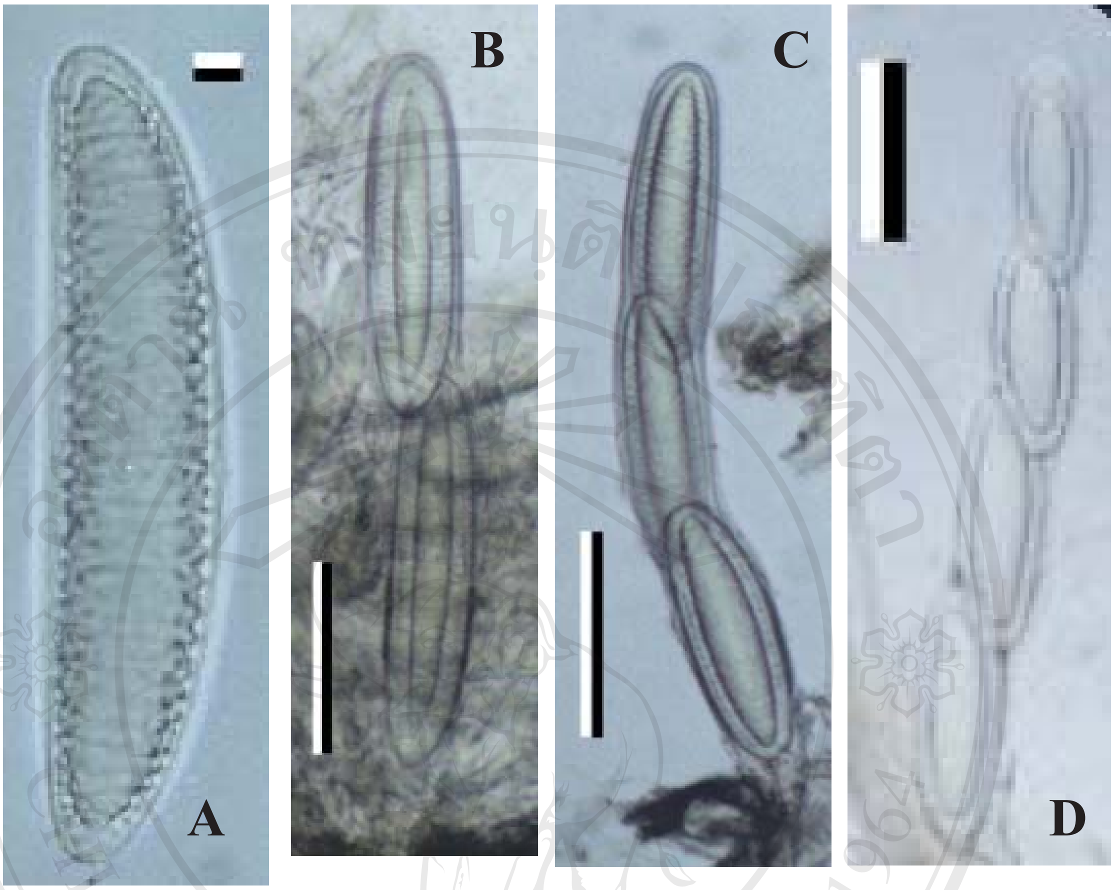


Figure 4.12 Rough ascospores of Pertusaria, number and arrangement
A. *P. takensis, S. Jariangprasert 1319* (QSBG)
B. *P. lansangensis, S. Jariangprasert 3779* (QSBG), disporic ascus
C. *P. lansangensis, S. Jariangprasert 3779* (QSBG), trisporic ascus
D. *P. pallida, S. Jariangprasert 1400* (QSBG), tetrasporic ascus

A, scale bar =10 micrometre
B,C,D, scale bar =100 micrometre

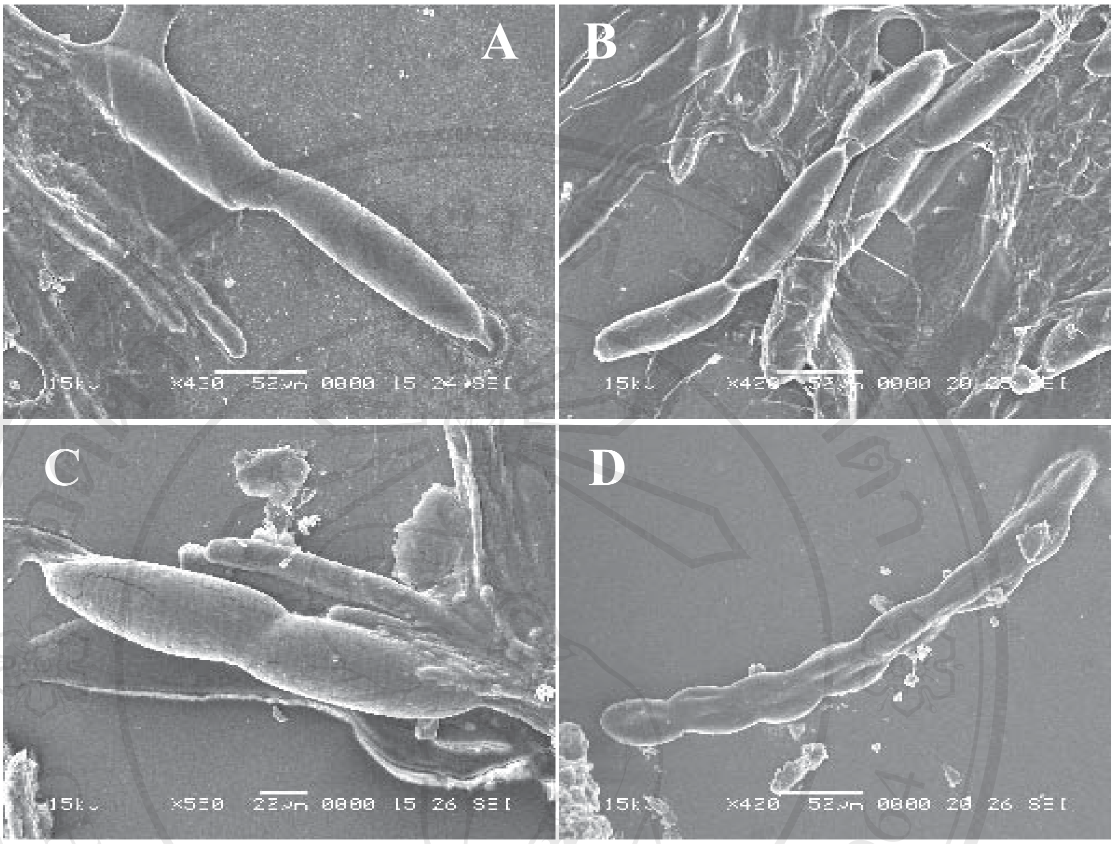


Figure 4.13 Ascus of *Pertusaria* viewed by SEM

A. *P. lansangensis,* holotype (QSBG), cylindrical ascus with two rough ascospores

B. *P. litchicola,* RU 5528 (RAMK), cylindrical ascus with three rough ascospores

C. *P. tetrathalamia* var. *plicatula, S. Jariangprasert 2287* (QSBG), cylindrical ascus with two rough ascospores, scale bar = 22 micrometre

D. *P. leucostigma, S. Jariangprasert 3871* (QSBG), long cylindrical ascus with eight smooth ascospores

A, B, D, scale bar = 52 micrometre

4.10), the shape of asci depended on both ascospores number and its arrangement. The number of ascospores per ascus was 1-8. However, rough ascospores numbers were up to 4 (Figure 4.12) and there was no solitary ascospore per ascus in *Ochrolechia*. Most of ascospores wall were thick and more than one layer especially in *Pertusaria* which occur in verruciform apothecia but a thin layer in *Ochrolechia* and disciform *Pertusaria* apothecia except *P. velata*. Ascospores wall textures were smooth or rough as shown by SEM in Figure 4.14.

Pycnidia

A few species had pycnidia on thallus *e.g. Ochrolechia androgyna* which had indistinct ostiole and plenty in *Pertusaria pertusa* and *P. tetrathalamia*, only specimens from Huai Mae Dee, Huai Kha Khaeng Wildlife Sanctuary, Uthai Thani and Khun Tan National Park, Lamphun-Lampang Provinces. They were collected from dry dipterocarp forest. Pycnidiospores are rod shaped (Figure 4.15 B, E) and found in a flask like pycnidium which immerse under dark brown ostiole (Figure 4.15 C-D).

All taxa could be classified by characters as shown in Table 4.1 and 4.2. Most of *Ochrolechia* were disciform apothecia and rarely sorediate thallus. While *Pertusaria* had verruciform apothecia as, the highest character which had 8 ascospores within. A rare character was the combination of two characters, verruciform apothecia and isidia or soredia. Asexual reproductive forms were fewer than fertile species. In the disciform group, almost every species had a solitary ascospore ascus, except *P. asiana* which had two ascospores per ascus.

Table 4.1 Percentage of various characters of *Ochrolechia*

Characters	No. of species	%	Species
Soredia	1	16.67	*O. androgyna,*
Disciform	3	50.00	*O. africana, O. osorioana, O. trochophora*
D+I	2	33.33	*O. yasudae, O. yasudae* var. *corallina*
Total	6	100	

Note D means disciform apothecia and I mean isidia.

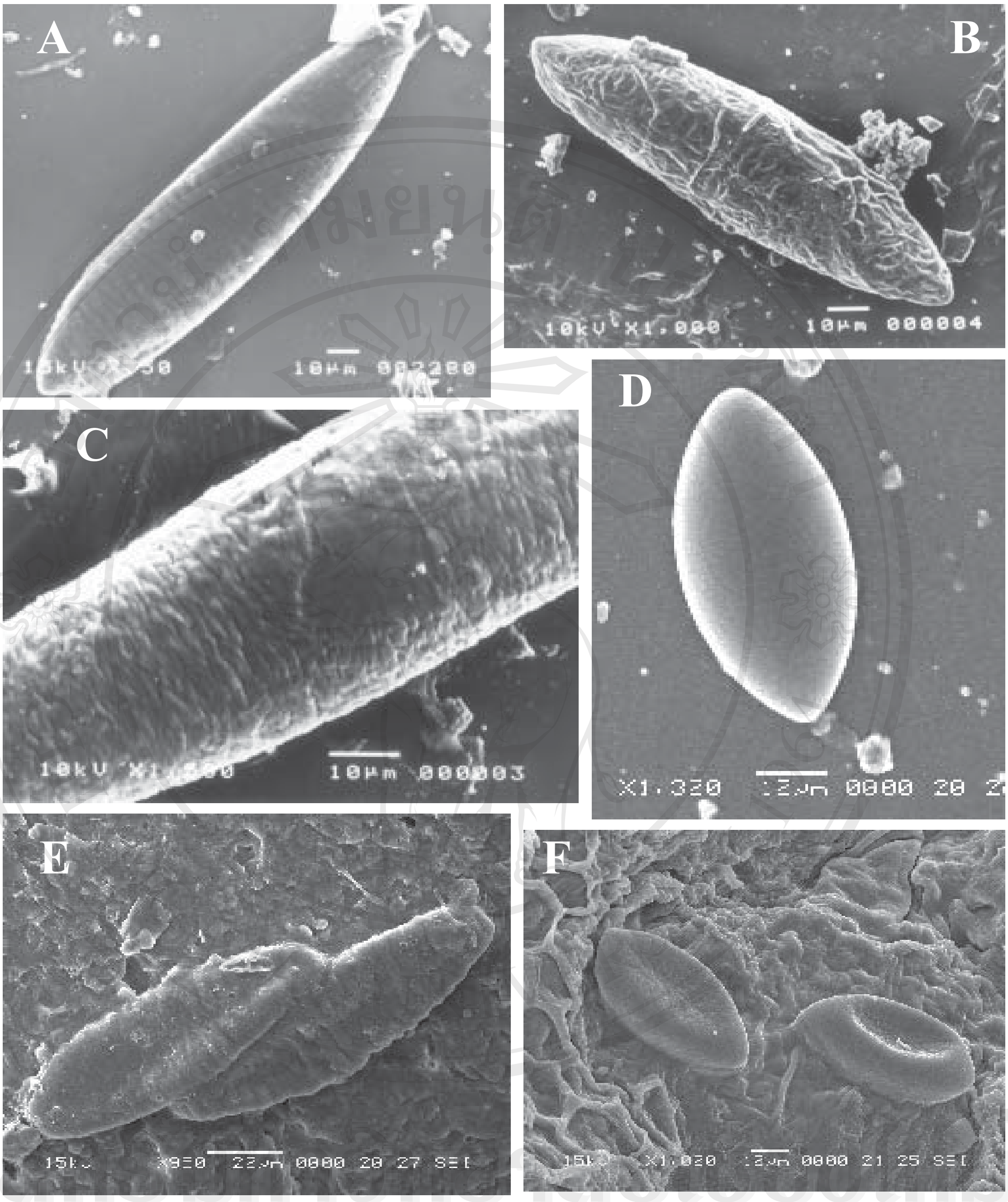


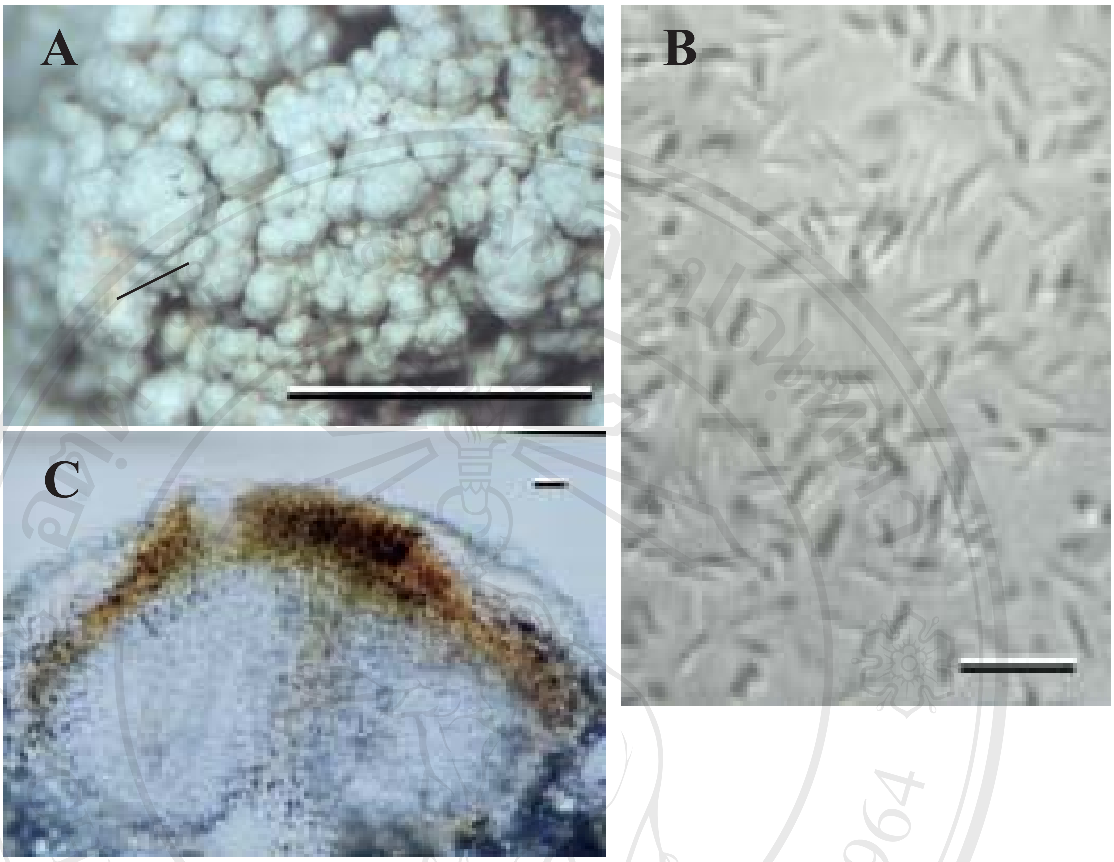
Figure 4.14 Ascospores of *Pertusaria* viewed by SEM
A. *P. cicatricosa, S. Jariangprasert 2280* (QSBG), rough ascospore
B. *P. cicatricosa* var. *deficiens,* RU 8637 (RAMK), rough ascospore
C. *P. macounii, S. Jariangprasert 2446* (QSBG), rough ascospore
D. *P. leucostigma, S. Jariangprasert 3871* (QSBG), smooth ascospore
E. *P. takensis, S. Jariangprasert 3832* (QSBG), rough ascospores
F. *P. howeana, S. Jariangprasert 4514* (QSBG), smooth ascospores

A, B, C scale bar = 10 micrometre
D, F scale bar = 12 micrometre
E scale bar = 22 micrometre

Table 4.2 Percentage of various characters of *Pertusaria*

<table>
<tr><th>Characters</th><th>No. of sp.</th><th>%</th><th colspan="5">Species</th></tr>
<tr><td>Isidia</td><td>8</td><td>8.79</td><td colspan="5">P. angabangensis, P. hypostictica, P. montpittensis, P. muricata, P. pilosula, P. ramulifera, P. umbricola, P. wauensis</td></tr>
<tr><td>Soredia</td><td>7</td><td>7.69</td><td colspan="5">P. albescens, P. amara, P. moreliensis, P. psoromica, P. puffina, P. scaberula, P. uttaraditensis</td></tr>
<tr><td>Disciform apothecia</td><td>12</td><td>13.19</td><td colspan="5">P. asiana, P. asterella, P. clarkeana, P. commutata, P. erubescens, P. miscella, P. ophthalmiza, P. patellifera, P. scutellifera, P. tropica, P. velata, P. xantholeuca</td></tr>
<tr><td rowspan="3">Verruciform apothecia</td><td rowspan="3">62</td><td rowspan="3">68.13</td><td colspan="2">(20) 2 ascospores (21.99 %)</td><td colspan="2">(14) 4 ascospores (15.38 %)</td><td>(28) 8 ascospores (30.77 %)</td></tr>
<tr><td>(7) rough (7.69 %)</td><td>(13) smooth (14.29 %)</td><td>(2) rough (2.2 %)</td><td>(12) smooth (13.19 %)</td><td rowspan="2">P. alboaspera, P. alboaspera var. deficiens, P. bokluensis, P. gibberosa, P. howeana, P. hylocola, P. krabiensis, P. leiocarpella, P. leioplacella, P. leucostigma, P. limbata, P. lordhowensis, P. mattogrossensis, P. mundula, P. nanensis, P. norstictica, P. omkoiensis, P. orarensis, P. paradoxica, P. petrophyes, P. phaeostoma, P. sommerfeltii, P. stenostoma, P. subplanaica, P. subrigida, P. texana, P. thiophaninica, P. xylophyes</td></tr>
<tr><td>P. allothwaitesii P. cicatricosa, P. cicatricosa var. deficiens, P litchicola, P. macounii, P. tetrathalamia var. plicatula, P. thwaitesii</td><td>P. archeri, P. cinchonae, P. glomerata, P. irregularis, P. loeiensis, P. nahaeoensis, P. nebolusa, P. novaeguinea, P. pertusa, P. pertusella, P. ramuensis, P. siamensis, P. xanthonaria</td><td>P. pallida, P. tetrathalamia</td><td>P. alboaspera var. tetraspora, P. bonariensis, P. ceylonica, P. elixii, P. radiata, P. endochroma, P. follmanniana, P. inthanonensis, P. kansriae, P. leioplaca, P. subplanaica var. tetraspora P. thailandica</td></tr>
<tr><td>V+I</td><td>1</td><td>1.1</td><td colspan="5">P. takensis</td></tr>
<tr><td>V+S</td><td>1</td><td>1.1</td><td colspan="5">P. lansangensis</td></tr>
<tr><td>Total</td><td>91</td><td>100</td><td colspan="5"></td></tr>
</table>

Frontal number in bracket is species number in each character.



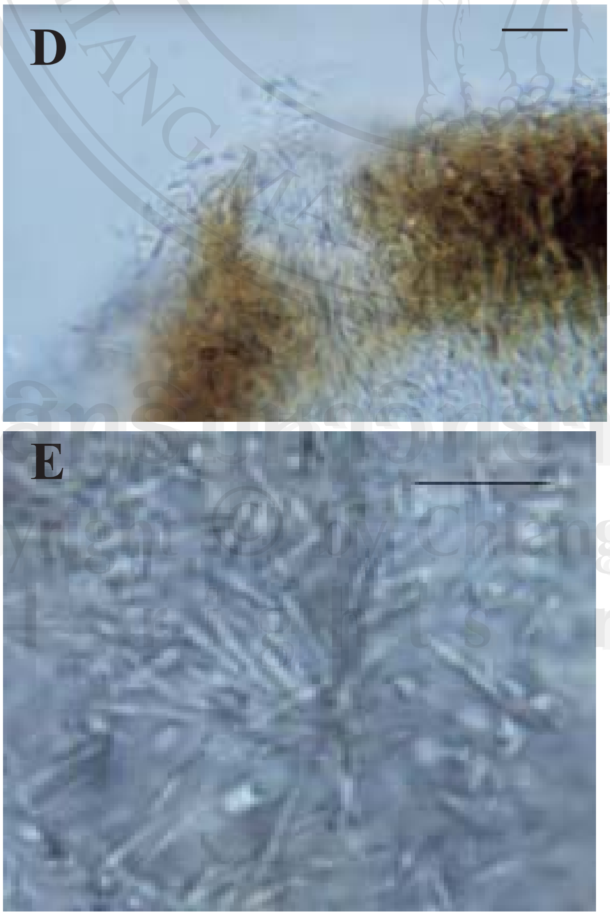


Figure 4.15 Pycnidia of Pertusariaceae
A. Pycnidia (arrow) in *Ochrolechia androgyna, S. Jariangprasert 2816* (QSBG), scale bar = 1 mm
B. Pycnidiospores rod shape of *O. androgyna, S. Jariangprasert 2816* (QSBG), scale bar = 10 micrometre
C. Sectioned pycnidium of *Pertusaria pertusa, K. papong 16* (QSBG), scale bar = 10 micrometre
D. Dark brown l-sectioned of ostiole of pycnidium in *P. pertusa, K. Papong 16* (QSBG), scale bar =10 micrometre
E. Pycnidiospores rod shaped of *P. pertusa, K. Papong 16* (QSBG), scale bar = 10 micrometre

UV test

The thallus under long wave ultraviolet light (UV) showed fluorescence (Table 4.3). It was differentiated by different lichen substances, xanthone especially; *e.g.* bright yellow fluorescence (lichexanthone), bright orange fluorescence (thiophaninic acid). Other chlorinated xanthones gave a dull orange fluorescence (*e.g.* 4,5-dichlorolichexanthone) or negligible colour. Some specimens with hypothamnolic acid (*Pertusaria tropica*) sometimes gave a bright blue fluorescence on apothecia or medulla. The variable colour concentration indicated the concentration ratio of the lichen substances. Fresh thallus or moisten thallus showed stronger colour than dried ones and greener surfaces were darker. Such specimens as *P. tetrathalamia* which were dark green were darker orange when exposed to UV than the paler ones although the same xanthone was present. However, variable concentration in the same colour should be confirmed by chromatography because some were differentiated but some were the same xanthone.

Table 4.3 Examples of species thalli showing UV fluorescence

species	Colour of fluorescence	Major substances
P. ceylonica	Pinky red	Di and trichlorolichexanthones
P. cicatricosa	Reddish orange	Di and trichlorolichexanthones
P. leiocarpella	Yellow-orange	4,5-dichlorolichexanthone
P. moreliensis	Bright yellow	lichexanthone
P. novaeguineae	Pinkish orange	2-chlorolichexanthone
P. patellifera	Grey	Atranorin
P. pertusa	Pale orange (salmon orange)	4,5-dichlorolichexanthone
P. thiophaninica	Bright orange	Thiophaninic acid
P. tropica	Bright blue	Hypothamnolic acid

Spot test

The reaction with K, C, KC and Pd solutions on cortex and/or medulla ranged from unchangeable to colour. Some K+ (such as in *P. asiana* and *P. norstictica*) reactions were yellow and then changed to red needle crystals (of norstictic acid).

Some were pale rose pink then fleeting especially in KC reaction. Sometime it took time to allow the reactions such as for KC+ reddish purple of picrolichenic acid. Many substances did not change colour by spot test but could be detected by TLC test *e.g.* orcinol *para* depsides group. Examples of lichen substances causing coloured reactions with K, C, KC and Pd reagents were shown in Table 4.4.

Table 4.4 Colour reactions of some lichen substances of *Ochrolechia* and *Pertusaria* species with K, C, KC and Pd reagents

Lichen substance	Chemical reagent and colour reaction				Example species
	K	C	KC	Pd	
Arthothelin	orange yellow		orange	-	*P. howeana*
Dihydropertusaric â	-	-	-	-	*P. ophthalmiza*
Gyrophoric â	-	rose pink	rose pink	-	*O. africana*, *O. androgyna*
Haemathamnolic â	yellow	-	-	yellow	*P. moreliensis*
Hypostictic â	orange	-	-	pale yellow	*P. hypostictica*
Hypothamnolic â	purple	-	-	-	*P. tropica*
Lecanoric â	-	dark red	dark red		*P. velata*
Norstictic â	yellow→red	-	-	yellow-orange	*P. asiana*, *P. glomerata*, *P. norstictica*
Pertusaric â	-	-	-	-	*P. ophthalmiza*
Picrolichenic â	-	-	purple	-	*P. amara*, *P. patellifera*
Protocetraric â	yellow-brown	-	fleeting red orange	orange-red	*P. thwaitesii*
Psoromic â	Pale orange	-	-	sulphur yellow	*P. psoromica*, *P. wauensis*
Stictic â	yellow	-	-	orange	*P. radiata*, *P. ramuensis*
Thamnolic â	deep yellow	-	-	orange	*P. commutata*, *P. moreliensis*
Thiophaninic â	Pale orange	-	orange	-	*P. omkoiensis*

Microcrystallization

Identification of crystals is achieved by comparison with published photographs of crystals in various solvents. Photographs of micro crystals of numerous substances were published by Asahina (1934; 1936-1940); Hale, 1961; Culberson (1965-1966; 1967a; 1967b); Culberson (1958) Culberson & Culberson (1966; 1968); Taylor (1967-1968); Galun (1970) and Huneck & Yoshimura (1996). The form of crystals depends on the solvent used and to some extent on the concentration of the substances. Photographs of various substances were shown in Figures 4.16-4.17. The forms of the crystals were for example: small rhombic crystal of hypothamnolic acid in GE (Figure 4.16D), rectangular prisms of haemathamnolic acid in GE (Figure 4.16C), narrow boat-shaped lamella of haemathamnolic acid in An (Figure 4.16B), thin curve needles of lecanoric acid in GE (Figure 4.16F).

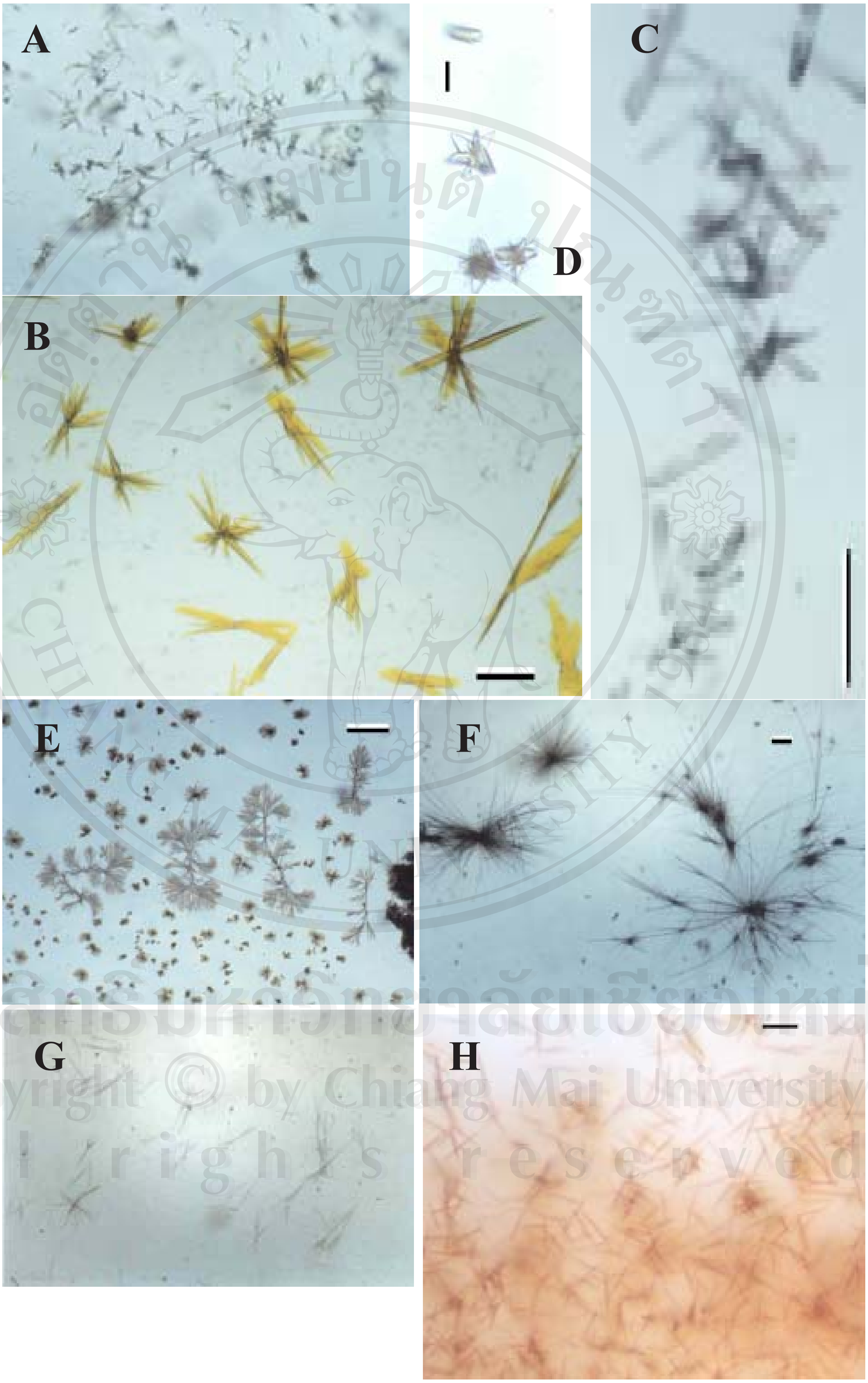
Tlc test

All chemicals recorded in Thai Pertusariaceae species were listed in Table 4.5 and the combinations between species and chemistry in Table 4.6. Ninety-three lichen substances were found: 50 depsides, 18 depsidones, 5 depsones, 13 xanthones and other chemical groups. The structures and formulae of them were detailed by Huneck & Yoshimura (1996); Archer (1997). Orcinol *para*-depsides and *β*-orcinol depsidones were mostly groups of depsides and depsidones in *Pertusaria*. Every species of *Ochrolechia* contained gyrophoric acid. The most common chemical in *Pertusaria* was stictic acid followed by 4,5-dichlorolichexanthone. Some of the lichen substances were rarely found in *Pertusaria* as a major compound such as alternariol and methyl 2-*O*-methyldivaricatate. A few species did not yield lichen substances *i.e. P. albescens* and *P. subrigida*.

Morphological study is the easiest method for early separation of lichen families and to differentiate, between genera and other taxa. Anatomical section is necessary for sub groups. The most important and unavoidable test is chemical identification. The only one species that can be identified without this step was *P. amara* the sorediate thallus, because of the unique and extremely bitter taste of picrolichenic acid.

Figure 4.16 Microcrystal forms 1 of some lichen substances of Thai *Pertusaria*
A. Rod like prisms of confluentic acid in GAW of *P. cinchonae,* RU 2505 (RAMK)
B. Yellow narrow boat-shaped lamella of haemathamnolic acid in An of *P. moreliensis,* RU 1070 (RAMK)
C. Rectangular prisms of haemathamnolic acid in GE of *P. moreliensis,* RU 2358 (RAMK)
D. Small rhombic crystal of hypothamnolic acid in GE of *P. tropica*, RU 903 (RAMK)
E. Fine needles branched mass of lecanoric acid in GAW of *P. velata*, RU 4337 (RAMK)
F. Thin curve needles of lecanoric acid in GE of *P. velata*, RU 4337
G. Needles of lichexanthone in GE of *P. tropica*, RU 903
H. Red needles of norstictic acid in K of *P. norstictica,* RU 3802 (RAMK)

A-H, scale bar = 10 micrometre


A
B
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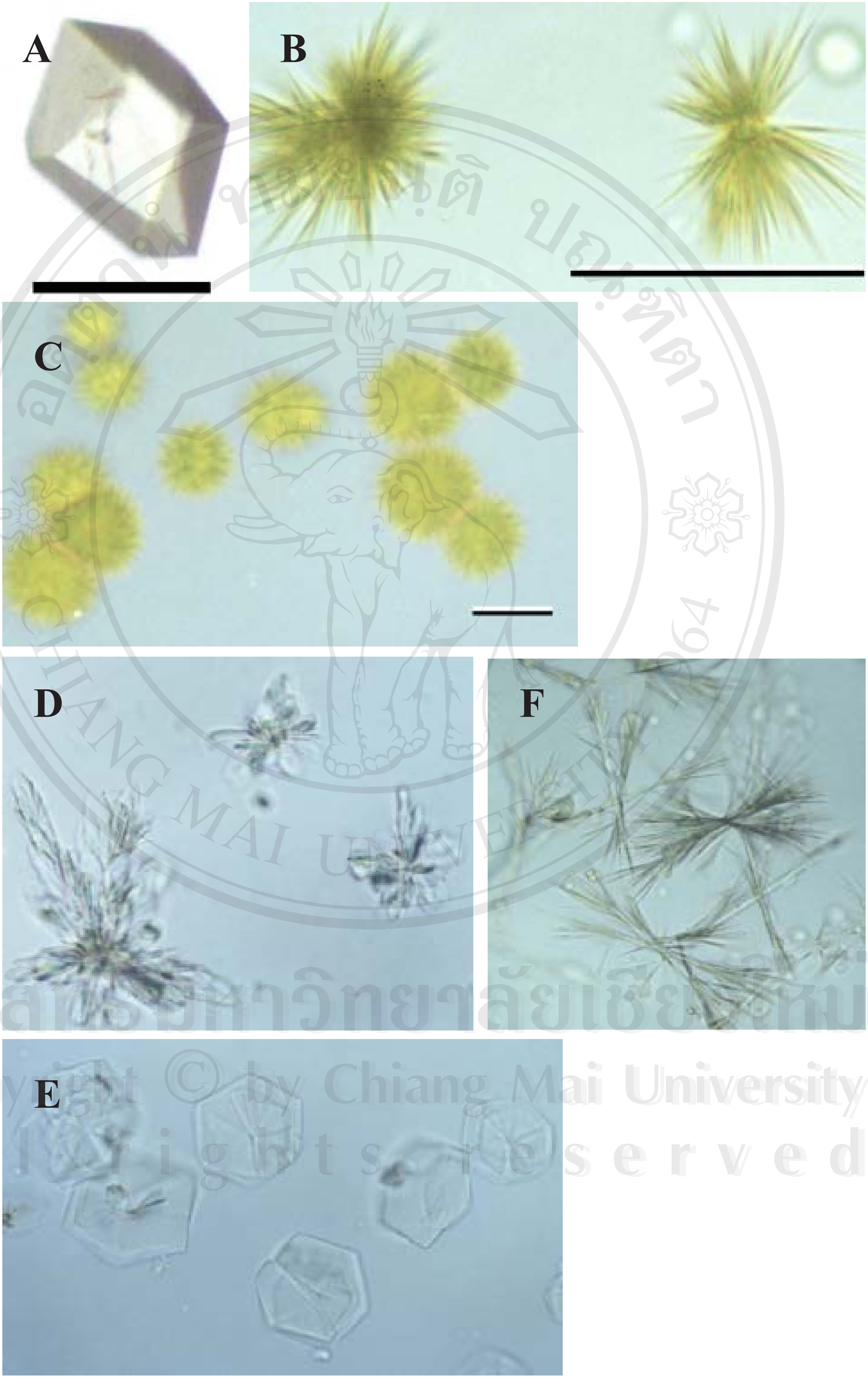
D
E
F
G
H

Figure 4.17 Microcrystal forms 2 of some lichen substances of Thai *Pertusaria.*
A. Rhombic or hexagonal prisms of picrolichenic acid in GE of *P. amara*, RU 1794 (RAMK)
B. Yellow fine needles cluster of picrolichenic acid in oT of *P amara*, RU 1976 (RAMK)
C. Yellow fine needles cluster of protocetraric acid in oT of *P. thwaitesii,* RU 1380 (RAMK)
D. Cluster of irregular thin lamella of protolichesterinic acid in GAW of *P. ophthalmiza,* RU 2548 (RAMK)
E. regular hexagonal lamella of stictic acid in oT of *P*. RU 5228 (RAMK)
F. Aggregate yellow needles of thamnolic acid in An of *P. miscella*, RU 3217 (RAMK)

A-F, scale bar = 10 micrometre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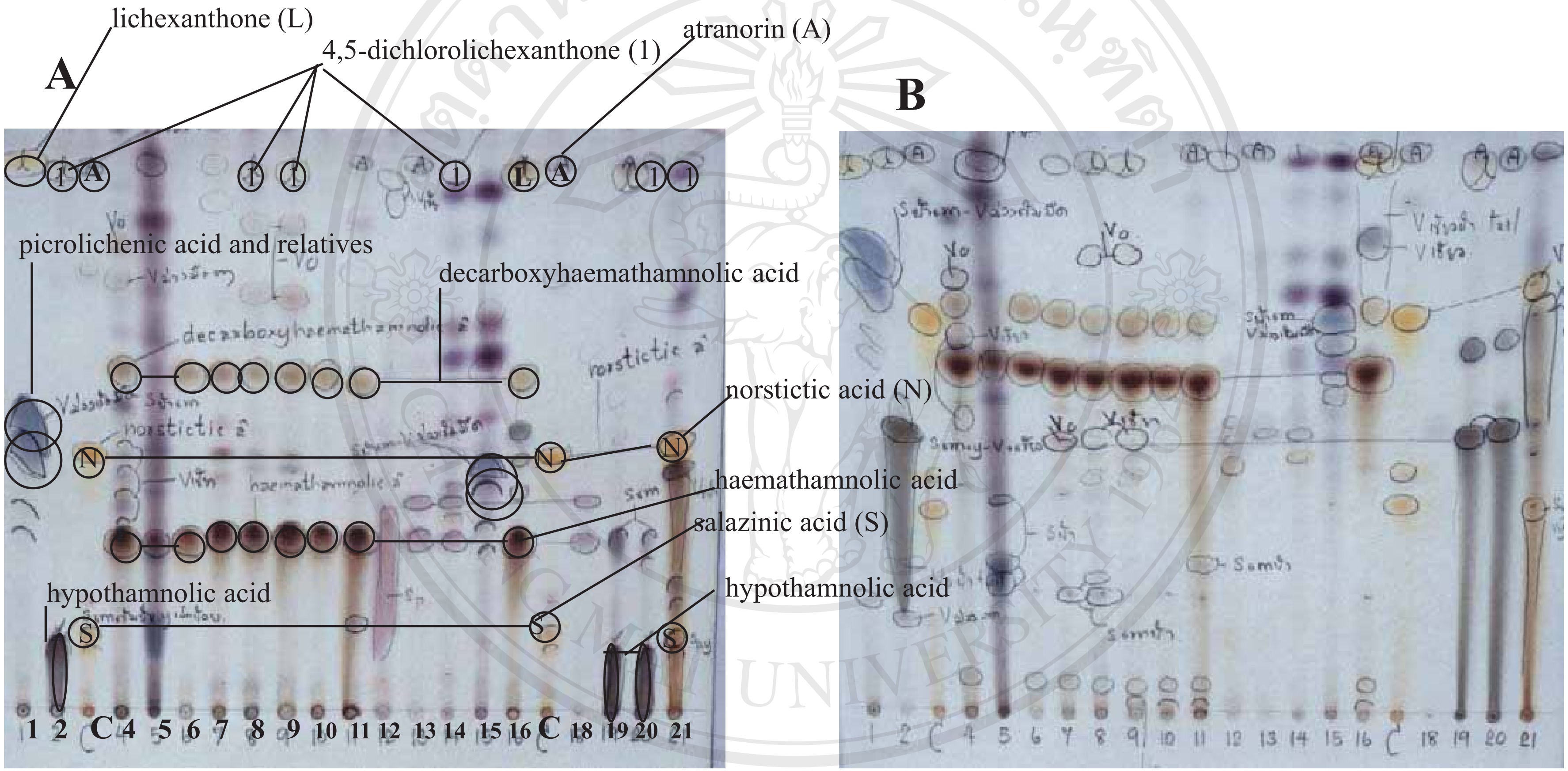

Figure 4.18 Lichen substances on tlc plates
(A & G, run in solvent system showing colour of spots after developing with 10 % sulphuric acid and heated at 110 celcius)
A. Tlc plate A
B. Tlc plate G

Table 4.5 Chemistry of Thai Pertusariaceae

Lichen substances	Rf class		UV before heating	Spot colour after acid and heating	UV after heating	No. of sp.	%	Species
	A	G						
Alternariol*●						1	0.86	*P. nahaeoensis*
Alternariol methyl ether*●						1	0.86	*P. nahaeoensis*
Arthothelin(= 2,4,5-Trichloronorlichexanthone) ♦	4-5	4-5	R-O	pale O	bright O	1	0.86	*P. howeana*
Atranorin ♠	7	7	-	Y-O	O-Br	19	16.38	*P. amara, P. asiana, P. cinchonae, P. clarkeana, P. commutata, P. follmanniana, P. moreliensis, P. nahaeoensis, P. novaeguineae, P. patellifera, P. pilosula, P. ramulifera, P. takensis, P. thailandica, P. velata, P. wauensis, P. xanthoeuca, Pertusaria* sp. 5, *Pertusaria* sp. 7
Barbatic acid♠	4	5-6	-	straw Y, G margin	Br-Bl margin	1	0.86	*P. allothwaitesii*
Chloroatranorin♠	7	7	pale O	pale O	pale O	1	0.86	*P. thailandica*
2-Chlorolichexanthone ♦	7	7	-	pale Y	G	15	12.93	*P. cicatricosa, P. follmanniana, P. lansangensis, P. limbata, P. lordhowensis, P. nebolusa, P. norstictica, P. novaeguineae, P. orarensis, P. pallida, P. pertusella, P. puffina, P. takensis, P. thwaitesii, P. xanthonaria*
2-Chloro-6-*O*-methylnorlichexanthone ♦	5-6	5-6	G	pale Y	G	2	1.72	*P. hylocola, P. xylophyes*
Confluentic acid♠	5	5-6	-	pale Y	Br-G margin	3	2.59	*P. cinchonae, P. inthanonensis, Pertusaria* sp. 9

Table 4.5 Chemistry by tlc of Thai Pertusariaceae (continued)

Lichen substances	Rf class		UV before heating	Spot colour after acid and heating	UV after heating	No. of sp.	%	Species
	A	G						
Connorstictic acid♣	2	2	-	rose O	-	4	3.45	*P. asiana, P. glomerata, P. ramulifera, Pertusaria* sp. 8
Conpsoromic acid (= 2′-*O*-Demethylpsoromic acid) ♣	3	3	-	pale Br-G	pale Y-Br	1	0.86	*P. wauensis*
Consalazinic acid♣	1	1	-	rose O	O	1	0.86	*P. asiana*
Constictic acid♣	1	1	-	Br-O	Br	38	32.76	*P. alboaspera, P. alboaspera* var. *tetraspora, P. angabangensis, P. bonariensis, P. ceylonica, P. cicatricosa, P. cinchonae, P. elixii, P. hylocola, P. hypostictica, P. inthanonensis, P. lansangensis, P. leiocarpella, P. leioplaca, P. leioplacella, P. limbata, P. loeiensis, P. macounii, P. montpittensis, P. novaeguineae, P. omkoiensis, P. pallida, P. paradoxica, P. pertusa, P. pertusella, P. pilosula, P. puffina, P. sommerfeltii, P. takensis, P. tetrathalamia, P. tetrathalamia* var. *plicatula, P. texana, P. thailandica, Pertusaria* sp. 2, *Pertusaria* sp. 3, *Pertusaria* sp. 4, *Pertusaria* sp. 6, *Pertusaria* sp. 12
Cryptostictic acid♣	1-2	2-3	-	Br-O	Br-O	11	9.48	*P. ceylonica, P. cinchonae, P. follmanniana, P. hylocola, P. hypostictica, P. krabiensis, P. leioplaca, P. lordhowensis, P. muricata, P. pertusa, P. sommerfeltii*
Decarboxyhaemathamnolic acid♠	5-6	5-6	-	Y-Br	Br	2	1.72	*P. commutata, P. moreliensis*

Table 4.5 Chemistry by tlc of Thai Pertusariaceae (continued)

Lichen substances	Rf class A	Rf class G	UV before heating	Spot colour after acid and heating	UV after heating	No. of sp.	%	Species
Decarboxythamnolic acid♠	1	3-4	-	pale Br	Br	3	2.59	*P. miscella, P. scaberula, P. scutellifera*
2,4-Dichlorolichexanthone♦	7	7	O-R	pale Y-O	O-R	8	6.70	*P. ceylonica, P. cicatricosa, P. lansangensis, P. lordhowensis, P. pertusella, P. puffina, P. takensis, P. xanthonaria*
2,5-Dichlorolichexanthone♦	7	7	O-R	pale Y-O	O-R	8	6.70	*P. ceylonica, P. cicatricosa, P. lansangensis, P. lordhowensis, P. pertusella, P. puffina, P. takensis, P. xanthonaria*
4,5-Dichlorolichexanthone♦	7	7	G-Y	-	G-Y	31	26.72	*P. angabangensis, P. bokluensis, P. bonariensis, P. cinchonae, P. gibberosa, P. irregularis, P. kansriae, P. leiocarpella, P. leioplaca, P. litchicola, P. loeiensis, P. macounii, P. montpittensis, P. mundula, P. muricata, P. nahaeoensis, P. pertusa, P. pilosula, P. siamensis, P. sommerfeltii, P. stenostoma, P. subplanaica, P. subplanaica* var. *tetraspora, P. tetrathalamia, P. thailandica, P. xanthonaria, Pertusaria* sp. 2, *Pertusaria* sp. 5, *Pertusaria* sp. 6, *Pertusaria* sp. 8, *Pertusaria* sp. 11
2,4-Dichloronorlichexanthone♦	4-5	4-5	pale O	pale O	O	1	0.86	*P. howeana*
2,5-Dichloronorlichexanthone♦	4-5	4-5	pale O	pale O	O	1	0.86	*P. howeana*

Table 4.5 Chemistry by tlc of Thai Pertusariaceae (continued)

Lichen substances	Rf class A	Rf class G	UV before heating	Spot colour after acid and heating	UV after heating	No. of sp.	%	Species
4,5-Dichloronorlichexanthone♦	4-5	4-5	G	pale O	G	1	0.86	*P. howeana*
Dihydropertusaric acid○	4-5	4-5	-	-	-	1	0.86	*P. ophthalmiza*
Dihydropicrolichenic acid♥	4-5	4-5	-	pale Y	G	1	0.86	*Pertusaria* sp. 5
4,5-Di-*O*-methylhiascic acid♠	3-4	4	-	W-Bl	G	5	4.31	*O. africana. Ochrolechia* sp. 1, *Ochrolechia* sp. 2, *Ochrolechia* sp. 5, *Ochrolechia* sp. 6
2,2′-Di-*O*-methyldivaricatic acid♠	4	4	-	Y-Gy margin	G-Pur margin	2	1.72	*P. subplanaica, Pertusaria* sp. 11
2,2′-Di-*O*-methylstenosporic acid♠	4-5	4-5	-	Y-Gy margin	G-Pur margin	10	8.62	*P. alboaspera. P. alboaspera* var. *deficiens, P. alboaspera* var. *tetraspora, P. bokluensis, P. nanensis, P. omkoiensis, P. subplanaica, P. subplanaica* var. *tetraspora, Pertusaria* sp. 4, *Pertusaria* sp. 11
Divaricatic acid♠	4-5	5-6	-	Y-Gy margin	Br-Bl margin	2	1.72	*P. allothwaitesii, P. orarensis*
Elatinic acid♠	3	5-6	-	pale O	-	1	0.86	*P. asiana*
Graciliformin@	5	5-6	-	Y-Gy margin	Br-G margin	1	0.86	*P. inthanonensis*
Gyrophoric acid♠	3	3	-	streak Y-Gy margin	streak G	13	11.21	*O. africana, O. androgyna, O. osorioana, O. trochophora, O. yasudae, O. yasuadae* var. *corallina, Ochrolechia* sp. 1, *Ochrolechia* sp. 2, *Ochrolechia* sp. 3, *Ochrolechia* sp. 4, *Ochrolechia* sp. 5, *Ochrolechia* sp. 6, *Ochrolechia* sp. 7

Table 4.5 Chemistry by tlc of Thai Pertusariaceae (continued)

Lichen substances	Rf class A	Rf class G	UV before heating	Spot colour after acid and heating	UV after heating	No. of sp.	%	Species
Haemathamnolic acid♠	2	5	-	Br	Br	2	1.72	*P. commutata, P. moreliensis*
Hiascic acid♠	1	4-5	-	O	-	1	0.86	*Ochrolechia* sp. 1
Hyperconfluentic acid♠	4	5	-	colourless	Bright Bl	1	0.86	*P. inthanonensis*
Hyperlatolic acid♠	5-6	6	-	pale Y-Gy	Br-G margin	1	0.86	*P. hylocola*
Hyperplanaic acid♠						2	1.72	*P. follmanniana, P. krabiensis*
Hypoconstictic acid♣	2	2	-	rose R	O-R	1	0.86	*P. leioplacella*
Hypostictic acid♣	4-5	5-6	-	bright cherry R	vivid O-P	3	2.59	*P. hypostictica, P. leioplacella, P. omkoiensis*
Hypothamnolic acid♠	1-2	2-3	W-Bl	O-Br	G	1	0.86	*P. tropica*
Isohyperplanaic acid*♠						2	1.72	*P. follmanniana, P. krabiensis*
Isoplacodiolic acid*◊						1	0.86	*P. omkoiensis*
Isosubpicrolichenic acid*♥						1	0.86	*P. clarkeana*
Lecanoric acid♠	3	3	-	streak Y-Gy margin	streak G	11	9.48	*O. africana, O. osorioana, O. yasudae, O. yasudae* var. *corallina, P. clarkeana, P. velata, Ochrolechia* sp. 1, *Ochrolechia* sp. 2, *Ochrolechia* sp. 5, *Ochrolechia* sp. 6, *Ochrolechia* sp. 7
Lichexanthone♦	7	7	O	pale Y	vivid Bl-G	18	15.51	*P. alboaspera, P. alboaspera* var. *deficiens, P. alboaspera* var. *tetraspora, P. asterella, P. clarkeana, P. commutata, P. elixii, P. inthanonensis, P. leucostigma, P. miscella*

Table 4.5 Chemistry by tlc of Thai Pertusariaceae (continued)

Lichen substances	Rf class		UV before heating	Spot colour after acid and heating	UV after heating	No. of sp.	%	Species
	A	G						
Lichexanthone♦ (continued)								*P. moreliensis, P. nanensis, P. phaeostoma, P. scaberula, P. tetrathalamia* var. *plicatula*
Menegazziaic acid♠	2-3	2-3	-	Gy	-	1	0.86	*P. pertusa*
Methyl baeomycesate*♠						1	0.86	*P. nahaeoensis*
Methyl barbatate*♠						1	0.86	*P. angabangensis*
Methyl 2,2′-di-*O*-methyldivaricatate*♠						2	1.72	*P. orarensis*
Methyl 2-*O*-methyldivaricatate*♠						2	1.72	*P. litchicola, P. orarensis*
Methyl 2-*O*-methylperlatolate*♠						6	5.17	*P. archeri, P. loeiensis, P. novaeguineae, P. pallida, Pertusaria* sp. 3, *Pertusaria* sp. 7
Methyl 2′-*O*-methylstenosporate*♠						2	1.72	*P. alboaspera* var. *tetraspora, Pertusaria* sp. 3, *Pertusaria* sp. 11
6-*O*-Methylarthothelin (= 2,4,5-Trichloro-6-*O*-methylnorlichexanthone)♦	6	6	-	colourless	O-R	1	0.86	*P. howeana*
2-*O*-Methyldivaricatic acid♠	4-5	5-6	-	Y-Gy margin	Br-G margin	1	0.86	*P. litchicola*
2′-*O*-Methyldivaricatic acid♠	5	5-6	-	Y-Gy margin	Br-G margin	4	3.45	*P. elixii, P. kansriae, P. thailandica, Pertusaria* sp. 1
5-*O*-Methylhiascic acid♠	2		-		G	7	6.03	*O. africana, O. osorioana, Ochrolechia* sp. 1, *Ochrolechia* sp. 2, *Ochrolechia* sp. 5, *Ochrolechia* sp. 6, *Ochrolechia* sp. 7

Table 4.5 Chemistry by tlc of Thai Pertusariaceae (continued)

Lichen substances	Rf class		UV before heating	Spot colour after acid and heating	UV after heating	No. of sp.	%	Species
	A	G						
2-*O*-Methylhyperlatolic acid♠	4-5	5-6	-	Y-Gy margin	Br-G margin	2	1.72	*P. follmanniana, P. krabiensis*
Methylhyperphyllinic acid*♠						1	0.86	*P. cinchonae*
4-*O*-Methylisocryptochlorophaeic acid♠	4-5	6	-	G-Br	dull V	1	0.86	*P. paradoxica*
2-*O*-Methylisohyperlatolic acid♠	5-6	5-6	-	pale	G	2	1.72	*P. follmanniana, P. krabiensis*
2′-*O*-Methylmicrophyllinic acid♠	4	5	-	colourless	Bright Bl	3	2.59	*P. cinchonae, P. inthanonensis, Pertusaria* sp. 9
4-*O*-Methylolivetonide*♠						1	0.86	*P. cinchonae*
2-*O*-Methylperlatolate*♠						1	0.86	*P. loeiensis*
2-*O*-Methylperlatolic acid♠	4-5	5-6	-	Y-Gy margin	Br-G margin	12	10.34	*P. follmanniana, P. krabiensis, P. leucostigma, P. mattogrossensis, P. nahaeoensis, P. novaeguineae, P. pallida, P. petrophyes, P. xylophyes, Pertusaria* sp. 3, *Pertusaria* sp. 5, *Pertusaria* sp. 7
2′-*O*-Methylperlatolic acid♠	5	5-6	-	Y-Gy margin	Br-G margin	15	12.93	*P. archeri, P. cinchonae, P. elixii, P. gibberosa, P. novaeguineae, P. pallida, P. pilosula, P. subplanaica, P. thailandica, P. uttaraditensis, Pertusaria* sp. 1, *Pertusaria* sp. 2, *Pertusaria* sp. 7, *Pertusaria* sp. 10, *Pertusaria* sp. 12

Table 4.5 Chemistry by tlc of Thai Pertusariaceae (continued)

Lichen substances	Rf class A	Rf class G	UV before heating	Spot colour after acid and heating	UV after heating	No. of sp.	%	Species
Methyl planaiate*♠						5	4.31	*P. archeri, P. novaeguineae, P. pallida, Pertusaria* sp. 3, *Pertusaria* sp. 7
Methyl pseudolusitanate*						1	0.86	*P. hylocola*
2-*O*-Methylsquamatic acid*♠						1	0.86	*P. xantholeuca*
2-*O*-Methylstenosporic acid♠	4-5	5-6	-	Y-Gy margin	Br-G margin	1	0.86	*Pertusaria* sp. 5
2′-*O*-Methylstenosporic acid♠	5	5-6	-	Y-Gy margin	Br-G margin	10	8.62	*P. alboaspera* var. *deficiens, P. archeri, P. elixii, P. kansriae, P. subplanaica, P. subplanaica* var. *tetraspora, P. thailandica, Pertusaria* sp. 1, *Pertusaria* sp. 6, *Pertusaria* sp. 11
Methyl stictic acid*♣						5	4.1	*P. ceylonica, P. cinchonae, P. hylocola, P. pertusa, P. sommerfeltii*
2-*O*-Methylsuperlatolic acid*♠						1	0.86	*P. follmanniana*
Norstictic acid♣	4	5-6	-	bright Y	Br	13	11.21	*P. allothwaitesii, P. asiana, P. erubescens, P. glomerata, P. leiocarpella, P. leioplacella, P. limbata, P. moreliensis, P. norstictica, P. paradoxica, P. ramulifera, P. sommerfeltii, Pertusaria* sp. 8
Orsellinic acid♠	3-4	4-5	-	Y-Gy streak	G streak	1	0.86	*P. velata*

Table 4.5 Chemistry by tlc of Thai Pertusariaceae (continued)

Lichen substances	Rf class		UV before heating	Spot colour after acid and heating	UV after heating	No. of sp.	%	Species
	A	G						
Peristictic acid*♣						17	14.66	*P. ceylonica, P. cinchonae, P. follmanniana, P. hylocola, P. hypostictica, P. krabiensis, P. leioplaca, P. loeiensis, P. lordhowensis, P. muricata, P. novaeguineae, P. paradoxica, P. pertusa, P. pertusella, P. stenostoma, Pertusaria* sp. 7, *Pertusaria* sp. 10
Perlatolic acid♠	5-6	6	-	Y-Gy margin	Br-G margin	4	3.45	*P. hylocola, P. mattogrossensis, P. nahaeoensis, Pertusaria* sp. 5
Pertusaric acid*○						1	0.86	*P. ophthalmiza*
Picrolichenic acid♥	4-5	4-5	-	pale	dull V	3	2.59	*P. amara, P. clarkeana, P. patellifera*
Planaic acid♠	5-6	6	-	Y-Gy margin	Br-G margin	12	10.34	*P. alboaspera* var. *tetraspora, P. archeri, P. bonariensis, P. omkoiensis, P. pallida, P. siamensis, P. subplanaica, P. subplanaica* var. *tetraspora, P. tetrathalamia, Pertusaria* sp. 3, *Pertusaria* sp. 7, *Pertusaria* sp. 11
Protocetraric acid♣	1-2	2	-	Gy	dull V	3	2.59	*P. nanensis, P. thwaitesii, P. umbricola*
Psoromic acid♣	4	5-6	pale Gy	Br	Br	2	1.72	*P. psoromica, P. wauensis*
Salazinic acid♣	2	2	-	O	dull O	2	1.72	*P. asiana, P. ramulifera*
Skyrin@	4-5	4-5	-	Gy	dull	3	2.59	*P. angabangensis, P. inthanonensis, P. pertusa*
Squamatic acid♠	2-3	2-3	W-Bl	streak Y	pale O	2	1.72	*P. asiana, P. xanthoeuca*
Stenosporic acid♠	5-6	5-6	-	Y-Gy margin	Br-G margin	1	0.86	*P. orarensis*

Table 4.5 Chemistry by tlc of Thai Pertusariaceae (continued)

Lichen substances	Rf class		UV before heating	Spot colour after acid and heating	UV after heating	No. of sp.	%	Species
	A	G						
Stictic acid ♣	3	3-4	-	deep O	O-Br	49	42.24	*P. alboaspera, P. alboaspera* var. *tetraspora, P. angabangensis, P. asiana, P. bonariensis, P. ceylonica, P. cicatricosa, P. cicatricosa* var. *deficiens, P. cinchonae, P. elixii, P. follmanniana, P. hylocola, P. hypostictica, P. inthanonensis, P. krabiensis, P. lansangensis, P. leiocarpella, P. leioplaca, P. leioplacella, P. limbata, P. loeiensis, P. lordhowensis, P. macounii, P. montpittensis, P. muricata, P. novaeguineae, P. omkoiensis, P. pallida, P. paradoxica, P. pertusa, P. pertusella, P. pilosula, P. puffina, P. radiata, P. ramuensis, P. sommerfeltii, P. stenostoma, P. tetrathalamia, P. tetrathalamia* var. *plicatula, P. texana, Pertusaria* sp. 1, *Pertusaria* sp. 2, *Pertusaria* sp. 3, *Pertusaria* sp. 4, *Pertusaria* sp. 6, *Pertusaria* sp. 7, *Pertusaria* sp. 10, *Pertusaria* sp. 11, *Pertusaria* sp. 12
Subnorstictic acid*♣						1	0.86	*P. ramulifera*
Subpicrolichenic acid♥	3	3-4	-	colourless	dull V	1	0.86	*P. clarkeana*
Substictic acid♣	1	2	-	Br	Br	4	3.45	*P. hypostictica, P. leioplaca, P. muricata, P. pertusa*
Superpicrolichenic acid♥	5	5-6	-	colurless	dull V	1	0.86	*P. clarkeana*

Table 4.5 Chemistry by tlc of Thai Pertusariaceae (continued)

Lichen substances	Rf class		UV before heating	Spot colour after acid and heating	UV after heating	No. of sp.	%	Species
	A	G						
Superplanaic acid*♠						2	1.72	*P. follmanniana, P. krabiensis*
Thamnolic acid♠	1	2-3	-	O-Br	Br	3	2.59	*P. miscella, P. scaberula, P. scutellifera*
Thiophaninic acid (= 2,4-Dichloro6-*O*-methylnorlichexanthone) ♦	6	6	O	pale O	O-Pi	9	7.76	*P. endochroma, P. hylocola, P. leioplacella, P. omkoiensis, P. paradoxica, P. petrophyes, P. texana, P. thiophaninica, P. xylophyes*
2,4,5-Trichlorolichexanthone♦	7	7	O-R	pale O-R	O-R	8	6.70	*P. ceylonica, P. cicatricosa, P. lansangensis, P. lordhowensis, P. pertusella, P. puffina, P. takensis, P. xanthonaria*
Virensic acid♣	2	3-4	-	streak Gy-Bl	Br	1	0.86	*P. thwaitesii*

*did not see on tlc plates or overlap by main related compound, but detected by hplc.

♠ = depsides, ♣ = depsidones, ♥ = depsones, ♦ = xanthones, @ = anthraquinones et al, ◊ = usnic acid, ○ = aliphatic acid. ● = benzocoumarin; Bl = blue, Br = brown, G = green, Gy = grey, O = orange, Pi = pink, R = red, V = violet, W = white, Y = yellow

93 lichen substances were detected by tlc (and later confirm by hplc). They composed of 50 depsides, 18 depsidones, 5 depsones, 13 xanthones and other chemical groups. The commonest chemical was stictic acid. It can be detected from 49 species (42.24%). 4,5-dichlorolichexanthone was the most highest xanthone in 31 species (26.72%). There is not xanthone in *Ochrolechia*. All of *Ochrolechia* species contained gyrophoric acid.

Table 4.6 The taxa on the basis of chemistry

Ochrolechia

Taxa	Chemicals
O. africana Vainio	5-*O*-Methylhiascic acid (major-minor), gyrophoric acid (major-minor), lecanoric acid and ±4,5-di-*O*-methylhiascic acid (trace)
O. androgyna (Hoffm)	Gyrophoric acid
O. osorioana Verseghy	Gyrophoric acid (major), lecanoric acid (minor) and 5-*O*-methylhiascic acid (trace)
O. trochophora (Vainio) Oshio	Gyrophoric acid
O. yasudae Vainio	Gyrophoric acid (major) and lecanoric acid (minor)
O. yasudae Vain. var. *corallina* Poelt	Gyrophoric acid (major) and lecanoric acid (minor)
Ochrolechia sp. 1	Gyrophoric acid (major), lecanoric acid (minor), 5-*O*-methylhiascic acid (minor-trace), ±hiascic acid (trace) and ±4,5-di-*O*-methylhiascic acid (minor-trace)
Ochrolechia sp. 2	5-*O*-Methylhiascic acid (major), gyrophoric acid (submajor), lecanoric acid (minor) and 4,5-di-*O*-methylhiascic acid (minor-trace)
Ochrolechia sp. 3	Gyrophoric acid
Ochrolechia sp. 4	Gyrophoric acid
Ochrolechia sp. 5	5-*O*-Methylhiascic acid (major), gyrophoric acid (submajor), lecanoric acid (minor) and ±4,5-di-*O*-methylhiascic acid (minor-trace)
Ochrolechia sp. 6	5-*O*-Methylhiascic acid (major), gyrophoric acid (submajor), lecanoric acid (minor) and 4,5-di-*O*-methylhiascic acid (minor-trace)
Ochrolechia sp. 7	Gyrophoric acid (major), lecanoric acid (minor) and 5-*O*-methylhiascic acid (trace)

Pertusaria

Taxa	Chemicals
P. albescens (Huds.) Choisy & Wern.	Nil

Table 4.6 The taxa on the basis of chemistry (continued)

Taxa	Chemicals
P. alboaspera A. W. Archer & Elix	Lichexanthone (major), 2, 2′-di-*O*-methylstenosporic acid (major), stictic acid (minor) and constictic acid (minor)
P. alboaspera A. W. Archer & Elix var. *deficiens* Jariangprasert & A. W. Archer	Lichexanthone (major), 2,2′-di-*O*-methylstenosporic acid (major) and 2′-*O*-methylstenosporic acid (minor)
P. alboaspera A. W. Archer & Elix var. *tetraspora* Jariangprasert	Lichexanthone (minor), 2,2′-di-*O*-methylstenosporic acid (major), planaic acid (trace), methyl 2,2′-*O*-di-methylstenosporate (trace), stictic acid (minor)and constictic acid (minor)
P. allothwaitesii Jariangprasert & A. W. Archer	Norstictic acid (major), divaricatic acid (major-minor) and barbatic acid (minor-trace)
P. amara (Ach.) Nyl.	Picrolichenic acid (major) and atranorin (trace)
P. angabangensis A. W. Archer & Elix	4,5-Dichlorolichexanthone (minor), skyrin (major), methyl barbatate (minor), stictic acid (major) and constictic acid (minor)
P. archeri Jariangprasert	2′-*O*-Methylstenosporic acid (major), planaic acid (minor), 2′-*O*-methylperlatolic acid (minor), methyl 2-*O*-methylperlatolate (minor) and methylplanaiate (minor)
P. asiana Vainio	Norstictic acid (major), salazinic acid (major-minor), ±atranorin (minor), ±elatinic acid (minor), stictic acid (trace), connorstictic acid (minor-trace), ±consalazinic acid (trace-minor) and ±squamatic acid (trace)
P. asterella Aptroot	Lichexanthone
P. bokluensis Jariangprasert	4,5-Dichlorolichexanthone (minor) and 2, 2′-di-*O*-methylstenosporic acid (major)
P. bonariensis Malme	4,5-Dichlorolichexanthone (trace), planaic acid (minor), stictic acid (major) and constictic acid (minor)
P. ceylonica Müll. Arg.	2,4,5-Trichlorolichexanthone (minor), ±2,4-dichlorolichexanthone (minor-trace), ±2,5-dichlorolichexanthone (minor), stictic acid (major), constictic acid (submajor-minor), methyl stictic acid (minor-trace), cryptostictic acid (trace) and peristictic acid (minor-trace).

Table 4.6 The taxa on the basis of chemistry (continued)

Taxa	Chemicals
P. cicatricosa Müll. Arg.	2-Chlorolichexanthone (minor), 2,5-dichlorolichexanthone (major-minor), 2,4-dichlorolichexanthone (major-minor), 2,4,5-trichlorolichexanthone (major-minor), ±stictic acid (major) and ±constictic acid (minor).
P. cicatricosa Müll. Arg. var. *deficiens* A.W. Archer, Elix & Streimann	Stictic acid
P. cinchonae Müll. Arg.	4,5-Dichlorolichexanthone (major-minor), ±atranorin (trace), confluentic acid (major-minor), ±2′-*O*-methylperlatolic acid (trace), ±4-*O*-methylolivetonide (minor), ±methylhyperphyllinic acid (minor), ±2′-*O*-methylmicrophyllinic acid (trace), stictic acid (major-minor), constictic acid (minor), ±cryptostictic acid (trace), ±methyl stictic acid (trace) and ±peristictic acid (minor-trace).
P. clarkeana A.W. Archer	Lichexanthone (minor), ±atranorin (minor-trace)), picrolichenic acid (major), subpicrolichenic acid (major), isosubpicrolichenic acid (minor), superpicrolichenic acid (minor) and lecanoric acid (trace).
P. commutata Müll Arg.	±Lichexanthone (minor-trace), ±atranorin (minor-trace) haemathamnolic acid (major) and decarboxyhaemathamnolic acid (minor).
P. elixii Jariangprasert	Lichexanthone (minor), 2′-*O*-methylstenosporic acid (major), 2′-*O*-methyldivaricatic acid (minor), 2′-*O*-methylperlatolic acid (minor), stictic acid (minor), and constictic acid (minor).
P. endochroma Müll. Arg.	Thiophaninic acid.
P. erubescens (Taylor) Nyl.	Norstictic acid.
P. follmanniana A.W. Archer & Elix	±2-Chlorolichexanthone (major-minor), atranorin (minor), stictic acid (major-minor), cryptostictic acid (minor), peristictic acid (minor), ±2-*O*-methylperlatolic acid (minor), 2-*O*-methylhyperlatolic acid (minor), ±2-*O*-methylisohyperlatolic acid (minor), 2-*O*-methylsuperlatolic acid (major-minor), isohyperplanaic acid (minor), superplanaic acid (minor) and rarely hyperplanaic acid (trace).
P. gibberosa Müll. Arg.	4,5-Dichlorolichexanthone (minor) and 2′-*O*-methylperlatolic acid (major).

Table 4.6 The taxa on the basis of chemistry (continued)

Taxa	Chemicals
P. glomerata (Ach.) Schaer.	Norstictic acid and connorstictic acid.
P. howeana A.W. Archer & Elix	Arthothelin (major), 6-*O*-methylarthothelin (minor), 2,4-dichloronorlichexanthone (minor), 2,5-dichloronorlichexanthone (trace) and 4,5-dichloronorlichexanthone (trace).
P. hylocola Jariangprasert & A.W. Archer	Stictic acid (major), constictic acid (major), perlatolic acid (minor), hyperlatolic acid (minor), thiophaninic acid (minor), cryptostictic acid (trace), peristictic acid (trace), methyl stictic acid (trace), methyl pseudolusitanate (trace) and 2-chloro-6-*O*-methylnorlichexanthone (trace).
P. hypostictica Jariangprasert	Stictic acid (major), hypostictic acid (minor), cryptostictic acid (minor), peristictic acid (minor), substictic acid (minor) and constictic acid (trace).
P. inthanonensis Jariangprasert	Lichexanthone (major-minor), confluentic acid (major), hyperconfluentic acid (minor), stictic acid (major), constictic acid (minor), 2′-*O*-methylmicrophyllinic acid (minor-trace), ±skyrin (minor) and ±graciliformin (minor).
P. irregularis Müll Arg.	4,5-Dichlorolichexanthone
P. kansriae Jariangprasert	4,5-Dichlorolichexanthone (minor), 2′-*O*-methylstenosporic acid (major) and 2′-*O*-methyldivaricatic acid (trace)
P. krabiensis Jariangprasert	2-*O*-Methylsuperlatolic acid (major), 2-*O*-methylhyperlatolic acid (minor), 2-*O*-methylisohyperlatolic acid (minor), superplanaic acid (minor), hyperplanaic acid (trace), isohyperplanaic acid (minor), stictic acid (major) peristictic acid (minor) and cryptostictic acid (minor).
P. lansangensis Jariangprasert & A.W. Archer	2,4-Dichlorolichexanthone (minor), 2,5-dichlorolichexanthone (minor), 2,4,5-trichlorolichexanthone (minor), 2-chlorolichexanthone (trace), stictic acid (major) and constictic acid (minor).
P. leiocarpella Müll. Arg.	4,5-Dichlorolichexanthone (minor), stictic acid (major), constictic acid (minor) and ±norstictic acid (trace).

Table 4.6 The taxa on the basis of chemistry (continued)

Taxa	Chemicals
P. leioplaca DC.	4,5-Dichlorolichexanthone (minor), stictic acid (major), constictic acid (submajor-minor), peristictic acid (minor), cryptostictic acid (minor) and substictic acid (minor).
P. leioplacella Nyl.	Thiophaninic acid (minor), hypostictic acid (minor), stictic acid (major), constictic acid (minor), hypoconstictic acid (trace) and rarely ±norstictic acid
P. leucostigma Müll. Arg.	Lichexanthone (minor) and 2-*O*-methylperlatolic acid (major).
P. limbata Vainio	±2-Chlorolichexanthone (major), ±norstictic acid (minor), stictic acid (major) and constictic acid (major).
P. litchicola Jariangprasert & A.W. Archer	Methyl 2-*O*-methyldivaricatate (major), 2-*O*-methyldivaricatic acid (major-minor) and 4,5-dichlorolichexanthone (minor-trace).
P. loeiensis Jariangprasert	4,5-Dichlorolichexanthone (trace), 2-*O*-methylperlatolic acid (major), methyl 2-*O*-methylperlatolate (trace), stictic acid (minor), constictic acid (minor) and peristictic acid (trace).
P. lordhowensis A.W. Archer & Elix	2-Chlorolichexanthone (trace), 2,4-dichlorolichexanthone (trace), 2,5-dichlorolichexanthone (minor), 2,4,5-trichlorolichexanthone (minor), stictic acid (major), peristictic acid (minor) and cryptostictic acid (minor).
P. macounii (Lamb) Dibb.	4,5-Dichlorolichexanthone (minor), stictic acid (major) and constictic acid (minor).
P. mattogrossensis Malme	2-*O*-Methylperlatolic acid (major) and ±perlatolic acid (trace).
P. miscella A.W. Archer	Lichexanthone (major-minor), thamnolic acid (major) and decarboxythamnolic acid (minor-trace).
P. montpittensis A.W. Archer	4,5-Dichlorolichexanthone, stictic acid and constictic acid.
P. moreliensis B. de Lesd.	Lichexanthone (minor-trace), haemathamnolic acid (major), decarboxyhaemathamnolic acid (minor), ±atranorin (minor) and ±norstictic acid (minor).
P. mundula Müll. Arg.	4,5-Dichlorolichexanthone (major).
P. muricata J.C. David	4,5-Dichlorolichexanthone (trace), stictic acid (major), peristictic acid (minor), cryptostictic acid (minor) and substictic acid (minor).

Table 4.6 The taxa on the basis of chemistry (continued)

Taxa	Chemicals
P. nahaeoensis Jariangprasert & A.W. Archer	4,5-Dichlorolichexanthone (minor), 2-*O*-methylperlatolic acid (major), atranorin (minor), alternariol (minor), alternariol methyl ether (minor), methyl baeomycesate (minor) and perlatolic acid (minor).
P. nanensis Jariangprasert & A.W. Archer,	Lichexanthone (major), 2,2′-di-*O*-methylstenosporic acid (major) and protocetraric acid (minor).
P. nebulosa A.W. Archer	±2-Chlorolichexanthone (major).
P. norstictica A.W. Archer	Norstictic acid (major) and ±2-chlorolichexanthone (trace).
P. novaeguineae A.W. Archer & Elix	±2-Chlorolichexanthone (minor), 2′-*O*-methylperlatolic acid (major), planaic acid (minor), 2-*O*-mehtylperlatolic acid (minor), methyl-2-*O*-methylperlatolate (minor), methyl planaiate (minor), stictic acid (major-minor), ±constictic acid (trace), ±atranorin (minor) and ±peristictic acid (trace).
P. omkoiensis Jariangprasert & A.W. Archer	Thiophaninic acid (minor), isoplacodiolic acid (minor), 2,2′-di-*O*-methylstenosporic acid (minor), planaic acid (minor), stictic acid (major), constictic acid (major) and hypostictic acid (minor),
P. ophthalmiza (Nyl.) Nyl.	Fatty acids, pertusaric acid, dihydropertusaric acid
P. orarensis A.W. Archer & Elix	2-Chlorolichexanthone (minor), divaricatic acid (major), methyl 2,2′-di-*O*-methyldivaricatate (minor), methyl 2-*O*-methydivaricate (trace) and stenosporic acid (trace).
P. pallida A.W. Archer & Elix	±2-Chlorolichexanthone (minor), 2′-*O*-methylperlatolic acid (major), planaic acid (minor), 2-*O*-mehtylperlatolic acid (minor), methyl 2-*O*-methylperlatolate (minor), methyl planaiate (minor), stictic acid (minor) and constictic acid (trace).
P. paradoxica A.W. Archer & Elix	±Thiophaninic acid (minor), 4-*O*-methylisocryptochloropheic acid (major), stictic acid (major), constictic acid (minor), peristictic acid (trace) and ±norstictic acid (trace).
P. patellifera A.W. Archer	Picrolichenic acid (major) and ±atranorin (minor).
P. pertusa (L.) Tuck.	4,5-Dichlorlichexanthone (major-minor), stictic acid (major), constictic acid (submajor-minor), ±cryptostictic acid (trace), ±methyl stictic acid (trace), ±peristictic

Table 4.6 The taxa on the basis of chemistry (continued)

Taxa	Chemicals
P. pertusa (continued)	acid (trace), ±substictic acid (trace) and ±menegazziaic acid (minor) and rarely skyrin (minor).
P. pertusella Müll. Arg.	2-Chlorolichexanthone (minor), 2,4-dichlorolichexanthone (minor), 2,5-ichlorolichexanthone (minor), 2,4,5-trichlorolichexanthone (minor), stictic acid (major), constictic acid (minor) and peristictic acid (trace).
P. petrophyes Knight	Thiophaninic acid (minor) and 2-*O*-methylperlatolic acid (major).
P. phaeostoma Müll. Arg.	Lichexanthone (major)
P. pilosula A.W. Archer & Elix	4,5-Dichlorolichexanthone (minor), 2′-*O*-methylperlatolic acid (major), stictic acid (major), constictic acid (minor) and rarely atranorin (minor).
P. psoromica A.W. Archer & Elix	Psoromic acid.
P. puffina A.W. Archer & Elix	2-Chlorolichexanthone (minor), 2,4-dichlorolichexanthone (major), 2,5-dichlorolichexanthone (major), 2,4,5-trichlorolichexanthone (minor), stictic acid (major) and constictic acid (minor).
P. radiata Oshio	Stictic acid.
P. ramuensis A.W. Archer & Elix	Stictic acid
P. ramulifera H. Magn.	Norstictic acid (major), connorstictic acid (minor), atranorin (minor), subnorstictic acid (minor) and salazinic acid (trace).
P. scaberula A.W. Archer	±Lichexanthone (minor), thamnolic acid (major) and decarboxythamnolic acid (minor).
P. scutellifera A.W. Archer & Elix	Thamnolic acid (major) and decarboxythamnolic acid (minor).
P. siamensis Jariangprasert	4,5-Dichlorolichexanthone (minor) and planaic acid (major).
P. sommerfeltii (Flörke ex Somm.) Fr.	4,5-Dichlorolichexanthone (minor), stictic acid (major), constictic acid (submajor), norstictic acid (minor), cryptostictic acid (minor) and methyl stictic acid (minor).
P. stenostoma Vainio	4,5-Dichlorolichexanthone (major), stictic acid (major) and ±peristictic acid (minor).
P. subplanaica A.W. Archer & Elix	4,5-Dichlorolichexanthone (minor), 2,2′-di-*O*-methylstenosporic acid (minor), 2′-*O*-methylperlatolic acid (minor), 2′-*O*-methylstenosporic acid (minor), 2,2′-di-*O*-methyldivaricatic acid (minor) and planaic acid (minor).

Table 4.6 The taxa on the basis of chemistry (continued)

Taxa	Chemicals
P. subplanaica A. W. Archer & Elix var. *tetraspora* Jariangprasert & A.W. Archer	4,5-Dichlorolichexanthone (minor), 2,2′-di-*O*-methylstenosporic acid (major), 2′-*O*-methylstenosporic acid (minor) and planaic acid (minor).
P. subrigida Müll. Arg.	Nil
P. takensis Jariangprasert & A.W. Archer	2,4-Dichlorolichexanthone (minor), 2,5-dichlorolichexanthone (minor), 2,4,5-trichlorolichexanthone (minor), 2-chlorolichexanthone (trace), stictic acid (major), constictic acid (minor) and ±atranorin (trace).
P. tetrathalamia (Fée) Nyl.	4,5-Dichlorolichexanthone (minor), stictic acid (major) and constictic acid (minor), rarely planaic acid (minor).
P. tetrathalamia (Fée) Nyl. var. *plicatula* Müll. Arg.	Lichexanthone (major), stictic acid (major) and constictic acid (minor).
P. texana Müll. Arg.	Thiophaninic acid, stictic acid and constictic acid
P. thailandica Jariangprasert	4,5-Dichlorolichexanthone (minor-trace), 2′-*O*-methylstenosporic acid (major), 2′-*O*-methyldivaricatic acid (minor), 2′-*O*-methylperlatolic acid (minor-trace), stictic acid (minor), constictic acid (minor), ±atranorin (minor) and ±chloroatranorin (minor).
P. thiophaninica A.W. Archer	Thiophaninic acid.
P. thwaitesii Müll. Arg.	Protocetraric acid (major), ±virensic acid (trace) and ±2-chlorolichexanthone (minor-trace).
P. tropica Vainio	±Lichexanthone (major-minor) and hypothamnolic acid (major).
P. umbricola A.W. Archer & Elix	Protocetraric acid.
P. uttaraditensis Jariangprasert	2′-*O*-Methylperlatolic acid (major).
P. velata (Turn.) Nyl.	Lecanoric acid (major), atranorin (minor) and ± orsellinic acid (minor).
P. wauensis Elix & A.W. Archer	Psoromic acid (major), 2′-*O*-demethylpsoromic acid (=conpsoromic acid) (minor), subpsoromic acid (trace) and atranorin (trace).
P. xantholeuca Müll. Arg.	±Lichexanthone (minor), squamatic acid (major), atranorin (minor) and 2-*O*-methylsquamatic acid (trace).
P. xanthonaria A.W. Archer & Elix	2-Chlorolichexanthone (minor), 2,5-dichlorolichexanthone (major-minor),

Table 4.6 The taxa on the basis of chemistry (continued)

Taxa	Chemicals
P. xanthonaria (continued)	dichlorolichexanthone (major-minor), 2,4,5-trichlorolichexanthone (major-minor) and ±4,5-dichlorolichexanthone (minor).
P. xylophyes A.W. Archer	Thiophaninic acid (minor), 2-*O*-methylperlatolic acid (major) and ±2-chloro-6-*O*-methylnorlichexanthone (trace).
Pertusaria sp. 1	Lichexanthone (minor), 2′-*O*-methylstenosporic acid (major), 2′-*O*-methyldivaricatic acid (trace), 2′-*O*-methylperlatolic acid (trace) and stictic acid (trace).
Pertusaria sp. 2	4,5-Dichlorolichexanthone (minor), 2′-*O*-methylperlatolic acid (major), stictic acid (minor) and constictic acid (minor-trace).
Pertusaria sp. 3	Methyl 2′-*O*-methylstenosporate (major), planaic acid (minor), 2-*O*-methylperlatolic acid (minor), methyl 2-*O*-methylperlatolate (minor), methylplanaiate (minor), stictic acid (major) and constictic acid (trace).
Pertusaria sp. 4	2,2′-Di-*O*-methylstenosporic acid (major), stictic acid (major) and constictic acid (minor).
Pertusaria sp. 5	Atranorin (trace), 4,5-dichlorolichexanthone (minor), 2-*O*-methylperlatolic acid (major), perlatolic acid (trace), dihydropicrolichenic acid (trace) and ±2-*O*-methylstenosporic acid (trace).
Pertusaria sp. 6	4,5-Dichlorolichexanthone (minor), 2′-*O*-methylstenosporic acid (major), stictic acid (minor) and constictic acid (minor).
Pertusaria sp. 7	Atranorin (minor), 2′-*O*-methylperlatolic acid (major), 2-*O*-methylperlatolic acid (minor), planaic acid (minor), methyl 2-*O*-methylperlatolate (minor), methyl planaiate (minor), stictic acid (major) and peristictic acid (trace).
Pertusaria sp. 8	4,5-Dichlorolichexanthone (minor), norstictic acid (major) and connorstictic acid (minor).
Pertusaria sp. 9	Confluentic acid (major) and 2′-*O*-methylmicrophyllinic acid (minor-trace).
Pertusaria sp. 10	2′-*O*-Methylperlatolic acid (major), stictic acid (minor) and peristictic acid (trace).
Pertusaria sp. 11	4,5-Dichlorolichexanthone (minor), 2,2′-di-*O*-methylstenosporic acid (major), 2,2′-di-

Table 4.6 The taxa on the basis of chemistry (continued)

Taxa	Chemicals
Pertusaria sp. 11 (continued)	*O*-methyldivaricatic acid (major), 2′-*O*-methylstenosporic acid (minor), methyl 2′-*O*-methylstenosporate (minor), planaic acid (minor) and stictic acid (major).
Pertusaria sp. 12	2′-*O*-Methylperlatolic acid (major), stictic acid (minor) and constictic acid (trace).

*The chemicals without concentration in bracket were only tested by TLC.